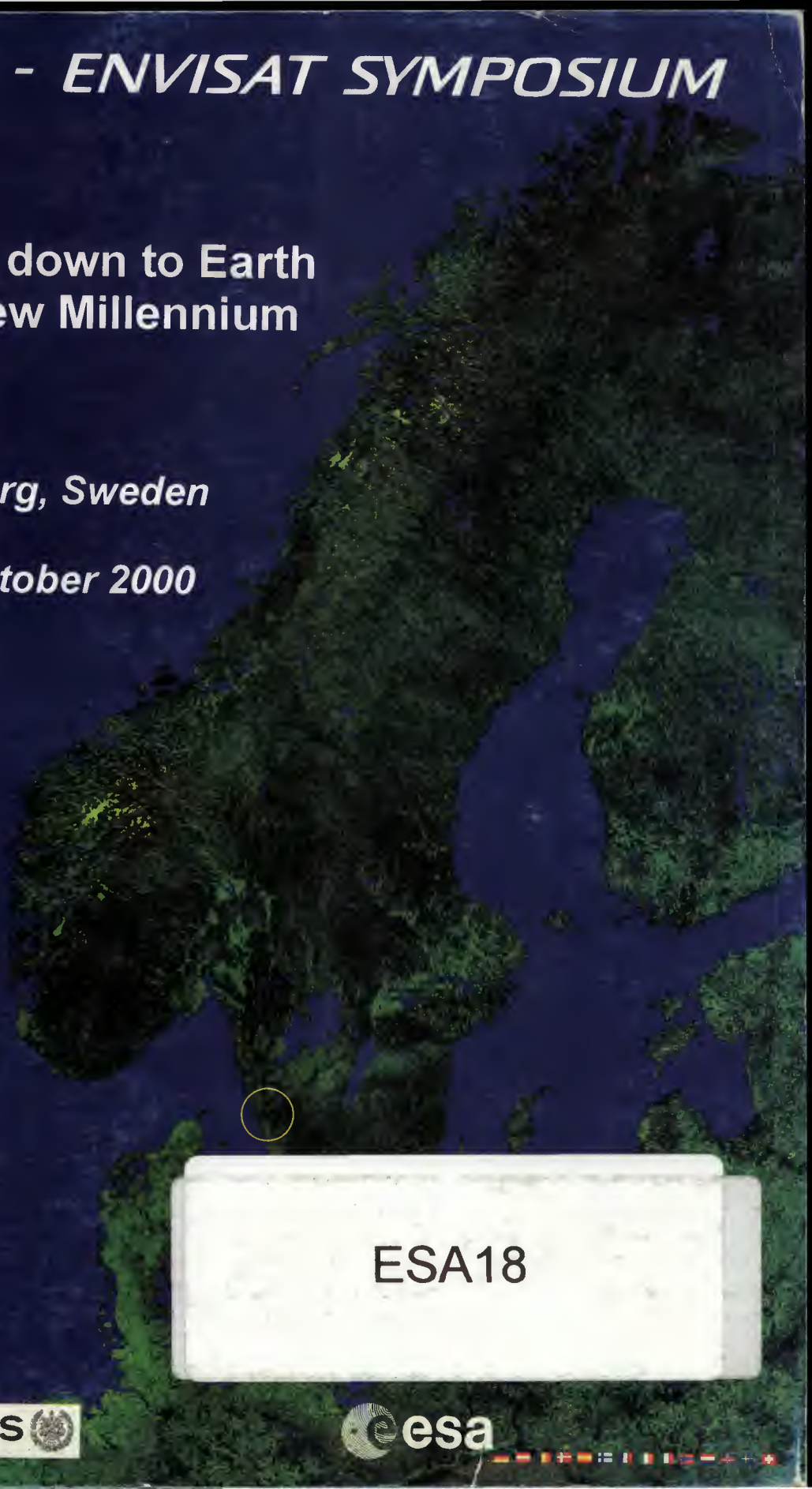
ERS - ENVISAT SYMPOSIUM

Looking down to Earth in the New Millennium

Gothenburg, Sweden

16 - 20 October 2000



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ERS - ENVISAT SYMPOSIUM

"Looking down to Earth in the New Millennium"

ABSTRACTS

Note: This volume includes abstracts of verbal, posters, demo presentations. CD with Proceedings will be edited after the Symposium.

All abstracts are accessible on-line at:
http://www.esa.int/sympo2000

16 - 20 October, 2000
Gothenburg, Sweden

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Background and objectives of the Symposium

Since the launch of ERS-1 in 1991, ESA has hosted a number of Symposia and Workshops. These include:

- the ERS Scientific Symposia in Cannes (1992), Hamburg (1993) and Florence (1997);

- the ERS Pilot Projects and Thematic Application Workshops in Toledo (1994), London (1995), Frascati (1995,1996,1999), Zurich (1996) and Liege (1999)

ESA continues to support the development of Earth Observation along the following main lines:

- Science & Methodology;
- Development of Applications/Public Services;
- Development of the commercial market for EO-based Services

The fourth Scientific Symposium – jointly hosted by ESA and the Chalmers University of Technology in Goteborg, Sweden – is meant to cover both, the ERS and Envisat missions.

The Symposium is open to all interested parties, from scientists to operational, commercial users and service providers. It offers an opportunity to appraise the current status of ERS applications and to explore future applications of Envisat.

Over 450 contributions in the form of verbal, poster or demo presentations build up the contents of the Symposium. They are the result of the work by the ESA Principal Investigators, particularly those working under the Third Announcement of Opportunity of ERS Data (AO3) scheme, the Envisat CAL/VAL projects, and national investigations and projects.

In addition, over 25 ''Exhibitors'' gathered in Hall ''H'' have ensured their support to the event. These represent entities involved in EO-related activities (ERS and ENVISAT payload data domain, in particular) in various modes and within different but complementary operational frameworks.

SUMMARY OF SESSIONS

MONDAY 16 0CT	
1400	PLENARY SESSION
1420	
1440	
1500	
1520	
1540	
1600	
1620	
1640	
1700	
1720	
1740	
1800	

TUESDAY 17 0CT	PARALLEL SESSION	PARALLEL SESSION	PARALLEL SESSION	PARALLEL SESSION
900	ATM: Ozone	Ocean Dynamics	Forestry (Siberia)	Methods 1
920				
940				
1000				
1020				*Coffee Break*
1040	*Coffee Break*	*Coffee Break*	*Coffee Break*	Methods 2
1100	ATM: Ozone	Ocean Dynamics	Forestry (Siberia)	
1120				
1140			Forestry	
1200	ATM: Clouds			
1220				
1240				
Lunch Break				
1400	ATM: Clouds	Landslides	Forestry	Coastal Zones 1
1420				
1440				
1500				
1520				
1540		*Coffee Break*		
1600	*Coffee Break*	Earthquakes	*Coffee Break*	*Coffee Break*
1620	ATM: Calibration		Rice	Coastal Zones 1
1640				
1700				Coastal Zones 2
1720				
1740				
1800				
1820				
1840				
1900				

WEDNESDAY 18 OCT	PARALLEL SESSION	PARALLEL SESSION	PARALLEL SESSION	PARALLEL SESSION
900	ATM: UV rad	Wind Waves 1	ENVISAT RA2	Land Cover/Use
920				
940				
1000				
1020				
1040	*Coffee break*	*Coffee break*	*Coffee break*	*Coffee break*
1100	ATM: UV rad	Wind Waves 1	ENVISAT AATSR	Land Cover/Use
1120				
1140				
1200				
1220				
1240				
Lunch Break				
1400	Methods 3	Wind Waves 2	ENVISAT ASAR	Land Cover/Use
1420				
1440				
1500				Vegetation
1520				&
1540				Agriculture
1600		*Coffee break*	*Coffee break*	*Coffee break*
1620	*Coffee break*	Wind Waves 2	ENVISAT Atmospheric Instruments	
1640	Methods 4			Vegetation
1700				&
1720				Agriculture
1740				
1800				
1820				

THURSDAY 19 OCT	PARALLEL SESSION	PARALLEL SESSION	PARALLEL SESSION	PARALLEL SESSION
900	Hydrology 1	Services & Market	Geology Volcanoes	Ice 1
920				
940				
1000				
1020				
1040	*Coffee break*	*Coffee break*	*Coffee break*	*Coffee break*
1100	Hydrology 2	Services & Market	Volcanoes	Ice 1
1120				
1140			Floods / Storms	
1200				
1220				
1240				
Lunch Break				
1400	Hydrology 2	ENVISAT ESA 1	Floods / Storms	Ice 2
1420	Sea Ice 1			
1440				
1500				
1520				Geodesy
1540			*Coffee break*	
1600	*Coffee break*	*Coffee break*	Earth Motion	*Coffee break*
1620	Sea Ice 2	ENVISAT ESA 2		Geodesy
1640				
1700				
1720				
1740				
1800				
1820				
1840				

FRIDAY 20 OCT	PARALLEL SESSION	PARALLEL SESSION	PARALLEL SESSION	PARALLEL SESSION
900	**Performances**	**LST**	**Sea Features**	**Topography**
920				
940				
1000				
1020				
1040	*Coffee break*	*Coffee break*	*Coffee break*	*Coffee break*
1100	**Performances**	**SST**	**Sea Features**	**Topography**
1120				
1140				
1200	**ESA EO Future programmes**			
1220				
1240	***Closing Session***			
1300				

PRELIMINARY PROGRAMME

NOTE: Daily sessions are running parallel in four different meeting rooms

TUESDAY 17 OCTOBER 2000

	ID Nr	Title	Presenter
		ATM Ozone: Total Column, Profiles	
9.00 – 9.20	146	Review of Five Years GOME/ERS-2 Operational Trace Gas Retrieval	Werner Thomas
9.20 – 9.40	376	Improved GOME ozone column retrieval	Pieter Valks
9.40 – 10.00	457	Temperature Independent Differential Absorption Spectroscopy (TIDAS) and Simplified Atmospheric air Mass Factor (SAMF) techniques for the measurement of total ozone using GOME data	Claus Zehner
10.00 – 10.20	185	Ozone from GOME data using neural network technique	Martin Mueller
10.20 – 10.40	366	Observation and theoretical analysis of the record ozone mini-hole of 30 November 1999	Henk Eskes
10.40 – 11.00		*Coffee Break*	
11.00 – 11.20	1058	Derivation of an extensive height-resolved ozone data-set spanning the troposphere and stratosphere from GOME	Richard Siddans
11.20 – 11.40	373	Near-real time delivery of GOME ozone profiles.	Ronald van der A
11.40 – 12.00	400	Ozone profiles estimates by using GOME measurements and a neural network algorithm	Stefano Casadio
		ATM Clouds/Aerosols	
12.00 – 12.20	111	Radiation and cloud studies with GOME in preparation for future spectrometer missions	Piet Stammes
12.20 – 12.40	481	CRAG - Cloud Retrieval Algorithm for GOME	Albrecht von Bargen
12.40 – 13.00	282	Cloud Retrieval for SCIAMACHY	Diego Loyola
13.00 – 13.20			
13.20 – 13.40		*Lunch Time*	
13.40 – 14.00			

		ATM Clouds/Aerosols (Cont.)	
14.00 – 14.20	367	Automated cloud-top height, amount and winds from ATSR2 in EU-CLOUDMAP project	Jan-Peter Muller
14.20 – 14.40	468	Remote Sensing of Aerosol over oceans using visible and infrared measurements from ATSR-2 and AATSR	Philip Watts
14.40 – 15.00	131	Tropospheric aerosol characterisation: from GOME towards an Envisat perspective	Maria João Costa
15.00 – 15.20	100	Synergetic retrieval of aerosol properties: from ERS to ENVISAT	Marion Schroedter
15.20 – 15.40	437	Aerosol retrieval over land and over sea	Gerrit De Leeuw
15.40 – 16.00	162	Validation of Aerosol Properties Retrieved from GOME Measurements	Marco Cervino
16.00 – 16.20		*Coffee Break*	
		ATM Calibration. Radiative Transfer. Assimilation	
16.20 – 16.40	149	Degradation of GOME observations in the UV : summary of the GDAQI project	Ilse Aben
16.40 – 17.00	358	GOME degradation correction at solar activity maximum	Ernst Hegels
17.00 – 17.20	421	Improving the polarisation correction of GOME	N.A.J. Schutgens
17.20 – 17.40	120	Comparisons between GOME and modelled backscattered radiances using in-situ measured aerosol data from the ACE-2 campaign	Johan Jansson
17.40 – 18.00	98	The LIDORT package - a generic forward-model radiative transfer tool for the simultaneous generation of intensities and weighting functions for atmospheric retrieval	Robert Spurr
18.00 – 18.20	297	Analysis of global synoptic chemical constituent maps by 4D variational assimilation of satellite data	Hendrik Elbern
18.20 – 18.40	1403	Assimilation of 3D ozone field in global chemistry-transport models	G. El Serafy
18.40 – 19.00	99	Temperature dependent absorption cross section of O3, NO2, and other atmospheric trace gases measured with the SCIAMACHY spectrometer	Konstanze Bogumil
19.00 – 19.20	316	In-orbit optical path degradation: GOME experience and SCIAMACHY prediction	Ralph Snel
19.20 – 19.40			

TUESDAY 17 OCTOBER 2000

	ID Nr	Title	Presenter
		Ocean Dynamics	
9.00 – 9.20	58	Small scale processes in the South Atlantic observed in synergy of ATSR and SAR data during the Tandem Mission.	Ian Robinson
9.20 – 9.40	105	Feasibility of ERS altimeter data to study subsurface processes in the North Atlantic	Jacob Hoeyer
9.40 – 10.00	206	ERS-2 Altimetry in Operational NOAA Forecast Models	John Lillibridge
10.00 – 10.20	252	Analysis of the Atlantic Ocean response to Pressure Variations using the Altimeters of ERS-1 and ERS-2 Satellites during his Tandem Mission	Jesus Gomez-Enri
10.20 – 10.40			
10.40 – 11.00		*Coffee Break*	
11.00 – 11.20	287	Indian Ocean Circulation: an Integrated Model and Remote Sensing Study	Vibeke E. J. Haugen
11.20 – 11.40	348	Thermal plumes and internal solitary waves generated in the Lombok Strait studied by ERS SAR	Leonid Mitnik
11.40 – 12.00	496	Determination and Characterization of Global Mean Sea Level Change	C. K. Shum
12.00 – 12.20	534	Use of SAR derived Doppler data for obtaining quantitative current velocity information in the Gulf of Mexico	Marco van der Kooij
12.20 – 12.40	189	Internal solitary waves in the Sulu Sea studied by ERS SAR imagery	Werner Alpers
12.40 – 13.00	232	Local mean sea level slope from multi-satellite altimeter data: data analysis and unification in the Western Mediterranean Sea	Luciana Fenoglio-Marc
13.00 – 13.20			
13.20 – 13.40		*Lunch Time*	
13.40 – 14.00			

		Landslides	
14.00 – 14.20	395	Regional scale thematic maps for landslide hazard assessment using neural networks techniques.	Palma Blonda
14.20 – 14.40	207	Monitoring landslide activity in a peri-urban area by SAR Interferometry	Alberto Refice
14.40 – 15.00	234	The application of ERS SAR interferometry for the assessment of hazards related to slope motion and subglacial volcanism	Helmut Rott
15.00 – 15.20	181	Detection and Quantification of Rock Glacier Movements using ERS D-InSAR Data	Lado-Wani Kenyi
15.20 – 15.40	147	Civil Protection use of ERS1-2 SAR Data - the TS-SAR Project	Roberto Vidmar
15.40 – 16.00		*Coffee Break*	
		Earthquakes	
16.00 – 16.20	43	Merging seismotectonic displacement maps measured from SAR interferometry and optical satellite images.	Rémi Michel
16.20 – 16.40	265	Eight years of crustal deformation in Southern California observed with ERS SAR interferometry	Gilles Peltzer
16.40 – 17.00	84	The Coseismic Deformation Field of M=7.5 Mani Earthquake in Tibet Mapped by ERS Interferometric SAR Data	Guo Huadong
17.00 – 17.20	499	Applications of SAR Interferometry to Surface Deformation in Central and Southwest Asia	Eric Fielding
17.20 – 17.40	485	Triggered slip on a shallow low-angle thrust imaged by SAR interferometry: the Shahdad thrust, SE Iran	Barry Parsons
17.40 – 18.00	484	Crustal deformation of the North Anatolian Fault Zone measured with radar interferometry	Tim Wright
18.00 – 18.20	535	Coherence tracking measurements of the Agust 1999 Izmit earthquake	Dominique Derauw
18.20 – 18.40	54	Study of the September 7, 1999 Athens earthquake using ERS-2 SAR interferometry	Charalabos Kontoes
18.40 – 19.00	462	The coseismic displacement field of the Baotou earthquake mapped by differential radar interferometry	Zhang Hong
19.00 – 19.20			
19.20 – 19.40			

TUESDAY 17 OCTOBER 2000

	ID Nr	Title	Presenter
		Forestry: SIBERIA	
9.00 – 9.20	461	Russian Forest Inventory Requirements and Remote Sensing Parameters-Operational Aspects evolving from the SIBERIA Project	Christiane Schmullius
9.20 – 9.40	70.	The classification procedure in SIBERIA: rationale and methodology	Shaun Quegan
9.40 – 10.00	429	Assessing ERS and JERS SAR information content for large scale forestmapping in Siberia	Thuy Le Toan
10.00 – 10.20	328	Accuracy assessment issues in the SIBERIA project	Heiko Balzter
10.20 – 10.40	473	ERS Interferometric Processing for Boreal Forest Applications	Achim Roth
10.40 – 11.00		*Coffee Break*	
11.00 – 11.20	334	Global forest classification using JERS and tandem ERS data	Adrian Luckman
11.20 – 11.40	410	JERS-1 INSAR coherence over Siberian boreal forest	Andreas Wiesmann
		Forestry	
11.40 – 12.00	235	ERS and JERS-1 SAR data application for Russian boreal forests mapping and monitoring	Victoria Donchenko
12.00 – 12.20	81	Boreal Forest Monitoring with ERS Coherence	Maurizio Santoro
12.20 – 12.40	196	An Analysis of InSAR Coherence of Boreal Forests Based on Electromagnetic Scattering Modeling	Xianyun Luo
12.40 – 13.00	251	Mapping Siberian Landscapes: natural and Anthropogenic Factors affecting Carbon Balance	Jon Ranson
13.00 – 13.20			
13.20 – 13.40		*Lunch Time*	
13.40 – 14.00			

		Forestry (Cont.)	
14.00 – 14.20	469	Characterizing transpiration and biomass in a Siberian landscape by combining JERS / ERS-1/2 InSAR image classification, InSAR DEM analysis and field measurements	Reiner Zimmermann
14.20 – 14.40	308	Calculation of Microwave Backscatter from a Scots Pine Forest	Terhikki Manninen
14.40 – 15.00	295	ERS SAR data integration in the updating of vegetation maps	Guillermo Castilla
15.00 – 15.20	492	Combined use of soil and vegetation data, a digital elevation model and SAR classification for C and N Pool Assessment in a Central Alaskan landscape	Jan Dempewolf
15.20 – 15.40	369	An Operational Forest Mapping Tool using Spaceborne SAR Data	Eduard Dwyer
15.40 – 16.00	1053	Global burned Area mapping using the ERS-ATSR2	Jose Miguel Pereira
16.00 – 16.20		*Coffee break*	
		Rice	
16.20 – 16.40	430	Towards operational use of ERS SAR data for rice monitoring	Thuy Le Toan
16.40 – 17.00	116	Analysis of multi-temporal and multi-incidence angle data for rice crop using C band RADARSAT and ERS SAR data.	Manab Chakraborty
17.00 – 17.20	365	Rice Mapping using ERS SAR Data in Guangdong Province, China	Mike Wooding
17.20 – 17.40	372	An Operational Rice Field Mapping Tool using Spaceborne SAR Data	Urs Frei
17.40 – 18.00	231	Rice Yield Estimation Using SAR Images, Meteorological Data and GIS	Mika Karjalainen
18.00 – 18.20			
18.20 – 18.40			
18.40 – 19.00			
19.00 – 19.20			
19.20 – 19.40			

TUESDAY 17 OCTOBER 2000

	ID Nr	Title	Presenter
		Methods 1	
9.00 – 9.20	60	A new collocation system for satellite data	Sylvie Pouliquen
9.20 – 9.40	61	CERSAT Value Added Products	Sylvie Pouliquen
9.40 – 10.00	63	Value Added Geocoded SAR Products from the German ENVISAT PAC	Detlev Kosmann
10.00 – 10.20	174	Developments in AATSR and ATSR Product Algorithms and Data Products	Andrew Birks
10.20 – 10.40		*Coffee Break*	
		Methods 2	
10.40 – 11.00	260	SCANSAR data processing and radiometric calibration.	Andy Smith
11.00 – 11.20	18	INSAR Activities in Central Asia	Xia Ye
11.20 – 11.40	218	Speckle Filtering and Classification of ERS SAR Images using GAMMA Distribution	Youcef Smara
11.40 – 12.00	1357	Isolation of atmospheric artifacts in differential interferometry for ground displacement detection: different methods comparison	Francesco Sarti
12.00 – 12.20	1358	An efficient low-memory implementation of 2-D phase unwrapping based on minimum cost flow algorithm	Luca Galli
12.20 – 12.40	94	Multitemporal InSAR coherence from urban type objects.	Dan Johan Weydahl
12.40 – 13.00	1408	Iterated multitemporal filtering and its use in land applications	Shaun Quegan
13.00 – 13.20			
13.20 – 13.40		*Lunch Time*	
13.40 – 14.00			

		Coastal Zones 1	
14.00 – 14.20	336	Coastal Current Observation using Imaging SAR	Johnny Johannessen
14.20 – 14.40	406	Coastal Map reactualization by Radar SAR ERS Images, examples in the area of Nouakchott city in Mauritania and Douala, Cameroon	Herve Trebossen
14.40 – 15.00	1105	Mapping of Indonesian coastal waters by Synthetic Aperture Radar: an Indonesian-Netherlands initiative for starting new business	Han Wensink
15.00 – 15.20	209	The Alaska SAR Demonstration: RADARSAT-1 Experience and ENVISAT Plans	William Pichel
15.20 – 15.40	318	The ERS contribution to Oil Spill Monitoring- From R&D towards an operational service -	Jan Petter Pedersen
15.40 – 16.00	291	An investigation of coastal processes using the integration of ERS SAR, ocean colour and SST imagery.	Samantha Lavender
16.00 – 16.20		*Coffee Break*	
16.20 – 16.40	355	Multisensor studies of Oceanic Phaenomena in European Marginal Waters: Algae Blooms in the Baltic Sea and a River Plume in the Mediterranean	Martin Gade
16.40 – 17.00	306	Satellite Observations and Model Predictions of Harmful Algae Blooms in Coastal Waters	Lasse H. Pettersson
		Coastal Zones 2	
17.00 – 17.20	186	Cold season features of the Japan Sea coastal zone revealed by ERS SAR	Leonid Mitnik
17.20 – 17.40	277	Monitoring of water quality in lake and coastal regions using ENVISAT MERIS observations	Jouni Pulliainen
17.40 – 18.00	438	Coastal and Estuarine Water Monitoring by Sea Truth, Satellite Ocean Colour, and SPOT Data	I-I Lin
18.00 – 18.20	378	Coastal processes and features from ERS-2 data: two case studies at NE Brazilian continental shelf	Alexandre Cabral
18.20 – 18.40	517	Satellite Observations of the Southern California Bight: Surface Circulation, Oil Seepage, Storm Water Runoff and Biological Implications	Benjamin Holt
18.40 – 19.00	363	Fisheries monitoring in the CaboVerde Region using ERS data	Joana Fernandes
19.00 – 19.20	402	Coastal Engineering Construction Monitoring, Control and Prediction System	Marghany Maged
19.20 – 19.40			

WEDNESDAY 18 OCTOBER 2000

	ID Nr	Title	Presenter
		ATM UV Radiation. trace Gases other then Ozone	
9.00 – 9.20	47	Water vapour retrieval from GOME data including cloudy scenes	Stefan Noel
9.20 – 9.40	399	Empirical Retrieval of the Atmospheric air mass factor (ERA) for the measurement of water vapour vertical content using GOME data. Comparison with independent measurements.	Stefano Casadio
9.40 – 10.00	419	ATSR Total Atmospheric Water Vapor Content Retrieval and Comparison with GOME and Radar Altimeter Data	Paola Colagrande
10.00 – 10.20	124	GODIVAERS - GOME Data Interpretation, Validation and Application - ERS AO3-132	Albert Goede
10.20 – 10.40	22	The Pollution Tracing Technique and application within the Global Atmospheric Watch (GAW) network	Dominique Jeker
10.40 – 11.00		*Coffee Break*	
11.00 – 11.20	511	Evidences for a background of BrO in the free troposphere: status and implications for the global observing system	M. Van Roozendael
11.20 – 11.40	33	Remote-sensed Formaldehyde Observations from the ESA GOME Instrument	Kelly Chance
11.40 – 12.00	240	Algorithm of retrieving and mapping surface UV irradiance from GOME Level 1 Data (AOÇ-403)	Leonid Bobylev
12.00 – 12.20	244	A multi wavelength approach to the retrieval of tropospheric NO2 from GOME	Andreas Richter
12.20 – 12.40			
12.40 – 13.00			
13.00 – 13.20			
13.20 – 13.40		*Lunch Time*	
13.40 – 14.00			

		Methods 3	
14.00 – 14.20	108	Modeling backscattering from leafy vegetation: the incoherent and coherent approaches	Paolo Pampaloni
14.20 – 14.40	182	The application of wavelet-based filtering techniques for retrieving bio-physical parameters from multi-temporal ERS-images	Niko Verhoest
14.40 – 15.00	354	A Polarimetric radiative transfer model for radar remote sensing of land targets	Albert Guissard
15.00 – 15.20	145	Classification of Multi-temporal SAR Images and INSAR Coherence Images using adaptive neighborhood model and simulated annealing approach	Mingquan Bao
15.20 – 15.40	387	Influence of Auroral Zone Ionospheric Disturbances on Synthetic Aperture Radar and Interferometric SAR Data.	Laurence Gray
15.40 – 16.00	197	Cloud detection from satellite imagery by wavelets	Carmine Serio
16.00 – 16.20	268	Advances in Operational Cloud Clearing for ATSR-1,ATSR-2, and AATSR	Christopher Mutlow
16.20 – 16.40		*Coffee Break*	
		Methods 4	
16.40 – 17.00	281	Classification of Oceanic and Atmospheric Signatures in ASAR Dual Polarization Mode Imagery	Roland Romeiser
17.00 – 17.20	140	A Multi-Sensor Approach to Monitor Oceanography in the Gulf of Oman	Neil Stapleton
17.20 – 17.40	8	Inventory and monitoring of shrimp farms in Sri Lanka by ERS SAR data	Carlo Travaglia
17.40 – 18.00	415	Phasemap, a simple software intended to give an efficient access to interferometry	Didier Massonnet
18.00 – 18.20	383	ASAR ScanSAR modes: quality enhancemnt	A. Monti Guarnieri
18.20 – 18.40			
18.40 – 19.00			
19.00 – 19.20			
19.20 – 19.40			

WEDNESDAY 18 OCTOBER 2000

	ID Nr	Title	Presenter
		Wind/Waves 1	
9.00 – 9.20	113	Wind Speed and SWH Calibration for Radar Altimetry in the North Sea	Tilo Schoene
9.20 – 9.40	342	Use of ERS-2 Altimeter Wind/Wave Data for the Validation of Sea State Models	Jean Michel Lefevre
9.40 – 10.00	157	Mesoscale Wind Fields Retrieved from RADARSAT-1 ScanSAR in View of ENVISAT ASAR	Jochen Horstmann
10.00 – 10.20	301	ERS SAR wind retrieval in the marginal ice zone	Birgitte Furevik
10.20 – 10.40	315	Near Real-time Sea-surface Winds from ERS Synthetic Aperture Radar (SAR) Data	Tony Bauna
10.40 – 11.00		*Coffee Break*	
11.00 – 11.20	163	High Resolution Wind Fields and their Variation Extracted from ERS SAR	Jochen Horstmann
11.20 – 11.40	480	The Ocean and Sea Ice Satellite Application Facility Wind Product	Tilly Driesenaar
11.40 – 12.00	102	A Physically-based Model of Ocean Backscatter for Wind Speed retrieval from SAR, Scatterometer and Altimeter.	Trevor Macklin
12.00 – 12.20	275	Tracking of Tropical Cyclones with the ERS Scatterometer: Algorithm Performances and post-processed data examples.	Raffaele Crapolicchio
12.20 – 12.40	359	Use of scatterometer wind data in ECMWF's assimilation system	Lars Isaksen
12.40 – 13.00	1054	On the ERS scatterometer wind measurements accuracy: evidence of seasonal and regional biasses	Yves Quilfen
13.00 – 13.20			
13.20 – 13.40		*Lunch Time*	
13.40 – 14.00			

		Wind/Waves 2	
14.00 – 14.20	14	A new approach to remove the 180 degree ambiguity from the SAR image spectrum	Weigen Huang
14.20 – 14.40	166	Global Observations of Wind Speed and Sea Surface Features using SAR Wave Mode	Susanne Lehner
14.40 – 15.00	169	SAR Ocean Wave Inversion - A Hierarchic Approach	J. Schulz-Stellenfleth
15.00 – 15.20	16	A new composite model, including non-Bragg scattering effects for the estimate of radar cross-section and Modulation Transfer Function, in wind-scatterometer and SAR conditions	Daniele Hauser
15.20 – 15.40	440	Improvement of the high resolution mesoscale atmospheric model RAMS with ERS-SAR, for detailed sea surface wind reconstruction of small scalephenomena	Francesco Meneguzzo
15.40 – 16.00	279	ENVISAR ASAR wave mode data simulated by ERS SAR	Birgit Schaetller
16.00 – 16.20		*Coffee Break*	
16.20 – 16.40	6	Airborne polarimetric radar measurements in the context of the geophysical validation of the ENVISAT ASAR products over the ocean	Daniele Hauser
16.40 – 17.00	508	Validation of Envisat ASAR Wave Mode Level 1 and Level 2 Product Using ERS SAR Data	Harald Johnsen
17.00 – 17.20	23	Validation of ENVISAT SAR Wind Fields: Lessons from ERS and RADARSAT	Frank Monaldo
17.20 – 17.40	394	Comparisons of observed and modelled wave energy spectra using ERS-2 SAR observations and the Met.Office wave model.	James Gunson
17.40 – 18.00	368	The Possibility of Severe Storm Measurement with ENVISAT's Global Monitoring Mode	Paris Vachon
18.00 – 18.20	333	Waves and mixing in the coastal zone	F. Ocampo-Torres
18.20 – 18.40			
18.40 – 19.00			
19.00 – 19.20			
19.20 – 19.40			

WEDNESDAY 18 OCTOBER 2000

	ID Nr	Title	Presenter
		ENVISAT - RA-2	
9.00 – 9.20	34	An ENVISAT S-Band altimeter CAL / VAL experiment in the framework of the OSCAR project	Monique Dechambre
9.20 – 9.40	171	Radar Altimeter Calibration using Ground Based Transponders	Andrew Birks
9.40 – 10.00	276	The ENVISAT RA-2 Value-Added Ocean/Ice Processor at GFZ Potsdam	Alexander Braun
10.00 – 10.20	257	The ENVISAT Altimetry Mission Data Products	Jerome Benveniste
10.20 – 10.40	106	CLS contribution to Envisat CALVAL	Joël Dorandeu
10.40 – 11.00		*Coffee Break*	
11.00 – 11.20	135	Absolute and Relative Calibration of ERS-2 RA with Applications to ENVISAT	Philip Moore
11.20 – 11.40	142	Land Calibration and Monitoring of ENVISAT RA-2 Sigma0	Philippa Berry
11.40 – 12.00	337	Measurements and modeling of ocean surface slopes and calibration of the radar altimeter	Bertrand Chapron
12.00 – 12.20	427	The CATALA campaigns: Indirect calibration technique for ENVISAT altimeter calibration	J. J. Martinez-Benjamin
		ENVISAT - AATSR	
12.20 – 12.40	514	The proposed Global Land Surface Temperature Products for ENVISAT's AATSR: Scientific basis, algorithm description and validation protocol	Fred Prata
12.40 – 13.00	170	Laboratory Calibration of AATSR	David Smith
13.00 – 13.20			
13.20 – 13.40		*Lunch Time*	
13.40 – 14.00			

		ENVISAT - AATSR (Cont.)	
14.00 – 14.20	503	Near-surface ocean temperature variability - consequences for the validation of AATSR on Envisat.	Peter Minnett
		ENVISAT - ASAR	
14.20 – 14.40	386	ScanSAR interferometric monitoring using the PS technique	Andrea Monti Guarnieri
14.40 – 15.00	150	Alternative Large-Scale Distributed Targets for SAR Elevation Beam Pattern Characterization	Christopher Buck
15.00 – 15.20	45	PHARUS ASAR Demonstrator: simulation and application of ASAR data	Arthur Smith
15.20 – 15.40	423	ERS - ENVISAT combination for interferometry and super-resolution	Andrea Monti Guarnieri
15.40 – 16.00	494	External radiometric calibration activity on Italian test-sites for the ENVISAT mission	Francesco Posa
16.00 – 16.20		*Coffee Break*	
		ENVISAT - Atmospheric Instruments	
16.20 – 16.40	392	Acquisitions of the COSE project in the perspective of ENVISAT.	Martine De Maziere
16.40 – 17.00	38	German SCIAMACHY Validation Activities	Thomas Wagner
17.00 – 17.20	344	SCIAMACHY polarisation sensitivity and impact on trace gas retrieval	Sander Slijkhuis
17.20 – 17.40	439	SCIAMACHY Nominal Operations and Special Features	Stefan Noel
17.40 – 18.00	472	Validation of trace gas measurements of the ENVISAT instruments MIPAS, GOMOS and SCIAMACHY using in-situ and remote sensing balloon borne techniques	Hermann Oelhaf
18.00 – 18.20	497	Geophysical validation of level-2 products of MIPAS, GOMOS, and SCIAMACHY by dedicated campaigns of the high-altitude aircraft M-55 Geophysica	Cornelis Blom
18.20 – 18.40	446	An optimized forward model and retrieval scheme for MIPAS near real time data processing	Marco Ridolfi
18.40 – 19.00			
19.00 – 19.20			
19.20 – 19.40			

WEDNESDAY 18 OCTOBER 2000

	ID Nr	Title	Presenter
		Land Cover / Land Use	
9.00 – 9.20	357	Monitoring Rapid Urbanisation with Imaging Radars	David Archer
9.20 – 9.40	229	Synergy Study of Multisource Data for Characterisation and Monitoring of Soil Surfaces. Application to Algiers and Laghouat Regions (Algeria).	Youcef Smara
9.40 – 10.00	495	Application of ERS-SAR and scatterometer to the study of backscatter anisotropy in urban areas	Benedicte Dousset
10.00 – 10.20	445	Understanding ERS Coherence over Urban Areas	Attilio Fanelli
10.20 – 10.40	57	Urban Remote Sensing through Multispectral and Radar Data	Paolo Gamba
10.40 – 11.00		*Coffee Break*	
11.00 – 11.20	1405	Application of EO data for urban planning in Mega Cities	Christopher Boehm
11.20 – 11.40	309	Inferring building height from SAR interferometric phase coherence images	William Grey
11.40 – 12.00	288	Evaluation of Multisensor Spaceborne SAR for CORINE Land Cover Mapping in Sweden	Yifang Ban
12.00 – 12.20	39	SAR interferometric DEM construction for landscape process analyses in north-eastern Iceland	Jukka Käyhkö
12.20 – 12.40	332	Optimal use of multi-temporal SAR data for land use information extraction	Hugues Sassier
12.40 – 13.00	293	Use of ERS SAR Imagery in Refugee Relief	Øyvind Dalen
13.00 – 13.20			
13.20 – 13.40		*Lunch Time*	
13.40 – 14.00			

		Land Cover / Land Use (Cont.)	
14.00 – 14.20	401	Examples of SAR ERS images for development studies and up-dating existing mapping in amazonian area Projects ERS AO3-160 French Guyana and ENVISAT AO 539	Jean Paul Rudant
14.20 – 14.40	219	Evolution of the Hydrographical Network of the Karakum Desert and Environmental Implications for the Aral Sea	Catherine Mering
		Vegetation / Agriculture	
14.40 – 15.00	107	Global scale monitoring of soil and vegetation with ERS Wind scatterometer and SSM/I	Paolo Pampaloni
15.00 – 15.20	183	Interpretation of ERS WSC time series over Sahel during the period 1991-1999	Lionel Jarlan
15.20 – 15.40	393	Relating ERS Scatterometer Data to Global Vegetation Models	Maged Abdel-Messeh
15.40 – 16.00	304	Tree shape description for backscattering modelling of LAI	Terhikki Manninen
16.00 – 16.20		*Coffee Break*	
		Vegetation / Agriculture (cont.)	
16.20 – 16.40	79	ERS Data use for wide-area sampling of agricultural areas: Image Logic for Cereal Monitoring.	Richard Kidd
16.40 – 17.00	515	CAESAR CROP AREA ESTIMATION USING SAR IMAGES	F Mediavilla de Diego
17.00 – 17.20	176	Crops classification in southern Sweden with multitemporal ERS-2 SAR data	Xuetang Xie
17.20 – 17.40	323	Land-use mapping using airborne polarimetric SAR	Henning Skriver
17.40 – 18.00	408	Amazonia Bio-diversity Estimation using remote sensing and indigenous taxonomy	Luigi Fabbro
18.00 – 18.20			
18.20 – 18.40			
18.40 – 19.00			
19.00 – 19.20			
19.20 – 19.40			

THURSDAY 19 OCTOBER 2000

	ID Nr	Title	Presenter
		Hydrology 1	
9.00 – 9.20	53	Comparison ERS SAR Data derived Soil Moisture Distributions with SVAT-Model Results	Wolfram Mauser
9.20 – 9.40	338	Comparisons of detailed in-situ soil moisture and rain measurements with ERS radar backscattering data	Maurice Borgeaud
9.40 – 10.00	455	Applying surface roughness discriminator based on partially polarised SAR data to soil moisture inversion	Francesco Mattia
10.00 – 10.20	458	Generalised inversion algorithm for bare soil moisture mapping using ERS SAR data	Malcolm Davidson
10.20 – 10.40	417	Inferring the Effect of Plant and Soil Variables of C and L Backscatter over Agriculture Fields Based on Modeling Analysis	Katarzyna Dabrowska-Zielinska
10.40 – 11.00		*Coffee Break*	
		Hydrology 2	
11.00 – 11.20	62	An approach for radar backscatter and pedologic soil characteristic investigation	Piero Boccardo
11.20 – 11.40	205	Soil moisture mapping from ASAR imagery for the Flumendosa (Italy) and Meuse (Belgium-Netherlands) river basins	Claudio Paniconi
11.40 – 12.00	96	Combining the microwave model CLOUD and the growth model PROMET-V for soil moisture retrieval	Roswitha Stolz
12.00 – 12.20	193	Mapping and Monitoring of Wetlands in the Lake Chad-basin using ATSR-2 Data (Project AO3-151)	Jan Verhoeye
12.20 – 12.40	112	SAR-based monitoring of flood-induced landcover and landuse change in the region of the inland delta of the river Niger (Mali)	Elmar Csaplovics
12.40 – 13.00	67	On Estimating Snow Wetness Using ASAR Measurements	Jiancheng Shi
13.00 – 13.20			
13.20 – 13.40		*Lunch Time*	
13.40 – 14.00			

		Hydrology 2 (Cont.)	
14.00 – 14.20	247	Real Time Snowmelt Runoff Forecasting using ERS SAR PRI data	Thomas Nagler
		Sea Ice 1	
14.20 – 14.40	40	Arctic Ice Thickness from ERS1/2 Radar Altimetry	Seymour Laxon
14.40 – 15.00	19	SAR, SSMI and numerical model characterisation of Arctic Ocean coastal polynyas	Sverre Thune Dokken
15.00 – 15.20	239	Sea and lake ice studies in the Northwestern Russia using ERS SAR and other satellite data	Vitali Alexandrov
15.20 – 15.40	243	ERS SAR Data Application Use for Studying Sea Ice Parameters and Retrieving of Greenland Seals Migration	Vladimir Melentyev
15.40 – 16.00	317	Mapping Sea Ice Thickness with RADARSAT and a Helicopter-borne Electromagnetic-Induction System	Ingrid Peterson
16.00 – 16.20		*Coffee Break*	
		Sea Ice 2	
16.20 – 16.40	409	Lincoln Sea and Nares Strait - a remote sensing study	Preben Gudmandsen
16.40 – 17.00	303	Satellite Ice Monitoring for Navigation of an ice-going tanker in the Kara Sea	Stein Sandven
17.00 – 17.20	506	Operational Use of Satellite SAR for Sea Ice Monitoring in Canada - Past Experience and Future Possibilities	Dean Flett
17.20 – 17.40	516	Sea Ice Thickness from SAR-derived Kinematics	Benjamin Holt
17.40 – 18.00	160	Extraction of Sea Ice Parameters from Imagette Data	Thomas Koenig
18.00 – 18.20	74	SImA - A Software System for Motion Analysis in Satellite Image Sequences	Roland Neumann Rene Bartholomae
18.20 – 18.40	436	SAR Sea Ice Concentration in Baltic Sea Verified by Albedo Measurements	Maria Lundin
18.40 – 19.00	302	Satellite studies of ocean fronts and eddies for deepwater development in the Norwegian Sea	Stein Sandven
19.00 – 19.20			
19.20 – 19.40			

THURSDAY 19 OCTOBER 2000

	ID Nr	Title	Presenter
		Services and Market	
9.00 – 9.20		ESA E.O. Data User Programme	Olivier Arino
9.20 – 9.40	158	The ERS oil-spill research project in New Zealand: demonstrations to the commercial market	Stella Belliss
9.40 – 10.00	1106	Waveclimate.com the online offshore-climate assessment tool	Han Wensink
10.00 – 10.20	370	National-scale DEM Generation using ERS Tandem Data in Alpine Regions	Carla Poidomani
10.20 – 10.40	28	SAGA - Satellite data and Geoinformation for Agrologistics	Bernd Schieche
10.40 – 11.00		*Coffee Break*	
11.00 – 11.20	382	Support to the evaluation of the short-term exploitation opportunities for ERS data within the agribusiness market	Judith Johnston
11.20 – 11.40	428	Fast damages assessment from EO data for assistance to relief operations after major natural disasters	Richard Guillande
11.40 – 12.00	412	Advanced SAR/Optical Remote Sensing Techniques for Forestry Applications: A Case Study in Sarawak (Malaysia)	Edmond Nezry
12.00 – 12.20	482	ESA Mission Marketing Activities. The E.M.M.A. offer for the development of the ERS and ENVISAT market.	Andrea Celentano
12.20 – 12.40	486	Commercial distribution of ERS and ENVISAT products and services	Alain Hirschfeld
12.40 – 13.00		ESA E.O. Market Development	Steve Coulson
13.00 – 13.20			
13.20 – 13.40		*Lunch Time*	
13.40 – 14.00			

		ENVISAT ESA 1	
14.00 – 14.20	449	The ENVISAT Mission	Jacques Louet
14.20 – 14.40	450	The ENVISAT Calibration and Validation Programme	Guido Levrini
14.40 – 15.00	477	ASAR Instrument Calibration	Christopher Buck
15.00 – 15.20	504	ASAR ground Processor verification and Wave validation	Yves-Louis Desnos
15.20 – 15.40	447	MERIS instrument calibration	Steven Delwart
15.40 – 16.00	444	MERIS validation Plan	Jean-Paul Huot
16.00 – 16.20		*Coffee Break*	
		ENVISAT ESA 2	
16.20 – 16.40	475	MIPAS Calibration and Processor Verification	Herbert Nett
16.40 – 17.00	466	GOMOS Calibration and Processor Verification	Torgeir Paulsen
17.00 – 17.20	488	The validation of the products derived from the Atmospheric Chemistry Instruments	E. Attema
17.20 – 17.40	411	The SCIAMACHY Validation program	H. Kelder
17.40 – 18.00	454	RA-2 absolute range and Sigma-O calibration and in-flight verification	Mònica Roca
18.00 – 18.20	256	The RA-2 and MWR Validation and Cross-Calibration	Jerome Benveniste
18.20 – 18.40	502	The validation of the ENVISAT orbits	Patrick Vincent
18.40 – 19.00	29	The AATSR Cal/Val plan	Marianne Edwards
19.00 – 19.20			
19.20 – 19.40			

THURSDAY 19 OCTOBER 2000

	ID Nr	Title	Presenter
		Geology / Volcano monitoring	
9.00 – 9.20	32	Comparing spaceborne ERS-SAR and airborne geophysical data : Application to geology in the French Guiana rainforest landscapes	Jean-Paul Deroin
9.20 – 9.40	194	Reconstruction of the paleodrainage and geologic evolution of Lake Abhe, East Africa	Lucia Marinangeli
9.40 – 10.00	224	ERS SAR Data and DEM Analysis to complement the Geological Interpretation of the Kalecýk-Hasayaz basın, Ankara, Türkyye	Tamer Özalp
10.00 – 10.20	30	Studies of volcanoes of Alaska by satellite radar interferometry	Zhong Lu
10.20 – 10.40			
10.40 – 11.00		*Coffee Break*	
11.00 – 11.20	1055	First results from operational volcano monitoring in the Canary Islands	Daniel Carrasco
11.20 – 11.40	441	Operational use of InSAR for volcano observatories: experience in local reception at Montserrat	Geoff Wadge
		Floods / Storms	
11.40 – 12.00	104	China Remote Sensing Satellite Ground Station and its Flood Monitoring with ERS in China.	An Li
12.00 – 12.20	453	Flood monitoring in Bangladesh. An application of SAR imagery for impact assessments of flood extent, flood depth and duration.	Joris de Vente
12.20 – 12.40	327	Evaluation of multitemporal radar data for the mapping of inundation dynamics in the Save-flood plain (Croatia)	Thomas Schneider
12.40 – 13.00	122	Contribution of ERS SAR images and ERS coherence data to a flood information system on the Meuse basin -France	Hervé Yesou
13.00 – 13.20			
13.20 – 13.40		*Lunch Time*	
13.40 – 14.00			

		Floods / Storms (Cont.)	
14.00 – 14.20	123	Application of SAR-data for flood modelling in Southern Germany	Heike Bach
14.20 – 14.40	203	Validating soil moisture estimation with ERS PRI data: operational use in DeciDe, a decision support system for floods	Alberto Ortolani
14.40 – 15.00	118	Mapping Storm Forest Damage using SAR Coherence Data. The case of the Haguenau Forset - France	Hervé Yesou
15.00 – 15.20	165	Forest storm damage assessment with ERS tandem data	Andreas Wiesmann
15.20 – 15.40	210	The Devastation of Venezuela by Heavy Rains in December 1999: Assessment of the Situation using ERS InSAR Tandem Data and SPOT Images	Edmond Nezry
15.40 – 16.00		*Coffee Break*	
		Earth Motion	
16.00 – 16.20	294	Climate Change - Himalayan Peri-Glacial Lake, Moraine Dam Burst Surveillance.	Richard Stow
16.20 – 16.40	532	Assessment of SAR interferometry within operational applications: mapping and modelling of peri-urban subsidence	Claudie Carnec
16.40 – 17.00	426	ERS-1/2 SAR Interferometry for Urban Subsidence Detection in China	Chao Wang
17.00 – 17.20	50	ERS and ENVISAT Differential SAR Interferometry for Subsidence Monitoring	Urs Wegmuller
17.20 – 17.40	143	Validation of the Permanent Scatterers technique in urban areas	Claudio Prati
17.40 – 18.00	362	Temporal Analysis of Terrain Movements by Means of SAR Differential Interferometric Measurements on Sparse Coherent Areas	Mario Costantini
18.00 – 18.20	381	InSAR imaging of London surface movement for structural damage management and water resource conservation.	Julie Boyle
18.20 – 18.40			
18.40 – 19.00			
19.00 – 19.20			
19.20 – 19.40			

THURSDAY 19 OCTOBER 2000

	ID Nr	Title	Presenter
		Ice 1	
9.00 – 9.20	86	Processing interferometric ERS-1/2 Tandem data coast to coast in Greenland	Johan Jacob Mohr
9.20 – 9.40	3	Unsteady flow in the Antarctic ice sheet revealed by SAR interferometry and radar altimetry	Andrew Shepherd
9.40 – 10.00	36	ERS Altimetry in Antarctica	Frederique Remy
10.00 – 10.20	37	Interferometry and altimetry above Dome C, Antarctica	Benoit Legresy
10.20 – 10.40	134	SAR Interferometric Analysis of David Drygalski Glacial System and Nansen Ice Sheet (Antarctica)	Franco Coren
10.40 – 11.00		*Coffee Break*	
11.00 – 11.20	154	The evolution of a glacier surge observed with the ERS satellites	Tazio Strozzi
11.20 – 11.40	253	Investigation of Correlations Between Temporal Variations of Radar Backscatter and Altimeter-derived Ice Sheet Elevation Changes	Anita Brenner
11.40 – 12.00	284	Glaciological information derived from combining interferometric SAR with other remote sensing measurements	Niels Reeh
12.00 – 12.20	322	Flow Speed in the frontal area of the Filchner Ice Shelf derived from interferometry and numerical modelling	Jürgen Schmidt
12.20 – 12.40	396	Eight years of ERS1/2 observations of the evolution of West AntarcticGlaciers: What have we learned ?	Eric Rignot
12.40 – 13.00	471	Surface motion and grounding line detection, measured by differential ERS-SAR Interferometry, Thwaites Glacier, West Antarctica	Bernhard Rabus
13.00 – 13.20			
13.20 – 13.40		*Lunch Time*	
13.40 – 14.00			

		Ice 2	
14.00 – 14.20	500	Glaciological Investigation of Mertz Glacier, East Antarctica, usingSAR Interferometry and field observations	Anja Poetzsch
14.20 – 14.40	65	Equilibrium and firn line detection with multipolarisation SAR	Max Koenig
14.40 – 15.00	324	Features of Topography and Dynamics of Glaciers of the Western Antarctic Peninsular by the ERS SAR Interferometry	Rudolf Greku
15.00 – 15.20	320	Shrinking of the Arctic ice Coveer over the last two decades	Ola M. Johannessen
		Geodesy	
15.20 – 15.40	92	The KMS99 Global Marine Gravity Field from ERS and GEOSAT Altimetry	Ole Andersen
15.40 – 16.00	350	Improved Modelling of Earth Gravity and Impact on ERS POD	Christoph Reigber
16.00 – 16.20		*Coffee Break*	
		Geodesy (Cont.)	
16.20 – 16.40	248	Black Sea Geoid and Sea Surface Topography with the ERS-1 Altimeter Data	Rudolf Greku
16.40 – 17.00	226	The time tag bias of ERS altimeter data	Remko Scharroo
17.00 – 17.20	198	Identification and Correction of Clock Asymmetry in the ERS-1 and ERS-2 Radar Altimeters	Richard Francis
17.20 – 17.40	227	Analysis of geophysical corrections applied to ERS altimeter data	Remko Scharroo
17.40 – 18.00			
18.00 – 18.20			
18.20 – 18.40			
18.40 – 19.00			
19.00 – 19.20			
19.20 – 19.40			

FRIDAY 20 OCTOBER 2000

	ID Nr	Title	Presenter
		Performance	
9.00 – 9.20	459	Five Years of ERS-2 Low Bit Rate Mission: routine Cal/Val and Long Loop Sensor Performance Monitoring.	Pascal Lecomte
9.20 – 9.40	313	ERS and Envisat orbit determination and prediction at ESOC	Rene Zandbergen
9.40 – 10.00	208	Assessment of the new ERS-2 mono-gyro piloting mode on the quality of ERS SAR data and ERS SAR applications performance	Betlem Rosich
10.00 – 10.20	178	The performance of the ERS-2 Synthetic Aperture Radar	Peter Meadows
10.20 – 10.40	42	Orbit Control of ERS-1, ERS-2 and ENVISAT to support SAR interferometry	Mats Rosengren
10.40 – 11.00		*Coffee Break*	
11.00 – 11.20	128	Spatial and Temporal Errors in ERS-2 Radial Positioning	Philip Moore
11.20 – 11.40			
11.40 – 12.00			
12.00 – 12.20			
12.20 – 12.40		**ESA E.O. FUTURE PROGRAMMES**: Earth Explorers	Alberto Tobias
12.40 – 13.00		***Closing Session***	
13.00 – 13.20			
13.20 – 13.40			
13.40 – 14.00			

FRIDAY 20 OCTOBER 2000

	ID Nr	Title	Presenter
		Land Surface Temperature	
9.00 – 9.20	314	Synergistic use of ATSR-2 multispectral and dual-angle data for land surface studies	Zhao-Liang Li
9.20 – 9.40	204	Component temperature retrieval from ATSR-2	Claire Jacobs
9.40 – 10.00	101	Surface Temperature from ATSR-2 Data: Algorithms and Validation	José A. Sobrino
10.00 – 10.20	274	A Model-based Land Surface Temperature Retrieval Algorithm	Guangjian Yan
10.20 – 10.40			
10.40 – 11.00		*Coffee Break*	
		Sea Surface Temperature	
11.00 – 11.20	129	The relationship between in situ and Satellite Sea Surface Temperatures in the Southwestern Atlantic Ocean.	Ronald Souza
11.20 – 11.40	115	ATRS maps coral bleaching on Australia's Great Barrier Reef	Ian Barton
11.40 – 12.00	127	Changes in Sea level, sea surface temperature and sea surface pressure from Satellites - The impact of ERS and ENVISAT	Ole Andersen
12.00 – 12.20			
12.20 – 12.40			
12.40 – 13.00		***Closing Session***	
13.00 – 13.20			
13.20 – 13.40			
13.40 – 14.00			

FRIDAY 20 OCTOBER 2000

	ID Nr	Title	Presenter
		Sea Features	
9.00 – 9.20	221	Multisensor Observations of Internal Waves and their effects in the Bay of Biscay.	Jose da Silva
9.20 – 9.40	270	Identification and classification of mesoscale ocean features on ERS SAR imagery	Konstantin Litovchenko
9.40 – 10.00	245	Manifestations of Sea Currents and Eddies in ERS-SAR Images of the Bering Strait	Olga Lavrova
10.00 – 10.20	246	Internal waves in the Andaman Sea, new results from ERS SAR and other sensors	robert Potter
10.20 – 10.40	364	Multi-year ERS observations of ocean circulation features along the coast of Northern Norway	Richard Olsen
10.40 – 11.00		*Coffee Break*	
		Sea Features (Cont.)	
11.00 – 11.20	280	Depth Estimation of Internal Waves in South China Sea from SAR Imagery	Jingsong Yang
11.20 – 11.40	76	Small and meso-scale features of the marine atmospheric boundary layer detected by satellite microwave sensors	Stefano Zecchetto
11.40 – 12.00			
12.00 – 12.20			
12.20 – 12.40			
12.40 – 13.00		***Closing Session***	
13.00 – 13.20			
13.20 – 13.40			
13.40 – 14.00			

FRIDAY 20 OCTOBER 2000

	ID Nr	Title	Presenter
		Topography	
9.00 – 9.20	173	ENVISAT RA-2: Potential For Land Topographic Mapping	Philippa Berry
9.20 – 9.40	341	The LANDMAP project for the Automated Creation and Validation of multi-resolution orthorectified satellite image products and a 1" DEM of the British Isles from ERS tandem SAR interferometry.	Jan-Peter Muller
9.40 – 10.00	91	Evaluation of Methods used in Assessing the Accuracy of InSAR derived DEMs	Premalatha Balan
10.00 – 10.20	343	Using the LANDMAP British Isles 1" IfSAR DEM for Hydrological Network Derivation.	Alec Walker
10.20 – 10.40	380	DTM production by fusion of mixed sar and optical image data	Thierry Laurencot
10.40 – 11.00		*Coffee Break*	
		Topography (Cont.)	
11.00 – 11.20	507	Geomorphological and Geological Validation of Digital Terrain Models processed from spatial imagery. Applications in the Pyrennees (S France) and E Sénégal (W Africa)	Benoit Deffontaines
11.20 – 11.40	130	Automated tiepoint retrieval through heteromorphic image simulation for spaceborne SAR sensors	David Small
11.40 – 12.00	258	ERS Georeferencing Precision	Andy Smith
12.00 – 12.20			
12.20 – 12.40		***Closing Session***	
12.40 – 13.00			
13.00 – 13.20			
13.20 – 13.40			
13.40 – 14.00			

LIST OF POSTERS

ATMOSPHERE: Ozone, Total Column, Profiles

	ID Nr	Title	Presenter
	52	Expectations for GOME-2 on the METOP satellites	Rosemary Munro
	121	On the variability of total column ozone derived from ERS-2 GOME and TOMS	Thilo Erbertseder
	375	Validation of ozone profile retrieval at KNMI	Ronald van der A
	501	Science Objectives of EOS-CHEM's Ozone Monitoring Instrument (OMI)	P. F. Levelt
	175	GOME satellite detection of ozone vertical column over a snow/ice covered surface in the presence of broken clouds	Silvia Tellmann
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VERBAL PRESENTATIONS

ATMOSPHERE
Ozone: Total Column, Profiles

REVIEW OF FIVE YEARS GOME/ERS-2 OPERATIONAL TRACE GAS RETRIEVAL

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ABSTRACT

The Global Ozone Monitoring Experiment (GOME) is an atmospheric chemistry instrument on-board the ERS-2 satellite which was launched in April 1995. The GOME spectrometer was designed to measure a range of atmospheric trace constituents, with particular emphasis on global ozone distribution.

We present a review of five years of GOME data which were processed at DLR using the operational GOME Data Processor (GDP). The GDP incorporates a level 0 to 1 processing chain, the complete GOME data archive, a total column trace gas retrieval process (level 1 to 2), and an image processing chain for the generation of higher-level products. Some aspects on ozone variability derived from GOME total column ozone measurements by means of data assimilation techniques are discussed. Other important species which were retrieved from GOME backscatter measurements using GDP are bromine monoxide (BrO), chlorine dioxide (OClO), formaldehyde (CH2O), sulfur dioxide (SO2), and nitrogen dioxide (NO2), the latter on an operational basis. BrO and OClO are key species for the understanding of ozone destruction in high latitudes. The GOME data show episodes of tropospheric BrO production in polar springtime conditions and may contain evidence for a non-negligible BrO background amount in the troposphere. Formaldehyde has been measured in the troposphere in conjunction with biomass burning events and from biogenic production over North America in the summertime. Large sulfur dioxide concentrations are found from volcanic eruptions; smaller, but readily measurable concentration arise from human activities. Finally, the global distribution of nitrogen dioxide has been recorded for the whole lifetime of the instrument and the data set may be used as a starting point of a new NO2 climatology. An outlook will be given for the trace gases to be retrieved out of SCIAMACHY onboard ENVISAT (planned to be launched in 2001) and the GOME-2 instruments onboard METOP (the first of the series is scheduled to be launched in 2004).

IMPROVED GOME OZONE COLUMN RETRIEVAL

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ABSTRACT

Algorithms are developed to retrieve ozone columns from the GOME instrument header data (EGOIs). The main objective of the development of these algorithms is to demonstrate the feasibility of deriving near-real time ozone columns from GOME. The ozone columns are used for monitoring the ozone distribution, UV forecasts and will be used in numerical weather prediction. Presently, 95 63705010f the ozone columns are available on the Internet within 3 hours after the actual observation of GOME. This work is performed in the framework of the ESA-DUP project GOFAP (Van der A et al, this symposium).

In this paper, the level 0-2 algorithms are discussed. They follow the approach of DLR's GOME Data Processor (GDP), i.e. using DOAS for the spectral fitting, but there are some major differences. The Air Mass Factor (AMF) calculation is performed with the "doubling-adding" method in a pseudo-spherical model. The ECMWF temperature forecasts are used to account for the temperature dependance of the ozone cross sections. Cloud cover and cloud-top pressure used in the retrieval are derived with the FRESCO algorithm (Koelemeijer et al, this symposium). Further important differences with the GDP are in the use of other climatologies for ozone profiles and surface albedo, important for AMF calculations and ghost column estimates. The resulting ozone columns are compared to GDP values and to TOMS and ground station measurements. The results of this comparison are analysed.

TEMPERATURE INDEPENDENT DIFFERENTIAL ABSORPTION SPECTROSCOPY (TIDAS) AND SIMPLIFIED ATMOSPHERIC AIR MASS FACTOR (SAMF) TECHNIQUES FOR THE MEASUREMENT OF TOTAL OZONE USING GOME DATA

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ABSTRACT

A simple technique for the fast retrieval of ozone vertical amount from GOME (Global Ozone Monitoring Experiment) uncalibrated spectra is described in detail. The TIDAS (Temperature Independent Differential Absorption Spectroscopy) technique uses GOME's capability of measuring atmospheric spectra over a broad wavelength range with high spectral resolution. The ozone slant columns are retrieved by applying the Beer-Lambert law to two spectral windows where the ozone absorption cross sections show similar temperature dependence. A simple geometric air mass factor is computed for a fixed height spherical atmosphere (SAMF: Simplified Atmospheric air Mass Factor) to retrieve ozone vertical amounts. Vertical ozone values are compared to the EP/TOMS (Earth Probe Total Ozone Mapping Spectrometer), to the GDP (GOME Data Processor), and to ground based Brewer ozone measurements.

OZONE FROM GOME DATA USING NEURAL NETWORK TECHNIQUE

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ABSTRACT

A new approach for retrieving total ozone from extracted ERS-GOME data has been developed and is currently being tested extensively. Using selected GOME wavelength regions and orbital data as input, a feed-forward neural network has been trained to determine total ozone in a one step inverse retrieval algorithm. This way, processing can be performed with an operational speed of over ten orbits per second on a medium-range workstation. Neural networks can be considered universal nonlinear approximators and as such, their training requires an extensive database of ozone measurements to be collocated with satellite measurements. To this end, ground and sonde measurements mainly from the World Ozone and Ultraviolet Data Center (WOUDC) have been utilized. The resulting matchup database are divided into a training and an independent test data set, the latter yielding an RMS ozone retrieval accuracy of approximately 10 D.U. Results from some preliminary comparisons with TOMS and operational GOME ozone columns will also be presented.

The neural network software package has been developed in-house and thus can be adapted to different problems, one of which is the retrieval of height-resolved ozone profiles from GOME spectra. However, as opposed to the total ozone columns, the database available for collocations is much smaller in the case of ozone profiles, a problem aggravated by the fact that current satellite instruments are unable to measure ozone concentrations reliably in the troposphere while on the other hand, ozone sondes usually only reach heights of about 25-30 km. Some solution approaches to this dilemma will be presented, together with preliminary results from simulated GOME data created with the radiative transfer model GOMETRAN. Once the software package is operational, ozone profiles will be retrieved at an expected speed of about one orbit per second.

The methodology developed here is independent of any physical parameterization apart from the data preprocessing, which is performed by standard software. Thus, in view of the upcoming launch of ENVISAT, adaptation to SCIAMACHY could be carried out quickly, providing an additional complementary retrieval scheme for that instrument, too.

OBSERVATION AND THEORETICAL ANALYSIS OF THE RECORD OZONE MINI-HOLE OF 30 NOVEMBER 1999

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ABSTRACT

On 30 November 1999, an ozone mini-hole was observed over Northwestern Europe. Both satellite measurements by the GOME instrument as well as ground-based measurements by Brewer instruments showed total ozone columns of less than 200 DU. Furthermore, ozone soundings show a more than 50 percent decrease between 150 and and 50 hPa relative to climatologically mean conditions.

For this specific event, the ozone retrieval algorithms of the GOME and Brewer measurements have been improved. The actual temperature field and observed vertical ozone profile have been used in the retrieval algorithms instead of the climatological values that are normally used. Because of the large differences between the actual and climatological temperatures, improvements of up to 5 13505776n total ozone are found, resulting in even lower ozone values.

Three mechanisms to explain the low ozone values are studied: uplifting of the tropopause and lower stratosphere, ozone breakdown and PSC formation due to cooling related to the uplifting, and poleward transport of ozone poor air of sub-tropical origin. Tracer transport model simulations, initialised by assimilating GOME observations until a week before the low ozone event, are shown to reproduce the key features of the evolution of the minihole. Uplifting explains only about 10 0f the deviation from climatology. Although PSC's are observed during the low ozone event, our estimates indicate a chemical ozone breakdown of 15 DU or less. Therefore the assimilation/simulation studies demonstrate that the low ozone is mainly caused by horizontal transport of sub-tropical air.

DERIVATION OF AN EXTENSIVE HEIGHT-RESOLVED OZONE DATA-SET SPANNING THE TROPOSPHERE AND STRATOSPHERE FROM GOME

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ABSTRACT

A retrieval scheme has been developed at the Rutherford Appleton Laboratory to derive height-resolved ozone profiles spanning the troposphere and stratosphere from GOME data. This scheme has provided the first direct measurements of tropospheric ozone from a single satellite instrument.Through funding from the UK NERC, the efficiency of the scheme has been improved substantially, and throughput is now equivalent to "real-time". This has allowed an extensive sub-set of GOME flight data to be processed globally, including the entire (>5 year) mission to date sampling 1 day in 10. (In addition, selected periods are being analysed at higher temporal sampling for specific case-studies.) An overview of the scheme and its validation by comparison with an extensive set of ozone-sondes will be presented, together with a summary of initial findings concerning ozone in the troposphere and lower stratosphere. Height-resolved ozone data is accessible, along with associated cloud information derived from ATSR-2, at the British Atmospheric Data Centre (http://www.badc.rl.ac.uk). The ATSR-2 derived cloud data-set is described in a parallel paper.

NEAR-REAL TIME DELIVERY OF GOME OZONE PROFILES.

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ABSTRACT

In the framework of the ESA-DUP project GOFAP the delivery of GOME ozone products in near-real time (NRT) to users has been accomplished. Since 1998 NRT ozone columns are available through the KNMI website and since the start of 2000 they are accompanied by NRT stratospheric ozone profiles. The ozone products are retrieved from specific segments of the full GOME spectrum contained in the EGOI files. These files are originally meant for health checking of the instrument, but soon their suitability for NRT delivery of GOME products was recognized. Since the EGOI files contain raw, level 0, data a level 0-1 processor has been developed, largely based on the operational GDP processor. Detailed validation studies on the quality of the ozone products based on this level 1 data has shown that several steps in the level 0-1 had to be improved. Corrections for the wavelength calibration, the Peltier cooler interference, the polarisation sensitivity and the degradation of the sun-normalized radiance have been significantly improved. The retrieval of the ozone profiles demands accurate forward modelling putting a high demand on the available CPU. To be able to keep up with the data production rate of GOME, a fast and largely analytic radiative transfer model has been developed based on the LIDORT scheme of Spurr: LIDORT4A. This model produces radiances and weighting functions simultaniously using the discrete-ordinates method in the "4-stream" approximation. The presentation will provide an overview of the accomplishments of the project. Details of the work will be given in dedicated poster presentations.

OZONE PROFILES ESTIMATES BY USING GOME MEASUREMENTS AND A NEURAL NETWORK ALGORITHM

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ABSTRACT

The Global Ozone Monitoring Experiment (GOME) is an instrument on board of ERS-2 satellite. Its main objective is to measure the global distribution of ozone and other trace gases through spectral analysis of the sunlight scattered from the Earth's atmosphere and/or reflected by the surface in the spectral region 240-790 nm. Neural networks have been proven to be useful tools for inversion procedures in remote sensing of the atmosphere. They are composed of many nonlinear computational elements (called neurons) operating in parallel and connected by the so called synapses, each of which is characterized by a multiplying factor. In this paper a neural network approach for the retrieval of vertical profiles of ozone from spectral radiances measured by GOME is presented. The data sets consist of GOME measurements and the corresponding ozone profiles provided by KNMI (Koninklijk Nederlands Meteorologisch Instituut). Several ERS-2 orbits have been considered characterizing different seasonal periods and geographic regions. The used net is a multilayer perceptron with one hidden layerand the activation function of each unit is the sigmoid function. Topologies with different numbers of hidden units have been tested. The results have shown that the neural networks seem to provide very promising algorithms capable to perform the retrieval of ozone profiles in an operational context. The exploitation of such algorithms could be easily extended in view of the forthcoming launch of ENVISAT, with on board a new generation instrument to perform measurements of trace gases in the troposphere and in the stratosphere.

ATMOSPHERE
Clouds/Aerosols

RADIATION AND CLOUD STUDIES WITH GOME IN PREPARATION FOR FUTURE SPECTROMETER MISSIONS

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ABSTRACT

The Earth spectra measured by GOME since its launch in 1995 have revealed a lot of information regarding the atmosphere's chemical composition (e.g. ozone, nitrogendioxide, bromineoxide), and physical composition (e.g. clouds, aerosols), as well as interesting radiative processes (polarisation, Raman scattering). Still, GOME is the only space-borne spectrometer observing the entire spectral range from 240 to 790 nm with high spectral resolution. Its data are an important source of information to prepare for the analysis of future spectrometer data like those of SCIAMACHY on Envisat (launch 2001), OMI on EOS-AURA (launch 2002/3), and GOME-2 on METOP.

At the basis of the interpretation of GOME spectra lies the radiometric calibration of the instrument, including correction for its polarisation sensitivity. This correction may be improved by gaining more theoretical knowledge of Earthshine polarisation in the UV from numerical radiative transfer modelling including polarisation. As a practical approach, we use GOME reflectivity statistics to assess the accuracy of the GOME radiometric calibration.

Furthermore, we present an overview of the use of GOME data for multispectral studies of clouds, and the potential of the near-infrared bands of SCIAMACHY for cloud characterisation.

CRAG - CLOUD RETRIEVAL ALGORITHM FOR GOME

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ABSTRACT

The objective of GOME is the retrieval of total ozone column densities by measuring the Earth's reflectivity between 240 and 790 nm. For an accurate ozone retrieval the presence of clouds has to be taken into account. Therefore, the fractional cloud cover is derived by the Initial Cloud Fitting Algorithm (ICFA) from the spectral reflectivity between 758 and 778 nm covering the oxygen A band.

Goal of CRAG is to establish a cloud retrieval algorithm which is additionally based on the Polarisation Measurement Devices (PMD) measurements. In a two-step approach, the fractional cloud cover is derived from the PMD signals, first. Then, the cloud-top height and cloud optical thickness are determined from the reflectivity within and around the oxygen A band taking the fractional cloud cover as input.

We present for the PMD algorithm two developments: The PMD Cloud Recognition Algorithm (PCRA), which has been developed at SAO, is based on different thresholding tests utilising the PMDs covering the green and red spectral region. The alternative approach, the Optical Cloud Recognition Algorithm (OCRA) which has been established at DLR, compares the actual PMD measurements with a pre-determined cloud-free composite. The latter is composed by transposing the reflectances according to minimum brightness into color (RGB) space.

The second part of the algorithm, the Revised Cloud Fitting Algorithm, is based on a least-squares minimum search between - indirectly - GOME reflectivities in and around the oxygen A band and theoretical calculated templates. Therefore, an integration over the reflectivities of the oxygen A band is introduced. Furthermore, the slope and the offset of the baseline of the band is taken for the search.

We discuss the results of the prototypes and the implementation in the test environment of the GOME Data Processor, as well. Furthermore, a comparison to ICFA and other cloud detection schemes will be presented as outline.

We gratefully acknowledge the financial support of ESA/ESTEC for this project.

CLOUD RETRIEVAL FOR SCIAMACHY

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ABSTRACT

The ENVISAT Satellite Payload includes the SCIAMACHY instrument designed to measure a number of chemically important atmospheric trace constituents on a global basis. Accurate determination of cloud information out of SCIAMACHY nadir measurements is needed for the retrieval of ozone and other trace gases and it is crucial for more demanding applications like aerosol retrieval and the retrieval of trace gas concentrations in the troposphere. The Optical Cloud Recognition Algorithm (OCRA) presented in this paper is a novel algorithm for cloud recognition which uses the information provided by the SCIAMACHY polarisation measurement devices. OCRA is based on multitemporal data fusion and fuzzy logic techniques and overcomes the problems of the traditional threshold algorithms. The key of the OCRA algorithm is the determination of a so called "cloud-free composite" using historical data. The cloud coverage is obtained by comparing the actual measurement with the pre-determined cloud-free composite. OCRA was originally developed for the GOME sensor flying onboard the ERS-2 satellite and has been selected as the cloud retrieval algorithm to be used in the operational near-real-time and off-line SCIAMACHY processors. The demonstrate accuracy and the minimal computational and memory requirements made it perfectly well suite for its usage in such operational environments. The results obtained with GOME data show a high agreement between the cloud coverage derived by OCRA and the ICFA algorithm that uses GOME spectral measurements within the O2 A-band. Qualitative comparisons of GOME cloud fraction derived by OCRA with clouds detected with METEOSAT images, as well as quantitative comparisons with cloud information calculated from the ATSR/ERS-2 sensor using the APOLLO algorithm are very encouraging.

AUTOMATED CLOUD-TOP HEIGHT, AMOUNT AND WINDS FROM ATSR2 IN EU-CLOUDMAP PROJECT

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ABSTRACT

A new generation of satellite instruments for earth observation enables new techniques to retrieve macroscopic cloud properties (such as cloud-top height and amount), cloud optical and microphysical properties from space. Within the EU CLOUDMAP project, an evaluation has been performed of example cloud products from existing and soon-to-be-launched satellite instruments, both in terms of their accuracy, methods of validation and utility for operational weather forecasting, numerical weather prediction and climate modelling. The focus for macroscopic properties is on two techniques: stereo photogrammetry and the use of Oxygen A-band. We focus here on work performed at UCL using stereo photogrammetry with ATSR2. An operational algorithm for processing cloud-top height and amount from dual view ATSRs has been developed. Automated stereo matching is performed to find correspondences between pixels using the mean of the normalised differences within a patch. Photogrammetric camera modelling is then used to translate these matches into geometric heights. Given a ground terrain model, cloud cover (extents) can be identified from those pxiels whose height is greater than a user defined height threshold. Examples will be shown of the retrieval of cloud heights and amounts for a variety of different cloud types including complex multi-layer clouds and aircraft contrails. The evaluation of cloud-top heights has included (1) a comparison with brightness temperature derived cloud-top heights; (2) a comparison of cloud-free heights against a ground terrain model. A long-term validation approach has been developed using ground-based 94GHz radar and laser ceilometer measurements from the UK Chilbolton Radar Facility which have been applied to a long time series from the US ARM Southern Great Plains site. Example products have also been evaluated by KNMI and colleagues from other national meteorological organisations.

REMOTE SENSING OF AEROSOL OVER OCEANS USING VISIBLE AND INFRARED MEASUREMENTS FROM ATSR-2 AND AATSR

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ABSTRACT

Optimal estimation methods are applied to the remote sensing of aerosol characteristics over ocean areas using the visible and infra-red measurements of the ATSR-2 instrument. A Kalman filtering technique is applied to advect information in the horizontal and statistics of aerosol properties measured by several AERONET stations are used to constrain the filter. A comprehensive treatment of the radiative transfer underpins the method. Aerosol properties for several common 'classes' are generated using Mie theory and best available knowledge of composition sand size distributions. The reflectance of the combined aerosol-ocean system is computed using Cox and Munk wind dependent slope distributions and gaseous absorption is calculated using ECMWF temperature and humidity fields. This comprehensive treatment allows, in principal, retrievals both in and outside of glint areas. Simulations suggest that there is retrieval potential for aerosol optical depth and surface wind speed, but not for particle size or characteristic pressure. Aerosol class discrimination appears to be possible for moderate optical depths. Suprisingly, the simulations suggest that retrievals are possible in the presence of sun glint given a reasonable a priori estimate of wind speed. The methodology was applied to ATSR-2 observations and whilst retrievals were stable in non-glint areas, the predicted behaviour in glint was not found. Several cases were validated against AERONET observations and an error of around 20-40 0.000000 found.

TROPOSPHERIC AEROSOL CHARACTERISATION: FROM GOME TOWARDS AN ENVISAT PERSPECTIVE

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ABSTRACT

The interest in aerosol observations from satellite passive instruments is steadily increasing as a result of the better understanding of the key role played by aerosols within the climate system. Satellite instruments supply global observations for establishing the aerosol climatology and characterising single aerosol events.

Since the 1980s data from geostationary meteorological satellites, such as GOES and METEOSAT, and the NOAA-AVHRR polar orbiting instruments have allowed for monitoring the aerosol optical thickness (AOT) over the oceans. More recently, it has been shown that the knowledge of the aerosol spectral optical properties is equally needed to understand the interaction of solar and terrestrial radiation with aerosols, and the role of clouds and surface reflection. Satellite observation has thus been directed towards the retrieval of AOT together with absorption potential, scattering efficiency and angular dependence, that is the identification of the predominant aerosol type over the scene. The Global Ozone Monitoring Experiment (GOME), in particular, has proved instrumental for the detection and characterisation of the aerosol load, by exploiting its spectral coverage and resolution.

An algorithm to determine the aerosol size distribution, spectral refractive index and AOT from GOME spectral reflectances is presented. The method is based on a mathematical non-linear fitting model. In addition, AOT values and aerosol type parameters derived from the GOME operational aerosol product can provide information for the algorithm initialisation. Some examples are shown. Moreover, the combination of the aerosol properties retrieved from high spectral resolution measurements with higher temporal frequency data from METEOSAT geostationary satellites is included as an effective strategy for monitoring large atmospheric aerosol events. The algorithm is planned to be used with ENVISAT-1 data from SCIAMACHY, MERIS, and AATSR. An overall improvement of the results is expected given the wider spectral coverage and higher spatial resolution of the new instruments with respect to GOME leading to a likely reduction in the uncertainties associated to the retrieval method.

SYNERGETIC RETRIEVAL OF AEROSOL PROPERTIES: FROM ERS TO ENVISAT

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ABSTRACT

At the German Remote Sensing Data Center (DFD) of the German Aerospace Center (DLR) the new synergetic aerosol retrieval method SYNAER which exploits GOME and ATSR-2 data was developed. SYNAER combines the use of an automatic dark field technique of ATSR-2 visible reflectances with a least square fit of simulated spectra depending on properties of the aerosol load to GOME measurements in order to retrieve aerosol optical thickness and type in the boundary layer. Thorough cloud detection with a standard method developed for AVHRR data reduces erroneous aerosol detection due to cloud misinterpretation. The synergetic approach allows the application of SYNAER over land and ocean surfaces. Within the AO3-project PAGODA-2 "Extension of new retrieval methods from the project for ATSR-2 and GOME data application" validation with ground-based sunphotometer measurements and improvement for partly cloudy pixels were conducted. In one case on 15-08-1998 in the Pfaelzer Wald airborne in-situ measurements of aerosol optical parameters and size distributions covering the entire tropospheric column from the tropopause to the boundary layer were acquired during an ERS-2 overpass at clear sky conditions. In addition airborne lidar measurements at 1064, 532, and 354 nm were conducted. Patches of cirrus clouds were observed within the validation area of half a GOME pixel. Possibilities for differentiating optical thickness of 3 vertical layers of aerosols are under investigation. High resolution (1 km) boundary layer aerosol maps were produced. SYNAER will be adapted to SCIAMACHY and AATSR onboard ENVISAT within the ENVISAT-AO project SENECA "Synergetic ENVISAT data exploitation for cloud and aerosol retrieval". Use will be made of improved sensor capabilities (e.g.SCIAMACHY spectral range and limb mode) and data specifications (AATSR orbit products).

The final aim is the production of a 1-year tropospheric aerosol climatology dataset as input to improved climate models. The paper shows exemplary maps obtained with SYNAER and validation results of the new method. Applications of aerosol maps are discussed.

AEROSOL RETRIEVAL OVER LAND AND OVER SEA

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ABSTRACT

Algorithms have been developed to retrieve aerosol optical depth (AOD) over sea and over land, using ATSR-2 and GOME data in cloud-free conditions. Over sea the assumption of a dark surface with relatively well-known reflectance usually yields good results. However, over coastal waters the retrieved AOD values are often too high, and need further investigation. Over land the surface optical properties are highly variable, and wavelength dependent. An algorithm for application with GOME was developed based on the very low surface reflectance in the UV. This experience is now used for the development of an algorithm for OMI. For instruments working in the visible and near-IR, the surface reflectance needs to be corrected for. For ATSR-2 an algorithm was developed based on the dual view capability. The results from the ATSR-2 and GOME algorithms are mutually consistent. Retrieved AOD's compare favourably with ground-based sun photometer measurement (well within 0.1).

The dual view algorithm has been used to map the AOD over Europe in August 1997. Results show large AOD gradients over Europe, and regions with high pollution levels are clearly visible. The AOD patterns are similar to those of NO2 and SO2 over Europe. Comparison with chemistry transport models shows the contribution of the modelled aerosol types (sulphate and nitrate) to the AOD. To explain aerosol effects on climate also other aerosol types need to be included in the models.

The Ångström parameter can be derived from the variation of the AOD with wavelength. The AOD and the Ångström parameter together yield information on the aerosol size distribution. However, only column-integrated values can presently be retrieved, while the aerosol properties change significantly with height above the surface. The use of sophisticated models together with satellite retrievals may be a promising tool also in this respect.

The ATSR-2 and GOME aerosol retrieval algorithms will be extended for future application to AATSR and SCIAMACHY on ENVISAT. Synergy with other instruments on ENVISAT is investigated, as well as with instruments on other satellites.

VALIDATION OF AEROSOL PROPERTIES RETRIEVED FROM GOME MEASUREMENTS

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ABSTRACT

Aerosol optical thickness (AOT) values have been retrieved from radiances measured by radiometers and spectrometers such as METEOSAT, AVHRR, GOES and POLDER. Early single-band methods are now superseded by bi- or multi-spectral algorithms that derive aerosol properties, i.e. optical absorbing and scattering properties and size distribution.

The GOME Aerosol Spectral Processor (GASP) exploits the instrument's spectral coverage from UV to NIR and its moderately high spectral resolution to derive AOT and type. The retrieval method is based on the fusion of the two types of GOME measurements: 1) radiance and solar irradiance spectra measured by the CCD arrays, presenting high spectral but low spatial resolution, and 2) the coincident reflectance measured by the Polarisation Measurement Devices (PMD), that have opposite characteristics. The generation of the AOT product is based on the processing of the GOME Level 1 data product distributed by DLR. The synergistic use of PMD and array measurements allows for computing the AOT at the reference wavelength of 550 nm and the aerosol class at both spatial resolutions of 320x40 Km^2 (GOME pixel) and 20x40 Km^2 (PMD pixel). The main advantage is the increase of cloud-free pixels at the best spatial resolution.

The validation activity consists of three parts: i) A self-consistency check aimed to detecting suspicious spatial features or trends connected to the GOME observing geometry and spatial resolution; ii) Comparison with AOT and aerosol classes derived from ground-based sun-photometers; different scenarios are selected by selecting ocean or land surfaces and aerosol origin (desert, fires, background); iii) Co-location with different satellite-based aerosol retrieval products (AHVRR, POLDER, METEOSAT) allows for detecting differences related to the characteristics of each sensor and comparing time averages.

Recent results of the validation are presented together with feed-back on the processing algorithm, particularly on cloud identification and screening.

ATMOSPHERE
Calibration, Radiative Transfer, Assimilation

DEGRADATION OF GOME OBSERVATIONS IN THE UV: SUMMARY OF THE GDAQI PROJECT

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ABSTRACT

GDAQI (GOME Data Quality Improvement) is an ESRIN project conducted in collaboration between SRON and DLR. The aim is to improve the quality of the GOME level 1 data products: Earth radiances and Solar irradiances. Because level 1 data are at the beginning of the data processing chain, the quality of the level 1 data will in principle affect the quality of higher level GOME data products such as ozone profiles, aerosol optical thickness, etc. Other data products may not be affected at all, e.g. in case of inaccuracies lacking strong spectral signature. Particularly the retrieval of total columns using DOAS is very robust in that respect. A good understanding of the level 1 data inaccuracies is essential for accurate interpretation of higher level data products. Many issues concerning GOME level 1 data quality have been addressed within GDAQI: GOME polarisation sensitivity, air-to-vacuum changes in the radiance and polarisation response, etalon effect, and degradation of the observed GOME signal in time. In this presentation the focus will be on the latter topic: degradation of GOME observations in the UV. Signal degradation is common to many UV measuring satellite instruments, including GOME. In-flight degradation of instrument radiance response can be monitored using e.g. an on-board White Light Source as will be possible in SCIAMACHY. GOME, however, does not have an on-board White Light Source and relies therefore primarily on the daily Solar observations. However, the light backscattered by the Earth's atmosphere follows a different optical path through the spectrometer than the Solar irradiance. It is thus not obvious how the observed degradation in the Solar irradiance can be translated to correct for degradation in GOME Earth radiances, or Earth reflectivities, which is relevant for retrieval of atmospheric quantities. Within GDAQI we have used GOME Solar, Earth and Moon observations to study degradation in both the GOME radiance (science channels) and polarisation (PMD) measurements. Results of the combination of these observations in terms of instrument degradation will be presented.

GOME DEGRADATION CORRECTION AT SOLAR ACTIVITY MAXIMUM

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ABSTRACT

In this paper we present an approach to correct the degradation of GOME Solar irradiance measurements. Comparison of the solar irradiance spectra measured by GOME through the lifetime of the sensor with early GOME solar irradiance spectra or other space instruments, showed that the pre-flight radiance parameters were no longer applicable to the GOME in-flight situation. The GOME sensor shows degradation in all wavelength regions due to damages in its optical path. Most damage is done by hard UV light to the quartz-glass of prisms and lenses, but there might be also damage to coatings or to the detectors. Several changes insensitivity of the instrument are simultaneous monitored: degradation, geometric changes in optical paths, changes of coatings. A parameter set is provided to calibrate GOME level 1 spectra for the slow continuous changes in radiance response. This parameter set is calculated regularly and available on the web. The Sun itself is the light source used for the calibration. Changes in activity have to be considered, because the solar cycle reaches now the maximum. Especially for solar measurements since early 1999 the correction for low wavelengths (up to 260 nm), does not work accurate without taking into account the wavelength dependent changes of solar irradiance. Results of the new correction will be presented. This algorithm will also be of importance for SCIAMACHY starting soon at a high level of Solar activity. Most parts of this study have been performed inside the ESA/ESRIN financed projects GOME SUPPORT and GDAQI.

IMPROVING THE POLARISATION CORRECTION OF GOME

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ABSTRACT

An important step in the calibration of GOME radiances is the correction for the polarisation sensitivity of the spectral channels. This correction still permits errors up to 1013644808n the calibrated radiances in the UV. Ozone profile retrievals suffer strongly from such errors. We have studied various ways in which to improve the GOME polarisation correction.

The standard GOME polarisation correction proceeds as follows. Three polarisation detectors that are part of GOME allow polarisation measurements around 350, 500 and 700 nm. A theoretical value determined from single Rayleigh scattering is used at 300 nm. Interpolation between these values yields the polarisation for the whole wavelength range of earthshine spectra (290-800 nm). Finally, a correction factor depending on the polarisation and GOME instrument characteristics is applied to the measured signals.

We have validated the standard polarisation correction algorithm using numerically modelled Earthshine spectra and have found that errors as large as 10 may occur in the calibrated radiances in the UV. While the polarisation typically varies strongly from 300-350 nm, there is a significant lack of information (either theoretical or empirical) on polarisation behaviour in the UV of GOME spectra. Already crude knowledge on the typical wavelength dependency of polarisation in the UV lead to substantially smaller errors.

Also, we have determined parametrisations of the polarisation in the UV, which may be used in lieu of actual measurements. These parametrisations were deduced from extensive radiative transfer modelling of Earthshine spectra. In particular, we have constructed a database of Stokes parameters I, Q and U from 290-350 nm for clear atmospheres with only Rayleigh scattering and ozone absorption. The database consists of some 2300 spectra for different viewing geometries, solar angles and surface albedos.

These results are also relevant to other polarisation sensitive instruments like SCIAMACHY, to be launched on ENVISAT, and GOME-2, to be launched on METOP.

COMPARISONS BETWEEN GOME AND MODELLED BACKSCATTERED RADIANCES USING IN-SITU MEASURED AEROSOL DATA FROM THE ACE-2 CAMPAIGN

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ABSTRACT

The Global Ozone Monitoring Experiment (GOME) onboard the ERS-2 satellite provided measurements with poor spatial but high spectral resolution. On two occasions during the ACE-2 campaign GOME cloud-less groundpixels are available for the same day as in-situ properties of aerosols were measured. For the cases studied here two aerosol layers of different origin with different properties were present. The aim of this study is to compare modelled radiances to GOME measured radiances. Backscattered radiances are modelled for the measured aerosol proprties using a multiplescattering radiative transfer model (DISORT). Results will illustrate the effect clouds and aerosol properties have on GOME measured radiances.

THE LIDORT PACKAGE - A GENERIC FORWARD-MODEL RADIATIVE TRANSFER TOOL FOR THE SIMULTANEOUS GENERATION OF INTENSITIES AND WEIGHTING FUNCTIONS FOR ATMOSPHERIC RETRIEVAL

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ABSTRACT

We present a new radiative transfer (RT) software package (LIDORT) designed to deliver intensities and weighting functions. For non-linear atmospheric retrieval algorithms, the forward model component must generate both simulated backscatter intensities and weighting functions (intensity derivatives with respect to retrieval parameters). In contrast to the estimation of weighting functions using an external finite-difference approximation based on repeated calls to a radiation-only RT code, a single call to LIDORT will deliver complete fields of analytically-computed weighting functions. LIDORT is a generic tool for use in a wide variety of atmospheric scenarios, from retrievals based on satellite backscatter measurements from instruments such as GOME, SCIAMACHY, GOME-2 and OMI, to the processing of similar measurements from ground-based, balloon-based and airborne instruments. LIDORT solves the RT equation in a multi-layered atmosphere with multiple-scattering using the discrete ordinate method. Options are available for a plane-parallel atmosphere, and for an accurate pseudo-spherical treatment of the solar beam attenuation. Allowance is made for bi-directional reflectance at the surface, and surface thermal emission is included. A full internal perturbation analysis of the intensity field allows all weighting functions to be derived analytically to the same level of accuracy specified for the intensity. Upwelling and/or downwelling intensities and weighting functions can be generated at arbitrary optical depth and for any output stream angle. Mean value output (fluxes, mean intensities and their weighting functions) is available at arbitrary optical depth. LIDORT is called as a subroutine within a user-defined environment depending on the application. This environment will prepare necessary atmospheric inputs, namely the optical depth grid (vertical coordinate), layer single-scatter albedos, phase function moments, and for weighting functions, additional inputs specifying the variation of optical thicknesses and single-scatter albedos with respect to

those atmospheric parameters required for retrieval. Weighting functions for temperature, pressure, trace gas constituent amounts, molecular scattering, aerosol and cloud scattering and absorption may be calculated. LIDORT also produces weighting functions for surface quantities (albedo, surface temperature). In this presentation we discuss the application to ozone profile retrieval from GOME measurements, with particular reference to the use of a faster 4-stream approximation.

ANALYSIS OF GLOBAL SYNOPTIC CHEMICAL CONSTITUENT MAPS BY 4D VARIATIONAL ASSIMILATION OF SATELLITE DATA

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ABSTRACT

Assimilation of satellite observations of stratospheric constituents into a global chemistry transport model (CTM) is a means to produce value added synoptic maps of trace gases. The objective of the work to be presented is to provide an assimilation system which combines three sources of knowledge in a mathematically rigorous way: 1. a priori knowledge of the chemical distribution as given by climatologies or forecast runs of CTMs, 2. physical and chemical laws as encoded by a model, and most prominently 3. actual satellite observations.

The method of four-dimensional variational data assimilation (4D-var) complies with the above mentioned objectives also by providing the option to assimilate data scattered in time and space, as given by satellite measurements. A cost function is devised to measure a distance between modelled and observed concentration levels along the satellite tracks, irrespective of synoptic time points and measured quantities. This renders the 4D-var method superior to direct nudging and intermittent space-time data assimilation schemes.

Based on the CTM-version of the COlogne Model of the Middle Atmosphere (COMMA-CTM), the adjoint components of the dynamic transport operators are developed, and combined with a quasi-Newton minimization routine, to form a first version of a global chemical 4D-var satellite data assimilation system. The design is tailored to assimilate future ENVISAT observations, namely SCIAMACHY, MIPAS, and GOMOS.

In this presentation, results will be shown demonstrating the successful assimilation of data obtained from CRISTA 1 and 2 campaigns, and GOME data. The special emphasis will be placed on the capability of the 4D-var method to propagate information into data void regions, thereby producing a consistent picture of the chemical state of the entire globe after a limited time span of 48 hours. This also includes an efficient and consistent analysis of not observed polar regions. The 4D-var method will be shown to form a basis for a further extension to chemically active assimilation scheme, which ensures chemical consistency of observed an unobserved trace gases.

ASSIMILATION OF 3D OZONE FIELD IN GLOBAL CHEMISTRY-TRANSPORT MODELS

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ABSTRACT
Assimilation of total column from GOME using statistical interpolation in a 3D chemistry-transport TM3 is currently operational at KNMI. This approach is used to provide near-real time ozone distributions and three-day forecasts of ozone based on GOME observations.

Further developments in data assimilation of retrieved GOME ozone profiles in TM3 will be presented.

TM3 uses the meteorological data from ECMWF to transport the 3D ozone field and includes simplified chemistry scheme. The retrieved ozone profiles used in the assimilation are products of the fast-delivery service at KNMI. The details of the retrieval are presented in other contribution to the symposuim.

The Kalman filter technique is chosen as a data assimilation technique since it not only estimates the ozone distribution globally but also quantifies the uncertainty in its estimate.

Assimilation of ozone total column and/or profiles in existing models gives the possibility of a better forecast for the ozone distribution. Knowing the ozone distribution, the UV reaching the earth surface can be accurately forecasted. It can also improve the numerical weather prediction (NWP).

The data assimilation is demonstrated for the period of March 1997. Results and validation of the assimilated 3D ozone fields with the available ozone sondes for this period is discussed.

TEMPERATURE DEPENDENT ABSORPTION CROSS SECTION OF O3, NO2 AND OTHER ATMOSPHERIC TRACE GASES MEASURED WITH THE SCIAMACHY SPECTROMETER

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ABSTRACT

A unique set of temperature-dependent reference spectra of atmospheric trace gases was measured with the SCIAMACHY (Scanning Imaging Absorption Spectrometer for Atmospheric CHartography) satellite spectrometer prior to launch in 1998-2000. The SCIAMACHY spectrometer is a multi-channel grating spectrometer measuring simultaneously in the ultraviolet, visible and near-infrared wavelength region (230 - 2385 nm) at a spectral resolution between 0.22 - 1.5 nm. The new data set comprises absorption cross sections of O3, NO2, SO2, OClO, NO, O2, BrO, H2CO, H2O, CO, N2O, CH4, and CO2 in the temperature range between 203 K and 298 K and over the entire wavelength range of the instrument. The new absorption cross sections will be used for the retrieval of atmospheric trace gas concentrations and their vertical distributions from the satellite measurements in the SCIAMACHY data processing. Furthermore, the molecular absorption spectra were already successfully used for improving the wavelength calibration and for characterising the slit function and stray light properties of the instrument. Finally, because of the broad wavelength range and large temperature coverage, these spectra also provide new accurate information for molecular spectroscopy.

IN-ORBIT OPTICAL PATH DEGRADATION: GOME EXPERIENCE AND SCIAMACHY PREDICTION

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ABSTRACT

It is well known that degradation of optical components is to be expected after prolonged exposure to the conditions experienced in orbit. In particular it is expected that the instrument response to ultra-violet light will change. If instrument degradation is not properly corrected for, the scientific data products of the instrument in question may be affected, possibly mimicking trends such as ozone depletion.

GOME and SCIAMACHY are prone to degradation. In order to minimise the impact on the scientific data products, several means of monitoring possible degradation were incorporated in the instrument design and operations. GOME degradation is monitored on a regular basis, using light sources both internal and external to the instrument. This paper presents some results of the measured GOME instrument monitoring using the Sun and the Moon as sources of stable radiation. The unexpected behaviour of the degradation observed can be qualitatively explained by changes in the reflective properties of the scan mirror, resulting in scan-angle and polarisation dependent degradation.

With the degradation model, based on the Fresnel equations for reflection coefficients of media with known refractive index, predictions are made for GOME degradation behaviour for other angles and polarisation states than the Solar and Lunar viewing angles. The GOME experience is used to make predictions for SCIAMACHY degradation, under the assumption that a similar degradation mechanism is present and dominating in the SCIAMACHY instrument.

OCEAN DYNAMICS

SMALL SCALE PROCESSES IN THE SOUTH ATLANTIC OBSERVED IN SYNERGY OF ATSR AND SAR DATA DURING THE TANDEM MISSION

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ABSTRACT

During the ERS1-2 Tandem Mission in 1995-6, the SAR swath on one satellite overlapped the ATSR swath on the other with a 30 min interval, at latitudes greater than 50 degrees. A number of matching pairs of SAR and cloud-free ATSR images were found in the ERS archive covering the South Patagonian Shelf, the Drake Passage and the Antarctic Peninsula. The SAR.PRI image data were reduced to 200m pixels by rms averaging, and the ATSR.GBT and GSST 1km image products were warped onto the same 200m grid as the corresponding SAR scene. Following image enhancement, requiring a detrending of the SAR image to remove the response of NRCS to the viewing geometry, visual comparison was made between the two types of data. While no strong mesoscale dynamical features were encountered, a number of small-scale thermal signatures were detected, mainly close to the coast and in the Magellan Strait. A variety of signature types were found in the corresponding SAR scenes, which closely matched the location of the thermal signatures, including linear NRCS features, step changes of NRCS and changes in NRCS texture. These are systematically analysed and related to theoretical models of radar-ocean interaction. Some of the images include ice edge features and processes. In this remote region, for which there is little systematic oceanographic knowledge, the combination of the radar and thermal signatures facilitates the interpretation of the data, and demonstrates the usefulness of the synergetic approach for studying coastal ocean dynamics. Coupled with previous analyses of north-east Atlantic data, these matched image pairs point to the potential in future for oceanographic applications of synergetic analyses of combined simultaneous AATSR, ASAR (ScanSAR mode) and MERIS data from Envisat.

DEVELOPMENT OF A NEAR REAL TIME SYSTEM FOR REMOTE SENSING DATA FOR THE MEDITERRANEAN FORECASTING SYSTEM PILOT PROJECT

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ABSTRACT

The operational phase of MFSPP project started on the 1st December 1999 and will finish in June 2000. One of its major goals is to show that Near Real Time (NRT) forecasts of the large scale basin currents are possible. A forecasting system of such kind requires two essential parts, an observing system and a numerical modelling/data assimilation component that can use the past observational information to optimally initialise the forecast. A part of this project (the work package 3000) is dedicated to the development and the test of a near real time system that acquire and process remote sensing data such as satellite altimetry (T/P and ERS-2) and sst (AVHRR) data. The proposal will benefit from some past and present MAST/MTP projects in the Mediterranean sea, such as MERMAIDS in MAST-II and MATER in MAST-III. The processing steps specific to MFSPP are the extraction of along-track Sea Level Anomaly relative to a new mean sea, the correction of orbit error using a local inverse method and the mapping of Sea Level Anomaly using an improved optimal interpolation method. The validation of this Near Real Time system consists in the comparison with a delayed time (HH, here after). The rms of the differences between NRT and HH is of about 3.7 cm rms for combined maps (T/P + ERS-2) and 3 cm for T/P maps. The associated errors are mainly induced by the orbit, the differences in the spatio-temporal coverage, and the shift in the observation period (2 weeks before, 1 week after) used in the objective analysis.

FEASIBILITY OF ERS ALTIMETER DATA TO STUDY SUBSURFACE PROCESSES IN THE NORTH ATLANTIC

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ABSTRACT

The spatial coverage of the ERS satellites makes it feasible to investigate mesoscale phenomena. In this paper we present evidence that mesoscale subsurface processes such as overflow of dense bottom water through the Denmark Strait and the Faroe Bank Channel are detected in the ERS 1+2 altimeter data as enhanced high frequency sea level variability and eddy kinetic energy. The location of the Faroe Bank Channel overflow plume is in agreement with hydrographic observations and records from moored instrumentation. In the Denmark Strait the observations show significant enhancement in sea level variability in an area downstream of the sill where also highly variable currents with a period of a few days have been observed. The long record with observations allows for an investigation of the annual and interannual variation in the overflow signals, and in agreement with other studies the location of the Faroe Bank Channel overflow on the slope does not exhibit significant annual variation.

ERS-2 ALTIMETRY IN OPERATIONAL NOAA FORECAST MODELS

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ABSTRACT

NOAA's Laboratory for Satellite Altimetry has been producing real-time altimetry products from ERS-1 and ERS-2 since 1995. Significant enhancements are made to ESA's fast-delivery data sets, most notably the addition of orbit information provided by the Delft University of Technology. In late 1998, several enhancements were made to the NOAA/Delft altimetry products: ESA's fast-delivery data now include measured wet troposphere corrections from the on-board radiometer; the Delft DGM-E04 gravity model (specifically tuned for ERS) is used in the orbit determination system; and an iterative feedback scheme is now performed to refine the real-time orbits by incorporating altimetric heights and crossovers. Within NOAA, several collaborative efforts are utilizing real-time ERS-2 data in their operational forecast models. At the largest scales, the Climate Modeling Branch at the National Centers for Environmental Prediction (NCEP) is assimilating Topex/Poseidon and ERS-2 altimetry into a coupled model for El Niño / Southern Oscillation prediction. Timeliness is not as critical as absolute accuracy in this modeling effort. Thus, we are combining the ERS-2 data with the more accurate Topex/Poseidon altimetry to further reduce orbit and environmental correction errors before assimilation in the ENSO model. At finer resolution, the NCEP Ocean Modeling Branch is assimilating Topex/Poseidon and ERS-2 altimetry into the Coastal Ocean Forecast System, which produces nowcast and 24-hour forecast fields for the Gulf Stream/western North Atlantic region. Evaluations carried out during a recent demonstration project established that addition of sea surface height anomalies derived from Topex/Poseidon added significant detail to the real-time products: sea surface heights, 1-meter currents, and subsurface temperatures. Parallel forecast experiments are now in progress to determine the impact of the addition of ERS-2 altimetry. The increased spatial resolution provided by ERS-2 is expected to further improve the model's skill at determining mesoscale features. Recently, a unique use of altimetry data was begun with NOAA's National Hurricane Center. Products containing surface height anomalies, Upper Ocean heat content, and upper layer thickness will be available operationally to the forecasters this hurricane season for the Western Atlantic Ocean. The upper ocean heat content and upper layer thickness are inferred from sea surface heights, which augment sea surface temperature and in-situ subsurface measurements. Again, the increased spatial resolution provided by ERS-2's sampling will greatly benefit the determination of these oceanic parameters, thereby improving the prediction of tropical cyclone intensity.

ANALYSIS OF THE ATLANTIC OCEAN RESPONSE TO PRESSURE VARIATIONS USING THE ALTIMETERS OF ERS-1 AND ERS-2 SATELLITES DURING HIS TANDEM MISSION

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ABSTRACT

The sea level response to fluctuations in barometric pressure is currently modelled by the inverted barometer (IB) approximation which implies a change of approximately 1 cm in sea level for 1 mb change in atmospheric pressure (isostatic assumption). Therefore, sea level gradients perfectly compensate the horizontal gradients in atmospheric pressure fields and there is no pressure gradient at the sea surface. As a consequence, pressure-induced sea level slopes are not dynamically significant and are usually subtracted from altimetric records of sea surface height. The validity of the IB assumption and the character of the sea level response to barometric forcing is dependant on the time and space scales considered. In this work the magnitude of the Atlantic Ocean response to pressure variations will be quantified, 1 in order to verify the validity of the isostatic assumption. To do that, we will calculate the correlation coefficients (a) between the sea level anomaly (SLA) and pressure variations (DP), which should be ~1 cm/mb if the oceanic response is isostatic. The time period used corresponds to May 1995 and June 1996 in which ERS-1 and ERS-2 satellites were put in the same ground track (the so-called Tandem Mission) with a time lag of approximately one day. Two different techniques will be applied to quantify the coefficients above mentioned, simple regression analysis and empirical orthogonal function decomposition (EOFD) analysis. The SLA time series have been produced following the recommendations of the Ocean Product User Manual applying the suggested instrumental and geophysical corrections. Apart from that, several corrections have been also applied, such as a new orbital altitude which significantly reduces the orbital error, time tag bias correction, SPTR correction, USO drift correction, etc. The AP time series have been derived from the dry tropospheric correction by inverting the Saastamoinen formula.

INDIAN OCEAN CIRCULATION: AN INTEGRATED MODEL AND REMOTE SENSING STUDY

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ABSTRACT

The overall objective of this investigation is to gain an improved understanding of the ocean circulation and variability in the Indian Ocean in response to the monsoon system, by integrated use of radar altimeter data and numerical modeling. The model is based on the Miami Isopycnic Coordinate Ocean Model (MICOM) and has been used in a multiyear simulation forced by synoptic atmospheric data. The model covers all of the Indian Ocean, but with enhanced resolution in the northern part. The main results from the model experiment can be divided into model circulation, volume transport and the analysis of water masses. The surface circulation, variability and sea level anomalies have been qualitatively validated using the new combined global gridded altimeter data set of the ERS and Topex/Poseidon. Quantitative validation has been done using available in situ and model results to find its ability to reproduce the ocean system before integrating this into a data assimilation system using the ensemble Kalman Filter. The model does an excellent job in reproducing the major currents and gyres. The simulated and observed sea level anomalies are also well correlated in phase and time, but it is clear that the model resolution is too coarse to resolve the finer structures seen from the observed data.

THERMAL PLUMES AND INTERNAL SOLITARY WAVES GENERATED IN THE LOMBOK STRAIT STUDIED BY ERS SAR

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ABSTRACT

The Lombok Strait separates the Indonesian islands Bali and Lombok and is the second most important strait through which water is exchanged between the Pacific Ocean and the Indian Ocean. The south end of the Lombok Strait is split by a small island and on each side of the island are rugged sills with an average depth of about 200 m. On the sill, tidal current speeds up to ±3.5 m/s are encountered.

There exists a strongly variable southward flow of warm surface water through the strait into the Indian Ocean, which forms a well-developed thermal plume south of the sill and which can reach as far as 30 km into the Indian Ocean. Its extent depends on the water transport through the strait which is strongly varying in time (from about 1 Sv to 4 Sv) depending on the annual cycle of the monsoon winds. The position of the front associated with this plume has been identified on several ERS SAR images. Thus we suggest that ERS SAR imagery acquired over the southern entrance of the Lombok Strait may be used for obtaining information on the variation of the throughflow of Pacific water into the Indian Ocean.

Another oceanic phenomenon that can be studied by ERS SAR images acquired over the Lombok Strait and its adjacent sea areas are the internal solitary waves that are tidally generated at the sill and propagate in both directions. The waves propagating northward into the Java Sea have always a quite regular circular shape while the ones propagating southward into the Indian Ocean have a very irregular shape. Physical explanation for this behavior is presented. We attribute this mainly to the strongly horizontally varying current field in the southern section of the sill. Since the sea surface manifestations of the internal waves vary very strongly with time, we hypothesize that the internal wave characteristics south of the Lombok Strait depend on the stratification of the water body and the strength of the water flow through the strait. Thus, we suggest that ERS SAR imagery showing internal waves in the southern section of the strait may also be used for obtaining information on the variability of the throughflow through this strait.

DETERMINATION AND CHARACTERIZATION OF GLOBAL MEAN SEA LEVEL CHANGE

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ABSTRACT

Sea level change represents consequences of complicated interactions of the solid Earth-atmosphere-hydrosphere-ocean-cryosphere system and in part forced by human-originated greenhouse effect. Estimates of the last century (40-100 years) sea level change are about 1-2.5 mm/yr (IPCC 1995, Warrick et al. 1996). Although there is no firm evidence of an acceleration in the rateof sea level rise over this time period [Woodworth, 1990], the projected future sea level rise is 13 +/- 4 cm during the next 40 years (1987-2027), and 61 cm over the next 100 years (1987-2087)[Woodworth, 1995]. The secular or long-term sea level change studies have primarily used tide gauges located near coastal regions and continental margins or near islands. The estimate has deficiencies from vertical land movements (e.g., due to postglacial rebound and local land motion) and the associated vertical datum knowledge, and the fact that the data only covers less than 5of the global ocean. Satellite radar altimetry measurement, both historic and current (Geos-3, Sea sat, Geosat, ERS-1, TOPEX/POSEIDON, ERS-2, GFO-1, and future (Envisat, Jason-1, NPOESS), would provide global coverage but has much shorter data span (less than 10 years of continuous data), and have measurement uncertainties caused by respective instrument biases and drifts. In this study, we will provide an analysis of the present-day global mean sea level change using multiple mission altimeter measurements and tide gauge data. Geosat, ERS-1, ERS-2 and Envisat (future mission) data cover critical portion of the polar ocean sand this paper will focus on their contributions to the global sea level studies. Second part of the study is intended to provide a characterization of the sea level change by using modern observations, including global sea surface temperature (spaceborne and in situ), ice extents, postglacial rebound models, glacier and ice sheet mass balance data.

USE OF SAR DERIVED DOPPLER DATA FOR OBTAINING QUANTITATIVE CURRENT VELOCITY INFORMATION IN THE GULF OF MEXICO

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ABSTRACT

Ocean current velocity information is perhaps the single most important type of information required for many applications in the ocean environment. This information is very difficult to collect synoptically and no spaceborne remote sensing technique is currently available that allows robust extraction of quantitative velocity information at spatial resolution scales of the order of 10 km or smaller. This article shows examples of validation and demonstration of a methodology to extract Doppler information from raw SAR imagery. This information allows the generation of current velocity maps at spatial resolutions in the order of 1-2 km and a precision of approximately 0.2-0.3 m/s. The northern section of the Gulf of Mexico represents an area with a need for good quality current velocity information. Large eddies are shedded from the Gulf Stream loop current and they can cause current velocity variations as much as 2-3 knots. These velocities can seriously affect offshore operations and production. The paper will review current sources of information used and will show examples of the benefit of using Doppler and SAR imagery for measuring current velocities and locating current velocity phenomena. Data sources used are Radarsat and ERS data, AVHRR, HF-radar and Topex/Poseidon altimeter data and buoys.

INTERNAL SOLITARY WAVES IN THE SULU SEA STUDIED BY ERS SAR IMAGERY

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ABSTRACT

The Sulu Sea is one of the areas of the world's ocean where large-amplitude internal waves are encountered. The generation and propagation of internal solitary waves in the Sulu Sea have been studied by Apel et al. (1985) by using in situ data and images acquired from the DMSP, Landsat, and Nimbus-7 satellites as well as from the Space Shuttle during the SIR-A mission. However the images acquired from satellites in the visible and infrared wavelength bands and the ones acquired from the Space Shuttle in the microwave band are very sparse and do not allow a detailed investigation of the sources of generation of internal solitary waves, their propagation characteristics, and their interaction with shallow bottom topography. We have screened about 100 ERS-1 and ERS-2 SAR images of the Sulu Sea that were received and processed at the Singapore and Taiwan ground stations. These images reveal that internal solitary waves in the Sulu Sea (1) are not only generated by tidal flow over the a shallow sill east of the Pearl Bank, but also by tidal flow over sills located west of the Pearl Bank, (2) change their wavelength, propagation velocity and curvature of their crest lines as they propagate into shallow water in the western section of the Sulu Sea, (3) dissipate when they approach the 50-m isobath line at the western boundary of the Sulu Sea and a shallow ridge south of the Palavan Island, and (4) are unaffected by submerged coral reefs and islands when their size is significantly smaller than the distance between the solitons. Furthermore, the ERS SAR images reveal that circular internal waves are radiated from these small-scale submersed coral reefs. These observations are also confirmed partly by SPOT quick-look images.

LOCAL MEAN SEA LEVEL SLOPE FROM MULTI-SATELLITE ALTIMETER DATA: DATA ANALYSIS AND UNIFICATION IN THE WESTERN MEDITERRANEAN SEA

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ABSTRACT

An accurate local mean sea level surface and its slope extend the area of the absolute calibration from the GPS buoys to the altimeter profiles and the tide gauge stations. Multi-satellite altimeter data are required to increase the data coverage in the area. The paper analyses the relative bias and drift of the ERS and Topex/Poseidon data from 1992 to 1999. A local unification of the multi-satellite mean profiles is performed by a dual crossover method, after removal of a sea level variability model estimated from the Topex/Poseidon data. The sea surface slope and its accuracy are computed from the unified data.

LANDSLIDES

REGIONAL SCALE THEMATIC MAPS FOR LANDSLIDE HAZARD ASSESSMENT USING NEURAL NETWORKS TECHNIQUES

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ABSTRACT

This work describes the classification results, obtained in the framework of the ESA AO3-320 project, from multi-source image analysis of a landslide-prone area in Italy. The study area, located in Southern Apennines, is characterized by frequent occurrence of mass movements caused by rainfall and seismic events. Land cover mapping, with particular attention to the identification of areas susceptible to erosion, was performed by using both centralised and distributed classification systems based on neural networks (NN) and fuzzy logic techniques. In the centralized classification system, all data from all available sources (multisensors or multitemporal) are used together by a single inference mechanism. In the distributed system, the partial conclusions reached by different classifiers are combined. The classifiers are different if relying on different sources of information, such as intensity and coherence SAR data, or if relying on different classification schemes. Numerous SAR tandem pairs and TM images, covering the years 1993-1996, were examined. To facilitate data integration and interpretation, the land use (e.g. erosion, farmland, forest, urban areas, bare rocks, water) and geomorphologic maps were combined in a GIS. The spatial distribution of erosion areas coincides with the presence of clay-rich sedimentary rocks that crop out along the central and most uplifted portion of the Apennine mountains. The results are compared with the ground truth data and multitemporal Landsat images.

MONITORING LANDSLIDE ACTIVITY IN A PERI-URBAN AREA BY SAR INTERFEROMETRY

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ABSTRACT

Operational monitoring of slope instabilities by SAR Interferometry poses a number of challenges due to the limited spatial extent of the landsliding areas and the rainy conditions usually associated with mass movement events [1]. In this work we present the results of the application of both conventional DInSAR techniques, and a point-by-point, multitemporal study of the long-term stability of selected high-coherence objects on the ground. The selected site is Caramanico Terme, thermal center and holiday resort located in the south-central Apennines, where landsliding has been the main and most frequently occurring geological hazard throughout history. Regular in situ controls conducted since 1990 revealed seasonal activity of several mass movements, which threaten the town's historic center, cemetery and infrastructures. The landslides are relatively large, up to 1 km in maximum dimension and move slowly or very slowly with resultant displacements potentially detectable from SAR data. Several SAR frames were processed over the area. The various factors influencing the suitability of the selected data for interferometric applications, i.e. resolution, time and spatial baselines, and times of acquisition, were reviewed. A simplified approach to the so-called "permanent scatterers" (PS) technique, originally proposed in [2], has been applied to monitor small displacements between couples of points sufficiently close to each other so that atmospheric phase delay effects are negligible.

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THE APPLICATION OF ERS SAR INTERFEROMETRY FOR THE ASSESSMENT OF HAZARDS RELATED TO SLOPE MOTION AND SUBGLACIAL VOLCANISM

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ABSTRACT

The ERS AO3 project No. 239 on "Interferometric Monitoring of Slope Motion and Volcanic Deformation for Risk Management" is aimed at applications of differential SAR interferometry for hazard assessment. The phenomena being studied include mass wastes at mountain slopes and surface deformation related to subglacial volcanism. Test sites for slope motion studies are located in the Austrian Alps. At selected slopes time series of surface displacements over periods up to seven years, generated from ERS SAR interferograms of annual and bi-annual time spans, were analysed in detail. Typically, the motion of these slopes, which are characterised by deep-seated rockslides, is of the order of millimetres to centimetres per year. In addition, the limits of application due to decorrelation and due to imaging geometry were studied over a large area, covered by six different SAR frames over the Austrian Alps. For Alpine areas above the tree-line ERS SAR interferometry is an excellent tool for detecting and monitoring slope movements. At lower elevations severe constraints result from decorrelation due to dense vegetation. Effects of subglacial volcanic activity were studied at the ice cap Vatnajökull in Iceland. Several rivers which drain Vatnajökull are affected by floods due to water outbreaks coming from subglacial lakes in geothermal areas, meltwater produced during volcanic eruptions, or marginal ice-dammed lakes. The melting of basal ice, the accumulation of meltwater in subglacial lakes, and changes of the hydraulic regime of the glaciers cause surface deformation and movements which can be observed by SAR interferometry. ERS-1/2 tandem interferograms, acquired during the years 1995 to 1999, were used to study the filling of ice cauldrons with subglacial meltwater and to analyse the ice deformation after a volcanic eruption. In addition, several sites of local vertical displacement, so far unknown, were detected which are probably related to increased bottom melting due to strong geothermal heating. The studies in Austria and Iceland confirm the great potential of ERS SAR interferometry for detecting and monitoring hazard phenomena related to unstable mountain slopes and volcanic activity as a contribution to risk management.

DETECTION AND QUANTIFICATION OF ROCK GLACIER MOVEMENTS USING ERS D-INSAR DATA

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ABSTRACT

Although the differential SAR interferometric technique (D-InSAR) has been shown to derive surface displacement in the radar line-of-sight, a number of questions related to the properties of rock glaciers and the imaging geometry of the SAR sensor remain to be answered. These include the relative small size of the rock glaciers in comparison to the SAR pixel resolution, the rough surface topography composed of debris and rocks, the perennial snow patches and snow cover most of the year in the areas of interest, the rather small flow velocities of active rock glaciers in the range of centimetres to few meters (in some cases) per year, the look angle of the SAR sensor, and the geometric and temporal baselines requirements for successful D-InSAR data sets.

In this paper, the detection of active, i.e. creeping, rock glaciers and consequently the quantification of the observed surface movements and also its temporal change using D-InSAR methods and the prerequisites to perform such analysis on a regional scale is presented. Five ERS-1/2 single look complex (SLC) image data sets acquired during the period 1992 to 1997 over the Hohe Tauern range (Central Alps) in Austria were compiled and interferometrically processed.

In one of the study cases, the active Doesen rock glacier, where the coherency of interferometric pairs was very high and the perpendicular component of the baselines were relatively small, flow velocities of about 1.8 cm per month along the range direction were estimated. This value agrees very well with the geodetic flow velocity measurements of 22 cm per year of the same rock glacier. Some mass movements around the rock glacier area were also observed.

CIVIL PROTECTION USE OF ERS1-2 SAR DATA - THE TS-SAR PROJECT

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ABSTRACT

SAR interferometry has been used to monitor ground deformation in the urban area of Trieste (Italy) in the period between 1996-1999 for the Civil Protection Department of the Municipality. The urban setting is characterised by a series of hills made of flysch (thin alternations of sandstone and clay layers) that present marginal stability problems. The outback is characterised by the presence of a very stable carstic highland constituted by limestone. A set of interferograms has been computed in order to identify sliding areas and at the same time verify the general urban area stability. Because of the lack of ground control points, permanent scatteres located in the stable highland area have been used as references. This procedure allowed a more confident approach evaluating artefacts due to atmospheric inhomogenities, to changes in soil moisture and also to unwrapping errors. The results outlined by the height change maps derived by interferometry have been validated using ground evidence. These areas are now monitored using differential GPS methodology. SAR amplitude images have been combined in order to achieve a multitemporal product and a series of thematic maps like fire risk evaluation, forest and land use changing. In addition an accurate morphological analysis of the interferometric derived digital elevation model has been carried out.

EARTHQUAKES

MERGING SEISMOTECTONIC DISPLACEMENT MAPS MEASURED FROM SAR INTERFEROMETRY AND OPTICAL SATELLITE IMAGES.

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ABSTRACT

ERS Differential SAR interferometry and SPOT offsets yield maps of ground displacement that differ in accuracy, sensitivity to decorrelation and geometry. Applied to the Izmit, August 1999, earthquake, INSAR yields far field, near vertical Measurements with an accuracy of about 0.5 cm.

SPOT offsets yield best orientated horizontal measurements near the fault with an accuracy of about 25 cm. Put together those measurements allow to constraint parameters of elastic modeling both near the surface and at depth: SAR interferometry yields thigh constraints on the geometry of faults at depth and on offshore ruptures (not measured from SPOT images) while offsets allow direct cartography of ruptures and slip estimate consistent with in situ geodetic measurements. Applied to the Landers earthquake, SPOT offsets of coseismic displacements show anelastic deformations near the fault where strong displacement gradients occur. Particularly asymmetric deformation gradients are measured at each side of the faults.

INSAR shows post seismic deformations that may be due to fluid. It suggests that both kind of measurements can help to the overcome first order elastic modeling of ground displacement.

EIGHT YEARS OF CRUSTAL DEFORMATION IN SOUTHERN CALIFORNIA OBSERVED WITH ERS SAR INTERFEROMETRY

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ABSTRACT

Between 1992 and 2000, Southern California has been the locus of 4 earthquakes of magnitude greater than 6 producing surface displacement of up to 3 m, and the coastal area, west of the San Andreas fault, moved steadily to the north-west by ~24 cm with respect to the North America plate. Surface displacements produced by the tectonic activity have been imaged by the ERS satellites, giving scientists new insights into processes occurring in the crust and the upper mantle. This paper will present examples of deformation associated with those processes and will focus more particularly on the observation of small surface displacements associated with interseismic strain accumulation along the San Andreas fault and with post-seismic relaxation after the 1992 Landers earthquake. The long-term, horizontal slip rate of ~3 cm/yr along the Mojave section of the San Andreas fault projects into a range change rate of ~1 cm/yr along the ERS satellite line of site on descending passes, producing a phase change of ~1/3 of a cycle per year in radar interferometric maps. Because of the small amplitude and distributed nature of the inter-seismic signal, special treatments of errors were necessary. Precise estimate of the interferometric baseline was obtained by least-square adjustment of the observed phase to a simulated phase. Errors due to phase propagation delay through the troposphere was reduced by averaging independent interferograms. Crustal velocities observed with GPS and InSAR are in excellent agreement with a statistical difference of less than 3 mm/yr. Using a similar processing strategy, ERS data covering 5 years after the 1992 Landers (M7.3) earthquake revealed the effects of two dominant post-seismic relaxation processes. Large surface strain observed in the step-overs of the earthquake rupture were caused by poro-elastic relaxation due to the gradual dissipation of the pore fluid pressure gradients induced by the earthquake in the shallow part of the crust. The larger scale deformation pattern observed around the rupture revealed visco-elastic relaxation processes occurring in the lower crust and upper mantle. Visco-elastic models showed that a highly ductile uppermost mantle beneath the central Mojave domain was required to account for the observed deformation.

THE COSEISMIC DEFORMATION FIELD OF M=7.5 MANI EARTHQUAKE IN TIBET MAPPED BY ERS INTERFEROMETRIC SAR DATA

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ABSTRACT

Many earthquakes of M=7.5 in north Tibet occurred on Nov. 8, 1997. Due to inconvenient transportation and cruel plateau environment with average altitude of 5,000 meters above sea level, geodetic observation and field investigation are difficult to be carried out. Thus, radar interferometry is almost the only way for mapping deformation field of this earthquake. Two frames of ERS SAR images acquired on three separate dates spanning the earthquake event were selected to cover the vicinity of the earthquake. The ERS-1 image acquired on April 15, 1996 and ERS-2 image acquired on April 16, 1996 (A tandem pair) were used to extract DEM. The ERS-2 image pair acquired on April 16, 1996 and December 2, 1997 were used to compute a raw interferogram with fringes due to both topography and surface displacement. After the topographic fringes were simulated by the DEM generated with the tandem image pair, and removed from the raw interferogram, the resulting interferogram is a contour map of the change in range. The incoherence belt along Margaichaka-Nolacuo fault on this change map implicates that the surface ruptures may distribute along this fault and large displacement gradient within a buffer along this fault causes the incoherence. The fringe patterns along this fault indicates that left-lateral slip is the main deformation type.

APPLICATIONS OF SAR INTERFEROMETRY TO SURFACE DEFORMATION IN CENTRAL AND SOUTHWEST ASIA

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ABSTRACT

Much of the mid-latitude belt of Asia is semi-arid or arid, providing generally good conditions for repeat-pass synthetic aperture radar (SAR) interferometry (IntSAR) measurement of surface deformation with C-band ERS and Envisat data. The primary limitation on ERS IntSAR in most of this area is the sparse data coverage due to the lack of ground receiving stations. Temporary station deployments in 1995-96 and 1998-99 allowed the acquisition of some valuable ERS imagery in central and southwest Asia.

The large surface deformation field that accompanies co-seismic fault slip is the easiest signal to detect with limited data. More localized non-tectonic deformation, such as subsidence due to groundwater or petroleum withdrawal or salt flow, and the more gradual interseismic or post-seismic deformation fields are more difficult to distinguish from atmospheric variations and other error sources.

The Alpine-Himalayan Belt is one of the tectonically active zones on the earth overlaps the arid to semi-arid swath of Asia. While some parts of the zone are well instrumented with GPS or other ground-based measurements, other parts are logistically or politically inaccessible to detailed field studies so IntSAR is the best way to make geodetic measurements of the surface deformation. Several recent large (M>6) earthquakes, especially in Iran, show complex mechanisms of fault rupture, both in their seismic signatures and the IntSAR deformation maps.

One example is the 10 May 1997 Zirkuh earthquake (Mw=7.2) in east Iran that had 125 km of surface rupture mapped in the field, and a long, complex seismic signal. ERS IntSAR pairs, with time intervals from two to six years, include the co-seismic deformation. While a large part of the Zirkuh IntSAR signal can be explained by strike-slip motion on a near-vertical fault, there are substantial variations between fault segments. The fortunate overlap of ascending and descending ERS pairs in the southern part give two components of the surface deformation and require that the southern segment rupture must have a substantial dip-slip component. This is consistent with seismic modeling that fit late waveform arrivals with a thrust-mechanism sub-event.

* Work partially performed under contract with the National Aeronautics and Space Administration.

TRIGGERED SLIP ON A SHALLOW LOW-ANGLE THRUST IMAGED BY SAR INTERFEROMETRY: THE HAHDAD THRUST, SE IRAN

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ABSTRACT

Many geological structures are believed to develop in response to faulting. Using SAR interferometry, we have observed small fault displacements over a broad, shallow, low-angle thrust beneath the Shahdad fold-and-thrust belt, which parallels the strike-slip Gowk fault system in SE Iran.

On March 18, 1998, an Mw = 6.6 earthquake struck a sparsely inhabited area centred on the town of Fandoqa in the Kerman province of SE Iran. This event ruptured part of the 160 km long Gowk fault system, a predominantly right-lateral strike-slip zone, which had previously failed in 1981. Although the only available coseismic pair of ERS SAR images spans an interval of 2.3 years, the topographically-corrected interferogram has excellent coherence in most areas, due to the lack of vegetation in this arid region. Source parameters for the Fandoqa earthquake estimated through elastic dislocation modelling of the interferogram are in good agreement with those obtained by body-wave modelling of seismograms.

When the predicted range-changes are subtracted from those observed, a roughly rectangular area, 22 by 35 km, of 20-40 mm of decreased range remains over the centre of the Shahdad fold-and-thrust belt, east of the Fandoqa earthquake rupture. We performed a second inversion for the parameters of an elastic dislocation fault model, using the residuals over the Shahdad belt as constraints and holding the fault parameters for the Fandoqa event fixed. The resulting fault model has 77 mm of almost pure thrust motion on a plane dipping at 7.8 degrees between depths of 1.5 and 4.5 km. The slip plane projects to the surface to the east of the eastern edge of the Shahdad thrust belt; most of the slip on the shallow thrust is probably transferred to more steeply dipping faults.

Slip on the shallow thrust could have occurred at any time within the 2.3 year interval; however, the fact that the area of the shallow thrust coincides with that of increased Coulomb failure stress due to the Fandoqa earthquake, suggests it occurs in response to that event. Even if the thrusting event occurred as an earthquake, its small size would make it difficult to detect seismically.

CRUSTAL DEFORMATION OF THE NORTH ANATOLIAN FAULT ZONE MEASURED WITH RADAR INTERFEROMETRY

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ABSTRACT

The North Anatolian Fault Zone accommodates the westward motion of Turkey relative to Eurasia by right-lateral shear and regularly generates large (M>7) earthquakes. In 1999, two earthquakes ruptured nearly 200km of the fault and were the first for which interferometric data have been available.

The (M=7.4) 17 August 1999 Izmit earthquake was the largest to occur on the North Anatolian Fault for 60 years. The surface rupture was mapped for 100km from Duzce in the east to the Gulf of Izmit; the western limit of faulting has been inferred to be east of the prominent Hersek delta (29.5E), as no surface rupture was observed there, but aftershocks continue for another 50km beyond the delta. We use radar interferometry to map the displacement field of the earthquake, which largely conforms to that predicted for deformation in an elastic upper crust. Our interferometric data includes ascending and descending pairs on several tracks, including two pairs with a separation of just 35 days. We determine the earthquake source parameters including the distribution of slip and the location of faulting offshore in the Gulf of Izmit, showing that significant slip continued for around 15km West of the Hersek delta. In addition, we demonstrate that additional small displacements occurred on parallel strands of the North Anatolian Fault Zone. This slip did not rupture the surface and we argue that it is triggered slip, caused by changes in static stress due to the mainshock or the dynamic release of regional stresses.

We have also used InSAR to study the (M=7.2) 12 November 1999 Duzce earthquake. The interferogram for this earthquake has a deformation pattern that is asymmetrical, more fringes being observed on the north side of the rupture than the south: consistent with a fault plane that dips to the north. Although the earthquake is smaller in magnitude than the Izmit earthquake, surface slip amount is similar, over a shorter length. In addition to studying the coseismic signal in the 1999 earthquakes, we have investigated ways of extracting the smaller interseismic deformation across the North Anatolian fault zone.

COHERENCE TRACKING MEASUREMENTS OF THE AUGUST 1999 IZMIT EARTHQUAKE

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ABSTRACT

The 17th of august 1999, an important earthquake of magnitude 7.6 occurred along the north anatolian fault in the area of izmit (turkey). Relative horizontal displacements up to 4.5 meters were observed. This earthquake was followed by several important aftershocks of magnitude between 4 and 6. The most important aftershock occurred the 13 of september (magnitude 5.8). We have used ers1/2 tandem pairs acquired above the izmit area both before and after the 17 august 1999 earthquake to perform a dinsar study of this dramatic event. Tandem pairs show an ambiguity of altitude that does not allow to produce a valuable topographic reference due to phase unwrapping difficulties. Thanks to adequate orbital maintenance manoeuvres on both satellites, long-term (i.e. 35 days) pairs have very short baseline allowing to perform dinsar studies without having to remove a topographic phase reference. Long-term interferograms show fringe pattern allowing to generate a good mapping of the along-range displacements.despite the low coherence level observed, we made coherence tracking measurement successfully. This technique is based on local coherence maximization used in coregistration process to generate a map of local azimuth and range displacement with respect to the global coregistration with a subpixel accuracy. Coherence tracking allows us to obtain a qualitative and a quantitative measurement of the azimuth displacements. Even if inaccurate, these coherence-tracking measurements give results in good agreement with on-ground measurements, as well in amplitude than in orientation of the observed movements.

STUDY OF THE SEPTEMBER 7, 1999 ATHENS EARTHQUAKE USING ERS-2 SAR INTERFEROMETRY

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ABSTRACT

For the purpose of identifing the seismogenic fault and characteristics of the area affected by the September 7, 1999 Athens earthquake, several raw format ERS2-SAR images were processed to produce co-seismic interferograms. The study was realized in the frame of a bilateral collaboration initiated between the National Observatory of Athens and the ESA. The SAR image acquisitions were extending in the period between December 1995 to October 1999, providing the possibility to calculate various co-seismic interferograms, as well as interferograms corresponding to times frames before the occurrence of the main shock. The calculated co-seismic interferograms show that the earthquake caused surface deformations, which appear with at least two concentric, but not symmetric fringes, centered at 38.10oN; 23.60oE. This point is located in a distance of less than 2.7 km away from the main epicenter (38.10oN, 23.56oE). The resulted fringes indicate 56 mm of change in slant range direction. The study of the interferograms shows that the observed fringes are rather constant in shape, position and magnitude and that they are the result of a co-seismic surface deformation. The fringes define an active zone of more than 20km in the E-W and 10km in the N-S directions, bounded by the Fili Mountain in the NE and the Aegaleo Mountain in the SE. This area encompasses the vast majority of the epicenters located in the period from September 8th to October 5th 1999, extending S-W to the Fili Mountain with a striking along a WNW-ESE axis.

The observed fringes were used to infer a modeled solution of the seismogenic structure. The model solution suggests a fault having the characteristics: length=12km, width=6.5km, depth of upper edge=8km, strike=97.5°, dip=43°, seismic moment=11.6 1017. This fault has experienced a slip of 50cm at the depth of 8km and it is responsible for the observed surface deformations. According to this study the modeled faults intersect the Earth surface at points 38.17oN; 23.53oE and 38.14oN; 23.76oE, defining a trace which lies about 5 km northern to the Thriassion depression, crosses the Fili mountain and shows a WNW-ESE trending.

Our study returns strong evidence that in general, the activation of a fracture zone located at the Fili Mountain is mainly responsible for the observed surface deformations. However, the fact that no direct association to any of the existing faults was possible make us to believe that is very probable that it could have been activated one not mapped, not visible or most likely a blind fault existing in the affected area. It is certain that we need to conduct further research integrating SAR interferometric and tectonic observations together with aftershock data to clarify and determine more reliably the seismic characteristics of the area.

THE COSEISMIC DISPLACEMENT FIELD OF THE BAOTOU EARTHQUAKE MAPPED BY DIFFERENTIAL RADAR INTERFEROMETRY

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ABSTRACT

It is possible to map a coseismic displacement field resulting from a major earthquake by differential SAR intereferometry and to achieve results comparable in magnitude to those obtained by conventional field survey techniques. Here we use differential SAR interferometry to capture the movements produced by the 1996 earthquake (M=6.4) in Baotou, Neimeng province. Three interferograms constructed from ESR-1/2 SAR data were used to analyze the earthquake mechanism by three- pass method and the digital elevation model elimination (DEME) method. The differential interferograms produced by the three-pass method indicate the extent of the displacement field, those produced by DEME method indicate fine geometrical features. Combined two methods, we can reveal the behavior of the landslide that could not be observed with the discrete GPS measurements.

FORESTRY 'SIBERIA'

RUSSIAN FOREST INVENTORY REQUIREMENTS AND REMOTE SENSING PARAMETERS-OPERATIONAL ASPECTS EVOLVING FROM THE SIBERIA PROJECT

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ABSTRACT

The transition to a sustainable forest management paradigm requires significant improvement of national forest inventory and monitoring systems. The Russian Federal Forest Service introduced criteria and indicators for sustainable forest management in February 1998 and initiated the development of a new forest inventory and monitoring system (FIMS). Remote sensing applications using multi-sensor techniques are considered as an obligatory element of all three structural and functional parts of the new FIMS, i.e. national forest inventory, operational management inventory and planning on the enterprise level, and monitoring. The SIBERIA project is an international effort to map Siberian boreal vegetation characteristics using ERS-1/-2 and JERS-1 SAR images and interferometric products. SIBERIA started in August 1998 and has recently finished the project phase of developing an operational methodology to classify a total of 113 ERS frames covering a 1.2 mio sqkm area between the Yenissei river and Lake Baikal.

This paper presents a concentrated overview of how the project philosophy (based on the user requirements) has influenced the processing steps leading to the operational classifier: interferometric processing, calibration issues, co-registration of ERS- and JERS-scenes, information content and selected classification algorithm. After an overview of these technical issues (presented in more depth in dedicated papers during this symposium), the paper elaborates how radar remote sensing meets FIMS' requirements. SIBERIA's results illustrate for a first time real-world capabilities and limitations for an operational, non-interactive thematic information retrieval for very large area mapping of boreal forests.

THE CLASSIFICATION PROCEDURE IN SIBERIA: RATIONALE AND METHODOLOGY

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ABSTRACT

The major methodological challenge of the SIBERIA project was to derive a well-founded approach to classification which could be applied in a consistent fashion across a vast geographical territory using a variety of radar-derived quantities and with a minimum of operator intervention. The available data were: a Tandem pair and corresponding coherence image, which allowed the formation of DEMs over a significant part of the territory; a further ERS-2 intensity image (so that temporal change images could be formed); and a single JERS image. Our problem was to identify the number of classes which could realistically be recovered from this dataset (bearing in mind the requirements of the Russian forestry sector) and to find effective and efficient means to extract these classes from the available data. This paper describes the reasoning, which led us to adopt a particular approach amongst the range of options we considered. Essentially, there are two major stages to the procedure. The first is a data preparation step, which included correction of data to, registration of different image types, geocoding, filtering and masking out of areas where uncorrected topographic effects were too great to allow viable classification. The second stage is the classification procedure itself. Here we combined database and scatterplot analysis, physical reasoning and both supervised and unsupervised classification methods to produce a number of candidate approaches (with an option to refine these by a context-sensitive noise removal algorithm). The candidate algorithms were compared on the basis of accuracy (assessed using ground data), generality and ease of use. The results of this exercise and their application to a number of Siberian sites will be demonstrated.

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ASSESSING ERS AND JERS SAR INFORMATION CONTENT FOR LARGE SCALE FOREST MAPPING IN SIBERIA

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ABSTRACT

The objective of the SIBERIA project has been to generate information about the state of Siberian forest by exploiting an extensive coverage of the area in terms of ERS and JERS data. The main available ERS SAR data includes tandem intensity and interferometric coherence data acquired in1997 over 113 scenes. The JERS dataset, which spans most of the ERS coverage, is made up of single-date intensity images taken in 1998. To define classifiers, decision rules and classification strategy applicable to the large dataset, the information content of ERS tandem coherence and ERS and JERS intensity was analysed as a function of landcover type and forest characteristics, the latter information having been provided by more than 40 forest databases established by Russian project partners. Among the different attributes of the forest stands (relative stocking, growing stock volume, species composition, age, height, diameter of the dominant species), the growing stock volume is the best related to the interferometric coherence. The relationship, interpreted using physical knowledge, could be used to separate the forest into volume classes. However, the dynamic range of the coherence could have a scene to scene variation due to the effects of observation geometry, surface topography and meteorological conditions. On the contrary, ERS and JERS intensities ofthe forest classes have high stability but lie in a small dynamic range. The analysis showed that ERS tandem coherence and JERS intensity can be used to classify the scenes into three non-forest classes (water, open areas, agricultural fields) and the four forest biomass classes (clear cut and <20 m3/ha; 20-50 m3/ha; 50-80 m3/ha and >80 m3/ha). A classification strategy has been derived consisting in initialising the classification process with statistics derived from the analysis of the forest database and knowledge of the SAR responses of the non-forest classes. A Maximum APosteriori process was subsequently applied to take into account the inter-scene variation of the coherence. In addition to the general mapping, the results also pointed out areas which had undergone forest fire or clear cutting which occurred since the last updating of the forest database.

ACCURACY ASSESSMENT ISSUES IN THE SIBERIA PROJECT

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ABSTRACT

Russia's boreal forests host 116336647 of the world's live forest biomass. They play a critical role in Russia's economy, as well as in stabilising the global climate. The boreal forests of Central and Western Siberia represent the largest unbroken tracts of forest in the world, and are listed as "Last Frontier Forests" by the World Resources Institute. The EU-funded SIBERIA project aims at producing a forest map covering an area of 2 million square kilometres. Two operational Synthetic Aperture Radars (SAR) on board of the satellites ERS-1, ERS-2 and JERS-1 are used to provide remote sensing data. Analysis at two different wavelengths can thus be combined with SAR interferometry. The development of an appropriate classification algorithm proved difficult because of large variation in image features between frames. An accuracy assessment of the classification results is carried out using spatial forest inventory data from several Russian Forestry Enterprises. Issues of geometric, radiometric, and classification accuracy are discussed and a method for accuracy assessment is presented.

ERS INTERFEROMETRIC PROCESSING FOR BOREAL FOREST APPLICATIONS

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ABSTRACT

The boreal forests of central and western Siberia represent the largest unbroken track of forest on Earth. They serve Russia and the world as a source of wood and a critical stabilizer of the global climate. Even though the region is of increasing interest for conservation and climatologic objectives as well as for political and industrial aspects the current state of the Siberian forest is unknown due to recent large-scale natural and human-induced disturbances. Therefore an international consortium is currently producing a forest map of central Siberia within the project SIBERIA (SAR Imaging for Boreal Ecology and Radar Interferometry Applications) utilizing ERS and JERS SAR intensity, supplemented by interferometric information. This paper presents the processing chain and the interferometric ERS-SAR products provided for the forest mapping.

DLR's German Remote Sensing Data Center (DFD) acquired the ERS and JERS data with its mobile receiving station in Ulan Baataar, Mongolia. The data were processed to intensity and coherence products. Where coherence allows the interferometric generation of digital elevation models the image products were orthorectified and a local incidence angle correction of the backscattered signals could be performed. Additionally to the ERS Tandem data acquired in autumn 1997 an ERS-2 acquisition of a second campaign in spring 1998 are incorporated. The products and improvements of the processing chain will be presented. One important aspect regarding an operational readiness of Tandem SAR Interferometry is the success rate of producing digital elevation models. Within SIBERIA it is planned to process 120 sets of ERS tandem pairs together with the corresponding spring acquisition, giving a total number of 360 ERS full scenes. So far, 114 sets have been completed, 50 ERS tandem pairs allowed a DEM production while 64 sets were corrected using the coarse GLOBE elevation model (1km resolution). The reasons are the dense forest coverage and the rather hilly terrain in the southern part of the study area.

GLOBAL FOREST CLASSIFICATION USING JERS AND TANDEM ERS DATA

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ABSTRACT

Remote sensing using SAR is promoted for its qualities in signal stability and global repeatability yet only a few forest studies (e.g. TREES, GBFM/GRFM, SIBERIA) consider a wider context than the single satellite frame. The EU SIBERIA project (http://pipeline.swan.ac.uk/siberia) is unique in developing a forest classification methodology based on multiple satellite sensors which is applicable across over 100 ERS frames of 10,000 square km each. The SIBERIA methodology uses ERS tandem coherence and JERS backscatter intensity to discriminate water and non-forested land and stratify the forest according to three growing-stock-volume classes. It has been tested using Russian ground data across the entire Siberian boreal forest sector and shown to provide an impressive level of accuracy despite the geographic extent of the region. This paper tests whether the generic classification methods developed in SIBERIA are applicable to other forest types around the globe. ERS tandem coherence and JERS backscatter intensity data were compiled for temperate, tropical and boreal test sites in the UK, Brazil and Sweden along with ground data comparable to that used within the SIBERIA project. The SIBERIA pre-processing and classification methodology was applied to these data and tested for classification accuracy. Preliminary results show that SAR sensors indeed have the capability of providing a globally applicable forest classification strategy.

JERS-1 INSAR COHERENCE OVER SIBERIAN BOREAL FOREST

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ABSTRACT

The coherence is a measure of the phase noise of the interferogram. It depends on sensor parameters (wavelength, system noise, image resolution), parameters related to the imaging geometry (interferometric baseline, temporal baseline, local incidence angle) and target parameters. Volume scattering and temporal change (i.e. random motion of the scatterers, change of the scatterers) decrease the coherence. While the coherence obtained from ERS INSAR especially with data from the tandem mission is widely used for landuse mapping and forest applications the potential of JERS INSAR coherence is not explored yet. On one hand the longer wavelength of JERS-1 yield a higher temporal coherence due to the fact that larger structures in the natural environment are more stable than small structures. On the other hand, the long temporal baseline of the 44 day repeat cycles of JERS-1 leads to lower coherence val-ues since the ground is more prone to change and the spatial baseline varies so that intercomparison of coherence values originating of different images is difficult. In this work we discuss the potential of interferometric JERS-1 coherence over southern Siberia. The data is available thanks to the mobile German receiving station set up in Ulan Bator in 1997 and 1998.

FORESTRY

ERS AND JERS-1 SAR DATA APPLICATION FOR RUSSIAN BOREAL FORESTS MAPPING AND MONITORING

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ABSTRACT

Boreal forests have global economic and ecological importance as being the source of valuable natural resources and performing the regulating function in carbon, water and energy exchange between land-based ecosystems and atmosphere. Spatial distribution and characteristics of Russian boreal forests are poorly studied. This is due to the vast area of the territory and its inaccessibility, which renders the use of remote sensing data mandatory for mapping and monitoring.

This study is aimed at assessing ERS and JERS-1 SAR data application for Russian forests mapping and monitoring. The choice of the SAR sensor is substantiated by its well-known advantages, such as independence of cloud cover and sensitivity to humidity, volume of forest phytomass and structure of forest stands. The studies are carried out for test area in the St. Petersburg region.

The study comprises preprocessing of SAR imagery, thematic processing of satellite images obtained within different vegetation seasons, assessment of correlations between SAR and in-situ data and land types and forest types discrimination and combined use and comparison of ERS and JERS-1 SAR data. The analysis is based on methods of supervised and unsupervised classification, as well as developed algorithm of automatic classification with several texture parameters included.

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BOREAL FOREST MONITORING WITH ERS COHERENCE

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ABSTRACT

It is well known that C-band coherence is more accurate than micorwave backscatter to predict boreal forest stem volume. Recent research has shown that the Interferometric Water Cloud Model (IWCM) is able to accurately describe the behaviour of total forest coherence as a function of stem volume in all meteorological conditions studied. Results regarding stem volume retrieval using an IWC model have been presented in an earlier study including a multi-temporal retrieval by combining seven interferometric pairs. This work address the problem of boreal forest monitoring using ERS-1/-2 SAR data. The data available consisted of nine ERS-1/-2 tandem pairs acquired during the tandem mission between June 1995 and April 1996 over an area northwest of the city of Uppsala, Sweden. The estimates of the low forest coherence values have been improved by careful processing and bias reduction. For a set of 21 forest stands, an IWC model has been fitted to the coherence measurements and a water cloud model to the corresponding backscatter measurements. For an independent set of forest stands (21 stands), stem volume retrieval (both coherence based and backscatter based) is accomplished. A multi-temporal combination of retrieved stem volumes is finally performed. Comparison between retrieval accuracies from a single image and from multi-temporal combination is carried out. In the latter case the accuracy is in the order of the in situ data. The accuracy is in principle determined by the four best coherence images and the backscatter does not have any practical effect. Finally, results are presented for a larger surrounding area of the test site.

AN ANALYSIS OF INSAR COHERENCE OF BOREAL FORESTS BASED ON ELECTROMAGNETIC SCATTERING MODELING

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ABSTRACT

Observations of interferometric SAR (InSAR) coherence for forests have shown the promising possibility to retrieve forest parameters, e.g., stem volume, from InSAR coherence images. However, coherence for forests is dependent on many factors including forest parameters, weather conditions, etc, leading to a high variability in the accuracy of forest parameter retrieval. To understand the relationship of coherence between forest parameters, it is important to develop models to understand mechanisms inducing decorrelation of signals scattered back from forests.

In this paper a semi-empirical model, named interferometric water cloud model (IWCM), and an electromagnetic scattering model, MIMICS, were used to simulate coherence of boreal forest at C-band. The coherence is related to the backscattering coefficients of the vegetation and the underlying ground surface, and transmissivity of forests via IWCM model where interactions between vegetation and ground are ignored at C-band. Using MIMICS backscatter contributions of vegetation and ground, and the transmissivity of forests can be related to forest and ground properties, hence by combining these models, coherence can be related to forest and ground parameters. Allometric relationships, developed specially for the Swedish forest, were used to provide the structure parameters input to MIMICS.

The coherence results predicted by the model are compared with the experimental data of ERS SAR at a test site, Kättböle, in Sweden, where the dominant tree species are Scots pine and Norway spruce. The dependence of the stem volume-coherence relationship on the moisture of trees and ground, the roughness of ground surfaces, and tree species are discussed. The effects of weather conditions on coherence, for example, dry or frozen conditions for vegetation, snow cover of the ground, are also addressed through numerical simulations.

MAPPING SIBERIAN LANDSCAPES: NATURAL AND ANTHROPOGENIC FACTORS AFFECTING CARBON BALANCE

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ABSTRACT

Siberia is a vast area that contains over 5064133760 of the world's coniferous forest. The Siberian forests are undergoing changes due to several natural and anthropogenic factors including insects, fires, logging, pollution and mineral exploration. This paper discusses on going and planned research to develop and use methods to map forest type and monitor forest disturbances within the Siberian boreal forest from satellite data. The area under study includes the proposed IGBP Western Siberian Transect and is subject to natural and anthropogenic changes which may affect carbon balance. Currently, the project is using AVHRR optical data (1 km resolution) and Radarsat radar data (0.1 km) to map the 600 X 3000 km area. The use of the two technologies is designed to improve results of previous classification maps (AVHRR only). This map is be tested over areas where detailed ground truth information is available. Areas of known (from existing studies at the Sukachev Institute) and potential change (identified from the satellite map) will be examine din detail using higher resolution satellite sensors (e.g., Landsat TM, JERS, ERS, and RADARSAT). Characteristic features related to these forest disturbances are developed using appropriate mapping and monitoring methods. The methods will be tuned to take advantage of new data sources including NASA's Terra and ESA's Envisat as they become available.

CHARACTERIZING TRANSPIRATION AND BIOMASS IN A SIBERIAN LANDSCAPE BY COMBINING JERS / ERS-1/2 INSAR IMAGE CLASSIFICATION, INSAR DEM ANALYSIS AND FIELD MEASUREMENTS

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ABSTRACT

Growth and physiologic activity of Central Siberian pine forests is limited by seasonal water availability. This results in low rates of transpiration and carbon storage. In contrast, other major vegetation types like bogs and mixed forests on alluvial soils are both well water supplied but their carbon storage patterns are quite different from pine stands. Due to the large areal extend, changes affecting Central Siberian boreal biomes may play an important role in the global water and carbon cycle. For evaluating the potential effects of changes the current water use and carbon pool parameters together with the areal extend of these large boreal biomes need to be reliably assessed. Spatial variability of land cover in Central Siberia strongly depends on topographic and edaphic factors which determine potential vegetation cover. Disturbance and subsequent succession processes occur as a result of forest fires. These events are hard to predict. Available satellite SAR remote sensing data provide current information about structural vegetation properties and their spatial variation. SAR allows separation of bogs, closed forests and disturbed areas with low vegetation. However, ecophysiological and hydrological functions such as transpiration rates or biomass distribution can not be directly obtained by remote sensing. We explore the capability of a DEM analysis for the creation of an terrain dependent potential vegetation map. Combined with an InSAR image classification and ecophysiological field data the potential vegetation map might be used for upscaling transpiration and biomass in a Central Siberian landscape. The InSAR Image classification is based on terrain corrected backscatter-intensity images of ERS-1/2 and JERS, 3-day Coherence images of ERS-1/2 and additional texture analysis. The result is a functional-ecological vegetation classification, driven by eco-physiological factors relevant for transpiration and biomass assessment in a Siberian landscape. We investigated the contribution of Scots pine forests (Pinus sylvestris) to regional transpiration and biomass in a typical Central Siberian landscape near the Yenisey river. Xylem flux rates, structure and biomass was directly measured and transpiration estimated for a chronosequence of pristine pine stands. This work is funded by the German Aerospace Center (DLR).

CALCULATION OF MICROWAVE BACKSCATTER FROM A SCOTS PINE FOREST

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ABSTRACT

A coherent scattering model for vegetation, developed at DERA, Malvern, has been combined with tree architectural models and used to predict microwave backscatter from forests. Tree architectural models, developed fromthe observation of biological growth processes, have been provided by the Faculty of Forestry, University of Joensuu, and also by the Finnish Forestry Research Institute, Helsinki, Finland. Forest structure has been modelled using ground truth obtained from optical mosaics produced by VTT Automation of a test site at Tuusula, Finland. Sample trees obtained from the architecture models are placed in the positions of observed trunks in the optical mosaic. Terrain topography has been incorporated into the forest model using a DEM with 25m resolution. Forest parameters, such as timber, foliage and soil moisture contents have been estimated on the basis of a long term measurement data set provided by the University of Helsinki and existing pointwise soil moisture measurements. Novel techniques adopted in the calculations permit the simulation of synthetic aperture radar (SAR) image formation, and predict image structure as well as mean backscatter levels. Scattering interactions associated with different elements of the simulated forest scene are focussed at appropriate positions in the simulated SAR image, and full account is taken of phase. A first-order, mean-field model is adopted in backscatter calculations, with emphasis placed upon local environment when estimating attenuation effects on local field strength. Calculations for specific forest stands, at frequencies ranging from C-band to VHF, are compared with actual SAR observations of the same areas using ERS, JERS, and CARABAS data. The model provides a uniquely flexible tool for investigating the response of SAR to forest management practices.

ERS SAR DATA INTEGRATION IN THE UPDATING OF VEGETATION MAPS

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ABSTRACT

This paper shows the applicability of ERS SAR imagery to update vegetation maps. We deal with the verification of the Forest Map of Spain (FMS) in a 28x18.5 sq. km test site from a hilly region in Central Spain. We used 20 ERS SAR products along with 3 Landsat TM images, a DEM and the FMS coverage, to produce a vector layer of incongruent spots. We first reduced the feature space using an index based on the degree of separability of FMS polygons in each image. Then we applied a region growing algorithm that merges the most similar adjacent regions, allows only one merger per region in each iteration, and stops when the above index begins to decrease. The resulting partition is a compound of patches or segments internally homogeneous that are smaller than FMS polygons. In order to assess the congruency between this partition and FMS, we applied an agglomerative hierarchical clustering on the segments within each FMS polygon, so that segments inside that polygon that lay out of the polygon's branch in the dendrogram are exported to a vector layer of incongruent spots. Finally we assessed the contribution of the synergic use of SAR data by applying the same methodology to respectively only the optic and only the SAR variables. We compared the resulting vector layers and derive some conclusions based on a field inspection of selected incongruent spots.

COMBINED USE OF SOIL AND VEGETATION DATA, A DIGITAL ELEVATION MODEL AND SAR CLASSIFICATION FOR C AND N POOL ASSESSMENT IN A CENTRAL ALASKAN LANDSCAPE

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ABSTRACT

Changes in boreal carbon and nitrogen pools are suspected are believed to play a major role for future global climate development. Predicted warming in the northern latitudes may cause an increased heterotrophic respiration of organic matter stored in boreal forest ecosystems while concurrent mobilization of soil nitrogen could foster plant growth and temporarily compensate carbon losses from soils. Thus a current assessment of boreal C and N pools is desirable for modeling purposes. Spatial variability of vegetation and its correlation with existing C and N pools in boreal landscapes depends mainly on site climate, edaphic conditions and disturbance factors such as fire and flooding. We investigate the potential of synergistic use of radar remote sensing and field data for C and N pool assessment in a typical central Alaskan landscape. We choose the Caribou Poker Creek experimental watershed near Fairbanks for a detailed soil and vegetation structure analysis. A total number of 88 plots with all major soil and forest types were studied. The field measurements, available topographic information, and the forest structure classification from SAR imagery are combined to predict the spatial distribution of actual vegetation cover and its ecologically relevant attributes. Spaceborn L-band multi-temporal SAR imagery from the JERS-1 Global Boreal Forest Mapping (GBFM) project was assembled that allows the mapping of general vegetation features. These data include 100 meter resolution backscatter imagery as well as SAR texture products. We plan to use in addition ERS coherence imagery to enhance the JERS classification.

Occurrence of permafrost on the studied plots was almost entirely limited to a single forest type, namely coniferous P. mariana stands. However, crown cover density as a potential SAR detectable structural canopy property was not a clear indicator of dominant forest type and thus of the occurrence of permafrost and associated soil properties. Correlations were found between slope and aspect and dominating forest type but disturbance effects offset a good predictability. These results prohibit exclusive use of either a field data derived potential vegetation classification or

SAR imagery as a sole source. Thus, a combination of DEM, SAR imagery, acquired field data and known ecological relations between abiotic factors and the development of organic soil layers and vegetation units is used to produce an ecotype map for predicting and upscaling carbon and nitrogen pools in a Central Alaskan landscape.

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AN OPERATIONAL FOREST MAPPING TOOL USING SPACEBORNE SAR DATA

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ABSTRACT

SAR data has been shown to offer useful information for forestry applications, and especially in cases of major forest change such as that caused by severe storms or fires. In these situations, the possibility of exploiting radar remotely sensed data, which is not affected by phenomena such as water vapour, smoke or clouds, provides great advantages with respect to optical sensors. Under these circumstances, the availability of operational tools dedicated to forest monitoring is of great interest. This paper presents the main achievements of a project that was carried out in the framework of ESA's Data User Programme (DUP), and which was dedicated to the development of an operational software tool for mapping of forests and forest damage using SAR data as the primary input. The modular SAR processing chain, is embedded in the Arc/View GIS environment. In this way, within the processing chain SAR data can be merged with other remote sensing and/or auxiliary data, in vector or raster format (e.g. ATSR hot spot products for fire detection). Such modularity allows the system to be used in a very flexible way and the processing flow can be decided by the user in order to combine various data products for extracting different information. The performance of this system, and the resulting thematic products are shown for a number of sites, where different events have been mapped and monitored. One example of hurricane damage mapping is shown over the swiss / french Jura region. Various examples of burn scar mapping and their evolution in time are shown for sites in Canada, Madagascar and southern Italy.

GLOBAL BURNED AREA MAPPING USING THE ERS - ATSR2

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ABSTRACT

Biomass burning is an environmental process of great importance, due to its atmospheric, climatic and ecological impacts, at scales ranging from local to global. Public awareness of its importance has been growing during the last 20 years, in particular as a consequence of extreme events in Brazil, Indonesia, Australia, Russia, etc. The severe El Niño Southern Oscillation events of 1982-83 and 1997-98 are associated with the occurrence of some of these extreme situations. There is a great need for reducing uncertainties in the estimates of area burned at the global scale, in order to improve the accuracy of biomass burning estimates. To date, most continental and global analyses of fire using satellite remote sensing have relied on the detection of active fires, which is strongly affected by spatial and temporal sampling problems. We present the development of a set of algorithms for global burned area mapping, using ERS ATSR-2, developed under a cooperative project between the Instituto Superior de Agronomia (Lisbon, Portugal), the ESA/ESRIN Earth Observation Applications Department (Frascati, Italy) and the Space Applications Institute, Joint Research Centre (Ispra, Italy). At the current stage of development, algorithms focus on tropical regions, and study areas have been analysed in Africa, South America, and Australia. The spectral characteristics of the ATSR-2 were found to be very favourable for the detection of burned surfaces, due to its spectral characteristics, high radiometric sensitivity, and generally good geometric accuracy. Algorithms developed rely on multiple thresholding, bispectral space analysis and Bayesian statistics, and teme-series analysis for change detection. High spatial resolution imagery from Landsat TM was used at the three study sites to develop reference burned area maps used for accuracy assessment. Results obtained indicate that the algorithms deal adequately with the range of ecological conditions found at the three sites, and further development and testing is planned to extend the algorithms for burned area mapping in temperate and boreal ecosystems.

RICE

TOWARDS OPERATIONAL USE OF ERS SAR DATA FOR RICE MONITORING

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ABSTRACT

Rice is the second most important cereal produced in the world. In the context of population growth and demand for food, especially in Asia, there is a need for consistent rice monitoring and yield prediction methods. In the past years, the possibility to monitor rice crop using ERS data has been assessed at several places in the world. Acreage has been determined through rice field mapping using multitemporal ERS data, and in a recent study, rice yield has been estimated by coupling the information derived from SAR data with a rice growth model. To initiate the operational use of the method, an effort remained to be done in terms of validation and development of operational software tools. This paper summarises the overall background of the use of ERS data for rice monitoring, and presents the works of validation and development of operational software carried out in 1999, in the frame of the RISAR project (Rice Mapping and Yield Prediction with SAR). The rice monitoring processing chain was developed under MULTISCOPE platform, providing an integrated tool dedicated to rice monitoring using multitemporal ERS data. The test and validation were performed over a test site in the South of France (Camargue).

ANALYSIS OF MULTI-TEMPORAL AND MULTI-INCIDENCE ANGLE DATA FOR RICE CROP USING C BAND RADARSAT AND ERS SAR DATA

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ABSTRACT

Investigations were carried out using multi-temporal and multi-incidence angle data from RADARSAT Standard Beams (S1, S5, S6 and S7), ScanSAR Narrow B and ERS for rice crop. The work has been carried out under ADRO programme.

The study area lies in the Bardhaman district of West Bengal state in eastern India. Rice crop grown during monsoon season under both irrigated and rain fed conditions is addressed in this study. Three-date data each from RADARSAT Standard beam mode S1, S5, S6 and S7, two-date ScanSAR Narrow B and ERS data were acquired during July to August 1997.

The digital numbers were converted to backscattering coefficients σ using the calibration coefficients. Geo-referencing of the data was carried out for the S7 beam of July 10. All other data were co-registered with this date using an image-to-image registration process. Accuracy assessment was made based on training site and blind site pixels using J-M distance and Kappa coefficient.

The backscatter of fields showed a decline of 5 to 7 dB with the onset of puddling of fields. The backscatter increased steadily with crop growth. The backscattering coefficient was analysed as a function of plant age, height and tiller numbers. Backscatter increased with plant age upto 70-80 days for all the incidence angles. High correlation (R^2>0.8) was observed between backscatter and plant age for all the beams. Very high correlation (R^2 >0.9) was observed between crop height and backscatter.

The unique temporal signature of rice enabled classification accuracy of more than 90 per cent for rice using three-date data in all the beams as observed from training site and blind site pixels. Shallow angle data S7 gave 4 to 5 per cent higher accuracy than steep angle S1 data due to higher separability of water in shallow angle data. S1 data resulted more variability than S7 data from the same fields, resulting more sub-classes for same training site. Shallow incidence angle S7 data were found to enhance the separability of water and puddled rice fields compared to steep angle S1 data. Identification of linear features like road, canal etc. was also higher in S7 data.

RICE MAPPING USING ERS SAR DATA IN GUANGDONG PROVINCE, CHINA

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ABSTRACT

This study has been carried out within the framework of the ESA-MOST China Cooperation Project to investigate the potential of ERS SAR data for rice mapping and monitoring in Guangdong Province. This part of southern China has two rice growing periods, and includes both irrigated and rain fed rice. Irrigated rice production is confined to low lying plains and valley bottoms, whilst rain fed production occurs on terraced fields in hilly areas.

Using ERS SAR image, rice crops show distinctive changes in backscatter over time. Low backscatter is associated with the flooding of fields before the rice has been planted. During crop growth and development, backscatter increases and reaches a maximum at the heading stage. Backscatter then decreases slightly during the grain filling stage.

The use of two images taken at the beginning and end of each growing season has produced good classification results. Experimentation with different techniques has shown that filtering, pixel spacing, classification limits and post classification filtering can all affect the area mapped. Fine tuning of classifications has been carried out using detailed field maps of sample areas.

Remote sensing derived rice areas have been compared with agricultural statistics at the county and district levels. Whilst some of these area results are very similar, in other cases there are discrepancies of as much as 40.These discrepancies are unable to be explained fully by image classification errors, and seem to indicate inaccuracies in some of the agricultural statistics. The results of detailed analysis to quantify the errors in the agricultural statistics will be presented, because if major deficiencies can be proven this will provide a strong justification for the operational use of satellite radar data.

AN OPERATIONAL RICE FIELD MAPPING TOOL USING SPACEBORNE SAR DATA

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ABSTRACT

Rice is of significant importance for many tropical countries, both as staple food and as an agricultural product for international trading. Crucial parameters for yield forecasting are the areal extent of the rice fields and the rice growth status. Spaceborne microwave remote sensing is a technology that permits mapping and monitoring of the rice growth over large areas at regular intervals. This paper presents the main achievements of a project that was carried out in the framework of ESA's Data User Programme (DUP), and which was dedicated to rice field mapping in tropical areas. The major result of the project is a tailor-made software for rice mapping and rice growth monitoring. It utilises ERS and Radarsat SAR/InSAR data (and in the near future, ENVISAT ASAR data) as input. The modular SAR processing chain, is embedded in the Arc/View GIS environment. This facilitates merging of both the final product and intermediate results with other remote sensing and/or auxiliary data (vector or raster data). This allows novice users, even if they are not at all familiar with SAR technology, to generate thematic products such as rice maps and to monitor the rice growth in a fully automatic way. Expert users may interactively change the processing chain as they wish. The performance of this system, and the resulting thematic products are shown for two different sites: Polonnaruwa (situated in north eastern Sri Lanka, one of the major rice baskets of the country), where multitemporal ERS SAR/InSAR acquisitions combined with Radarsat data were used. The Mekong River Delta (Vietnam) served as a second demonstration site, where a multitemporal ERS-2 data set was processed and classified.

RICE YIELD ESTIMATION USING SAR IMAGES, METEOROLOGICAL DATA AND GIS

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ABSTRACT

The objective is to develop a method for estimating potential rice yield during a rice growing period.

SAR images will be used to estimate the acreage of rice fields and on the other hand meteorological data will be used in yield estimation. GIS will be used to combine the rice field acreage and the rice yield estimates to produce quantitative estimates of rice production e.q. in commune level. Additionally GIS will have an important role in the system since the detection of the rice fields, the storage of all map data and the visualisation of the results will be done using GIS.

Two growing periods summer-autumn 1999 and winter-spring 2000 will be used in development and testing of the method. Totally eight ERS-2 SAR PRI images covering the test area have been ordered, three from the summer-autumn period and five from the winter-spring period. There is also one cloudless SPOT XS image available from march of 1998 for establishing a general land use map.

The detection of rice fields from SAR images is based on the multitemporal variation of radar backscattering. The yield estimates are calculated with the crop growth model (CROPWATN) which uses meterological data from the growing period as well as soil data and crop calendars of different rice types. There is also intention to study if there is some relationship between the radar backscattering and the rice growth, which could give additional information to the yield estimation. Some results will be represented in the final paper.

METHODS 1

A NEW COLLOCATION SYSTEM FOR SATELLITE DATA

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ABSTRACT

As collocated datasets seemed to be essential to satellite-driven data applications, we have decided to build a new system, which could "easily" collocate any n-uplets since they were handled by the CERSAT databases. These data are needed for two types of applications using collocated products: calibration/validation and geophysical applications. For calibration/validation applications, the user wants to compare individual measurements made by the different sensors in order to improve the algorithms used to calculate the geophysical parameters or to study the impact of some parameters upon others. For these applications we have designed the Minimal Products. These products, specifically designed for a n-uplet of sensors, provide, for each collocated measurement, a subsetting of parameters from each sensor as well as statistics on the other nearest measurements if this information is relevant. For geophysical applications, the user is interested in studying a phenomenon, like a cyclone for instance. He wants to retrieve, on a specific zone, during the occurrence of the phenomenon, the information collected by all the sensors which have witnessed it more or less at the same time. For this type of application we have designed the Total Products which, on each collocation zone, extract the data from the different sensor databases and send it to the user. These products are available on our WWW server through a geographical and temporal subsetting interface (http://www.ifremer.fr/cersat).

CERSAT VALUE ADDED PRODUCTS

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ABSTRACT

Most oceanographers need more elaborated datasets than along track products. They want, for example, products they can directly use in ocean circulation models. They also need to have continuity in data distribution. Therefore, we decided to produce atlases both on CDROM and on our WWW server (http://www.ifremer.fr/cersat), providing user-friendly tools such as browsers, subsetting interface, reading software.

WIND Atlas - Since winds estimated at a point can vary significantly over periods of a few hours, reconstruction of synoptic fields of surface winds on basin scales from discrete observations is difficult, without using an appropriate method. We therefore developed a statistical technique for the objective analysis of remote sensor wind data. We produce global weekly and monthly mean wind fiels over a1°x1° grid. The first ERS-1 mean wind field CDROM was issued in June 1995. In April 2000, CERSAT produced a third version of this CDROM containing 9 years of weekly and monthly ERS-1, ERS-2 and NSCAT mean winds. These wind fields have already been distributed to nearly 1800 users worldwide.

SEA-ICE Atlas - Over polar oceans, values of the ERS-2 AMI-WIND/ADEOS NSCAT measurements depend on the dielectric properties of the observed materials, sea water, first-year ice and multi-year ice, on their relative concentrations and on the surface topography. Algorithms, specific to ERS C-band scatterometers, were applied to produce in 1996 a sea-ice atlas on CDROM derived from ERS-1 WNF data. This atlas was extended to ERS-2 and NSCAT at the beginning of 1998. It provides maps of the sea-ice coverage as well as a characterization of the sea-ice at 50km resolution, each week for ERS and every 3 days for NSCAT. Distributed on the same grid as SSM/I sea-ice products from the NSIDC to nearly 200 users, these 7 years of data are a good input for studies on sea-ice climatology.

These two atlases will be extended to QuikSCAT and to new sensors that will be launched in the future (Seawinds on Adeos2, Ascat on Metop). We plan to merge different sensors together in order to increase the spatial and temporal resolution these atlases.

VALUE ADDED GEOCODED SAR PRODUCTS FROM THE GERMAN ENVISAT PAC

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ABSTRACT

Since the launch of ERS-1 in 1991 the German Remote Sensing Data Center (DFD) of the German Aerospace Center (DLR) is part of the ESA ground segment network for SAR processing as D-PAF. The DFD will also host the D-PAC for ENVISAT on behalf of ESA and will be one of the nominated ASAR processing and archiving centers. In addition to its role of ESA the DFD will provide a wide range of products generated under national responsibility to serve the user community with higher level value added products. Besides generating the ESA standard products the German PAC is developing and implementing with national funding a system (Envisat GEOcoding system-EGEO) to provide the worldwide community with value added geocoded products. Their availability is not longer restricted to Germany. EGEO is designed to produce two major product types: * Enhanced Ellipsoid Geocoded (EEG); * Geocoded Terrain Corrected (GTC). Both pursue the well-known product line from ERS-1 and ERS-2. The EEG has the following characteristics: * Integration of the GLOBE digital elevation model in the geometric correction, * support of national cartographic systems, * support of the different modes of the ASAR sensors, * geometric accuracy of about 50 m. The GTC is the follow up of the ESA product type GTC01, which is no longer supported by ESA. The GTC has following new features: * worldwide availability using InSAR digital elevation model from the ERS tandem mission, SRTM and ENVISAT InSAR, * integration of national mapping systems, * support of different modes of ASAR, * radiometric correction. These products are necessary for multiple applications, e. g. mapping, land use and disaster monitoring. The system will be ready at launch and after six months of commissioning phase products will be available on a routine basis via the user services of the DFD.

DEVELOPMENTS IN AATSR AND ATSR PRODUCT ALGORITHMS AND DATA PRODUCTS

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ABSTRACT

The Advanced Along-Track Scanning Radiometer (AATSR) is the successor to ATSR-2 and will fly aboard ENVISAT-1 to provide continuing accurate and precise global measurements of sea surface temperature.

This paper presents an overview of the AATSR system, with particular reference to the AATSR ground processor architecture, processing algorithms and data products. The AATSR processor makes full use of the ATSR series heritage, but the data products have been redeveloped. The new products are introduced and recent developments in the processing algorithms are outlined.

METHODS 2

SCANSAR DATA PROCESSING AND RADIOMETRIC CALIBRATION

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ABSTRACT

The RADARSAT mission has demonstrated the practical utility of a SCANSAR imaging mode for the acquisition of SAR data across a wide swath. In order for ENVISAT SCANSAR image data to be readily accessible for applications research it is important that the image data is accurately georeferenced and radiometrically calibrated. In this paper we describe some of the design features of a new SCANSAR data processing architecture developed in the UK, and the practical performance achieved, in terms of focus, radiometry and georeference over a series of RADARSAT SCANSAR images of corner reflector sites in the UK.

INSAR ACTIVITIES IN CENTRAL ASIA

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ABSTRACT

Land instabilities including mass movements e.g. landslides etc. are among the most several hazards of Central Asia. Nuclear waste deposits and huge dams provide that the vulnerability of the area is still increasing. Events such as intermediate size or even small earthquakes may trigger landslides that itself may trigger cycles of reactions resulting in major disasters that severely affect live and property. In addition to field and airborne investigations, the GFZ aims at contributing to the knowledge of the distribution and sizes of local mass movements and related mechanisms (GIS system) in Central Asia, namely Kirgistan und Usbekistan. SAR data will help assessing sizes and distribution of areas prone by land instability and D-INSAR might act as a tool to monitor related motion. Expected strain rates are significantly higher than those related to the loading cycle. From March 7th 1999 till July 2nd 1999 an INSAR campaign of GFZ/DLR with a mobile receiving station was established at Kitab in Usbekistan. Besides receiving and archiving the ERS-1/2 radar data, the task of the campaign is to test a simultaneous SAR- and INSAR-Processing of the ERS-1/2 data in field. The aim of the processing in field is to demonstrate an enable near-real-time SAR-Interferometry. The mobile ground station contains three subsystems: receiving system, SAR processing system and INSAR processing system. Everyday more than 10 scenes of the received SAR raw data were processed to single look complex image data, then the corresponding interferograms from tandem pair as well as differential interferograms can be produced. In this paper some preliminary results of the campaign in the selected test area Fergana-Valley are presented. The results show that using a mobile SAR receiving station and an additional SAR/INSAR data processor system, besides produce of accurate DHM, the land instabilities or surface changes of the covered areas can be also near-real-time monitored. The impact of the predicted orbits on the accuracy of DHM and determination of surface deformation is discussed and finally, the paper gives some strategy of the phase unwrapping process for the mountainous region.

SPECKLE FILTERING AND CLASSIFICATION OF ERS SAR IMAGES USING GAMMA DISTRIBUTION

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ABSTRACT

Classification plays a key role in many image-processing applications, including Synthetic Aperture Radar image analysis. However, the presence of a strong, multiplicative noise known as speckle makes classification of SAR images very difficult. In this communication, some techniques of speckle filtering and classification using the Gamma distribution are developed and evaluated. Effectively, the most well known adaptive filters of speckle in SAR images do not use an explicit probability density function (pdf) for the detected I and the underlying scene R intensities. Scene properties incorporated in the filtering process are also limited to the local mean and variance. The Maximum A Posteriori (MAP) approach considered by Kuan et al. for speckle filtering uses an appropriate speckle model and a Gaussian scene modelisation. More realistic texture models are introduced by Lopes et al. By replacing the Gaussian probability density function by a Gamma and a symmetrical Beta pdfs. In this communication, and at the light of recent works concerning coherent image statistics, the kuan et al. filter is analysed and improved by implementing more realistic a priori statistical models for the scene. The implemented filters are applied in different regions of Algeria such Algiers town and Laghouat zone situated in a semi arid region and the obtained results are established and confronted with aerial photographs and maps. In other hand, classification of SAR images has important applications in many fields such as geology, agriculture, urban areas, etc. A statistical model based on the Gamma distribution is reviewed and a maximum likelihood classification algorithm is developed for the classification. Automatic extraction algorithm is developed to estimate target mean levels, and a test to partially compensate for imperfect extraction is introduced. The algorithm is tested using ERS-1 SAR imagery over the town of Algiers in Algeria.

ISOLATION OF ATMOSPHERIC ARTIFACTS IN DIFFERENTIAL INTERFEROMETRY FOR GROUND DISPLACEMENT DETECTION: DIFFERENT METHODS COMPARISON

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ABSTRACT

Several techniques exist in order to detect ground motion using radar phase information when a series of radar acquisitions are available. However, the limiting factors are interferometric coherency loss and atmospheric heterogeneities that can corrupt the radar interferograms.

Aiming at removing atmospheric artifacts, the simplest solution consists in generating phase differences (interferograms) and summing several of them over the same site in order to average the atmospheric effects out. A more recent and performing technique consists in analyzing the phase history of a large number of isolate, coherent pixels (permanent scatterers) when a very large archive is available.

When only a few acquisitions are available (at least four), an original technique proposed by CNES is based on the complex correlation of the generated differential interferograms without common dates. This allows, under given conditions, to separate displacement fringes from atmospheric artifacts. This technique has been assessed on several sites. Two applications (subsidence in Paris, geological motion in Portugal) will be shown. The limitations of the technique will be discussed, as well as the comparison with other existing techniques.

More recently, CNES has been investigating the use of the radar image 'internal coherence' with regards to several applications. For this, we primarily extract two sub-looks from one single-look image (e.g. one corresponding to the upper part of the azimuth doppler spectrum and the other one to its lower part). Subsequently the interferogram of the two sub-images is derived. The resulting interferogram coherence is expected to be zero over developed speckled areas (the azimuth spectrums of the two sub-images do not overlap). In the presence of point targets however, published results indicate that the coherence locally differs from zero. This technique has been successfully used for target detection, and will be assessed in the frame of atmospheric artifacts filtering. If promising results are obtained and in the frame of the ENVISAT preparation, the multi-polarisation extension of this technique would be equally considered.

AN EFFICIENT LOW-MEMORY IMPLEMENTATION OF 2-D PHASE UNWRAPPING BASED ON MINIMUM COST FLOW ALGORITHM.

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ABSTRACT

For many applications two-dimensional (2-D) phase unwrapping, that is, compute unambiguous phase values from a 2-D array of 2 pi modulo known values, is an essential processing step in interpreting, for interferometric purposes, data acquired with synthetic aperture radar. Many algorithms have been developed to solve the phase unwrapping problem, but algorithms for fast and reliable phase unwrapping are still under investigation. Recently a promising approach based on the network theory has been proposed by Costantini (1998). This method minimises the weighted deviations between the estimated and the unknown neighbouring pixel differences of the unwrapped phase by using minimum cost flow (MCF) networks.

In general these MCF networks have been well studied, hence efficient algorithms exist (i.e. RELAX-4 available by ftp). However general purpose minimum cost flow code is not computationally practical for large data sets since it requires huge amount of memory. Moreover an algorithm implementation for commercial InSAR packages running on low-cost systems (such as personal computers with low memory capacities) is required.

We developed a new MCF implementation more adapted to the specific constraints of the phase unwrapping problem, optimised with respect to the memory and speed for 2-D phase unwrapping. Our algorithm is a modification of the 'successive shortest path' algorithm. It has been suggested that solutions, which minimise the number of places, where unwrapped and wrapped phase gradients differ, the so-called minimum L0-norm problem, are more correct. Therefore among a set of equivalent MCF solutions we tried to find one with a reduced L0-norm. This is done by selecting among the weighted shortest paths the one with the minimum number of steps and cancelling all the cycles with zero cost. By using interferometric data we demonstrate the improvement of this new method. Now we are able to unwrap an image of 2700X2700 pixels with only 166 MB, which is just 1/10 of the RELAX-4 implementation and better than the result obtained by Eineder et al. [Proc. Of IGARSS'98].

MULTITEMPORAL INSAR COHERENCE FROM URBAN TYPE OBJECTS

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ABSTRACT

The stable platform of ERS-2 makes it possible to do repeat pass interferometric SAR (InSAR) processing. Long multitemporal baselines of several months or years may reduce the InSAR coherence substantially. This is due to changing surface cover conditions between the two SAR data acquisitions. This effect is particularly present in vegetated areas. However, buildings and other man-made objects in urban areas may be able to preserve the coherence over a long time period.

This paper is making use of many ERS-2 SAR scenes that have been acquired over the capital of Norway (Oslo) during the last years. The same satellite repeat track has been used in the acquisitions. It is then possible to combine multitemporal InSAR pairs of n*35 days, where n is the number of ERS-2 satellite cycles. The SAR raw data are processed to single look complex images using a special phase preserving algorithm developed at Norwegian Defence Research Establishment.

The single look complex images are co-registered to each other using an appropriate interpolation and resampling algorithm to preserve the InSAR phase properties. The SAR coherence from hard objects are investigated with respect to weather conditions (precipitation), SAR intensity values, and SAR intensity changes between the two acquisitions. The interferometric phase from the high coherence objects are analysed in more detail, and the phase stability is studied with respect to man-made object size and material type.

The results show that SAR coherence may be preserved from certain man-made features even when using long temporal baselines in the InSAR processing. It is thus possible to establish a set of stable InSAR objects even in highly vegetated areas with the possibility of large seasonal surface changes (e.g. Norway). This technique is therefore promising with respect to establishing a global satellite SAR reference point database that may be used for subsidence and earthquake monitoring.

COASTAL ZONES 1

COASTAL CURRENT OBSERVATION USING IMAGING SAR

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ABSTRACT

Oceanic fronts and eddies with current shear, convergence and divergence zones influence wind-wave-current interactions leading to small scale surface roughness anomalies that in turn can provide distinct expressions in SAR images. Several well known examples of this type of image expression including near coincident SAR/AVHRR/ATSR images have been published in recent years. In spite of the existence of these fascinating images the quantitative relation between the gradients in SAR image intensity and the physical properties of the surface current is, on the other hand, not fully understood. It is also a question whether any such relation can be considered unique.

At the onset of this new millennium two wide swath SAR system will soon be in operation. It is therefore expected that improvement in SAR image modeling of current features combined with increased temporal and spatial coverage may lead to opportunities for systematic use of SAR data for monitoring and retrieval of coastal ocean fronts and eddies. In turn, this may moreover open up for regular use of SAR image data for validation of high resolution (~1 km) numerical coastal ocean models. Such validation is highly needed in the context of the growing activities in coastal ocean monitoring and modelling.

Based on this scientific rationale, and in preparation for the launch of Envisat in 2001, a dedicated 10 days coastal current field study took place off the West Coast of Norway in February 2000. During the cruise we obtained four high quality AVHRR data acquisitions, combined with 6 ERS SAR and Radarsat images. In addition, a high resolution ocean model was run in prediction and hindcast mode to characterize the 3D mesoscale circulation regime in the study region. The dedicated SAR investigation formed part of larger study - EuroROSE, in which also a coastal HF radar system collected surface current, wind and wave data.

Highlights from this study will be presented with emphasize on the SAR imaging capabilities of surface current features. The preliminary outcome will also be considered in the context of implementation of an optimal data collection system during the Envisat ASAR calibration and validation phase.

COASTAL MAP REACTUALIZATION BY RADAR SAR ERS IMAGES, EXAMPLES IN THE AREA OF NOUAKCHOTT CITY IN MAURITANIA AND DOUALA, CAMEROON

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ABSTRACT

Nautical charts on African coasts are old and had often been established in the fifties. Local geodetic reference systems used are not well known, so maps are not in accordance for GPS navigation. We are interested in nautical charts reactualization with RADAR SAR imagery and will present in this communication solutions we have retained for different problems: First, for geocoding in a global geodetic reference system our ERS images, we used precise orbitographic products: evaluation of this step was made by GPS measurements and comparison between images acquired in ascending and descending mode. Second, ground interpretation permit first in Mauritania to follow coastal evolution and particularly coastline erosion and flood zones, and last in Cameroon to understand high and low vegetation distribution in mangrovia and in Wouri estuary, to follow sand banks which obstruct Douala city channel.

MAPPING OF INDONESIAN COASTAL WATERS BY SYNTHETIC APERTURE RADAR: AN INDONESIAN-NETHERLANDS INITIATIVE FOR STARTING NEW BUSINESS

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ABSTRACT

The importance of accurate depth charts in shallow water coastal seas can hardly be overestimated. Navigation channels need to be monitored at regular time intervals to guarantee safety for shipping traffic. Depth maps are required for offshore activities like routing of oil pipes, dredging and beach nourishment. Long term depth monitoring is needed to assess the future behaviour of the coastline in order to defend the land against flooding. Depth information is nowadays gathered by ship borne (single or multi-beam) echo sounders. The depth is obtained from the travel time of an acoustic pulse. It is corrected for ship movements and tidal elevation. These observations are very time consuming and therefore also very expensive. Remote sensing techniques offer an alternative, giving an almost instantaneous overview over large areas at relatively low costs. Microwave techniques like Synthetic Aperture Radar (SAR) have the advantage that clouds do not hinder them. Techniques for mapping coastal areas with the help of SAR imagery were developed at ARGOSS. These techniques were implemented in a Bathymetry Assessment System (BAS). Supported by the Dutch Ministry of Transport and Public Works, several projects were carried out and have demonstrated the usefulness and cost effectiveness of BAS. In Europe the BAS has gained a lot of attention and at the moment projects are under execution to map coastal areas by using ERS SAR imagery. In south-east Asia there is an increasing need for accurate depth maps of the coastal zone. Because of increased population density and economic activities in the coastal zone, effective use and management of these areas require accurate maps. These maps are insufficiently available and also the capacity to generate the required information is not present. Remote sensing techniques can be used to generate these maps in a cost-effective way and to cover larger areas with the existing fleet of sounding ships. The Indonesia government has recognised this problem, has given priority to monitoring of the coastal zone and wants to build up a private sector to provide coastal monitoring services. To demonstrate the potential of radar remote sensing technology in Indonesia a consortium was formed in the Netherlands to co-operate intensively with the Indonesian partners BPPT, Dishidros and PT Prakora Daya Mandiri (PTPDM).In a first project in 1998 and 1999 satellite radar imagery were used to produce high quality depth maps of two representative Indonesian coastal areas: Banka Straight and Banten Bay (see figures below). Indonesian specialists and potential users evaluated both the depth maps and the mapping method, implemented in the Bathymetry Assessment System. The results of this Indonesian-Netherlands co-operation were presented to Indonesian organisations that are working in the coastal zone during a workshop in Jakarta at the end of 1999. This workshop was concluded with the recommendation to introduce this radar remote sensing technology in Indonesia for the production of high-quality maps in a quick and cost-effective way. At the workshop more information on this initiative will be presented.

THE ALASKA SAR DEMONSTRATION: RADARSAT-1 EXPERIENCE AND ENVISAT PLANS

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ABSTRACT

The U.S. National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS) ENVISAT project is focused on a pre-operational demonstration of wind and vessel position products using, predominately, the wide-swath mode of the ENVISAT ASAR. The necessary scientific algorithms, data management techniques, and product production and dissemination procedures are being prototyped using RADARSAT-1 data. A near real-time demonstration of SAR product production has been underway since October 1999 for the waters surrounding Alaska. Wind speed, wind vector (with 180 degree ambiguity) and vessel position products are generated within about 6 hours of satellite acquisition and provided to operational agencies for evaluation and validation. Users include the National Weather Service, the U.S. Coast Guard, and the Alaska Department of Fish and Game. Products are provided as images and text files on a web site and via an Internet-based interactive data browse, analysis, and fusion system. This latter system allows display of SAR, other satellite, and meteorological/oceanographic model data; overlay of derived wind vectors and vessel positions; and analysis of data in relation to topography and bathymetry. These functions take place within a fully georeferenced environment. Currently the products are being evaluated and validated. Wind validation is accomplished by comparing SAR-derived winds with model output in Alaska and with buoy measurements from the NOAA buoys in the Atlantic off the U.S. East Coast to determine the accuracy. For validation of vessel positions, fishery observer reports are being paired with SAR-derived positions to ascertain the detection success. ENVISAT data will first be taken over the U.S. East Coast buoys to test and validate the wind algorithm. The vessel detection algorithm will be tailored for ENVISAT and tested as well. Once the algorithms are operating properly, ENVISAT data will then be taken over Alaska (in near real-time if possible) and made available to users for a demonstration. If RADARSAT-1/2 or ALOS SAR imagery are available as well, a two-satellite demonstration will be attempted.

THE ERS CONTRIBUTION TO OIL SPILL MONITORING-FROM R&D TOWARDS AN OPERATIONAL SERVICE

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ABSTRACT

A project for utilisation of ERS-1 SAR data for detection of oil spill at sea was started in 1991 as part of the Norwegian Space Centre's (NSC) national ERS-1 programme, and a pre-operational service for near real-time detection of oil spill at sea is now provided by Tromsø Satellite Station (TSS). The main objective of the service is near real-time detection and early warning of possible oil spills at sea. TSS is operational 24 hours a day, and both day and night passes are analysed. The service development has undergone a lot of phases from R&D into the current operational phase. Important factors contributing to the success will be presented, i.e. such as the user contribution from the beginning of the development as well as the involvement of R&D institutions.

The main customers for this service requires information in 1-2 hours about a possible oil spill. The customers are national pollution control authorities (NPCA) and offshore oil companies. Especially the latter group has developed during the recent years, and the background for this development will be assessed. The presentation will also discuss how the pollution control customers utilises the satellite acquisition information for pre-flight planning of surveillance aircraft operations, and how the oil companies utilises the information for production process and environmental monitoring,

The pre-operational phase has documented the limitations of ERS concerning coverage and data availability, and the requirements for a fully operational service have been derived. Service costs and potential models for involving the customers will be addressed. Finally, a presentation of how this service has contributed to the development of a new service, as well as future perspectives e.g. represented by the continuity and the improvements from ERS to ENVISAT will be discussed.

AN INVESTIGATION OF COASTAL PROCESSES USING THE INTEGRATION OF ERS SAR, OCEAN COLOUR AND SST IMAGERY

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ABSTRACT

Synthetic Aperture Radar (SAR) imagery, made available through ESA announcement of opportunity (ERS-AO3), has been combined with the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) ocean colour and Advanced Very High Radiometric Resolution (AVHRR) Sea Surface Temperature (SST) imagery. SeaWiFS has been providing imagery since September 1997 and the availability of concurrent data (in this case imagery obtained on the same day) from the three systems is limited. This is the effect of the relatively long ERS revisit time (repeat cycle of 35 days for ERS-2 compared to daily imagery from SeaWiFS and AVHRR), correct wind conditions for the ERS imagery and the presence of cloud cover which obscures the ocean colour and SST imagery.

The synergy of remotely sensed parameters is influenced by large scale coastal features e.g. sediment plumes and phytoplankton blooms. Ocean colour and SST imagery can aid in the interpretation of SAR imagery, where the surface roughness is dependant on atmospheric and marine properties. Coastal imagery from the South West of the United Kingdom and Europe (Southern Portugal and Spain) were studied at times of particular interest (fieldwork campaigns and during significant events e.g. large phytoplankton blooms) using the sensors mentioned above. The imagery will be presented and conclusions drawn about the visibility and inter-comparison of coastal features, for example frontal area, using these methods.

The synergy of SAR, ocean colour and SST imagery is of importance to the future ESA Envisat mission as it will carry the three sensor technologies and research on the current datasets will highlight future areas of development

MULTISENSOR STUDIES OF OCEANIC PHAENOMENA IN EUROPEAN MARGINAL WATERS: ALGAE BLOOMS IN THE BALTIC SEA AND A RIVER PLUME IN THE MEDITERRANEAN

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ABSTRACT

Within the frame of the European project 'Clean Seas' we have used a multisensor approach for studying the imaging of different oceanic phenomena by satellite-borne sensors working at different (optical, IR, and microwave) frequencies. For this purpose, algae blooms in the Baltic Proper and a river plume in the north-western Mediterranean have been chosen as case studies. The used sensors are the Synthetic Aperture Radar (SAR) and the Along-Track Scanning Radiometer (ATSR) aboard the ERS-2, the Advanced Very High Resolution Radiometer (AVHRR) aboard the NOAA satellites, the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) on the SeaStar satellite, the Thematic Mapper (TM) onboard Landsat-5, Enhanced Thematic Mapper (ETM) on the Landsat-7 satellite, the Synthetic Aperture Radar (SAR) onboard Radarsat, the Wide Field Scanner (WiFS) onboard the Indian IRS-1C satellite, the Modular Optoelectric Scanner (MOS) and the Linear Imaging Self Scanner (LISS) onboard the IRS satellites. Each data set comprises remote sensing data from the same spot acquired by at least three different sensors within a few hours (i.e. quasi-simultaneously). The images of the Baltic Sea algae bloom clearly show the correlation between reduced surface roughness (visible in the SAR images) and presence of blue-green algae (inferred from the TM NIR channel). Moreover, an oceanic front caused by cold water inflow from the Bothnian Sea can be detected on images from the different sensors. By analysing images acquired over a time period of several days the history of an ongoing algae bloom could better be derived. A series of images from the mouth of the river Llobregat (located close to Barcelona) allowed us to better track the river plume and its environmental impact. It is shown that a strong river outflow is correlated with enhanced occurrence of surface films (derived from SAR images), enhanced chlorophyll-a content (derived from SeaWiFS images), and reduced sea surface temperature (SST, derived from ATSR images). As an overall summary, we show that the combination of data from different sensors working at different electro-magnetic wavelengths yields better insight into the imaging mechanisms on the one hand and into the kind of the imaged oceanic phenomena on the other hand.

SATELLITE OBSERVATIONS AND MODEL PREDICTIONS OF HARMFUL ALGAE BLOOMS IN COASTAL WATERS

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ABSTRACT

During the last decade the concern for toxic or harmful algae blooms in coastal zone has obtained much more public interest in Norway. The increased awareness for such events is mainly through the impact they have aquaculture activities and the increased concern for use of the environment. It is particularly sensible in Norway where fisheries and aquaculture industries count for significant part of the export, representing 5163751000f the total market for Atlantic salmon (1996 figure). After the severe harmful and toxic algae blooms in southern Norwegian waters during 1988, an ad-hoc operational monitoring program was set up, providing monitoring and information about the algae bloom situation and its development. Since 1988 the national algae monitoring efforts has developed to system which produces a weekly bulletin based on a regular in situ observation network aiming for monitoring the bloom initiation, development and decay from early spring to fall. The use of satellite ocean colour information in this service is under development and implementation. A 3D coupled physical and biogeochemical numerical model, tuned for the North Sea, is used for forecasting algae blooms and spreading. Since 1997, MOS and SeaWiFS satellite sensors deliver in near-real time, ocean colour data from which are derived synoptic maps of chlorophyll-a concentration and phytoplankton distribution during cloud free conditions. This new source of information, together with AVHRR-derived sea surface temperature maps are being integrated to the algae bloom monitoring service at three different levels: 1) daily acquisition and processing of EO data for improved early warning; 2) synergetic use of in situ, modelled and EO data for better prediction of bloom spreading; and3) use EO data as forcing field for improved model initialisation.The applications and advantages of integrating satellite-derived information in the operational system for algae bloom monitoring is demonstrated and validated. Examples of such use are presented the successive toxic algae blooms in spring 1997, 1998 and the until now non-harmful algae blooms of 1999.

COASTAL ZONES 2

COLD SEASON FEATURES OF THE JAPAN SEA COASTAL ZONE REVEALED BY ERS SAR

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ABSTRACT

The Japan Sea is characterized by great variability in the upper 200m waters where water properties are altered by lateral exchanges through the shallow straits and vertical exchanges with the atmosphere. At the mesoscale (10-500 km), the upper column is known to be a complex of warm and cold currents, eddies and upwelling zones. At still lesser scales a significant contribution to the variability gives the narrow streamers, internal waves, river plumes, etc.

More than 100 ERS SAR images were analyzed to investigate the features of surface circulation in the Japan Sea coastal zone during the winter monsoon season. 35 images were eliminated from the analysis due to strong winds that were observed during SAR sensing. Most of images covered the northwestern coastal zone. In December-March sea surface temperature derived from NOAA AVHRR data varied here from -1.8 to + 3-5°C. Thermal contrasts were associated with eddies and streamers in the polar front zone and also near coast where sea ice formation took place.

Dynamics and thermal factors were responsible for formation of radar signatures of oceanic phenomena such as eddies and fronts. Sometimes the location of radar signatures were correlated with the boundaries of eddies. These signatures had both positive and negative contrast against the background, probably, due to the change of angle between sensing direction and current direction. The oceanic radar signatures were also detected in the areas without clear thermal features. Background radar characteristics varied from practically uniform when the marine boundary layer of the atmosphere was stable or neutral to highly variable when the boundary layer was unstable. The differences in radar signatures allowed us to distinguish the imprints of oceanic phenomena against variable background

MONITORING OF WATER QUALITY IN LAKE AND COASTAL REGIONS USING ENVISAT MERIS OBSERVATIONS

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ABSTRACT

The ENVISAT AO project "Assessment of the usability of ENVISAT MERIS, AATSR and ASAR data in monitoring of coastal waters, lakes and snow in Finland" (ESA.AO.400) is concerned with the development of remote sensing-aided environmental monitoring techniques for operational use. An essential part of the methodology development is the analysis of the geophysical parameter retrieval accuracy of the ENVISAT remote sensing instrumentation. In this investigation, the feasibility of ENVISAT MERIS observations for water quality monitoring is studied by applying airborne spectrometer data and bio-optical modelling. Airborne measurements campaigns were carried out in Finnish lake and coastal regions during the years 1996 - 1998. Extensive in situ reference data collection at prefixed sampling stations was carried out simultaneously with the airborne measurements. Different lake and coastal water types under varying weather/seasonal conditions are well represented in the collected data set. The data set enables the simulation of MERIS observations and, thus, the quantitative assessment of the expected water quality parameter retrieval accuracy. The investigated water quality parameters include the chlorophyll-a concentration, turbidity, suspended matter concentration and the Secchi depth. In addition to quantitative parameter retrieval, the feasibility of the MERIS instrument for water quality classification is investigated. The developed and tested algorithms include empirical algorithms based on channel indices (ratios) as well as techniques based on radiance/reflectance spectrum shape analysis. Bio-optical modelling is applied for sensitivity analysis, for the development of advanced inversion algorithms and for the development of techniques to assimilate remote sensing data to water quality models. The obtained results indicate that the MERIS spectrometer has a high potential for operative water quality monitoring in the case of turbid lake and coastal waters.

COASTAL AND ESTUARINE WATER MONITORING BY SEA TRUTH, SATELLITE OCEAN COLOUR, AND SPOT DATA

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ABSTRACT

The ROCSAT-1 OCI is Taiwan's first ocean colour sensor. One of its major objectives is to monitor the complex coastal processes in Taiwan. This research uses ROCSAT-1 OCI images to monitor the water quality of the estuarine and surrounding coastal region of a major Taiwan river, Tan-Sue River. Estuaries link rivers with the ocean. In estuaries complex dynamic processes including chemical, physical, geological, and biological processes coexist. They are the sites where most pollutants are introduced into the ocean, especially into coastal waters. Understanding the biogeochemistry of estuarine and coastal waters is an important environmental task. However, this understanding is much hindered by the lack of synoptic and frequent observation. In this research, a collaborative study with in situ water sampling, remote sensing and numerical modeling is carried out. The study site, the Tan-Sue River estuary and the surrounding coastal waters, covers an area of about 100km square. Bi-monthly field sampling in collected sea truth data is conducted at 20 stations at the study site. The average distance in between the stations is 10km. Sea truth data including chlorophyll-A, dissolved organic matter, and sediments, as well as other basic physical, biogeochemical parameters are collected. Sea truth data are used to develop algorithms in interpreting OCI images. SPOT images (20m spatial resolution) are used to provide detail spatial information of the distribution of pollutants and are used to validate the results of numerical model. The high-resolution mode (300m) of the ENVISAT MERIS sensor is aimed for coastal research and applications. This work provides a basis frame work for future incorporation of MERIS data in monitoring Taiwan coastal areas. The potential and applicability of MERIS sensor in monitoring Taiwan coastal water quality is assessed.

COASTAL PROCESSES AND FEATURES FROM ERS-2 DATA: TWO CASE STUDIES AT NE BRAZILIAN CONTINENTAL SHELF

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ABSTRACT

The NE Brazilian continental shelf presents a diversity of coastal environments with peculiar oceanographic characteristics. This work presents the results of the ERS AO3-389 Project. It characterises the main coastal processes and features of two different regions on that continental shelf: the Rio Grande does Norte (5oS-35o30'W) and the Abrolhos Bank regions (17oS-39oW). The Rio Grande do Norte shelf is a wide and shallow shelf (80 km width, with shelf break at 70 m depth). It is characterised by the presence of a unidirectional current flowing in NE-SW direction, with a series of bedform fields and coral reef patches. The Abrolhos Bank area is under the influence of the Brazil Current flowing N-S, with the wide presence of coral reefs. The following data from 1996 to 1999 were used: SAR.PRI images, SAR imagettes, Wind Scatterometer MWF product, Altimeter Significant Wave Height data. In association with ERS-2 data, TM-Landsat 5 and AVHRR images were used.

SAR image processing revealed the presence of a persistent tidal front at the Abrolhos Bank region, in different periods. The front has an average length of 200 km, been recognisable up to the 20 m isobath region. Combination of SAR data, TM-Landsat images, Wind and Wave data, shows the role of the tidal front and tidal current on the sediment transport in the area. SAR and AVHRR Sea Surface Temperature images shows the presence of eddies from the Brazil Current travelling on onshore direction, generated by shallow seamounts (30 m depth) located 150 km offshore.

In the Rio Grande do Norte shelf, SAR.PRI images show current boundaries from offshore to onshore zones related to depth gradients and the presence of coral reef patches. SAR imagettes, Altimeter Significant Wave Height and Wind Scatterometer data revealed the sharp seasonal contrast in the area, with increase of wave height and wind intensity from July to October. An intercomparison of the two regions is performed focusing in the role of the processes and features on sediment transport.

SATELLITE OBSERVATIONS OF THE SOUTHERN CALIFORNIA BIGHT: SURFACE CIRCULATION, OIL SEEPAGE, STORM WATER RUNOFF AND BIOLOGICAL IMPLICATIONS

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ABSTRACT

This synergistic, interdisciplinary study uses ERS-1/2 and RADARSAT Synthetic Aperture Radar (SAR) imagery, complemented by near-coincident satellite (SST: AVHRR, ATSR; Ocean Color: OCTS, SeaWiFS, MODIS) and field (via ships, moorings and drifters) data to describe small-scale coastal ocean phenomena in the Southern California Bight (SCB), particularly the Santa Barbara Channel and Santa Monica Bay/Basin regions. Though part of the California Current System, SCB circulation patterns are more complex than elsewhere off the U.S. pacific coast, due in part to temporally variable winds, eight nearshore islands, coastal promontories, narrow channels, and submarine canyons, basins and ridges.

We describe here the extensive appearance of small (from 1-50 kilometers in diameter) coastal ocean eddies in the SCB. Eddies are small (mostly < 20 km diameter), predominantly cyclonic, and possibly seasonal in their distribution. They appear to result from a number of mechanisms, including topographic forcing and current instabilities, and are smaller in size and more abundant than previously reported. They engender significant phytoplankton patchiness in the SCB, and likely have important ramifications for primary productivity, larval transport and recruitment, and the dispersal of pollutants. These pollutants result from both natural and anthropogenic sources. We examine the distribution and persistence of natural hydrocarbon seepage in the Santa Barbara Channel and Santa Monica Bay, likewise the fate of pollutant laden storm water runoff from the urban Los Angeles Basin, and subsequent algal bloom events.

ENVISAT (ASAR, AATSR, MERIS) data will be used to extend these ongoing analyses, providing the necessary spatial, temporal and spectral resolution data required to resolve these small-scale coastal ocean features in the SCB. It will also enable us to extend our analyses to the adjacent central California coastal region to the north, allowing for both interregional and interannual comparative studies.

FISHERIES MONITORING IN THE CABOVERDE REGION USING ERS DATA

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ABSTRACT

Altimetry and infra-red remote sensing have been applied with success to the study of large scale circulation patterns and fronts, and have proved to be a powerful tool in fisheries research. The aim of this study is the application of ERS data (ATSR2 and radar altimetry) to fisheries monitoring in the Cabo Verde region. This work is being done in the scope of the ESA A03-265 project. The Cabo Verde Archipelago lies under the influence of the southern portion of the Canarias Current, where it turns westward and becomes the North Equatorial Current. This transport nutrient-rich water upwells at the Western African coast. However, due to the seasonal north-south migration of the current system, the south-eastern region of the islands can be affected by the Equatorial Countercurrent. Two very different water masses meet forming a large scale frontal system in the vicinity of the archipelago. These frontal zones are potentially favourable for the aggregation of large pelagic highly migratory fish species. The knowledge of the front location and variability has a great socio-economic importance for the local fishing industry, as well as in the support of global stock management of these species. Using maps of surface geostrophic currents and sea level anomalies derived from satellite altimetry and maps of Sea Surface Temperature from ATSR2, the general features of the ocean circulation in the study area have been investigated. Due to the fact that Cabo Verde region has very cloudy conditions, the synergy of microwave and infra-red data is of great importance for this study. The methodology used in this analysis and the results obtained so far are presented. Future work involves the use of in situ data to validate satellite derived information and the investigation of the relationships between fishing success and the ocean conditions measured by satellite and in situ methods. The ultimate goal will be the development of an operational methodology for the location of potential favourable areas for the concentration of large pelagic fish in the area of local fishing fleet activity.

COASTAL ENGINEERING CONSTRUCTION MONITORING, CONTROL AND PREDICTION SYSTEM

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ABSTRACT

Coastal engineering constructions play a major role for coastal hazards. The coastal hazards such as erosion or sedimentation caused by coastal engineering constructions have negative effects on the economy of developing countries. The main objective of this paper to develop system by using remotely sensed data in order to predict and control the coastal engineering construction effect on coastal zone. The control system used in this study is based on coastal engineering construction effects on wave spectra along the Chendering port, Malaysia. Coastal engineering construction effects are model by using a remotely sensed data such as ERS-1 and aerial photography. The statistical numerical model of probability distribution function is used to predict the coastal engineering constructions effects on coastline of Chendering, Malaysia. The study shows that coastal constructions change the direction of littoral drift, in which caused erosion at the down of littoral drift and sedimentation on the upper littoral drift. The study shows also the coastal constructions along Chendering coastline induce a strong current movement in the Chendering basin, which induce sedimentation along the coastal construction. The maximum erosion is 4 m/year but the sedimentation rate is 2.5 m/year along the coastal construction.

The statistical numerical model shows that the rate of erosion over 30 years will be ranged from 4.5 to 6 m/year. In summery, the integration between remotely sensed data is useful for predicting and control the coastal engineering effects.

The study comments that the coastal construction should not be faced the direction of littoral drift as shown by using a different model in this study.

ATMOSPHERE
UV Radiation, Trace Gases Other Than Ozone

WATER VAPOUR RETRIEVAL FROM GOME DATA INCLUDING CLOUDY SCENES

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ABSTRACT

A method is presented to derive total water vapour vertical column amounts from measurements of the Global Ozone Monitoring Experiment (GOME) in the visible/near infrared wavelength region. This method is based on the Differential Optical Absorption (DOAS) approach which has been successfully used in the retrieval of the amounts of many other atmospheric constituents. To be applicable for water vapour retrieval, the standard DOAS approach has been extended to handle saturation effects arising from strong wavelength dependent absorption features. This is achieved by a parametrisation of the non-linearity between absorber amount and differential absorption depth. A radiative transfer model (GOMETRAN) is used to calculate appropriate reference spectra and parameter sets for different scenarios, i.e. different solar zenith angles and different model atmospheres. Moreover, O2 absorption features are used to account for inappropriate air mass factors arising from differences between the real atmospheric measurement conditions and those used in the model calculations.

It has been shown before that the water vapour retrieval method is applicable to cloud free ocean scenarios. Most recently, the algorithm has been further improved and is now capable of handling also cloudy scenes. This will be shown by comparisons between total water vapour column amounts derived from GOME measurements and results of the Special Sensor Microwave Imager (SSM/I).

EMPIRICAL RETRIEVAL OF THE ATMOSPHERIC AIR MASS FACTOR (ERA) FOR THE MEASUREMENT OF WATER VAPOUR VERTICAL CONTENT USING GOME DATA. COMPARISON WITH INDEPENDENT MEASUREMENTS

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ABSTRACT

A new empirical technique for the fast retrieval of vertical concentrations of water vapour from the GOME uncalibrated spectra is described in detail. The ERA technique (Empirical Retrieval of the Atmospheric air mass factor) makes maximum use of GOME's capability to measure atmospheric spectra over a broad wavelength range with high spectral resolution, by retrieving a normalization factor for the water vapour concentrations directly from the data (oxygen slant columns measurements). ERA results are compared to the ECMWF, SSMI, and ground based TCWV (Total Column Water Vapour) data showing good agreement.

ATSR TOTAL ATMOSPHERIC WATER VAPOR CONTENT RETRIEVAL AND COMPARISON WITH GOME AND RADAR ALTIMETER DATA

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ABSTRACT

The retrieval of the total atmospheric water vapor content from ATSR data (Along Track Scanning Radiometer, atmospheric instruments on board of ESA Remote Sensing Satellite ERS-2) is described. The simple method of the split-window covariance-variance ratio technique (SWCVR) [1,2,3,4] has been applied to ATSR 11 and 12 mm radiometric brightness temperatures. This spectral range is sensible to water vapor absorption. Then the method does not required ancillary information and it has been tested over the sea surface only in order to reduce the dependency from surface emissivity. Thanks to the simultaneous acquisition of the same instantaneous scene by other instruments on board of ERS-2, namely GOME and Radar Altimeter, the estimates of total water vapor content from ATSR data have been compared with measurements from those instruments [5, 6]. Although the ATSR total water vapor content estimate requires an accurate validation with in situ data, the preliminary results from the comparison with values of other instruments data seems to be promising for a further exploitation of this technique. REFERENCES:[1]: Ottle' et al., "Estimation of Total Atmospheric Water Vapor Content from Split-Window Radiance Measurements", Remote. Sens. Environ., 61, 410-418, 1997. [2)]: Jedlovec, G., "Precipitable Water Estimation from High-Resolution Split-Window Radiance Measurements", J. Appl. Meteo, 29, 863-877, 1990.[3]: Kleespies and McMillin, "Retrieval of Precipitable Water from Observations in the Split Window over Varying Surface temperature", J. Appl. Meteo., 851-862, 1990.[4]: Sobrino et al. "Improvements in the Split-Window Technique for Land Surface Temperature Determination", IEEE Trans. Geos. and Rem. Sen., Vol. 32, N. 2, 243253, 1994. [5]: Casadio et al., "Empirical retrieval of the Atmospheric Air Mass Factor (ERA) for the measurement of water vapor vertical content using GOME data", submitted to Geophys. Res. Lett, 1999.(6): "Altimeter & Microwave radiometer ERS Products", User Manual, Ref. C2-MUT-A-01-IF, Ver. 2.2, 1996.

GODIVAERS - GOME DATA INTERPRETATION, VALIDATION AND APPLICATION - ERS AO3-132

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ABSTRACT

The ERS AO3 project Godivaers (AO3-132) has been directed at the improvement of the quality of existing GOME data products, such as total ozone and NO_2 columns and spectral radiances, and the development of new and advanced GOME data products such as columns of BrO and HCHO, slant columns of OClO and ozone altitude profiles. Validation of these improved and advanced GOME data products formed an essential part of the project. For this purpose ozone sondes, lidar and spectroscopic ground-based and balloon-borne measurements were employed. Interpretation of the data was achieved by comparison of assimilated GOME data with atmospheric chemistry transport model output. During the winters of 1999 and 2000 near-real time (NRT) GOME data were produced for the benefit of scientific users participating in the European Arctic ozone campaigns THESEO and EuroSOLVE. The experience and information on the accuracy of GOME data products gained has allowed specification of operational retrieval algorithms for the EUMETSAT Ozon Satellite Application Facility (O3-SAF) which is responsible for the data products generated by GOME-2, operational on the Metop satellite series from the year 2004 to 2017 and beyond. The project was funded by the European Union 4th Framework Programme on the Environment and Climate, under the name GODIVA, as a pilot project for application of space techniques. The project started in February 1998 and was completed in April 2000. An overview of the project results will be presented at the Symposium.

THE POLLUTION TRACING TECHNIQUE AND APPLICATION WITHIN THE GLOBAL ATMOSPHERIC WATCH (GAW) NETWORK

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ABSTRACT

Here we show how a combination of satellite and ground-based measurements at remote sites can be used to help identify sources and sinks of pollutants. A number of such ground stations are operated within the framework of the Global Atmospheric Watch (GAW) programme. Among other parameters, the trace gases carbon monoxide (CO) and methane (CH4) are measured, both of which are also available from satellite instruments such as SCIAMACHY and MOPITT. A technique called "pollution tracing" is introduced, which permits reconstructing the concentration evolution of (long-lived) trace gases in an air-parcel of interest. In the analysis, meteorological fields of the European Center for Medium Range Weather Forecast (ECMWF) are used to calculate a back trajectory, started at the station of interest. This way, the geographic displacement of the air-parcel over time is obtained. In a second step, the trace gas concentration within the air-parcel (at earlier time steps) is determined where vertical satellite profiles intersect the back trajectory. The analysis thus provides a "Lagrangian perspective" of the parcel's trace gas concentration evolution. Significant concentration increases or decreases within an air-parcel indicate the presence of sources or sinks. Hence, the pollution tracing analysis provides additional information for trajectory statistics techniques, commonly used for source region identification at remote sites. Moreover, the concentration evolution inside the air-parcel can be used to validate Lagrangian chemical models. An application of the pollution tracing technique is given in a case-study illustrating the effect of long-range pollution transport to a high Alpine site (Jungfraujoch, Switzerland).

EVIDENCES FOR A BACKGROUND OF BRO IN THE FREE TROPOSPHERE: STATUS AND IMPLICATIONS FOR THE GLOBAL OBSERVING SYSTEM

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ABSTRACT

Despite their low abundance (typically a few pptv), bromine species are playing a significant role in the processes that control the ozone amount in the lower atmosphere. Although tentative observations of HBr and HOBr have been reported, the direct experimental study of inorganic bromine species almost entirely relies on remote sensing observations of bromine monoxide (BrO), which can be obtained by UV-visible spectroscopy.

Since a few years, an increasing number of BrO column and profile measurements have been reported from ground-based, aircraft and balloon platforms; and since the launch in April 1995 of the Global Ozone Monitoring Experiment GOME on the ESA ERS-2 satellite, the global monitoring of BrO has now become possible providing a wealth of interesting material that mostly remains to be exploited. So far scientific investigations have mainly focused on BrO behaviour in the stratosphere as well as in the planetary boundary layer where the so-called polar-sunrise bromine explosion phenomenon could be characterised for the first time by the GOME instrument. Recently, careful analysis of existing BrO observations from GOME, ground-based and balloon instruments have lead to the likely identification of a small but significant background of BrO ubiquitous in the free troposphere.

In the present study the current evidences for this free-tropospheric BrO background are reviewed and first attempts to characterise its seasonal and latitudinal variations are presented. Particular emphasis is given to northern mid- and high latitudes over the period 1998-2000, based on the integrated use of GOME and ground-based data at Harestua (60°N) and Observatoire de HauteProvence (44°N). The implications of the results for future BrO monitoring from the global observing system are discussed.

REMOTE-SENSED FORMALDEHYDE OBSERVATIONS FROM THE ESA GOME INSTRUMENT

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ABSTRACT

Formaldehyde (HCHO) is an important indicator of photochemical activity and hydrocarbon reactivity in the troposphere. In the continental boundary layer it reflects hydrocarbon production from biogenic activity, including forest production of isoprenes. In the remote marine troposphere, where methane oxidation dominates its production, HCHO is an important proxy for tropospheric OH, which cannot be measured from satellites by any currently envisaged technique. We present vertical column abundances of HCHO retrieved from the Global Ozone Monitoring Experiment (GOME) spectrometer aboard the ERS-2 satellite. Previous GOME studies have shown that HCHO can be measured from space. The present study provides the sensitivity to measure HCHO globally for the first time. We determine slant columns of HCHO to better than 0.15 DU sensitivity by directly fitting GOME radiances using a nonlinear least-squares algorithm. This method has been quantitatively compared with DOAS fitting and found to give superior results for the fitting of trace gases in GOME spectra. The fitting includes correction for interfering species, the Ring effect, and the spectrum undersampling by GOME. Improved wavelength calibration using cross- correlation with a Fraunhofer reference spectrum, which was determined as part of the SAO Ring effect determination for GOME, was also implemented. We transform the slant columns to total vertical columns by correcting for vertical profile variability in the presence of Rayleigh and aerosol scattering. This transformation is achieved using the SAO LIDORT multiple scattering radiative transfer model to determine scattering weights for HCHO versus height in conjunction with vertical profile shape factors derived from the Harvard-GEOS global 3-D model of tropospheric chemistry. Total HCHO columns over North America in July 1996 determined in this manner show significant biogenic activity (isoprene production) over the southeastern United States. These HCHO determinations are compared with in-situ surface and aircraft measurements and with the Harvard-GEOS model predictions. Selected examples of HCHO from biomass burning in South America, Asia, and Africa are also presented.

ALGORITHM OF RETRIEVING AND MAPPING SURFACE UV IRRADIANCE FROM GOME LEVEL 1 DATA (AOÇ-403)

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ABSTRACT

The Global Ozone Monitoring Experiment device (GOME) on board of the ERS-2 satellite is supposed to supply information about a range of meteorological and geophysical parameters. The estimation of the surface active ultraviolet irradiance (UVB) using GOME data is considered in this study as one of the possibilities that could be useful for many applications.

A method for the UVB estimation from GOME Level 1 data is suggested. Two data sets are used during the study: GOME Level 1 data and GOME Level 2 data for the whole year of 1999. The suggested method is based on the assumption that the ratio of UVB value to GOME spectral data value is constant. A model for UVB calculation using GOME Level 2 data is developed for real atmospheric conditions. This model is based upon the simple Berd model for a cloudless atmosphere. To validate the model the calculated values of UVB were compared with in situ Brewer spectrometer measurements.

The results of the comparison showed that the relative deviations of the modeled UVB values from in-situ ones were from +18to -22The average value of the relative deviation was 1.4The simulated UVB values and real GOME Level 1 data are used to calculate the correlation coefficient. The validation of the method allowed to conclude that the suggested approach ensures 12 9.429029e-305rror in UVB retrievals.

Acknowledgements. GOME Level 1 data and GOME Level 2 data are provided through the ESA Project AOÇ-403 "Retrieving UV irradiances from GOME Level 1 data".

A MULTI WAVELENGTH APPROACH TO THE RETRIEVAL OF TROPOSPHERIC NO2 FROM GOME

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ABSTRACT

The main focus of the Global Ozone Monitoring Experiment (GOME) is the global mapping of stratospheric O3. However, the broad spectral coverage and the relatively good spectral resolution enable the retrieval of a number of other absorbers, including BrO, OClO, NO2, SO2, HCHO, and H2O. Some of these absorbers are mainly located in the stratosphere, but others have also strong tropospheric contributions, at least under specific conditions. The columns derived from GOME measurements are composed of both stratospheric and tropospheric contributions. Separation and quantification of the tropospheric part is not a trivial task, in particular if the bulk of the absorber is located in the lowermost atmosphere.

The sensitivity of GOME measurements towards the planetary boundary layer (PBL) depends on the solar zenith angle and the wavelength. It also varies strongly with cloud cover, surface albedo and aerosol loading. As a result of the limited information on the latter parameters, the accuracy of tropospheric columns retrieved from GOME data is generally limited by the uncertainty in the radiative transfer rather than by the fit.

In this study, GOME measurements have been analysed for NO2 absorptions in several wavelength regions. Owing to the increase in Raleigh scattering at shorter wavelengths, the sensitivity of the measurements towards the PBL decreases from 500 to 350 nm by about a factor of two. This effect is further enhanced by the fact that surface albedo is generally lower in the UV than in the visible. By comparing NO2 retrievals from different wavelengths and applying the appropriate airmass factors, some information can be inferred about the height distribution of the absorber. In addition, the consistency of the assumptions made for the radiative transfer calculations can be checked, thereby reducing the uncertainties of the retrieved columns. The potential of this method for the retrieval of tropospheric absorbers will be discussed, and some applications to measurements of tropospheric NO2 from biomass burning, industrial sources and lightning will be discussed

CONTRIBUTION OF ERS-2 GOME TO THE GLOBAL MEASUREMENT SYSTEM FOR ATMOSPHERIC NO2

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ABSTRACT

Nitrogen dioxide (NO2), a trace gas of the atmosphere, plays a crucial role in the photochemistry of atmospheric ozone in both the troposphere and the stratosphere. Its column abundance and vertical distribution are monitored by several sensors operating from space, balloon, aircraft and the ground. The different observation techniques and platforms of the current global measurement system provide invaluable complementary information. By design, field experiments and airborne remote-sensing observe with good accuracy the smaller spatial and temporal scales, and consequently remain the preferred approach for many studies that focus on detailed processes. Results of such process studies require satellite measurements in order to extend them to the global domain.

The present study relies on the integrated use of NO2 data acquired by measurement systems operating from space, balloon and the ground. Within the framework of the Network for the Detection of Stratospheric Change (NDSC), the vertical column abundance of sunrise/sunset NO2 and of daytime NO2 is monitored from pole to pole by a network of ground-based UV-visible and Fourier Transform infrared spectrometers, respectively. The NASA's Stratospheric Aerosol and Gas Experiment (SAGE) series and the UARS HALogen Occultation Experiment (HALOE) measure sunrise and sunset stratospheric profiles over an extended range of latitude and a variety of seasons. The global picture of mid-morning total NO2 is inferred from measurements by the ESA's Global Ozone Monitoring Experiment (GOME) operating aboard ERS-2. Sunset and occasionally sunrise profiles in the stratosphere and upper troposphere are measured sporadically by the SAOZ-balloon experiment at high and middle Northern latitudes and in Brazil.

In this work, the geophysical consistency and complementarity of currently available NO2 data records is investigated, with special emphasis on the contribution of GOME to the global measurement system for atmospheric NO2. As an illustration, the studied data records are combined altogether to derive the global behaviour of atmospheric NO2 as well as a new NO2 reference atmosphere.

METHODS 3

MODELING BACKSCATTERING FROM LEAFY VEGETATION: THE INCOHERENT AND COHERENT APPROACHES

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ABSTRACT

The availability of a considerable amount of Synthetic Aperture Radar data, obtained in recent years from airborne and spacecraft systems, has stimulated significant research for the purposes of interpreting backscattering data and investigating the potential of radar remote sensing for various applications. Vegetation has been one of the subjects most studied; however, most of the work has been carried out in forestry while less attention has been paid to agricultural crops. Experimental research has demonstrated that the microwave backscattering coefficient is sensitive to crop biomass, and is affected by the shape and dimensions of plant constituents (leaves and stems). On "broad leaf" crops, such as sunflower, backscattering increases with an increase in the biomass, as it is typical of media in which scattering is dominant. On the contrary, on "narrow leaf" plants, such as wheat, the trend is flat or decreasing, denoting a major contribution of absorption. Theoretical simulations were performed with an incoherent radiative transfer model and with a coherent approach in which the scattered fields are added coherently and the attenuation in the canopy is computed by means of Foldy's approximation. In the latter case the field scattered by a collection of plants within the radar footprint can be computed in two steps: by applying the coherent model to a single crop plant and, by then performing a Monte Carlo simulation over a large number of plants generated from ground truth measurements or derived from an architectural growth model (fractal model, for instance). In both models leaves and stems were approximated by dielectric disks and cylinders. The scattering matrices of these elements were obtained by using the finite cylinder approximation for the cylinders and the Rayleigh Gans approximation for the disks, while the underlying soil was represented by a semi-empirical model valid for gentle rough surface. Simulations performed for two typical crops, that are well representative of the two categories investigated, confirmed the trends of the experimental data and made it possible to evaluate the contribution of single plant constituents (stems and leaves) to total backscattering. Also a detailed description of the main scattering mechanisms that contribute to the backscattering coefficient has been obtained. In addition the coherent model was found able to interpret interferometric data by computing the position of the scattering phase center.

THE APPLICATION OF WAVELET-BASED FILTERING TECHNIQUES FOR RETRIEVING BIO-PHYSICAL PARAMETERS FROM MULTI-TEMPORAL ERS-IMAGES

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ABSTRACT

As the microwave backscattering from bare soil surfaces is sensitive to the moisture content of the upper soil layer, radar remote sensing has gained a lot of attention by the hydrologic community, as it provides the potential for initializing and updating distributed hydrologic models. However, topography, soil roughness and vegetation cover also strongly influence the backscattered intensity. It has been shown by Verhoest et al. (1998) that a principal component analysis on a winter time series of eight speckle filtered ERS images, taken over the Zwalm catchment (Belgium), is able to separate topography, soil moisture and vegetation effects within the signal. During the observation period (period 1995-1996), the soil roughness can be considered to remain constant and therefore does not introduce temporal signal changes. Yet, the obtained principal component images are still corrupted with noise, which can partly be related to the speckle observed in the SAR images. In order to get noise reduced images, which are more appropriate in hydrological modeling schemes, we apply a recently developed a wavelet-based image denoising technique (Pizurica et al., 1999) that preserves the spatial patterns and observed edges, while increasing the signal to noise ratio significantly. This technique applies the classical Bayes estimation theory to estimate the wavelet coefficients using prior knowledge of their spatial distribution. The suitability of this denoising technique is investigated by comparing the information included in these visually well-appearing images with field data. Improved results are obtained with respect to their non-filtered counterparts.

Pizurica, A., W. Philips, I. Lemahieu and M. Acheroy, Image denoising in the wavelet domain using prior spatial constraints, Proc. IEE Conf. on Image Processing and its applications, IPA'99, Manchester, 216-219, 1999. Verhoest, N.E.C., P.A. Troch, C. Paniconi and F.P. De Troch, Mapping basin scale variable source areas from multitemporal remotely sensed observations of soil moisture behavior, Water Resources Research, 34(12), 3235-3244, 1998.

A POLARIMETRIC RADIATIVE TRANSFER MODEL FOR RADAR REMOTE SENSING OF LAND TARGETS

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ABSTRACT

The information provided by radar and SAR instruments can be used in two possible ways. The qualitative approach is based on relative values of the scattering coefficient and image analysis techniques are applied, after appropriate filtering, for segmentation, classification or point and linear object detection. On the other hand, the quantitative approach aims at extracting absolute values of the scattering coefficient and relating these to geophysical parameters of interest. Several models have been developed as tools for simulation and for the quantitative interpretation of radar echoes. These models are generally based on radiative transfer theory and differ by their ability to represent more or less accurately the land targets of interest and to account for polarisation properties. We have developed a polarimetric radiative transfer model for the simulation of bare soil, low vegetation such as cultivations, dense vegetation such as bush, and high vegetation such as forest. The main features of this model are that all components, i.e. leaves, branches and trunks, are described in detail by their orientations, dimensions and vertical distributions. For each particular component, a choice between several probability distribution functions is available. Leaves can be circular, rectangular or elliptical, allowing the representation of different kinds of vegetation. For the case of forest, the trunks are modelised either as cylinders or as cones. The dielectric properties are introduced either as permittivity values, or are calculated from moisture values. Also for each kind of component a choice is provided between several scattering models, depending on the ratio between the characteristic dimensions and the wavelength. Reciprocity is forced for those scattering models which are not reciprocal. Also in double bounce mechanisms, the signals along the two opposite paths are added coherently before the powers are combined. The basic quantity is the Stokes vector and the output is in the form of the Mueller matrix, from which either the scattering coefficients or the polarimetric properties can be extracted. Applications of the model are: simulation of backscattering and polarimetric signatures, sensitivity analysis, interpretation of polarimetric radar, or SAR, measurements, and the retrieval of geophysical parameters. Examples of sensitivity analysis results will be presented for tropical targets, including tropical forest, tek plantation and savannas. In a companion paper [M. Leysen et al.], applications will be discussed for the characterisation of tropical ecosystems.

CLASSIFICATION OF MULTI-TEMPORAL SAR IMAGES AND INSAR COHERENCE IMAGES USING ADAPTIVE NEIGHBORHOOD MODEL AND SIMULATED ANNEALING APPROACH

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ABSTRACT

A classification algorithm for multi-temporal SAR images and InSAR coherence images is developed. This is done by minimizing an energy function which is defined by the sum of (1) the difference between the pixel value and the cluster center (mean value of a class) and (2) the difference between the pixel label (class) and its neighborhood. The global minimization of the energy function of the whole image is achieved by a simulated annealing approach. The cluster centers for different classes are calculated using fuzzy c-mean and possibility c-mean algorithms or determined manually from the image values. In order to preserve the details of the original images, a neighborhood structure with a 5*1 window is used to calculate the energy function, whose orientation is determined by the local homogeneity (e.g. the variance of the pixel values within the window) of the original images. This algorithm is used to classify three ERS-2 SAR images over the Mekong delta region, Vietnam. By comparing visually the color composite SAR images and the classified image, it is shown that the classification result is reasonable. Moreover, this algorithm is also used to classify an InSAR coherence image acquired from two JERS SAR images over south Sumatra, Indonesia. The classified InSAR coherence image delineates the bare land and forest clearly, since the coherence of bare land is larger than that of forest.

INFLUENCE OF AURORAL ZONE IONOSPHERIC DISTURBANCES ON SYNTHETIC APERTURE RADAR AND INTERFEROMETRIC SAR DATA.

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ABSTRACT

When interferometric analysis of polar satellite SAR data is carried out there are often streak-like 'artifacts' in the differential phase or coherence. Images of the fine scale registration of the 2 complex images often show similar patterns, indeed it is this mis-registration that is the primary cause of the coherence fluctuations. Examples of 'azimuth streaks' from ERS, RADARSAT and JERS-1 will be shown.

Our explanation of azimuth streaks depends on small-scale ionospheric disturbances such that the phase history of targets on the surface of the Earth is modified from that which would be obtained with imaging through a homogeneous atmosphere. As a result, pixel mapping in azimuth can be corrupted, and this will show up in an interferometric analysis. Results obtained using a straightforward simulator, comparisons with ionospheric activity as monitored through magnetometer activity, and comparison of results at C- and L-band support this interpretation of the phenomena.

Because the azimuth shift data will be unique to an ionospheric propagation problem, we have investigated the idea that the azimuth shift data may be used to correct for the associated phase fluctuations arising from the ionospheric disturbances. A first attempt at phase correction for ionospheric fluctuations will be shown and discussed.

CLOUD DETECTION FROM SATELLATE IMAGERY BY WAVELETS

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ABSTRACT

Retrieval of the cloud mask is an important and difficult task in remote sensing and meteorological applications. The thresholding techniques are the most consolidated to solve the problem, however they experience troubles in some circumstances that limit reliability of the retrieval. Presently research is active in developing alternative methods, generally based on simultaneous analysis of a set of pixels in a region. In this respect we want to prove feasibility of wavelets to retrieve the cloud mask. Clouds are good candidates to be analyzed by wavelet methods: it is well known that they have a precise fractal dimension and it is also well known that wavelets can be effectively used in analyzing fields having this property. Therefore it is natural to think of wavelets as a tool for retrieving the cloud mask from data taken either from polar or geostationary platforms, e.g., MERIS flying on ENVISAT or SEVIRI flying on MSG. The key point is that cloudy (or partly cloudy) and clear sky conditions have deeply different characteristics that can be made evident by a proper cloud classification scheme. We show how wavelets can be useful to analyze the statistical distribution of sensor data, that is the basis for classification schemes. To this purpose we consider as an example some scenes taken from METEOSAT data for different cloudy sky conditions. Images are analyzed both in their physical domain and after a suitable transform into the wavelet domain. It is shown that orography and boundary coasts do not give significant contribution to the highest scale in the wavelet domain; this depends on the intrinsic scale of orography and coasts compared with that of clouds. Therefore wavelet transform is able to make classification techniques more robust with respect to artifacts due to orography or coasts. Moreover, distribution of sensor data are obtained. In the physical domain they show a quite complicated pattern (bimodal distributions in general). On the contrary in the wavelet domain distributions are always unimodal; their statistical properties are analyzed. The net result is that classification algorithms for the retrieval of the cloud mask can benefit the prior transform of the remote sensed image in the wavelet domain.

ADVANCES IN OPERATIONAL CLOUD CLEARING FOR ATSR-1, ATSR-2, AND AATSR

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ABSTRACT

The ATSR instruments are high quality, well-calibrated instruments capable of producing extremely accurate measurements of the ocean and land surface temperature. However, one of the major problems in the processing of ATSR data is the reliable identification of cloud contaminated pixels in the data set, particularly over land. Small amounts of residual cloud still remain in the ocean data sets from the current operational processing scheme that can under some circumstances cause errors of several degrees in the SST values produced. The operational ATSR cloud identification scheme developed by Zavody et al (2000) works extremely well during the daytime over oceans. However, it has severe limitations when applied to data over land, and also has some problems at night time over the oceans - in particular over the tropical Pacific and in areas where uniform clouds are present.

Recently there have been further advances in cloud identification methodology in the form of the CLAVR algorithm for AVHRR data (Stowe et al. 1999), the MODIS algorithm (Ackermann et al. 1999), and by Stevens et al. (2000) in connection with the use of ATSR-2 data in GOME retrievals. These new methods also have application to ATSR data, so during the last year the ATSR Project have been applying these new methods to the ATSR-2 data set to assess the improvements that can be gained from these new methods. The paper describes the findings of these studies, and describes the recent improvements that are being implemented in the ATSR processing scheme in preparation for the AATSR instrument.

METHODS 4

CLASSIFICATION OF OCEANIC AND ATMOSPHERIC SIGNATURES IN ASAR DUAL POLARIZATION MODE IMAGERY

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ABSTRACT

In this presentation we give an overview of a proposal to develop an automatic classification algorithm for signatures of oceanic and atmospheric origin in ASAR Dual Polarization Mode imagery of ocean scenes (ENVISAT AO ID 387). Current and wind variations near the ocean surface become visible in SAR images via a modulation of the surface roughness. Signatures of oceanic and atmospheric origin can be very similar in shape and magnitude and are often superimposed upon each other, which can make their discrimination and, thus, the interpretation of SAR images very difficult. Impressive examples are a number of ERS SAR images of the Mediterranean Sea which exhibit a variety of signatures of oceanic and atmospheric fronts, internal waves, and convection patterns within single frames. An automatic classification algorithm would be highly desirable. Recent experiments and theoretical studies have shown that the dependencies of different kinds of radar signatures on radar frequency and polarization can be significantly different. This results from the fact that current and wind variations modulate long and short ocean waves in different ways, and the relative contributions of surface roughness components at different wavenumbers and directions to the backscattered radar signal depend on a number of parameters. If suitable combinations of SAR images at different frequencies and / or polarizations are available, one can discriminate between signatures of oceanic and atmospheric phenomena on the basis of this effect. This has been demonstrated successfully, for example, with multi-frequency / multi-polarization data from the SIR-C/X-SAR experiment. However, the suitability of ASAR Dual Polarization Mode data for the proposed approach is not obvious, since ASAR is limited to C band and moderate incidence angles, while most pronounced differences between dual-polarization SAR signatures of oceanic and atmospheric phenomena have been observed and theoretically predicted at higher frequency bands and near-grazing incidence. We discuss expected capabilities and limitations of the proposed classification algorithm on the basis of an analysis of available C band data at VV and HH polarization from ERS SAR and RADARSAT SAR, respectively, SIR-C/X-SAR data, and model simulations.

A MULTI-SENSOR APPROACH TO MONITOR OCEANOGRAPHY IN THE GULF OF OMAN

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ABSTRACT

As part of a 3rd ERS AO Study (Project 164) we are focussing on several different areas including the Gulf of Oman, Baltic Sea, Barents Sea, Norwegian Sea and the Hebrides Shelf. The idea is to assess the potential of satellite remote sensing data for routine monitoring of oceanography, globally. However, it is necessary first to confine studies to distinct areas, as the oceanography and modelling requirements are likely to be region-specific.

This paper concerns results obtained for the Gulf of Oman/Straits of Hormuz region, where ERS SAR, ATSR and scatterometer, as well as SeaWiFS, ADEOS OCTS, NOAA AVHRR, and TOPEX/POSEIDON and ERS altimeter data have been collected. Different sensor data have been compared to establish the benefit for improved monitoring of eddies and fronts in the Gulf of Oman. Generally, there is good correspondence for the features detected with different sensors. Satellite data reveal that this region is very dynamic and is often dominated by several eddies. The variability appears to arise due to interactions between outflow from the Straits of Hormuz, changeable monsoon winds and influences in the Northern Arabian Sea, including the Ras al Hadd front. Ultimately, satellite observations need to be assimilated into regional ocean circulation models to provide estimates for 3-D ocean fields and to gain insight concerning the driving physics in the area. Oceanic internal waves evident in a SAR imagery have been compared with numerical model predictions to assess whether the vertical structure of the ocean can be estimated. A depth-averaged tidal model is used to predict the flow in the Gulf of Oman. The tidal flow is then used as in put to an internal tide model to predict the generation of high-frequency, non-linear waves as the internal tide flows over the Gulf of Oman shelf edge. The models reproduce the wavelength and number of waves reasonably well, based on stratification profiles derived from climate data; however, the position of the observed waves does not match that predicted by the model.

INVENTORY AND MONITORING OF SHRIMP FARMS IN SRI LANKA BY ERS SAR DATA

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ABSTRACT

Inventory and monitoring of shrimp farms are essential tools for decision-making on aquaculture development, including regulatory laws, environmental protection and revenue collection. In the context of government aquaculture development policy, much attention has to be focused on the identification and monitoring of the expansion of shrimp farms. Therefore, the availability of an accurate, fast and mainly objective methodology that also allows the observation of remote areas assumes a great value. The satellite remote sensing approach is also economically viable, as the value of shrimps more than justifies an accurate inventory and monitoring of the development of the farms.

SAR data are unique for mapping shrimp farms, not only for their inherent all-weather capabilities, very important as shrimp farms occur in tropical and sub-tropical areas, but mainly because the backscatter from surrounding dykes allows for recognition and separation of shrimp ponds from all other water-covered surfaces.

The study is based on interpretation of SAR satellite data and a detailed image analysis procedure is described. Although hardware and software needed for the extraction of useful information from SAR data are currently available at most remote sensing laboratories, good knowledge in imaging radar theory and practice in handling and processing SAR data are not. The report aims at the necessary technology transfer for an operational use of the approach indicated in other similar environments. The methodology reported in this study has been tested under operative conditions in north-western Sri Lanka with the support of FAO project TCP/SRL/6712. The mapping accuracy achieved for shrimp farms, after field verification of preliminary results and refining of interpretation keys, is estimated to be more than 90 percent.

Keywords: aquaculture, mapping shrimp farms, remote sensing, Sri Lanka, synthetic aperture radar.

PHASEMAP, A SIMPLE SOFTWARE INTENDED TO GIVE AN EFFICIENT ACCESS TO INTERFEROMETRY

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ABSTRACT

The increasing number of non-specialized users of radar images and the continuous improvement of computing capabilities call for radar processing algorithms that are more and more transparent and user-friendly. In particular, most users reject the slant-range representation that is used by all interferometric software, at least as an intermediate step. As always for such an intrinsically differential technique, the optimal use of any existing data on the site being processed, in particular a topographic model is pivotal. Phasemap is a novel interferometric software based on a very straightforward architecture: architecture: 1) The results are displayed on a grid which is an over sampled, facetted version of a DEM-based grid, 2) Single-look complex images are projected and resampled onto this grid while undergoing a phase correction and 3) The results consists either on the 8-bits version of the amplitude or an 8-bits phase value. In the latter case, any radar scene can give an interferogram with any other by simple phase subtraction, provided the two scenes are physically interferometrable. The proposed architecture minimizes the cost of image combination, a valuable advantage in the case of multiple date acquisitions because of the quick rise of the number of potential pairs. The main features of the software are presented as well as results with various satellites. The capabilities of the architecture include in easy access to super-resolution in range and/or azimuth. The procedure requires an additional piece of software, which will be detailed. Additional, very straightforward pieces of software used for phase subtraction, phase filtering or orbital fringe removals are also presented.

ASAR SCANSAR MODES: QUALITY ENHANCEMNT

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ABSTRACT

This paper reports the results of a contract study on the optimisation of quality in ENVISAT ASAR ScanSAR mode, both for imaging and for interferometric applications. Both the "fine resolution" Wide Swath Mode (WSM, 150x150 m ground resolution) and the "coarse resolution" Global Monitoring Mode (GMM, 1x1 km resolution) have been studied. The achievable quality in these ScanSAR modes is discussed as a function of both system (quantization bits, transmitted bandwidth and on-board subsampling GMM) and processing parameters settings. The optimal performances achievable are proposed as a trade-off between noise equivalent sigma0, equivalent number of looks (ENL) and phase noise (for interferometric applications), both for WSM mode and for GMM mode. For what concern processing, two specific problems have been addressed and solutions are presented, namely: (a) the optimisation of look overlap, in order to maximize ENL, (b) the implications of low time (azimuth) bandwidth product in ScanSAR focusing.

WIND/WAVES 1/2

WIND SPEED AND SWH CALIBRATION FOR RADAR ALTIMETRY IN THE NORTH SEA

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ABSTRACT

Satellite altimetry is a valuable tool for determination of instantaneous sea levels or mean sea surface heights. Beside these quantities, the returning waveform and the backscatter coefficient can be used for computing significant wave heights (SWH) and wind speed. Both values are only raw estimates and have to be calibrated properly for useful operational services, like weather forecasting or storm warnings. The accuracy of the satellite derived wind speed and SWH is degraded due to insufficient in-situ data used for calibration or the large distance between the in-situ sensors and the measurements. Only a few locations worldwide, oil platforms or buoys, exist for calibrations. The limited geographical distribution causes problems due to the different sea state behavior in different regions. In some studies ECMWF wind fields are used for calibration, but the local wind may vary more rapidly than resulted from the models. In addition, the wind speed retrieval algorithm as used today was developed for GEOSAT and has to be calibrated and inter-calibrated between different satellites, e.g. to ERS-2 and Topex/POSEIDON in order to get comparable values. The German Weather Service (DWD) is operating weather stations shore and offshore, achieving highly accurate wind speed, wind direction and air pressure values. Moreover, the Federal Agency for Maritime Service (BSH) is operating a network of waverider buoys, estimating the SWH every 3 hours. Both data sets are available since 1992 and are compared to the altimetric derived quantities for ERS-1, ERS-2 and Topex/POSEIDON. In addition, a high resolution weather model (~7 km) is used for comparison. Furthermore, the accuracy and reliability is discussed.

USE OF ERS-2 ALTIMETER WIND/WAVE DATA FOR THE VALIDATION OF SEA STATE MODELS

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ABSTRACT

The interest of microwave sensors for the verification of numerical weather and sea state models has been pointed out in numerous studies. The present study is related to the use of ERS-2 altimeter wind/wave data for the validation of operational sea state models and for improving sea state models in the Black Sea and in the Mediterranean Sea.

MESOSCALE WIND FIELDS RETRIEVED FROM RADARSAT-1 SCANSAR IN VIEW OF ENVISAT ASAR

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ABSTRACT

In this paper an algorithm is presented and verified to retrieve mesoscale wind fields from the ScanSAR aboard the Canadian satellite RADARSAT-1, which operates at C-band with horizontal polarization in transmit and receive. The wind directions are extracted from wind induced streaks e.g. from boundary layer rolls, Langmuir cells, or wind shadowing, which are approximately in line with the mean wind direction. The algorithm defines wind direction as normal to the gradient of the amplitude image, which is approximated by finite differences over an appropriate length. The resulting wind direction is normal to the best and most frequent values of the retrieved local gradients. Wind speeds are derived from the normalized radar cross section (NRCS) and image geometry of the calibrated ScanSAR images, together with the local wind direction. Therefore semi empirical C-band models, e.g. CMOD4 or CMOD_IFR2, which describe the dependency of the NRCS on wind and image geometry are inverted. These models were developed for vertical and have to be modified for horizontal polarization, which is performed by considering several C-band polarization ratios including theoretical and empirical forms. To improve and verify the algorithm, wind speeds were computed from several RADARSAT-1 ScanSAR wide swath A images and compared to collocated measurements from the scatterometer aboard ERS-2 and to results of the Danish high resolution limited area model (HIRLAM). Using the collocated measurements, the polarization ratio was estimated and applied to improve the wind retrieval algorithm. Comparison of wind speeds retrieved from RADARSAT ScanSAR, using the empirical model under consideration of the estimated polarization ratio, to the HIRLAM results give a correlation of 0.8 and a bias of 0.07 ms-1 showing the applicability of the algorithm. Furthermore, the main error sources in SAR wind field extraction are discussed. To estimate relative errors of wind speed due to uncertainties in wind direction and NRCS, sensitivity studies were performed with respect to various settings of the ENVISAT ASAR. From these studies recommendations are given concerning the best settings of a SAR for wind speed retrieval.

This work was performed in the framework of the ENVISAT AO BIGPASO (AOE.220).
Keywords: synthetic aperture radar, polarization ratio, wind field retrieval, ocean surface, backscattering.

ERS SAR WIND RETRIEVAL IN THE MARGINAL ICE ZONE

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ABSTRACT

The wind stress in the marginal ice zone is important for the dynamics in the atmospheric boundary layer and in the ocean, as well as for the ice edge position and compactness. During winter, the wind field is important for the freezing of ice in the MIZ leading to brine release and ventilation of the deep ocean. Due to the rough weather and ice conditions, wind observations in the marginal ice zone is hard to obtain routinely using in situ observations from buoys or ships.

The Synthetic Aperture Radar (SAR) onboard the European Remote Sensing satellites is measuring sea surface roughness independent of weather and time of season. From the radar backscatter and a deduced wind direction, wind speed can be retrieved using a C band model such as the CMOD-4. Estimation of the wind direction can be done from features in the SAR scene such as Langmuir cells and atmospheric roll vortices. Due to the high resolution of the SAR it is possible to retrieve wind speed in leads and polynyas within the marginal ice zone.

In this project wind speed values retrieved from SAR scenes during field experiments near Svalbard show correlation with wind recordings from ship over time periods of up to 12 hours from the SAR passage time. Topographic induced variations in the SAR wind speed map are confirmed by the wind observations from the ship.

A numerical non-hydrostatic mesoscale model (MM5) has been employed for a summer situation using the actual wind field, topography and ice cover. Preliminary results from the comparison of data sets will be presented.

NEAR REAL-TIME SEA-SURFACE WINDS FROM ERS SYNTHETIC APERTURE RADAR (SAR) DATA

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ABSTRACT

There is an increasing request for wind information over the oceans. Within shipping, fisheries and offshore oil exploration there is a demand for better and more accurate weather forecast and other specialised weather information. In respond to this, Tromsø Satellite Station (TSS) has developed a near real-time wind information service in cooperation with NORUT Information Technology (IT), and Kongsberg Spacetec (KSPT). This service offers near real-time wind speed and - direction based on ERS-2 satellite Synthetic Aperture Radar (SAR) image mode data.

The wind service at TSS can provide the users with high resolution wind field observations far more closer to real-time than the current Scatterometer services are capable of. In addition, the wind information could be used for operational weather forecasting. Two potential customers have already stated their interest in this new wind product and have participated in a pilot demonstration. During the demonstration period wind speed and direction information has been extracted from a large number of ERS-2 SAR data from North European waters.

The SAR based wind information has been compared with model winds and with in-situ observations/measurements. Numerical models and scatterometers provide wind information at a resolution of 25 km, while the new SAR wind service can provide wind information at 10 km resolution. The wind speed and - direction parameters are provided at the following accuracies: Wind speed range 1-20 m/s: < 2 m/s, Wind direction range 0-360 deg.: < 20 deg.

This paper will include a presentation of the method applied for extracting the information and the results from comparing the various sources of wind data.

HIGH RESOLUTION WIND FIELDS AND THEIR VARIATION EXTRACTED FROM ERS SAR

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ABSTRACT

The synthetic aperture radar (SAR) aboard the European remote sensing satellites ERS-1 and ERS-2 acquire high resolution images that can be used to derive high resolution wind fields over the ocean surface. In this paper an algorithm for retrieving high resolution wind directions and wind speeds from SAR images are presented and applied to investigate the wind variation over the ocean surface. The wind direction is retrieved from wind induced streaks, e.g. caused by boundary layer rolls, Langmuir cells or wind shadowing. These streaks have widths of approximately 500 m to 2000 m, and are orientated parallel to the mean local wind direction. Their directions are extracted by derivation of the gradient of the amplitude image, which is approximated by finite differences over an appropriate length. The resulting wind direction is normal to the best and most frequent values of the retrieved local gradients. Wind speeds are derived from the normalized radar cross section (NRCS) of the calibrated SAR images by inversion of the semi empiric C-band models CMOD4 or CMOD_IFR2. These models describe the dependency of the NRCS on the local wind speed, wind direction and image geometry. The algorithm allows extraction of wind fields with a spatial resolution of up to 1 km for wind direction and up to 0.1 km for wind speeds. To show the applicability of the algorithm, images at different geographical locations and under different meteorological and oceanographical conditions were selected and compared to ground truth measurements. The large coverage together with the high resolution of the ERS SAR retrieved wind fields offer a unique opportunity to investigate the spatial variation of the marine boundary layer wind for scales of 0.1 to 100 km. It is shown that in the range of approximately 5 to 100 km the spectral energy decreases with increasing wavenumber according to the power law k^-5/3, which is also predicted by theory of two-dimensional isotropic turbulence. At scales below 5 km spectral energy increases with wavenumber according to the power law k. This is most likely due to domination of buoyant production of turbulence, which is explained by mixed-layer similarity theory, and in addition by the effect of SAR image speckle.
This work was performed in the framework of the ERS and ENVISAT AO's SARPAK (AO2D113) and BIGPASO (AOE.220).

Keywords: synthetic aperture radar, wind field retrieval, atmospheric turbulence, marine boundary layer.

THE OCEAN AND SEA ICE SATELLITE APPLICATION FACILITY WIND PRODUCT

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ABSTRACT

EUMETSAT supports the development of Satellite Application Facilities, SAFs, to become an integral part of the satellite ground segment. For scatterometer applications the Ocean and Sea Ice SAF and the Numerical Weather Prediction, NWP, SAF are the most relevant. During the life time of ERS-1 and ERS-2 the processing of ERS scatterometer winds has been developed considerably, and many operational centers using scatterometer data followed these developments. In the Ocean and Sea Ice SAF, preparations are made for the wind product of the ASCAT scatterometer on EPS/METOP. A pre-operational product based on the ERS-2 scatterometer is being developed. Quality control and monitoring are essential parts, as well as investigations on ice and sea state sensitivity, ambiguity removal, simulation studies, algorithm development, and documentation. The regional and global products becoming available from the Ocean and Sea Ice SAF will be presented at the meeting, with the focus on the most recent developments.

A PHYSICALLY-BASED MODEL OF OCEAN BACKSCATTER FOR WIND SPEED RETRIEVAL FROM SAR, SCATTEROMETER AND ALTIMETER

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ABSTRACT

Empirical models of ocean radar backscatter, such as the CMOD models for the ERS Wind Scatterometer, are widely used to provide quantitative information about wind fields. However, these models are limited because they do not include all the relevant physical effects, e.g. swell, rain, surface slicks and currents. Recent theoretical developments address these aspects, and here we attempt to construct a 'unified' theoretical model, that is, one with a common set of parameters applicable to SAR, scatterometer and altimeter. The model applies a scattering theory to a theoretical description of the ocean waveheight spectrum.

We compare predictions from the composite-surface and IEM (integral equation method) scattering models, using ocean spectra described by the models of Apel (1994), Elfouhaily (1997) and Lemaire (1999). We also incorporate swell and limited fetch, with published models of wave-spectrum perturbations due to rain, surface slicks or currents. The resulting model shows the sensitivity of the radar backscatter to all these factors. It also predicts dependences on radar parameters for future missions such as Envisat. Finally, it predicts when factors neglected by empirical models such as CMOD will be significant. The model predictions at nadir are compared against a new empirical algorithm developed using an extensive set of Topex data collocated with buoy measurements. The theoretical model reproduces the empirical dependence on wind speed very well, but it under-predicts the empirical dependence on swell. This discrepancy is reduced if an influence of swell on the relation between wind stress and wind speed is incorporated. We also consider implications of the modelling for predicting altimeter sea-state bias at different radar frequencies. This model is also tested against empirical scatterometer models at C and Ku band. The Lemaire spectrum produces best agreement with observations, provided a free parameter (the significant slope) is suitably chosen. However, the accuracy of the theoretical model off-nadir is limited by the present understanding of the description of ocean wave spectra. In particular, the directional spread of waves is not well understood; this leads to a systematic discrepancy between dependences of backscatter on wind direction predicted by the empirical and theoretical models.

TRACKING OF TROPICAL CYCLONES WITH THE ERS SCATTEROMETER: ALGORITHM PERFORMANCES AND POST-PROCESSED DATA EXAMPLES

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ABSTRACT

Every year Tropical Cyclones (TC) produce important damages on a high number of countries: the floods caused for the heavy rain, strong winds and bad sea conditions produce human and economic losses. Satellite data can help the scientific community to study these events. In particular the processing of the backscattering measurements acquired over the wind field at sea level. The knowledge of the wind field structure for the TC can help the scientific community to better understand and forecast these events. To meet the needs of the scientific community The Product Control Service (PCS) at ESRIN has developed a post-processing procedure for the fast delivery (FD) data acquired with the C-band Scatterometer (Scat) flew onboard the ERS satellites. The major skills of this post-processing are: the detection of TC, a quality improvement of the retrieved wind field and the availability on a web in near "real-time" of data and reports about TC. The paper describes the techniques adopted to detect the TC and to improve the Scat wind field. It also presents statistic results about the detection skill of the method and comparisons between post-processed data and fast delivery data.

USE OF SCATTEROMETER WIND DATA IN ECMWF'S ASSIMILATION SYSTEM

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ABSTRACT

ECMWF (European Centre for Medium-Range Weather forecasts) has since 1990 been heavily involved in the design of physical model functions relating back scatter measurements with near-surface winds (CMOD4), quality control and validation of scatterometer wind data. These steps were essential to understand and solve before an implementation of ERS data in the operational assimilation system, this took place in 1996. Recently assimilation experiments have also been performed with NSCAT and QuikScat Ku-band scatterometer data as a step towards operational use of QuikScat data. This presentation will present analysis and forecast impact of scatterometer wind data on tropical and extra-tropical events. Examples of impressive impact on forecasts of cyclones will be presented. Problems related to rain contamination of Ku-band scatterometer data and assimilation of high-density data will also be discussed. Intercomparison of model winds, ERS and QuikScat data will be shown and used to discuss quality control aspects required to remove contaminated QuikScat data. This is essential in order to obtain positive impact of the KU-band scatterometer data in ECMWF's high quality assimilation system.

ON THE ERS SCATTEROMETER WIND MEASUREMENT ACCURACY: EVIDENCE OF SEASONAL AND REGIONAL BIASES

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ABSTRACT

A validation of ERS scatterometer ocean wind measurements is performed using a formalism recently proposed for and applied to NSCAT and SSM/I measurements. This simple analytical model relates scatterometer measurements to true winds, taking into account errors in the satellite winds as well as errors in the data used for reference. In this study, NDBC buoys winds are the chosen reference. In addition, ECMWF analysis winds are used as a third data source to completely determine the errors via a triple collocation analysis. The resulting wind speed error analysis indicates that ERS scatterometer estimates are negatively biased at light winds. This result differs from recent results determined using standard regression analysis. It is also shown that ERS and NSCAT measurement accuracies are comparable in an overall sense. Taking full advantage of the long-term coverage of the ERS missions, the collocated data are then analysed to check for systematic seasonal and/or regional impacts on the wind speed error validation parameters. Data indicate a time-dependent bias between NDBC and ERS winds that is strongly correlated with the seasonal cycle. Buoy long wave and atmospheric stability parameter averages exhibit similar cycles and are the likely geophysical links to this scatterometer error. An illustration of regional/spatial error sources is provided using ERS data colocated with Tropical Atmosphere and Ocean (TAO) buoy array measurements. In this case the long-term average wind speed bias between TAO and ERS exhibits well-defined spatial structures within the equatorial belt (10 N, 10 S). Bias variations show qualitative agreement with a near-surface current climatology map for this Pacific region and also with the limited available buoy current measurements. Overall results indicate small but systematic non-wind sea surface effects on scatterometer products. We conclude that there can not be one set of values for ERS scatterometer wind validation parameters. Accounting for surface effects on scatterometer measurements may need consideration to insure proper assimilation of scatterometer data into weather forecasting and climate prediction models.

A NEW APPROACH TO REMOVE THE 180 DEGREE AMBIGUITY FROM THE SAR IMAGE SPECTRUM

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ABSTRACT

Ambiguity problem is inherent in synthetic aperture radar (SAR images of ocean waves. A new approach to remove the 180 degree ambiguity from the SAR image spectrum without using any external information has been developed based on the propagation theory of gravity waves. The approach has been demonstrated on ERS-1/2 SAR images.

GLOBAL OBSERVATIONS OF WIND SPEED AND SEA SURFACE FEATURES USING SAR WAVE MODE

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ABSTRACT

To prepare for the globally available ENVISAT ASAR wave mode data comparable complex imagettes where processed from the raw data of the ERS-2 SAR wave mode using DLRs research processor BSAR. Complex ERS-2 SAR wave mode imagettes have a size of 5 km x 10 km and are available every 200 km along the satellite track. The full high resolution image information of the wave mode imagettes opens up a large variety of oceanographic applications. Four main points are investigated in this study: Wind speed retrieval from imagettes using the CMOD algorithm (originally developed for the scatterometer, SCAT), and multi look techniques. A global comparison to 10 m wind fields from the European Center of medium Range weather Forecast (ECMWF) is given. As ERS wave mode imagettes are available at the same time and location as the SCAT data (with pixel size of 25 km x 25 km) the imagettes are used to test the SCAT flagging for land and sea ice. It is shown that seemingly wrong SCAT measurements of wind speed can be explained by surface features not dominated by the influence of wind e.g. surface slicks, sea ice. Several approaches, e.g. spectral filtering, derivation of entropy of the power spectrum and estimation of the decrease of backscatter in range, are carried out on the global dataset to characterize SAR image features. These characteristic feature parameters are compared to wind data provided by ECMWF on a global scale and their relation to atmospheric effects is discussed. The whole analysis is a validation an improvement of the planned operational measurement of wind speed from ENVISAT ASAR wave mode data. The work was performed in the framework of the ERS AO3 COMPLEX (ID 192), the ERS SAR wave mode raw data were kindly provided by ESA.

SAR OCEAN WAVE INVERSION - A HIERARCHIC APPROACH

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ABSTRACT

Retrieval of two dimensional ocean wave spectra from synthetic aperture radar data has been performed now for several years using a variety of different approaches. Due to the complexity of the problem potential users of SAR ocean wave retrieval schemes like weather centers have found it difficult to judge about the quality and the benefit of SAR retrieved wave spectra. The present study gives insight into the potential as well as the shortcomings of SAR wave retrieval. The study is based on a hierarchic approach, which starts with the most simple inversion schemes, based on strong simplifications of the imaging mechanism. Linear as well as quasilinear approximations are used for the inversion process. In a first step no a priori information is used in order to isolate the information coming from the SAR. SAR retrieved wave heights are compared with ECMWF wave height data. The comparison demonstrates different effects caused by the simplifications made in the retrieval scheme. Based on these observations the inversion scheme is extended step by step using more sophisticated forward models as well as a priori information. The a priori information is introduced using a maximum a posteriori approach.

The benefit of using cross spectra instead of conventional image power spectra is analyzed. The study is based on a global dataset of ERS-2 complex wave mode data, which were processed with the DFD processor BSAR. The presented work is meant to be a preparation for the coming ENVISAT ASAR ocean wave products.

A NEW COMPOSITE MODEL, INCLUDING NON-BRAGG SCATTERING EFFECTS FOR THE ESTIMATE OF RADAR CROSS-SECTION AND MODULATION TRANSFER FUNCTION, IN WIND-SCATTEROMETER AND SAR CONDITIONS

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ABSTRACT

Scatterometer are widely used wind estimate at the sea-surface. Most of the inversion methods are based on empirical models and not physical ones. This is because multi-scale composite models describing Bragg scattering and including tilting effects from larger scales, are not able to reproduce correctly the normalized radar cross-section (NRCS) in all configurations. In particular, it is recognized that such models do not provide consistent polarization ratios. Also, the azimuth dependence of the NRCS is still difficult to reproduce with the models in both HH and VV polarisations. For the analysis of SAR images over, the Modulation Transfer Function (MTF) is still not well understood and there are important differences between model and observations, in particular in HH. In all these cases, it is suspected that non-Bragg scattering may explain these discrepancies. In this context, our aim was to develop a physical model which takes into account non-Bragg scattering. We developed a single model which can reproduce on one-hand the behaviour of the NRCS with frequency, incidence, windspeed and polarisation, and on the other-hand the characteristics of the radar MTF in HH and VV polarisations. In addition to the conventional Bragg-part, the model includes a non-Bragg part associated to the specular reflection on breaking elements. The surface is described through a model of short windwaves based on the energy balance between wind input and wave breaking statistics. The distribution of wave breaking fronts, is parameterized as a function of the wave spectrum in the energy-containing part. Results are compared with available radar observations. We consistently reproduce the dependence of NRCS with incidence angle, wind speed, and polarization for frequencies from 3 to 14 GHz. For the MTF in HH-polarization, the only way to obtain agreement between model and observations is to take into account non-Bragg scattering This was shown by using MTF estimates from the Real-Aperture radar RESSAC. In summary we show that for HH polarization it is crucial to take into account non-Bragg effects both for the estimate of wind vector from radar measurement and for the inversion of SAR image spectra into wave spectra.

IMPROVEMENT OF THE HIGH RESOLUTION MESOSCALE ATMOSPHERIC MODEL RAMS WITH ERS-SAR, FOR DETAILED SEA SURFACE WIND RECONSTRUCTION OF SMALL SCALEPHENOMENA

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ABSTRACT

The ambiguity removal of sea surface wind reconstructions from SAR and Scatterometer observations is generally performed at the global scale by means of the comparison with coarse grid general circulation models. In this work we analysed the chance to improve reconstructions over regional and local scale areas, such as the Mediterranean, by means of the high resolution, full physics, mesoscale atmospheric model RAMS, where the ERS-SAR is used to detect local weather events such as wind fronts or cloud foot prints. Several case studies were analysed with model RAMS initialised from the ECMWF atmospheric fields and sparse in situ data (ground stations and raw insonde profiles).

ENVISAR ASAR WAVE MODE DATA SIMULATED BY ERS SAR

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ABSTRACT

SAR wave mode data are the only SAR measurements providing global coverage of radar data over the oceans. ERS SAR wave mode raw data, which are available every 200 km along the satellite track were focussed to 5x10 km complex imagettes using DLRs research SAR processor BSAR. As complex SLC imagettes and cross spectra will be a standard product for the ASAR on ENVISAT this dataset provides a unique test case for the ENVISAT era. The dataset is regarded as a basis for the user community to compare different new algorithms deriving wind spees and sea state, especially ocean wave propagation direction, from complex SAR data using multi look and cross spectral spectral techniques. For these techniques a high accuracy of phase is needed in order to estimate the propagation speed of e.g. ocean waves. Therefore processing techniques and quality tests regarding estimation of Doppler centroid frequency, in particular Doppler ambiguity resolving, range starting time and azimuth phase properties are discussed. The possibility to monitor sensor performance using this dataset is investigated. An overview of the amplitude detected browse images is given showing a variety of ocean features. Maps of global image statistics allow a first derivation of related marine parameters.

The work was performed in the framework of the ERS AO3 COMPLEX, the ERS SAR wave mode raw data were kindly provided by ESA.

AIRBORNE POLARIMETRIC RADAR MEASUREMENTS IN THE CONTEXT OF THE GEOPHYSICAL VALIDATION OF THE ENVISAT ASAR PRODUCTS OVER THE OCEAN

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ABSTRACT

The ASAR on board the ENVISAT satellite will have new capabilities which make the instrument very promising, but require complementary studies in addition to those already completed with the ERS data. In this context we propose a field experiment, using a new airborne polarimetric radar. This proposal has been accepted by ESA as part of the validation exercise of ENVISAT and it will be supported by French Agencies (INSU/CNRS, CNES, Météo-France). Our objectives are to contribute to the definition of the optimal mode of the ASAR for wind and wave estimates, and to develop or validate wind and wave inversion algorithms.

STORM is a new-version of our RESSAC C-Band airborne radar with a rotating antenna (Hauser et al, 1992). It will have a polarisation capability which will enable us to analyse the radar cross-section (NRCS) in HH, VV, HV. It will be used in a mode which will permit to measure simultaneously the NRCS at incidence angles between 10 and 40°, the directional wave spectra, and the Real-Aperture Modulation Transfer Function (MTF) around 30° incidence angle. We intend to perform about 20 flights under the ENVISAT SAR swath during a one-month experiment (during the CAL/VAL period of ENVISAT) off the coast of Brittany (France), with overpasses over a buoy equipped for wave wind measurements. The ASAR image mode or alternating polarisation mode will be requested during these flights. With this combination of measurements we will assess the performance of the ASAR products and inversion scheme for wind and wave estimates in various configurations of incidence angle and polarisation state. Using a new physical modelling (composite-scale model) we will analyse the contribution of non-Bragg scattering in HH polarisation, which will help to derive empirical models for HH polarization from those established for VV polarisation. The MTF obtained from the STORM data will be used to validate the one proposed for the SAR inversion. The non-Bragg effects will be particularly studied. Finally, mesoscale variations of radar-cross section as measured by the airborne radar will be analysed and related to observations of the ASAR and to mesoscale variations of surface wind.

VALIDATION OF ENVISAT ASAR WAVE MODE LEVEL 1 AND LEVEL 2 PRODUCT USING ERS SAR DATA

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ABSTRACT

A preliminary validation of the Envisat ASAR Wave Mode Level 1 and the Level 2 products have been conducted using ERS Wave and Image Mode SLC data collocated with in-situ measurements. The objectives of the validation were to optimize the algorithms, the processing settings and to predict the performance of the new products. The study also included developments of new methods for high-resolution wind field retrieval from SLC data. For the Level 1 product the main results show that when ocean swell systems are detected, the propagation ambiguity is resolved in 9064114570f the cases. The spectral peak wavelength and propagation direction RMS were 50m and 40 o , respectively. The mean peak wavelength was for this data set 250m, and the average azimuth cut-off value was 267m. We conclude that the cross spectra product of the ENVISAT Wave Mode is superior to the existing ERS Wave Mode product in terms of signal-to-clutter ratio and propagation ambiguity. For the Level 2 product the preliminary validation shows that the wave spectrum within the SAR imaging domain (i.e. swell) is unambiguously resolved in 800f the cases processed. In the remaining 2035720427264 of the cases, ocean swell is not present (does not exist or not detected by the SAR) or directional information not resolved. We conclude that the Level 2 product provides a unique wave spectra (i.e. swell) within the SAR imaging domain in most of the cases. For the wind field retrieval, an algorithm is developed based on the concept of combining, in a statistical sense, different estimators for the wind parameters. A large set of collocated in-situ and ERS SLC data is used to establish the required probability density functions. Validation results show that the algorithm provides wind speeds with RMS below 2 m/s, and wind directions with RMS from below 20 degrees to 35 degrees, the better the higher the wind speed.

VALIDATION OF ENVISAT SAR WIND FIELDS: LESSONS FROM ERS AND RADARSAT

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ABSTRACT

During the winter of 1999-2000, thousands of RADARSAT ScanSAR images have been converted into wind field maps and posted on the World Wide Web within a few hours of acquisition. The wind algorithm and methodology were developed first using ERS images, and afterward applied to RADARSAT. Now that thousands of images have been converted and analyzed, error trends and ideas for improvement are beginning to emerge that might have a direct bearing on the validation activities of the ENVISAT SAR. The paper will summarize the ERS and RADARSAT progress to date, and will offer suggestions for the validation phase of ENVISAT.

COMPARISONS OF OBSERVED AND MODELLED WAVE ENERGY SPECTRA USING ERS-2 SAR OBSERVATIONS AND THE MET.OFFICE WAVE MODEL.

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ABSTRACT

Global observations of ocean wave energy spectra are necessary for validating the forecasts of global wave models. The Met.Office has a 2nd-generation wave model in operational use. Comparisons between the modelled wave energy spectra and wave energy spectra as observed by the Synthetic Aperture Radar aboard the ERS-2 satellite are presented here. The comparisons show good agreement yet also highlight aspects of the model formulation that cause disagreement with the observations. Several case studies are chosen, and their results indicate the clear need to perform global validation of the wave model using SAR observations, and the potential for the assimilation of SAR observations to improve the model Sea State

THE POSSIBILITY OF SEVERE STORM MEASUREMENT WITH ENVISAT'S GLOBAL MONITORING MODE

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ABSTRACT

The RADARSAT-1 synthetic aperture radar (SAR) has acquired many ScanSAR Wide mode images of severe storms over the ocean, including hurricanes and polar lows. These unique images of storm imprints on the ocean surface, when taken with supporting remote sensing and in situ data, have provided new insight to storm morphology and evolution, and could eventually have a role in storm tracking and monitoring. However, these severe storm observations have presented many unique analysis challenges related to radiometric calibration of the SAR image data and the retrieval of quantitatively useful wind vectors. For RADARSAT-1, this situation has been exacerbated by the flawed operation of RADARSAT-1's automatic gain control and by the lack of a mature wind retrieval model function for C-band HH polarization SAR data. In this paper, we will present and discuss some of the technical difficulties experienced with RADARSAT-1 observations of extreme storms, and extrapolate our results to the ENVISAT Wide Mode case. We will show how these images can be used to diagnose marine atmospheric boundary layer stability, to locate the eye of the storm and associated zones of wind shear, as well as to identify bands or cells of intense precipitation. Of particular interest to ENVISAT is the Global Monitoring Mode that will provide wide swath imagery with lower spatial and radiometric resolution. We will show the results of wind retrieval from RADARSAT-1 ScanSAR Wide mode images that have been degraded in accordance with expected Global Monitoring Mode image quality parameters. A suitable radiometric calibration of the Global Monitoring Mode is essential for the quantitative development of this application.

WAVES AND MIXING IN THE COASTAL ZONE

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ABSTRACT

Progress in our research activities is reported for AO3-379 project on Wind, Waves, and Mixing in Coastal Regions. Wind, wave, and currents were measured for a few weeks in a coastal region off the north west of Baja California during January and February 1999, as part of an effort for a permanently instrumented study site. While a meteorological buoy and a wave and current sensor fixed to the sea floor have been in operation since early 1998, an acoustic current profiler was only deployed for a four-week period. Some analysis of synthetic aperture radar (SAR) images has been performed in order to explore on the influence of the wave field on mixing processes. From ERS-2 and Radarsat archived SAR images, those acquired on January 26th and February 17th are shown as example to look at the possible effect of low to moderate wave field on the mixing processes in the coastal zone. With these 2 cases, unstable and stable atmospheric conditions are represented and the presence of strong vertical current shear, as determined from in situ current profiler, is considered to determine their association with wave groups. Other interesting surface features such as curling surface streaks are also addressed to explore their implications as surface current detectors as well as their persistence under the action of the wave field.

ENVISAT

- RA-2
- AATSR
- ASAR
- ATMOSPHERIC INSTRUMENTS

AN ENVISAT S-BAND ALTIMETER CAL / VAL EXPERIMENT IN THE FRAMEWORK OF THE OSCAR PROJECT

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ABSTRACT

An ENVISAT CAL / VAL experiment is proposed and presented in the framework of the OSCAR project. The OSCAR project concerns the use of the ENVISAT altimeter for exploring the potential of a S-Band vertical sounding for studying the ice sheet, sea ice, forestry, desert, canopy, hydrology or for planetology applications.

More specifically, monitoring natural and anthropogenic changes can have a major impact in understanding exchanges between the Earth surface and atmosphere as well as surveying the good health of vegetation. Remote sensing altimeter techniques may have the potential of monitoring forest canopies and possibly inferring important structural parameters.

In parallel to scientific objectives, some technical studies will be performed in order to test nadir looking at low frequencies and a calibrated S-band polarimetric radar could be used over well-controlled homogeneous forested areas for CAL / VAL purposes. Calibration and validation could be done by measuring nadir looking radar cross section over forested areas during the ENVISAT commissioning phase, and testing inverse algorithms.

The experimental design consists in a small helicopter borne FM-CW high resolution radar René operating at 3.2 GHz in a nadir looking mode. This radar configuration associated to a good capability of S-band microwave to penetrate the vegetation will provide vertical profile of the vegetation. By analysing the return waveform, the radar cross section as well as the height of the vegetation can be retrieved. The range resolution of René and of the ENVISAT altimeter are quite similar. The test sites, located in Les Landes forest, covered by the spatial altimeter tracks are well managed giving a good knowledge of structural forest parameters. Simultaneous ground measurements will be conducted during the René or/and the spatial altimeter passes.

RADAR ALTIMETER CALIBRATION USING GROUND BASED TRANSPONDERS

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ABSTRACT

An important long-term objective of satellite radar altimeter measurements of the oceans is to provide truly global sea level measurements within a global geodetic system. Essential prerequisites of this goal are the accurate calibration and long-term monitoring of the range bias of the radar altimeter. The latter in particular requires an absolute calibration technique; relative calibration, by the comparison of sea surface measurements by different altimeters, cannot distinguish between a trend in the altimeter bias and a genuine trend in mean sea level.

Experiments in which transponders have been deployed beneath the ERS-1 satellite have shown that the radar altimeter can measure the range to a transponder deployed beneath it with sub-centimetre resolution. The accuracy of the range measurement then depends principally on the accuracy of the available water vapour path correction. This capability permits a number of applications to vertical position monitoring, orbit studies, and radar altimeter calibration.

Applied to altimeter bias calibration, the technique eliminates error sources such as tides and sea state bias. Best results are obtained when the range window of the radar altimeter is preset to a fixed value during the transponder overpass, and this technique has been in regular use on ERS-1 and ERS-2. A transponder also provides a target of stable radar cross-section, which can be directly measured, and can be used for calibration of the radar cross-section measurement. Transponder deployments beneath ENVISAT can make an independent contribution these calibration objectives.

Transponders offer a unique means to inter-compare the bias calibrations of satellite altimeters, capable of extension to future missions to maintain the continuity of radar altimeter data sets in the long term, and may be used as reference targets for the inter-comparison of radar cross-section measurements in a similar way.

THE ENVISAT RA-2 VALUE-ADDED OCEAN/ICE PROCESSOR AT GFZ POTSDAM

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ABSTRACT

A value-adding processor system for ENVISAT RA-2 Ocean/Ice-Products has been set up at GFZ Potsdam. It is a processing and database system for standard and value-added geophysical products to support ocean, climate and polar research. Two user inquiries, one national and one international, have shown a strong need for user-specific high-level altimetry products to be used in wide-spread and multidisciplinary applications. To fulfill the requirements of the user community, it is evident to enable the user to select and define his own specific products.

The processing system is divided into two modules, the first module is serving as a database for value-added products to be generated continuously during the mission, the second module is a user-specific processing system, where user-defined products are generated on demand. The data selection process includes user-defined temporal and spatial data coverage for both modules. However, the user-specific processing system furthermore allows the user to define the geophysical corrections, orbits, and gravity field model to be applied to the altimetry data. This system is build around the WWW, the user is able to enter the product specifications by filling out HTML-forms. A Perl-/Script-based processing chain is designed to generate the products, which are finally distributed via FTP or CDROM.

The standard products contain re-mapped ocean products, re-mapped ice products, geophysical ocean products, geophysical ice products and synergistic products. Such data is upgraded compared to the Level 1b and 2 products available from F-PAC by using state-of-the-art geophysical corrections, retracking algorithms, gravity field models and orbits. User-specific products are of the same type as the standard products, but have user-defined geophysical corrections, retracking corrections, gravity field models and orbits.

The different product classes will be explained in detail and the processing system as well as the user-interface will be introduced.

THE ENVISAT ALTIMETRY MISSION DATA PRODUCTS

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ABSTRACT

The ERS-1/2 tandem has been providing Altimetric data in the 90's. ERS-1 has ended its service after 9 years of successful data acquisition and ERS-2 is in good health to serve at least until the in-flight commissioning of ENVISAT, the next ESA Earth Observation Satellite to be launched in June 2001. ENVISAT will carry 10 different instruments. Among them are a Radar Altimeter of new generation (RA-2) and a microwave radiometer (MWR). RA-2 and the ground processing provide improved measurement performances and many new capabilities which will benefit the science and application community.

One of the major improvements of the RA-2 with respect to ERS RA is the second channel (S-band: 3.2 GHz), allowing range corrections due to ionospheric effects and many other new applications which will benefit from its low frequency, ranging from ice classification to canopy monitoring. Also, RA-2 has a different tracker philosophy from previous altimeters: robust collection of accurately quantified radar echo data. Conversion to meaningful geophysical quantities (re-tracking) is done solely on ground. A new features in RA-2 is the Model Free Tracker (MFT), robust at handling non-ocean like echoes, sampled over 128 bins. RA-2 switches autonomously between 3 different bandwidths to adapt the range window width to different surfaces and avoid losing track. Whereas previous altimeters had data dropouts in difficult terrain areas, RA-2 will remain longer in tracking, providing valuable data for applications involving ice edges, land, lakes, wetlands, coastal zones. RA-2 has the new capability of providing limited bursts of individual, i.e. un-averaged, echoes at 1800 Hz, delivered as a dedicated data product for purposes ranging from theoretical research on backscattering to precise monitoring of bright targets.

The data products are greatly improved. The retracking being done completely on-ground, we can afford to process the data in different complementary manners to optimise retrieval for each kind of surface. All data -over all surfaces- will be processed simultaneously by 4 different retrackers (Ocean, Ice1, Ice2 and Sea-Ice) to let the users choose the most suitable one for their particular application. Land echoes are so complex and diverse that they cannot be handled by a single retracker: the land application users will access the waveforms.

In near real time (NRT), the Altimetry data products will contain tropospheric path delay correction, water vapour and brightness temperatures from MWR. This is again an improvement with respect to ERS where only off-line products contained the MWR corrections and will permit accurate real-time monitoring of global oceanographic signals, especially in the tropics where the water vapour is high and where signals like El Niño are of major importance. ENVISAT-1 carries DORIS, which will contribute to the precise orbit determination. The quality of the data available in NRT -DORIS orbit, re-tracking, auxiliary data- makes the NRT geophysical product almost of the same high quality as the final GDR product, contributing to major NRT applications as the Global Ocean Data Assimilation Experiment (GODAE).

CLS CONTRIBUTION TO ENVISAT CALVAL

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ABSTRACT

The CLS Space Oceanography Division has been involved for many years in altimeter data validation, inter-calibration and merging as well as in ocean circulation monitoring and near real time applications. As described in the CLS/SOD response to the ENVISAT Announcement of Opportunity ("Multi-satellite altimeter processing for sea level and ocean circulation monitoring"), these activities will be developed further as part of the ENVISAT mission. An outline of these activities will be given. They will be illustrated by the analyses we have carried out with ERS-1/2 and T/P data (altimeter and radiometer inter-calibration and merging). The merging contribution for ocean circulation monitoring will be, in particular, quantified and we will describe how the techniques developed with T/P and ERS-1/2 will be improved with the addition of new satellites such as ENVISAT. We will finally discuss the near real time altimeter data processing issues. The DUACS system developed as part of an EC project is now processing T/P and ERS-2 data in near real time for both scientific and commercial applications. We will describe how this system will be upgraded to allow the near real time processing of ERS-2, T/P, GFO, ENVISAT and Jason-1 data.

ABSOLUTE AND RELATIVE CALIBRATION OF ERS-2 RA WITH APPLICATIONS TO ENVISAT

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ABSTRACT

In this paper we review our methodologies and results from absolute and relative calibrations of ERS-2 in preparation for the launch of ENVISAT. Absolute calibrations of ERS-2 have been undertaken around the UK coast using tide gauges tied to the Earth's reference frame by GPS. The procedure utilised short arc enhancement of the satellite radial positioning from near simultaneous observations by three or more lasers in the European network. Local geoid, storm surge and tidal models have been used to extrapolate from the tide gauge location to the sub-satellite point. In this way the misclosure of the altimetric equation yielded the altimetric bias. Of particular concern is the ocean tidal correction. As an alternative to modelling the ocean tides, the dominant constituents have been recovered from TOPEX at dual crossover locations between ERS-2 and TOPEX/Poseidon. Frequency analysis of TOPEX altimetry yielded the required ocean tidal time series which is equally applicable to ERS at a dual crossover location. Results using both ocean tide correction procedures will be presented. Relative calibration of the altimetric range may be achieved either through comparison against in situ tide gauge data or by comparison against another concurrent altimeter satellite. Results for ERS-2 will be presented for both approaches. The tide gauge approach utilised all gauges in the FASTWOCE network. A pre-requisite is to ensure that the tide gauge is representative of the altimetry and not corrupted by local effects or land movement. In contrast, direct comparison between ERS-2 and TOPEX/Poseidon requires that TOPEX itself is well calibrated. Finally, details will be given of future plans in readiness for the launch of ENVISAT.

LAND CALIBRATION AND MONITORING OF ENVISAT RA-2 SIGMA0

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ABSTRACT

A global evaluation has been carried out over all non-ice covered land surfaces for which altimeter data are available, using ERS-1 Geodetic Mission data, together with ERS-1 and ERS-2 35 day data. This global survey has identified several large land areas over which the surface characteristics and aridity permit cross-calibration of altimeter sigma0 to be made to an accuracy of +/- 0.1dB on individual measurements. The methodology used to characterise each site involves modelling the area using an expert system to select and interpret individual altimeter waveforms, and then combine these data to create a surface of sigma0 variation across the entire region. Somewhat unexpectedly, these optimal land calibration targets are found to contain appreciable topographic relief. Additionally, sigma0 is not constant spatially within the target regions, varying over a range of approximately 5 dB. However, the spatial variation is coherent and can be modelled. Crucially, within these areas sigma0 does not exhibit variation with time over the combined lifetimes of ERS-1 and ERS-2 (with the exception of extremely rare and dramatic environmental events which are immediately evident in affected sigma0 values). It is therefore proposed that these huge natural targets be used to monitor the performance in terms of stability of ENVISAT RA-2 sigma0 over the entire mission lifetime. This paper presents the results of the global analysis of altimeter sigma0 and demonstrates the consistency of cross-calibration of altimeter sigma0 over the identified sites using ERS-1 and ERS-2 ice and ocean mode data. A case study using TOPEX data is also presented, to illustrate the potential of this technique for other satellite missions.

MEASUREMENTS AND MODELING OF OCEAN SURFACE SLOPES AND CALIBRATION OF THE RADAR ALTIMETER

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ABSTRACT

Our study suggests a robust approach for absolute calibration of a satellite radar altimeter through use of the angulance dependence of near-nadir radar and optical observations.

THE CATALA CAMPAIGNS: INDIRECT CALIBRATION TECHNIQUE FOR ENVISAT ALTIMETER CALIBRATION

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ABSTRACT

The first CATALA campaign was made on March 15-18, 1999, off the Catalonian coast near Begur Cape/LLafranc in the NW Mediterranean Sea mainly to perform the first absolute calibration of TOPEX altimeter side-B of the US/French altimetric satellite TOPEX/POSEIDON using GPS Buoys. The campaign consisted of two reference stations on shore and two GPS buoys underneath the TOPEX/POSEIDON ground track to get the instantaneous sea level. The GPS Buoys were designed at the Cartographic Institute of Catalonia using GPS antennas placed inside floats of toroidal form. The satellite overflight was at 8:45 UTC on March 18, 1999, on an ascending orbit. Results comparing analysis from different groups and using different GPS solution techniques as GIPSY and KARS are presented. Preliminary results from the altimeter bias in the CATALA campaign have given 5.1+/-6 cm for GIPSY and 6.8+/-10 cm for KARS. Despite the 10 cm uncertainty, one measurement, there is a good indication that the buoy method seems to work very well. One of the main objectives of the CATALA campaigns is to map the Mean Sea Surface along the TOPEX/POSEIDON ground track. This ground track crosses somewhat south of Llafranc with the 35-day ERS/ENVISAT ascending ground track. At these crossings it is possible use the indirect calibration technique to calibrate these altimeters. The important fact is that the CATALA campaigns are laying the foundation for a general "indirect" calibration site which allows to calibrate any mission, with special relevance for ENVISAT, that crosses the GPS mapped MSS section of the ascending ground track of TOPEX/POSEIDON.The CATALA campaign and their data processing are made under a CICYT (Comision Interministerial de Ciencia y Technologia) National Coordinated R+D Project in Space Research, ref:ESP97-1816-CO4, that include several governmental/research Institutes and Universities from Spain with international participation from France and the United States.

THE PROPOSED GLOBAL LAND SURFACE TEMPERATURE PRODUCT FOR ENVISAT'S AATSR: SCIENTIFIC BASIS, ALGORITHM DESCRIPTION AND VALIDATION PROTOCOL

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ABSTRACT

The goal of determining accurate (better than 2 K) global land surface temperatures from satellite-borne infrared radiometers appears to be feasible with the advent of well-calibrated narrow band infrared radiometers typified by the ATSR series of instruments.

Recent research has shown that split-window type algorithms are capable of delivering accuracies as good as 1 K at night and 2.5 K during the day. These algorithms take specific account of the interfering effect of the atmosphere and account for surface effects in a variety of ways. This paper discusses the methodology chosen for deriving global LSTs from the AATSR. The constraints of providing global products in a time efficient manner coupled with the problems of access to independent ancillary data have narrowed the choice of algorithmic model to that of regression.

We show that a computationally fast and accurate algorithm which utilises climatological ancillary data is capable of providing global LSTs with a (simulated) accuracy of around 2 K. The algorithm can be shown to be logically consistent with physically-based schemes and inversion of the regression coefficients can provide information on the emissive properties of the surface.

The scientific basis for the algorithm is provided together with an algoritmic description and the methodology for deriving and updating the coefficients is discussed. The important process of validating the product is also discussed and a five-stage validation protocol developed.

LABORATORY CALIBRATION OF AATSR

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ABSTRACT

The Advanced Along-Track Scanning Radiometer, AATSR, is the third in the series of ATSR instruments designed to measure global sea-surface-temperatures to an accuracy of 0.3K, monitor global vegetation coverage and retrieve cloud properties. The primary goal of AATSR is to extend the existing ATSR-1 and ATSR-2 data sets well into the next decade. The project is funded by the United Kingdom's Department of Transport, Environment and the Regions (DETR). To meet its scientific goals, AATSR has to meet strict performance criteria. The thermal infrared channels at 12μm, 11μm and 3.7μm must measure radiances to an accuracy equivalent to a temperature error less than 0.1K for all pixels. The radiometric noise must be less than 0.08K at 3.7μm and 0.05K at11μm and 12μm, for a scene temperature of 270K. The visible and near-infra-red channels at 1.6μm, 0.87μm, 0.66μm and 0.56μm require radiances to be known to an absolute accuracy of ± 5 percent. In addition, the field-of-view for all channels must be aligned to within 0.1 pixels. The aim of the pre-launch calibration was to characterise the instrument performance and verify that the main requirements were met before launch. The calibration of the 12μm, 11μm and 3.7μm channels were verified over a range of target temperatures between 210K to 315K and corrections derived for detector non-linearity. Tests were also performed to measure the radiometric noise, determine any scan dependent variations and any effects due to changes in the thermal environment. The results are compared against those obtained from the calibrations of the previous ATSR instruments. The visible channel tests included the absolute radiometric responses, radiometric noise, polarisation sensitivity and calibration of the VISCAL unit.Data from an initial run-through of the calibration identified a major fault with the instrument's optical alignment, and was vital in establishing the solution for the eventual repair.

NEAR-SURFACE OCEAN TEMPERATURE VARIABILITY - CONSEQUENCES FOR THEVALIDATION OFAATSR ON ENVISAT

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ABSTRACT

Vertical temperature gradients in the top metre or so of the oceanic water column arise from heat flux between the ocean and atmosphere (the thermal skin effect) and from the absorption of solar radiation (the diurnal thermocline). These serve to decouple the skin temperature at the air-sea interface from conventionally measured sea-surface temperature in the bulk of the ocean. The signal received by satellite radiometers from which sea-surface temperatures are derived has its origin in the thin, skin layer, but the conventional approach to validating such retrievals is with in situ measurements. In these comparisons the near-surface temperature gradients are treated as an unresolved residual error that is attributed to the algorithm used to correct for the radiative effects of the intervening atmosphere, and consequently become included in the uncertainties in the satellite-derived sea-surface temperature. Recent technical advances have resulted in instruments capable of radiometric measurement of the skin temperature of the ocean in an almost-routine fashion. One such device is the Marine Atmospheric Emitted Radiance Interferometer (M-AERI) which operates from the deck of a ship. The M-AERI is a Fourier Transform Infrared radiometer that makes measurements in the spectral range of infrared wavelengths from ~3 to~18μm and measures spectra with a resolution of ~0.5 cm-1. The M-AERI includes two internal black-body cavities for accurate real-time calibration and the derived skin temperatures have residual uncertainties <0.1K. Comparison between M-AERI skin temperatures and satellite-derived sea-surface retrievals allows for a partition of the error sources in to those from unresolved atmospheric variability and near-surface oceanic gradients. The results of a comparison with AVHRR sea-surface temperatures in a wide range of atmospheric conditions has shown that the residual uncertainties are less that half of those derived by conventional comparisons within situ data from buoys. Thus the accuracy of the atmospheric correction algorithm is better than twice that previously demonstrated, and when applied to AVHRR data can lead to residual uncertainties of ~0.3K. The proper validation of Envisat sea-surface temperatures will require the use of such high-accuracy ship-board devices.

SCANSAR INTERFEROMETRIC MONITORING USING THE PS TECHNIQUE

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ABSTRACT

The paper focuses on the interferometric capability of the forthcoming ASAR sensor, in the field of monitoring ``small displacements" like those due to subsidence or tectonic motion. Specifically, we propose to exploit the ASAR ScanSAR\ Wide Swath Mode that provides a quite large swath (400 km corresponding approximately to 6 full resolution beams). This mode is suited to an extended coverage of the earth surface, with short revisiting times. Moreover, it will be possible to study tectonic motions and the atmosphere on a much larger scale than previously possible, enhancing the scientific returns of the mission.

The availability of ENVISAT\ ASAR interferometry is however limited by the temporal decorrelation in the 35 days orbit repeats time. ScanSAR interferometry is moreover prevented by the volume decorrelation in the large resolution cell (150 m, azimuth) and by the lack of synchronization between passes.

In the paper we propose to counteract for these problems by exploiting the Permanent Scatterers (PS) tool. PS interferometry has been demonstrated capable of providing a quite accurate monitoring of surface deformations, particularly in urban areas.

The use of PS provides a remedy for temporal decorrelation problems since (a) PS are stable and coherent in time; (b) their large radar cross section makes them the dominant scatterers in the neighborhood, and (c) they are spatially small e.g. their return is correlated over large baselines.

In the paper, we present the extension of PS technique to ScanSAR and we identify the limitations (and the potentials) of that technique basing on the statistics of PS, derived by exploiting a large data set of ERS acquisitions. The results, presented in terms of PS distribution in the unit area, coherence and capabilities in tracking small displacements, provide interesting perspectives of the proposed application.

ALTERNATIVE LARGE-SCALE DISTRIBUTED TARGETS FOR SAR ELEVATION BEAM PATTERN CHARACTERIZATION

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ABSTRACT

The Amazonian rainforest has long been recognized by the SAR community as an extremely useful large-scale distributed target. In particular, this is due to the region's relatively high sigma nought, its stability, isotropy and the well-defined relationship between its backscatter and the angle of the incident radiation. For these reasons, it has proved itself very valuable for the characterization of the in-flight elevation beam patterns of SARs such as on-board the ERS satellites and RADARSAT-1. However, should it be desirable to characterize the beam pattern at other latitudes - for instance in order to understand how the sun's illumination affects the performance of the antenna - it is necessary to look for suitable alternative distributed targets. This paper examines some of the alternatives to the tropical rainforest at different latitudes. In each case, an assessment is made of the potential a particular site shows together with the approach that should be taken in order to make use of it. The initial information is taken from the ERS scatterometer data over land which gives a good indication of the sigma nought, the stability, any seasonal changes and the relationship between sigma nought and incidence angle. Having selected a likely site, ERS SAR data are used to show its potential for characterizing the elevation beam pattern. Finally, recommendations are made for potential suitable distributed targets based on those examined, and indications are given for other sites which might be worth considering. The applicability of utilizing any of the sites for the characterization of the ENVISAT ASAR will also be reviewed.

PHARUS ASAR DEMONSTRATOR: SIMULATION AND APPLICATION OF ASAR DATA

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ABSTRACT

PHARUS is a polarimetric active phased array C-band SAR, designed and built for airborne use. To demonstrate ASAR's feasibility for a number of selected land and sea applications, data in image and alternating mode have been simulated with PHARUS. These applications concern landuse classification with several combinations of polarimetric channels, terrain relief estimation from a same-side stereo pair, geocoding of SAR imagery, and the determination of ocean wave spectra. PHARUS data of 3 m resolution were collected over the Black Forest in Germany and over the North Sea off the Dutch coast. The data were degenerated in the processing to ASAR's resolution of 30 m for two looks in alternating mode and four looks in image mode. Results show that ASAR dual-channel data from alternating mode give much better landuse classification results than the single-channel data of the ERS satellites. Moreover, with ASAR's resolution, terrain relief can be estimated with an accuracy of about 80 m, whereas SAR imagery can be geocoded with an accuracy of 100 m using ground control points. For the dominant wavelength in the North Sea, a value of about 70 m has been found.

ERS - ENVISAT COMBINATION FOR INTERFEROMETRY AND SUPER-RESOLUTION

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ABSTRACT

In the paper we suggest a new interferometric application that exploit the different central frequency (Df = -33.1MHz) between ERS-2 and ENVISAT. This combination assumes that ERS-2 and ENVISAT can fly in tandem formation with about 2.5km baseline. The advantages achieved by the short repeat time will be a small temporal decorrelation. The different central frequency could be compensated, for a given range of terrain slopes, by properly tuning the baseline. The frequency gap would be so exploited for getting super-resolution and / or interferometry. In the interferometric combination, very accurate DEM quality (sigma_h ~ 1 m) could be achieved on a "fine scale", e.g. by exploiting an existing "coarse" DEM. This could lead to interesting applications, like measuring ice surges (and generalized ice surfaces topographies).

EXTERNAL RADIOMETRIC CALIBRATION ACTIVITY ON ITALIAN TEST-SITES FOR THE ENVISAT MISSION

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ABSTRACT

The use of SAR data for environmental quantitative studies requires that users should have access to calibrated data. The instrument end-to-end transfer function has to be correctly defined through both internal and external calibration procedure. This paper deals with an external calibration effort planned for the ENVISAT mission on the Matera Italian test-site. On this site, many calibration experiments related to both space-borne and air-borne SAR missions such as ERS-1/2, SIR-C/X-SAR, AIRSAR and more recently SRTM have been carried out.

Based on the earned experience, this group will deploy calibration point targets consisting of Corner Reflectors (CR) and triggerable Active Radar Calibrators (ARC). Two sets of CRs are available, having a Radar Cross Section (RCS) in excess of 41 and 43 dBm2 respectively. These RCS values are well above the already known test-site backscattering properties, thus permitting a calibration error below 1 dB. The further advantage of using CRs is the extremely precise geographical location of the response peak, which also helps in the image geometric corrections and geocoding. Furthermore, three ARCs having RCS larger than 51 dBm2 with trigger and recording capabilities will be used. While they have better performances with respect to CRs for radiometric calibration and allow the recording of the ENVISAT azimuthal pattern, the intrinsic internal propagation delay affects the precise location of their response pattern on the SAR image. The envisaged calibration procedure will follow the assessed approach which compares the calibrator signal on the SAR image with a surrounding n x n pixels area centred around the CR peak and containing the side lobes in the azimuth and range directions. In this way, calibration constant, ISLR and PSLR, will be evaluated from the ENVISAT SAR images. This approach has been successfully tested in the previous SAR missions.

ACQUISITIONS OF THE COSE PROJECT IN THE PERSPECTIVE OF ENVISAT

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ABSTRACT

The EC project COSE, Compilation of atmospheric Observations in Support of Satellite Observations over Europe, has been running for two years since October 1998. A large portion of the ground-based observatories in Western Europe that contribute to the Network for Detection of Stratospheric Change (NDSC) has participated in COSE. The project aims, (i), at coordinating the remote sensing observations during major measurement campaigns, and (ii), at enhancing the value of ground-based networks for satellite validation purposes, in particular for ENVISAT validation. To achieve these goals, COSE has developed a relational database of European ground-based remote sensing data, and associated data documentation. The database index derives naturally from the adoption of a standardized data format, including the metadata that are necessary to identify the data sets unambiguously. The format and the metadata have been harmonised throughout the network, for the various techniques involved (lidar, microwave radiometry, UV-Visible and FTIR spectrometry, and ozone and aerosol sondes). In COSE, the CDF format has been implemented, but the adopted metadata standards can be transferred to any other standard data format, like the Envisat HDF format. The data documentation has been assembled in a data consolidation document that is available with the database. The document describes for each data type in the database the exact data content, the knowledge of which is indispensable for a correct use of the data for any comparison or validation purpose. This presentation will illustrate the major achievements of COSE regarding the data documentation, format harmonisation, and database.

GERMAN SCIAMACHY VALIDATION ACTIVITIES

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ABSTRACT

SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY) is a spectrometer designed to measure sunlight transmitted, reflected, and scattered by the Earth's atmosphere or surface. It is part of the payload of ESA's Envisat-1 satellite scheduled for launch in mid 2001. SCIAMACHY measurements will provide information about the atmospheric constituents O3, BrO, OClO, SO2, H2CO, NO, NO2, NO3, CO, CO2, CH4, H2O, N2O, and possibly ClO, as well as information about aerosol, pressure, temperature, radiation field, cloud cover, cloud top height, and surface reflectance. The objective of the SCIAMACHY validation is to determine the accuracy of both operational and scientific data products for all relevant atmospheric conditions. This will be achieved by comparison of the SCIAMACHY data products with temporally and spatially coincident measurements performed by independent instrumentation from various platforms. We present an overview of the planned German SCIAMACHY validation activities which include measurements performed from ground, aircraft, ship, balloon, and satellite.

SCIAMACHY POLARISATION SENSITIVITY AND IMPACT ON TRACE GAS RETRIEVAL

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ABSTRACT

In this paper we present an overview of the polarisation properties of the SCIAMACHY instrument. For currently used trace gas retrieval techniques, the polarisation sensitivity is an unwanted side-effect of the optical design which needs to be corrected for in the radiometric calibration. For the purpose of radiometric calibration, the instrument is capable of measuring both linear polarisation intensities (Q,U) of the Stokes vector at 850 nm, and one Stokes intensity (Q) at 5 other wavelengths between 350 nm and 2.4 micron; in the future it may be possible to use this additional polarisation information in height-resolved trace gas retrieval or in aerosol retrieval.

Several features of the polarisation sensitivity which have turned up during instrument calibration are highlighted; in particular the so-called polarisation phase shift which introduces strong features in the 315-400 nm channel.

A review is given of the mathematical description of the transfer of polarised light through the instrument, using the Mueller matrix formalism. This formalism is used in the in-flight calibration; the polarisation phase shift behaviour of the instrument is expressed in matrix elements which in an ideal instrument would be zero.

The measurement method for retrieval of atmospheric polarisation is reviewed, and error sources in the instrument calibration w.r.t. polarised light are identified. Finally, a discussion is given on the impact on trace gas retrieval, and on strategies how to minimise the influence of radiometric errors due to polarisation correction in the retrieval.

SCIAMACHY NOMINAL OPERATIONS AND SPECIAL FEATURES

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ABSTRACT

The Scanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY) is a contribution to the ENVISAT-1 satellite, which will be launched in mid 2001. The SCIAMACHY instrument is designed to measure sunlight transmitted, reflected and scattered by the Earth's atmosphere or surface simultaneously from the UV to the NIR spectral spectral region (240 - 2380 nm) in various viewing geometries, namely nadir, limb, and both solar and lunar occultation.

A realisation of these measurements modes requires a highly flexible concept both on instrument and mission planning side. This presentation describes the scientific, calibration, and monitoring measurements of SCIAMACHY during nominal operations and their implementation. This includes a description of nominal calibration and monitoring activities which have a direct impact on the operational data processing and thus on the quality of all data products.

Emphasis will be placed on the special features of SCIAMACHY which are especially important for data users in the calibration/validation context, among these the definition of spectral regions of interest with higher spatial resolution and the possible combination of limb and nadir measurements to derive tropospheric information for a large number of atmospheric constituents.

VALIDATION OF TRACE GAS MEASUREMENTS OF THE ENVISAT INSTRUMENTS MIPAS, GOMOS AND SCIAMACHY USING IN-SITU AND REMOTE SENSING BALLOON BORNE TECHNIQUES

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ABSTRACT

Coordinated campaigns for airborne observations of upper tropospheric and stratospheric species at high, middle, and tropical latitudes are planned to support the validation of ENVISAT level 2 products. Part of these activities will be covered by the ESABC (ENVISAT Airborne and Balloon Campaigns) project that is embedded in the ENVISAT core validation programme. Subsequent activities shall address the long-term aspect of validation.

This paper presents the planned activities of three German groups that have sound experience with scientific ballooning for several years (AO proposal ID 240). The related balloon borne measurements will provide vertical profiles of most of the target species of MIPAS, GOMOS and SCIAMACHY, such as O3, H2O, CH4, N2O, CFCs, NO2, HNO3, Halogen radicals, and complementary gases, as well as of T and p up to about 40 km. The combined use of the remote sensing MIPAS-B experiment and the multi-instrument payload TRIPLE with independent in-situ techniques (cryogenic whole air sampler, Lyman-alpha fluorescence hygrometer, ClO/BrO resonance fluorescence, O3 photometer) provide high data accuracy and precision for a critical test of ENVISAT data collection and retrieval procedures. The instruments use established techniques and have proven to provide reliable data in international intercomparison campaigns. Satellite validation experience has been achieved already in the framework of ILAS/ADEOS and UARS.

The measurement and validation strategy will be presented. Reference will be made to previous validation exercises and to instrument-instrument interconsistency checks. The validation strategy will rely on a careful planning of the balloon launch sites and times in order to minimise mismatches between satellite and correlative measurements. Residual mismatch issues shall be treated with the help of trajectory mapping and 3-D chemical transport modelling. Observation of nearly complete trace gas families and determination of correlations between long-lived trace gases further helps to increase the reliability of the comparisons.
The paper does not only cover the core validation phase but also addresses the long-term aspect of satellite instrument validation. A further important issue is that also correlative data sets of scientifically very important radicals and reservoir species will be obtained that are not foreseen for routine retrievals in the ENVISAT online processing software.

GEOPHYSICAL VALIDATION OF LEVEL-2 PRODUCTS OF MIPAS, GOMOS, AND SCIAMACHY BY DEDICATED CAMPAIGNS OF THE HIGH-ALTITUDE AIRCRAFT M-55 GEOPHYSICA

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ABSTRACT

The high-altitude aircraft Geophysica with a combined remote-sensing and in-situ payload will take part in the geophysical validation of level-2 products of the EDI's MIPAS and GOMOS and of the AOI SCIAMACHY. The payload is a coherent package of remote-sensing (MIPAS-STR and SAFIRE-A, MAL) and in-situ (HAGAR, FISH, ECOC, FOZAN, SIOUX) experiments that cover all level-2 chemical products of the EDI's. The measurements of the core payload and additional in-situ (HALOX) remote-sensing (GASCOD-A) instrumentation will also contribute to the validation of SCIAMACHY. Atmospheric models and data assimilation will be used for flight planning, for evaluation of data measured by the Geophysica payload, and for geophysical validation of Envisat products.

AN OPTIMIZED FORWARD MODEL AND RETRIEVAL SCHEME FOR MIPAS NEAR REAL TIME DATA PROCESSING

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ABSTRACT

The infrared emission limb sounder MIPAS (Michelson Interferometer for Passive Atmospheric Sounding) will be operated as an ESA core instrument on the ENVISAT-1 satellite. Near real time retrieval of pressure, temperature (p,T) and volume mixing ratio (VMR) of five key species (O3, H2O, N2O, CH4, and HNO3) from calibrated spectra will be performed in the Level 2 processor of the ENVISAT Payload Data Segment. An ESA supported study was carried-out for the development of an optimized (with respect to speed and accuracy) retrieval algorithm suitable for the implementation in MIPAS Level 2 processor. In the framework of this study, an optimized forward / retrieval code was implemented based on the global fit approach. In this approach all the spectra of a limb-scanning sequence are simultaneously fitted in order to correctly account for error correlations in the altitude domain. Besides, only spectral intervals which are sensitive to the retrieved parameters are analyzed by using a microwindow approach. This also minimizes interferences of spectral signatures from atmospheric species with unknown concentration. Finally, a sequential retrieval of the target species VMR profiles is performed. The trade-off between run time and accuracy of the retrieval was optimized from both the physical and mathematical point of view, with optimizations in the program structure, in the radiative transfer model and in the computation of the retrieval Jacobian. The attained performances of the retrieval code are: noise error on temperature < 2 K at all the altitudes covered by the typical MIPAS scan (8-53 km with 3 km resolution), noise error on tangent pressure < 3 , noise error on VMR of the target species < 5 at most of the altitudes covered by the standard MIPAS scan. The run-time required to perform p,T and VMR retrieval of the five MIPAS target species from a limb-scanning sequence of 16 limb-views is less than 1 minute on a modern work-station.

LAND COVER/LAND USE

MONITORING RAPID URBANISATION WITH IMAGING RADARS

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ABSTRACT

Up to date urban mapping and population data are required by policy makers, economists and planners in the developing world to ensure informed decision making. According to the UN, urban growth is highest in South Asia, Latin America and West Africa, where the proportion of people living in urban areas is expected to increase from less than 25 13625352n 1970 to more than 50by the year 2025. For many of these regions (particularly in the tropics) cloud and rain severely restrict the acquisition of optical remote sensing data. In these circumstances, imaging radars could provide a reliable and systematic monitoring capability.

The potential of SAR data to monitor rapid urbanisation in the context of a typical West African city is demonstrated using repeat-pass ERS SAR data acquired of Kumasi (Ghana) for the period December 1995 to February 1999. Verification of the method used is based on in situ observations and very high resolution airborne digital photography.

The results confirm the complexity of the relationship that exists between the radar cross section (RCS) and the built environment. The acquisition of additional data from the RADARSAT and SIR-C platforms is enabling the investigation of a unique imaging radar dataset of a typical urban environment in the developing world. Optimal sensor configurations for use in the built environment are addressed through the analysis of dominant backscattering mechanisms, identified from empirical observation and theoretical models. Future work is aimed at developing image processing techniques to maximise the available urban information content from multiparameter SAR datasets.

SYNERGY STUDY OF MULTISOURCE DATA FOR CHARACTERISATION AND MONITORING OF SOIL SURFACES. APPLICATION TO ALGIERS AND LAGHOUAT REGIONS (ALGERIA)

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ABSTRACT

With the availability of multisensor, multitemporal and multiresolution images data from operational Earth observation satellites, image data fusion has become a valuable approach to integrate multisources satellite data. It has been found that image data from different spectral domains (visible, near infrared, microwave) provides data sets with complementary information content and can be used to improve the spatial resolution of satellite images. This communication highlights advantages of using radar SAR data combined with multispectral data to improve characterisation and monitoring in two regions of Algeria. In effect, we present a number of pre-processing and processing techniques using radar SAR ERS-1 and Landsat TM data integration due to aspects of radar image enhancement techniques and the restitution of roughness of different types of urban and steppic regions. This communication presents satellite images analysis and interpretation methodologies using different multisources satellite data such as optical ones (Landsat TM, SPOT and Envisat Meris), SAR and ASAR radar data (ERS-1 and 2 and ENVISAT) investigating different combinations of integration and classification techniques. The methodology is applied for the characterisation and the monitoring of state surface of two different environments: one concerning an urban and coastal environment and the other concerns the semi arid environment of two regions of Algeria (Algiers and Laghouat) and we present two different kinds of problems which are: - The study of the management of the space of the Grand Algiers with all the problems of great town such as urban ones, agricultural and environmental ones. - The study of a change detection which has become a major application of remote sensing data and more particularly in the arid and semi-arid areas. The objective is to present results of degradation detection methodology with multidate remotely sensed data. Basic methods for visually land cover change in satellite imagery (optical and radar SAR) are employed in this study. These two regions are already studied and are always under study in our laboratory using optical (Landsat TM and SPOT) and SAR radar data (ERS-1) and we have to present the good results obtained with the support of the European Space Agency. The other goal of this communication is to present the project submitted and accepted at the « third Announcement of Opportunity for ERS Data (AO3) and the ENVISAT CAL/VAL Projects ». We have to do the research project for looking until which level the new data of ENVISAT satellite (optical Meris and ASAR radar data) could allow us a better interpretation of images both in urban (Algiers) and semi arid areas (Laghouat). Our wish is to achieve good results as objective as possible and for this goal the choice of parameters of the scenes is very important. Key words: Image processing, multisensor remote sensing, filtering, multiresolution analysis, Landsat TM, SPOT, ERS-1&2, ENVISAT, data fusion, radar interferometry.

APPLICATION OF ERS-SAR AND SCATTEROMETER TO THE STUDY OF BACKSCATTER ANISOTROPY IN URBAN AREAS

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ABSTRACT

ERS-SAR backscatter over natural land surfaces depends on parameters such as vegetation, foliage density, surface roughness at the Bragg-scale, and surface moisture content. Those parameters could be used to estimate the surface energy balance, and in particular the partition of the sensible and latent heat fluxes. Over urban areas, however, backscatter signal from surface parameters is at time obliterated or contaminated by dihedral and corner reflection effects over man-made targets. Series of ERS-SAR images, over Los Angeles, were used to look into this problem, and to extract high resolution masks of contaminated pixels. Since the study was inherently limited to a few discrete azimuth angles, we used ERS-SCAT and SeaWind on QuickScat, at a coarser scale and over a broader area, to determine the extent of contamination processes over a full range of azimuth angles. Results, over some regions of California, show how the seasonal cycle of backscatter progressively degrades as one shifts from rural to urban areas, and the spatial limits over which the data could be used to infer surface properties such as roughness and moisture availability. These limits were then applied to flag areas where SAR images are likely to be hopelessly contaminated.

UNDERSTANDING ERS COHERENCE OVER URBAN AREAS

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ABSTRACT

C band SAR interferometry has been shown to be a valuable instrument for land-cover studies, allowing the retrieval of properties of an imaged scene. For urban areas the relation between a target and its backscatter has been studied (Dousset, IGARSS'95; Gouinaud et al., Proc. Retrieval of Bio- and Geophysical Parameters from SAR Data for Land Applications, 1995). Concerning coherence, several studies have shown that it is a fundamental parameter for urban areas delimitation (Wegmuller, IGARSS'98 and Santoro, EUSAR2000). Nevertheless it has not been analyzed in depth what determines the decorrelation over an inhomogeneous land-cover such as the urban one and which parameters have influence on the level of coherence of man-made features (Usai, IEEE Geo 1999). In this work we want to get understanding of coherence behavior with different time acquisition intervals on urban areas. At first we focus on the InSAR image processing. The effect of using several coherence estimators and different window sizes is evaluated. We successively analyze in one coherence image values of point scatterers, infrastructures and large built-up areas in order to understand the dependence on InSAR system parameters and target properties. Finally we compare values over pairs acquired at different dates to determine the relevance of weather conditions during acquisition and to spot changes in an urban settlement (e. g. in residential areas). In order to have a global overview on different urban environments and structural typologies we consider urban areas, ranging from towns to cities, located in Sweden and Italy (and Greece). Imagery over the sites was acquired by ERS-1 and ERS-2 between 1995 and 1999. The SAR backscatter images together with in situ data (maps in digital and paper format, photos and local surveys) will be an aid in the investigation.

URBAN REMOTE SENSING THROUGH MULTISPECTRAL AND RADAR DATA

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ABSTRACT

The increasing need of data over urban areas, witnessed by the either technical literature and research projects, is strictly related to the ability to exploit all the possible sources of data that we have (or may have) at disposal. So, far, a very large number of sensors have been used for data collection, and the real challenge to be faced is the ability to combine the information we may extract from each data set in a significant way, in order to improve the overall knowledge of a site. So far, most of the analysis of satellite and aerial data over urban areas has been devoted to detect built areas or to separate different soil use classes, with no or little attention to exploit the available data sets near their resolution limits, looking for single (large) structures or blocks. Reasons are the different resolution available for multispectral and radar data (both interesting for this kind of application, but only if jointly considered), and the necessity to use pattern recognition procedures, more usual to machine vision than to remote sensing community, to exploit as much as possible the data resolution and information. In this paper we want to provide a framework for analyzing urban areas using 5 meter horizontal resolution AIRSAR data jointly considering hyperspectral data provided by the AVIRIS sensor at a 20 meter ground resolution. The approach is based on the enhancement of AVIRIS data with very simple yet powerful machine vision approaches to match the radar data resolution, and a coupled analysis of the SAR and hyperspectral data. First, the supervised classification of AVIRIS images provides a map useful to discard uninteresting areas. Then, higher resolution SAR classification is used to improve street, object or block detection. Finally, the refined mask (that maintains information on the membership of each pixel to a given class) is used to extract higher-level objects, using pattern recognition techniques. This is the case, for instance, of linear and curvilinear roads, obtained by grouping pixels recognized as belonging to the "street" class.

APPLICATION OF EO DATA FOR URBAN PLANNING IN MEGA CITIES

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ABSTRACT
The global phenomenon of urbanisation we witness today requires new concepts and strategies for the management of this urban world" - especially for the largest human agglomerations, where all the specific problems of this century's development appear most obviously Mega Cities.

The effects of urbanisation are not the same world wide, but differ regionally. Whereas the situation in the industrialised countries of the First and Second World is also challenging, but still under control, we have to face the fact, that the situation in the mega cities of the Third and Fourth World is escalating and in many cases out of control.

Urbanisation results not only in effects of urbanisation affecting the urban agglomerations theirselves as well as the environment which can reach a disastrous extent, but also natural disasters affect urban agglomerations to a growing extent. During the last decade the impact of natural and man made disasters on urban agglomerations resulted in a steadyly growing loss of lives and negative economic impact on the regions and nations affected by disasters, endangering sustainable development. Therefore the urban agglomerations of the 21st century require new concepts and strategies for the management of this urban world". The only tool which can be applied to regain control of Mega City development and to produce adequate planning material are spaceborne remote sensing data. Within URBAN21 project examples for town development monitoring from Chongqing (China), Buenos Aires (Argentina), New Dehli (India), Pretoria / Johannesburg (South Africa) and Mexico City by using Landsat TM, IRS, SPOT, Corona and ERS satellite data were developed and the potential of satellite data as a basis for planning and decision making in mega citieswas evaluated.

INFERRING BUILDING HEIGHT FROM SAR INTERFEROMETRIC PHASE COHERENCE IMAGES

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ABSTRACT

Three-dimensional models of urban structures can provide valuable information for planning, land use classification and modelling aerosol turbulence within cities. In this paper we present a technique for deriving building height from SAR interferometric phase coherence images. Permanent scatterers, such as buildings and other man-made structures, exhibit high coherence even between long time interval (years) SAR images. Therefore the most dominant source of interferometric phase decorrelation in these stable areas is geometric decorrelation (assuming that thermal noise and atmospheric decorrelation is negligible).

In practice, deriving building height directly from an interferometric DEM (digital elevation model) is very difficult since the phase signal rarely arises from scattering from individual buildings. Another way is to investigate the relative effect that building height has on decorrelation between image pairs with differing baselines. When the common band filter is applied, coherence is retained, even for large spatial baselines, provided that the surface is smooth, but for rough terrain and elevated features this does not hold. Thus for built-up areas, coherence drops off more rapidly with increasing baseline than for non-vegetated smooth surfaces, (e.g. car parks).

In this study, 67 co-registered coherence images of the city of Cardiff, UK were generated from subsets of 22 ERS scenes. The mean coherence for small windows covering the city, corresponding to different land covers, was calculated for all coherence pairs. By taking the gradient of the best fit line through a plot of mean coherence versus spatial baseline for a given stable area (window) it was possible to obtain a measure of surface roughness. Preliminary results show that the city centre exhibits the characteristics of a rougher surface (steeper gradient) while suburban residential areas are represented as a smoother surface. This is to be expected since the city centre contains a high concentration of large buildings. Hence it is possible to differentiate between high rise and low rise districts using multiple coherence images.

EVALUATION OF MULTISENSOR SPACEBORNE SAR FOR CORINE LAND COVER MAPPING IN SWEDEN

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ABSTRACT

Land use and land cover information is an important element in forming policies regarding economic, demographic and environmental issues at national, regional, and global levels. As part of European Community's COoRdination of INformation on the ENvironment (CORINE) program, Swedish national land cover mapping is being conducted using Landsat TM imagery and ancillary data. Due to Sweden's high-latitude and frequent cloud-cover, there is a need for a remote sensing system that can provide reliable imaging in all-weather and solar-illumination conditions. Thus, synthetic aperture radar (SAR) is an attractive data source for land cover mapping in Sweden.

The objective of this study is to evaluate spaceborne multisensor SAR data for land cover mapping in a Swedish environment. During the vegetation season of 1998, multitemporal ERS-2 SAR data (eight scenes), multi-resolution, multi-incidence-angle RADARSAT SAR data (fine-beam: one scene and standard-beam: two scenes), and multitemporal JERS-1 SAR data (four scenes) were acquired over an agricultural and forestry area in southern Sweden. Extensive ground data were also collected during the satellite overpasses.

Image processing of this study includes filtering using a statistical adaptive speckle filter, textural analysis using a grey level co-occurrence matrix, and multisensor data fusion. For image classifications, a sequential-masking classification are being applied to multitemporal ERS-2 and JERS-1 SAR data, and a neural network classification will be performed to the multisensor data.

The preliminary results show that fine-beam RADARSAT SAR data performs well for detailed land cover mapping, while a single scene, medium-resolution ERS-2 SAR, JERS-1 SAR or standard-beam RADARSAT SAR can only be used to defined broad land cover classes. The synergy of multitemporal ERS-2 SAR, JERS-1 SAR and multi-resolution, multi-incidence-angle standard-beam RADARSAT SAR has the potential to meet the CORINE land cover mapping requirements.

SAR INTERFEROMETRIC DEM CONSTRUCTION FOR LANDSCAPE PROCESS ANALYSES IN NORTH-EASTERN ICELAND

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ABSTRACT

The area north of Vatnajökull ice sheet in Iceland is severely eroded, consisting mostly of barren sand, gravel and lava surfaces. At the edges of this region, advancing fronts of wind-blown sediment destroy vegetation cover, hence threatening the surrounding pasture lands and human settlements.

The environmental parameters that sustain the erosion are poorly understood, but are believed include deforestation and overgrazing. In this remote area, however, also frequent volcanic eruptions and glacial floods serve as a potential land degradation mechanism. The rationale of this study is 1) to map the land cover with the aid of ERS-SAR and TM data (relative age, sedimentary deposits and processes and lava types, vegetation, hydrology etc), and 2) to map ancient catastrophic flood routes and potential future flood routes with SAR interferometry derived DEM.

Image selection for InSAR proved to be a difficult problem. Based on earlier experience in Finland it was believed that the seasonal snow cover would serve as a smoothing component on the ground and that the leafless vegetation layer would improve the coherence between tandem acquisitions. Severe problems, however, were encountered in the interferometric coherence with the winter images despite the fact that image selection was undertaken carefully using the available meteorological data. We believe the problems arise due to large altitudinal variation in the area plus highly maritime climate, which jointly induce wide temperature regime, uneven snow cover and varied surface moisture during winter.

Based on this unexpected experience, late summer images were experimented with instead. These proved to be better suited for InSAR in the Icelandic conditions, exhibiting satisfactory coherence and enabling DEM construction. This example indicates that further experience will be needed from variable study areas displaying different surface roughness parameters, climatic conditions and vegetation cover to improve the understanding of best suited data for InSAR. Especially in commercial applications (paid by the customer) there may be very limited possibility to experiment with a large number of images for best coherence. The DEM has now been completed and further studies are currently undertaken, including GIS analyses and data combination.

OPTIMAL USE OF MULTI-TEMPORAL SAR DATA FOR LAND USE INFORMATION EXTRACTION

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ABSTRACT

This paper presents the synthesis of the work conducted in the frame of the third "Announcement of Opportunities" AO3-405 project for ESA/ESRIN.

In the first part, we focused our work on the development of tools to extract temporal information from images. We used various image processing algorithms like filtering and/or segmentation to enhance the statistical accuracy of some features in order to give indication of the type of terrain (variation of radiometry and coherence). We also tested the contribution of multi-temporal data, contextual methods of classification with and without filtering and textural neo-channels for land cover discrimination.

Two test sites are used to perform the analysis: The Grand Morin, located in the south-east of Paris is an agricultural area. The data set is composed of 8 Single Look Complex images, both from ERS-1 and ERS-2, two pairs are acquired in the tandem mode. This site is interesting for thematic applications. The Minorca island whose temporal data set is composed of 12 images, one pair is acquired in ERS1/2 tandem mode. This site is a Mediterranean landscape and a biosphere reserve, it allows us to validate our algorithms in a more hilly terrain. In a second step, we study the influence of topography in the classification process. From one hand, due to the side looking characteristic of the system, Synthetic Aperture Radar (SAR) images show very important changes of the local mean intensity, especially in mountainous areas. In order to calibrate the data, the local incidence angle and the backscattering area have to be known. A method, based on SAR image localization and simulation taking into account the Digital Elevation Model (DEM) and the SAR acquisition geometry has been developed to estimate the local incidence angle. On the other hand, an a priori knowledge of the possible existence of vegetation classes according to the altitude can be introduced by means of DEM information. Futhermore, we have studied if a DEM generated by interferometric technique with an ERS tandem pair allows to increase classification rates. Comparison has been done with DEM obtained with non-radar data to evaluate the advantages and limitations of interferometry for classification purpose.

The preliminary results confirmed the importance of taking into account the topography in land cover classification.

USE OF ERS SAR IMAGERY IN REFUGEE RELIEF

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ABSTRACT

During the last years, the world has seen many disasters in which a large amount of people has died due to limited efficiency of relief-operations, e.g. in Ethiopia, Rwanda and the Sudan. Refugee camps are often established on the shelf, where the refugees have gathered. Such locations might not be ideal, neither for shelter nor for the surrounding environment, which might not be able to provide e.g. firewood and water for the suffering people over a longer period of time. The average refugee camp lasts for seven years, though there are those that last much longer. Geographic information is in general a key factor in decision-making processes during humanitarian relief-operations. Most operations can be divided into three phases, i.e. emergency, relief, and repatriation, each with varying needs for geographic information. Further, more and more governments hosting refugee camps wish to measure any possible longer-term environmental impacts caused by the refugee settlements. The aim of the European Commission share-cost project ENVIREF (www.enviref.org) is to demonstrate the pre-operational use of satellite remote sensing techniques for more efficient and cost-effective planning and management of refugee camps during their various stages, with special emphasis on environmental issues. War-affected countries having people on the run are often also exposed to a significant haze and cloud coverage, and as geographic data are needed rapidly satellite SAR imagery is an interesting data source. ERS SAR data are evaluated for its usefulness to map environmental changes that can be related to refugee settlements, and compared with similar analysis using optical images, e.g. Landsat ETM+. Examples from both the resent rather short Kosovo conflict and several longer lasting settlements in the Eastern Nepal show that the settlements can be detected, and changes mapped using ERS SAR.

EXAMPLES OF SAR ERS IMAGES FOR DEVELOPMENT STUDIES AND UP-DATING EXISTING MAPPING IN AMAZONIAN AREA (PROJECTS ERS AO3-160 FRENCH GUYANA AND ENVISAT AO 539)

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ABSTRACT

The available radar SAR images data base on French Guyana and its surroundings area especially in Brasil (Amapa, Rondonia, Roreima) lead us to study different applications within the development domain such as deforestation, growth of urban areas, and up dating of pre-existing mapping. We will present herein the following examples :-Impact of the highway N°1 (National road) on its environment (collaboration with the French Guyana Departemental direction of the equipment - DDE) ;-Deforestation evolution due to agricultural techniques such as bush fire ;-Monitoring of the growth of urban areas such as Macapa ;-Up-dating of the marine cartography at 1 :50000 scale (collaboration with the French SHOM, French Hydrographic and Oceanographic Marine Survey).

The major interest of ERS radar mosaic images is linked to the possibility of incrementation of existing geographic data base especially in wet season and due to the simplicity of the georeferencement without existing relief. The 1 :50.000 working scale selected by the French SHOM to up-date the French Guyana shoreline as well as the spatiocartes prototype in estuarian areas shows that ERS radar images maybe with a better ground resolution in a shoreline environment for mapping up-dating than to realise spatiocartes in classical onshore areas. Thus approach highlights the importance of ERS radar images for coastal studies.

EVOLUTION OF THE HYDROGRAPHICAL NETWORK OF THE KARAKUM DESERT AND ENVIRONMENTAL IMPLICATIONS FOR THE ARAL SEA

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ABSTRACT

The Amu Darya, which represents the biggest river of Central Asia, have carried melt waters from the Pamirs to the Caspian Sea for at least 6 Ma and to the Aral Sea for the last 150000 years. Recent geomorphologic and archaeological studies have recognised old river traces across western Karakum suggesting that drastic environmental changes have occurred in Central Asia over the last 2500 years. Preliminary field, DTM, Landsat TM and SPOT data suggest that the northward migration of the Amu Darya River and resultant expansion of the Karakum desert coincided with the uplift of the central E-W high produced by the Iran - Asia convergence. They do not however, provide detailed information for the hydrographic network. High resolution SAR-ERS images have been used for the extraction of linear structures such as active or fossil drainage patterns, valleys and interdune corridors. We have first carried out the speckle reduction because of the absence of zones with spatially uniform reflectivity on these images. In this case, the classical methods for automatic extraction of morphological features do not provide satisfactory results. The effects of several filters for speckle reduction have been tested and a new filtering method based on connected filters have been established. The ERS scenes of the western Karakum desert, have been subsequently processed and traces of ancient river beds have been found. The distribution of this drainage pattern has also been compared to the topographic data. From the ERS, the topographic and field data we have established a new scenario for the evolution of the hydrographic networks, the migration of the Amu Daria River, South of the Aral Basin, during the Late Quaternary which has resulted from the tectonic evolution of this region and that is responsible for the processes of desertification.

VEGETATION/AGRICULTURE

GLOBAL SCALE MONITORING OF SOIL AND VEGETATION WITH ERS WIND SCATTEROMETER AND SSM/I

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ABSTRACT

Monitoring of global bio-geophysical processes and their changes due to human activities and natural causes, is of vital importance for the earth system research. Microwave remote sensing can play a very significant role in the scientific understanding of the entire earth system. This paper aims at evaluating the capabilities of SSM/I data in monitoring land surface features and global changes in sinergy with ERS Wind Scatterometer. Investigations with SSM/I data have shown that significant changes in microwave features can be correlated to the land surface characteristics. A few examples are the following: The polarization index of microwave emission measured on an agricultural region (Po valley, Italy) changes during the year according to the vegetation cycle. The frequency spectrum, measured in the fall and spring on a Russian forest, is flat at both frequencies as is typical for dense vegetated areas; on the contrary, the spectrum shows a negative index in January, indicating the presence of snow. On this area the polarization index is small but not negligible as for the dense Equatorial Jungle. The brightness temperature measured in summer on the short grass of Tundra slightly increases with frequency, as typical for moderately vegetated areas, and the polarization index is quite low. On the other hand, in April, this area has the typical spectral trend of a snow cover.

A more detailed analysis with multi-temporal scatterometric data has allowed a significant improvement in the knowledge of the studied land surface features. The geophysical parameters of the areas have been extracted from microwave data through appropriate algorithms based on physical and semi-empirical models. In particular, vegetation biomass has been estimated from the backscattering coefficient at C-band and the polarization index of emitted radiation at 19 and 37 GHz, soil moisture from scatterometric C-band data and snow cover from multifrequency SSM/I brightness temperature.

INTERPRETATION OF ERS WSC TIME SERIES OVER SAHEL DURING THE PERIOD 1991-1999

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ABSTRACT

Despite their coarse spatial resolution, ERS wind-scatterometers (WSCs) have shown strong potential for terrestrial applications. Particularly, over arid regions, there is a strong sensitivity of ERS WSC response to changes in surface parameters, namely vegetation density and soil moisture content. Considering that the two main contributors to the radar signal are the amount of living vegetation and the soil moisture content, some attempts have recently been performed aimed at estimating these surface parameters (Magagi and Kerr, 1997; Frison et al, 1998; Wagner and Scipal, 2000; Woodhouse and Hoekman, 2000). However, retrieving surface characteristics from ERS time series is not an easy task since contributions from the soil and vegetation components remain difficult to deconvoluate. Presently, although a better understanding of the so temporal plots has been recently gained, there is still a need for a better assessment of the actual potentialities of WSC data for semi-arid land monitoring.

Within this context, the present study is an extension of a previous work (Frison et al, 1998) to a wider range of eco-climatic conditions within the Sahel, starting from the Northern edge to the Southern one. To this end, we have selected different sites located along a North-South gradient in the Sahel. It is assumed that these sites capture the main characteristics of the sandy sahelian zone. The so temporal plots are analysed with the assistance of a theoretical backscattering model. Afterwards, a new inversion method is used to retrieve temporal evolution of the herbaceous vegetation biomass and the soil volumetric water content. Retrieved surface parameters are compared to ground data. Finally, interannual variation of vegetation cover over Sahel are shown.

RELATING ERS SCATTEROMETER DATA TO GLOBAL VEGETATION MODELS

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ABSTRACT

Large-scale studies of vegetation dynamics could benefit greatly from a frequent source of satellite observations acquired at a global scale. ERS scatterometer (WSC) measurements seem to provide an ideal source of data for such a task because of their good coverage in a relatively short time. This paper examines the ways in which WSC data can be used to support global dynamic vegetation modelling, and issues concerning the required data analysis. The seasonal backscatter changes of a range of vegetation types are examined and related to the vegetation biophysical properties and weather patterns. Moreover, backscattering coefficient, s0, patterns are compared to the vigour of vegetation as indicated by its Leaf Area Index (LAI) which is based on the SDGVM model (a global vegetation model). Initial comparisons indicate good agreement between WSC data and annually averaged LAI estimations; ultimately this may allow us to validate the SDGVM model. An important issue in relating the data to the model is the fact that ERS scatterometer data must be referenced to the regular geographic grid of the model. Transforming the data into a geo-referenced grid involves averaging the data, which may conceal systematic variability in s0 in time, space and across incidence angle. Therefore, the relative magnitudes of the different variability components are evaluated with the problems involved discussed. These variability components, which are defined at each gridpoint, can be used as a measure of the representativity of the average s0 and also for monitoring land cover changes. Of them the most useful appears to be the coefficient of variation after a model-based correction for incidence angle effects. In general, images of variability indicate that for about 7565641510f the land surface the mean s0 images can be considered representative. However, some cover types display continual, significant variability on short timescales, particularly grasslands and sandy deserts. The former are important components of the model, and this variability may hinder the interpretation of the WSC signal. We also consider the issues involved in using the WSC data to provide snow cover and the freeze/thaw information, both of which are as important biophysical switches and affect model predictions.

TREE SHAPE DESCRIPTION FOR BACKSCATTERING MODELLING OF LAI

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ABSTRACT

The relationship between the backscattering properties of a forest and the leaf area index (LAI) values is studied in the ENVISAT AO-project "ENVISAT in boreal forest mapping and LAI estimation" (=ENBOR FORMAL). The first results of the three years long project concern the tree shape characterisation from the point of view of LAI. Several radiative techniques have been developed for inverse estimation of LAI using optical data measured below the canopy (e.g., hemispherical photography) or above the canopy (remote sensing). In the inversion, a model of the three-dimensional (3D) distribution of leaves in the canopy is used to define the required relation between LAI and canopy transmittance and reflectance. However, due to limited information (data), rather simplified models (e.g., uniform leaf area distribution) have commonly been used, which has lead to erroneous estimates of LAI especially in structurally heterogeneous forests. The 3D distribution of leaf area in a forest stand is formed by the spatial distribution of trees, and the amount and distribution of leaf area within individual trees. For a realistic description of forest canopy structure, therefore, we need information (submodels) of the LAI, and crown size and shape, at the tree level. For this purpose the 3D co-ordinates of the outermost surface points of Scots pine and Norway spruce trees were measured using a laser profilometer and video camera. The trees were felled and put in a rotating holder. A vertical laser line was scanning the surface while the tree rotated. At the same time the video camera was viewing the tree from a suitable angle, so that it recorded laser light profiles of the tree surface. Each video frame contained points of one vertical cross section. By combining frames of a whole circle the whole outermost surface was obtained. The number of 3D points was 1 - 10 millions per tree. These points were used as a basis for constructing 3D-models for the trees. The models were based on a series expansion of spheroidal harmonics. The difference between trees is revealed by the coefficients of the components of the series. Already at low orders the basic difference of a spruce and a pine showed up.

ERS DATA USE FOR WIDE-AREA SAMPLING OF AGRICULTURAL AREAS: IMAGE LOGIC FOR CEREAL MONITORING.

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ABSTRACT

Results from the investigation into and the development of a methodology allowing for the optimum monitoring of cereals with a SAR driven methodology are presented. This work has been undertaken in the framework of project defined under ESA's third announcement of opportunity. The main emphasis being the migration of this methodology to large, or wide, scale monitoring.

Only three areas of investigation from this project are presented here. These areas are error propagation, the use of pre-cursive crop information layers in combination with simple image logic techniques, and finally we look at one potential future for the direct application of this methodology.

In the quantification of errors and their propagation throughout the processing and classification methodology, we have included the use of simple image simulation techniques to model radiometric separation of class signatures and their effect on classification accuracy and derived crop area statistics. We demonstrate that the magnitude of the overall errors in the methodology can be in the same order of magnitude as the inter-annual crop area change, depending on the characteristics of the selected time series and ancillary data.

Rather than the production of classified images for inclusion in an area estimation scheme, we focus on the production of pre-cursive crop information layers from raster(ised) data sets. A pre-cursive crop information layer uses a-priori knowledge to assign labels to a (group of) pixel(s) stating the in- or exclusivity of a certain crop type, based on the acquired data. An example of an inclusive label is "is cereal", one for an exclusive label is "is not grassland". In some cases, exclusivity automatically follows from inclusivity (i.e. in a spring image "is rough bare soil" is "not winter cereal"). Labeling is also accompanied by a measure of uncertainty that determines the weight of the individual labels in the final decision on crop class assignment. Crop class assignment is then determined by the use of simple user defined logical rules.

Finally we show how this methodology can be used to focus and direct ground data collection in areas where high levels of confusion exist in the crop class assignment.

CAESAR CROP AREA ESTIMATION USING SAR IMAGES

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ABSTRACT

Estimation of cultivated areas and their production using traditional methods (field surveys) is a difficult task, which can hardly be performed with the necessary frequency, either at regional or national level, to monitor crops during the whole phenologic cycle.

Hence it can be concluded that a thorough and efficient control of fields during the whole natural cycle is of capital importance for a correct evaluation and management of the needs of the Agricultural Sector.

The use of series of SAR images obtained from the European satellite ERS-2 (every 35 days) and field data indexes (roughness, humidity, vegetation cover, etc.) allows the monitoring of growing fields and the estimation of crops surfaces.

Based on the observation of field preparation techniques during previous months and, thanks to the capability of SAR images to detect changes in soil roughness, prediction mapping of crop areas of the next season will be done and early crop surface estimation will be obtained.

CROPS CLASSIFICATION IN SOUTHERN SWEDEN WITH MULTITEMPORAL ERS-2 SAR DATA

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ABSTRACT

This research work is a part of EU project - Applied Remote Sensing and GIS Integration for Model Parameterization (ARSGISIP). The purpose is to provide input data and update existing land-use information with remote sensing technique for hydrological models. Radar satellites overcome the problem of cloud cover. Synthetic aperture radar (SAR) could be used for routine monitoring agriculture area yearly. This motivates investigating the potential value of SAR data in remote sensing of terrestrial environments.

Fifteen land-cover classes in southern Swedish agriculture area were analyzed and classified using multitemporal ERS-2 SAR PRI images acquired in 1998 and 1999. Different filters, for example, EPOS (edge preserving optimized speckle filter), Frost and Lee, were used and compared for reducing speckle from SAR image data. A number of filter size and other parameter(e.g. probability for choosing homogeneous regions in EPOS filter) were tested for each selected filter. Standard maximum likelihood classification, maximum likelihood classification with spectral subclasses based on clustering and sequential maximum a posteriori estimation (SMAP) was applied and their performance evaluated. Classification images for raw data, filtered data and logarithm transformed data were produced. Classification accuracy evaluation results indicated that the SMAP algorithm outperformed the maximum likelihood algorithm. The highest average classification accuracy was achieved when EPOS filter with 17 by 17 filter size and P=0.9 was used. Results also show that general land-use classifications can be performed with multitemporal radar data. But detailed subdivision of agriculture areas into different crops requires multitemporal data at critical periods of the crop cycle.

LAND-USE MAPPING USING AIRBORNE POLARIMETRIC SAR

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ABSTRACT

The multipolarization capabilities of ENVISAT are especially important for vegetation classification, and results simulating the performance of the ENVISAT ASAR have been obtained using an airborne polarimetric SAR system. The Danish Center for Remote Sensing (DCRS) is, in collaboration with the Danish mapping agency, conducting a study on topographic mapping using SAR data, and land cover mapping results will be presented. The Danish EMISAR system (an L- and C-band, fully polarimetric, airborne SAR) have in 1994 to 1999 during the growing season acquired a lot of data over a Danish agricultural site. The data acquisitions were co-ordinated with ground surveys to obtain a detailed land cover map. The test area contains a large number of different land cover classes, such as more than 10 different crop types, deciduous and coniferous forest types, wetlands, lakes, and urban areas.

EMISAR data from primarily the 1998 campaign have been used to analyze the potential of various combinations of parameters and acquisitions for land cover mapping. The data set includes combinations of the individual backscatter coefficients, i.e. HH, VV, and HV polarizations, acquired both at the two frequencies and at different times, simulating spaceborne SAR systems, such as ENVISAT. In addition, the data set also includes combinations of the full polarimetric information in terms of the covariance matrix, where the Wishard probability density function has been used for the discrimination function. The data used in the evaluation have been filtered by an advanced polarimetric speckle filter. Land cover classification results for a large number of different combinations of acquisitions and parameters will be shown.

AMAZONIA BIO-DIVERSITY ESTIMATION USING REMOTE SENSING AND INDIGENOUS TAXONOMY

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ABSTRACT

Measuring and monitoring global bio-diversity is a priority for safeguarding life on Earth. Philogenetic and taxonomic measures are the best estimators of biodiversity, however practical considerations impose the use surrogate measures. Remote sensing can provide surrogates: richness of classes of terrain, landscape, habitat and vegetation. Higher taxon richness (using genera or families) is also a useful surrogate for species richness. This allows the use of indigenous taxonomy and thus the employment of local inhabitants available at much lower costs than university scientists. Remotely sensed landscape structure and higher taxon richness can be compared to the two canonic layers of data used for the estimation of bio-diversity by USGS GAP.

Remotely Sensed Landscape Structure.
Region: Xixuau-Xiparina Nature Reserve and Lower Rio Jauperi Basin (61W-0S, 62W2S). The unexplored, pristine rainforest harbours a rich wildlife including several threatened mammal species.

Satellite Time Series Imagery
ASAR, MERIS, LANDSAT TM. GIS Tools : GRASS , FRAGSTATS.
Radiometric calibration of imagery to produce surface reflectance values whenever required Unsupervised multi-spectral multi-temporal image clustering and classification Transformed Vegetative Index and other spectral ratios Fragstats Landscape Metrics and other indices. Taxon Richness using indigenous taxonomy.

A preliminary higher taxon survey will be performed with the help of local inhabitants using indigenous taxonomy and with results precisely GPS localised. During this survey GPS localisation of indigenous toponyms will be made to furnish the framework for subsequent surveys made without the use of GPS.

Results Test.
Next year the Zoological Museum-University of Copenhagen will perform a full-scale mammal diversity survey in the Xixuaú-Xiparina. The results of this survey, and others in preparation (Perugia and Milano Universities), will test the estimation of biodiversity using remotely sensed landscape structure and indigenous taxon richness. All the data collected in the surveys will be inserted in the GIS database and a Java implementation of the GIS will be available on Internet. The participation of the Universities of Amazonas, Roraima, Rio de Janeiro, INPA, INPE and CABS is also expected.

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HYDROLOGY 1/2

COMPARISON ERS SAR DATA DERIVED SOIL MOISTURE DISTRIBUTIONS WITH SVAT-MODEL RESULTS

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ABSTRACT

Soil moisture plays a key role in hydrological, meteorological, and agricultural land surface processes. The moisture content of the soil influences the amount of evapotranspiration, surface runoff, infiltration, percolation to the ground water table and indirectly the development of vegetation. Latent and sensible heat fluxes associated with evapotranspiration provide energy for climate dynamics. For modeling the hydrological cycle the knowledge of both spatial distribution and temporal dynamics of soil moisture is crucial but also complicated due to the high spatial and temporal variability. To compare results of a spatial soil moisture model with remotely sensed soil-moisture distributions the Ammer watershed in the Bavarian Alpine Forelands (A = 1200 km², elevation difference = 1200 m) was chosen.

To convert the radar backscatter coefficient into dielectric constants additional geographical information (vegetation cover, biomass, soil type, terrain height, slope) are used within a semi-empirical RADAR-backscatter model to eliminate all non-soil-moisture contributions to the ERS backscattering signal in the test site. The corrected backscatter values of annual crops and grasslands are then converted into spatial distributions of top-soil-moisture content.

Spatial models of soil-vegetation-atmosphere-(SVAT)-processes are capable to model the spatial distribution of the soil-water-balance with a spatial resolution comparable to ERS-AMI. The spatial SVAT-model PROMET (Process Oriented Multiscale EvapoTranspiration, developed by the authors) is used to calculate a series of top soil moisture maps of the test site for 13 ERS overflights of 1995 and 1996. PROMET considers meteorology, plant development, soil types and relief and uses a multi-layer soil water balance model. Intensive ground measurements of soil water content were used together with the top-soil-moisture distributions extracted from ERS-1 to validate the modeled soil-moisture distributions. The overall correspondence between the measured and modeled soil-moisture distributions are good. Procedures to integrate the measured soil-moisture distributions from ERS into PROMET with the aim to improve model accuracy are discussed

COMPARISONS OF DETAILED IN-SITU SOIL MOISTURE AND RAIN MEASUREMENTS WITH ERS RADAR BACKSCATTERING DATA

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ABSTRACT

It has been recognised in the recent years that very often good quality in-situ data were lacking in order to model and retrieve quantitatively bio- or geo-physical information from remote sensing data. For instance, a lot of effort has been dedicated to study the relationship between the top surface soil moisture and its effect on the radar backscattering coefficient but very often reliable data were missing to check the models or inversion algorithms developed.

For the case of C-band radar data acquired by ERS over bare soils, the radar signal measured by the satellite is sensitive to the soil moisture (via the change of the soil dielectric permittivity) and the roughness of the soil. Taking advantage of the presence of the ESA transponders on the Flevoland test site, four automatic soil moisture stations have been spread out trough a nearby agricultural area. Soil moisture is collected every minute at two different depths (5 and 10cm) while rain precipitation is gathered at the same sampling time interval by rain gauges. To check the quality of the radar data, ERS SAR acquisitions are performed regularly by ESA during either the descending (once every cycle) or ascending (once every other cycle) orbits, i.e. three measurements per seventy-day period.

Both in-situ data as well as the radar measurements are incorporated in a database and a detailed analysis can be performed. In this paper, the variations of the backscattering coefficient due to soil moisture changes will be shown as well as the effect of rain precipitation's on the soil moisture at different depths. Using some limited information on the surface roughness, it will be shown how the radar signal can be modelled.

APPLYING SURFACE ROUGHNESS DISCRIMINATOR BASED ON PARTIALLY POLARISED SAR DATA TO SOIL MOISTURE INVERSION

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ABSTRACT

The effect of soil roughness represents a greatly complicating factor in SAR-data based soil moisture retrieval applications, since the dynamic range of sigma naught associated with variations in surface roughness conditions is often comparable or indeed larger than that due to soil moisture variability. Thus generalised soil moisture retrieval algorithms applicable to all roughness conditions require both independent information on the soil roughness conditions as well as accurate estimates of the contribution the surface roughness conditions to the soil moisture - sigma naught relationship. At the same time surface roughness is itself an important information required in different applications such as agronomy, geology and risk.

In this paper the problem of estimating roughness conditions using partially polarimetric data and integrating this information into a generalised soil moisture retrieval strategy is addressed. The context for the study is provided by the forthcoming ENVISAT mission whose ASAR imaging instrument will provide multi-polarisation HH, VV and HV data.

As a final step the "new" surface roughness indicator is integrated into a soil moisture inversion strategy, which consists in first segmenting the SAR image into rough and smooth bare soil surfaces and then estimating separately the soil moisture for the rough and smooth fields using an inversion algorithm adapted to each roughness category. The results of this approach are assessed over the sites of Matera (Italy) and Oberpfaffenhofen (Germany) using SIR-C/X-SAR data and the implications for ENVISAT discussed.

GENERALISED INVERSION ALGORITHM FOR BARE SOIL MOISTURE MAPPING USING ERS SAR DATA

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ABSTRACT

The sensitivity of radar backscatter to surface soil moisture conditions has lead to a considerable interest in exploiting data collected by current spaceborne radar imaging satellites, such as ERS-2, or future satellites, such as ENVISAT, for the retrieval of soil moisture information and the generation of soil moisture maps at various scales. From an applications perspective, however, there are few generalised soil moisture retrieval algorithms available for ERS SAR data which can be applied to a large variety of situations. This is due in large part to the difficulty in quantifying the confounding influence of soil roughness on soil moisture - radar backscatter relation and well as insufficient data on the roughness characteristics of natural and agricultural surfaces.

The aim of this paper is to present the possibilities for ERS-data based soil moisture inversion from an applications perspective. We make use of a large pan-European database of roughness measurements to derive a generalised inversion algorithm applicable to relatively smooth surfaces such as harrowed or sown agricultural fields. The inversion algorithm is based on the idea of selecting the soil moisture having the highest probability of being associated with the observed backscatter levels. An advantage of this algorithm is that it can be used to assess the achievable accuracy and the intrinsic limitations of the inversion process. The algorithm is validated using a extensive multi-site data set spanning a diversity of conditions in both Europe and Asia and the accuracy of the retrieved soil moisture estimates discussed and compared to the expected accuracies based on model simulations. Finally the retrieval algorithm is used within the context of a specific application; in this case the mapping of post-harvest soil moisture for a terraced rice ecosystem in north-eastern Thailand. The retrieval algorithm is used here to identify regions within the ecosystem suitable for a second crop following the rice harvest, and the results of the inversion process discussed in detail.

INFERRING THE EFFECT OF PLANT AND SOIL VARIABLES OF C AND L BACKSCATTER OVER AGRICULTURE FIELDS BASED ON MODELING ANALYSIS

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ABSTRACT

The goal of the study was to apply and modify the semiempirical water-cloud model to simulate backscattering coefficients of C-VV and L-HH as a function of LAI, vegetation water content and soil moisture. Backscattering coefficients were compared to these obtained from ERS-2.SAR and JERS.SAR measurements taken simultaneously for the agriculture area in Poland. During time of satellite overpasses the ground measurements of various soil-vegetation parameters were taken. Several approaches have been considered in order to obtain the best results of modelling. The various descriptors of the canopy have been applied in the modelling. The contribution of vegetation features as leaf area expressed in Leaf Area Index, dielectric feature of leaf surface expressed in Leaf Water Area Index and Vegetation Water Content in sigma values has been examined in order to obtain the best fit of the model. The simulation has been performed for various vegetation cover types. For better description of the results the L band backscatter obtained for rice field in Japan from scatterometer measurements have been included to the analysis. The model gave the possibility to obtain soil moisture and vegetation parameters using the combination of two microwave frequencies. The two-way attenuation of vegetation in three models for C-VV band and L-HH band has been examined. The final results gave the possibilities of comparison of the modelled soil moisture values with field measurements. The study has been done thanks to AO3-138 Project within which ERS-2.SAR data have been provided.

AN APPROACH FOR RADAR BACKSCATTER AND PEDOLOGIC SOIL CHARACTERISTIC INVESTIGATION

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ABSTRACT

The aim of this work is to analyze radar images acquired by satellite platforms in order to determine physics parameters correlated to soil pedology. The analysis regards a methodolocgic approach useful to determine the above-mentioned parameters using: 1. a set of radar images acquired by satellite platform; 2. meteorogical data in order to investigate soil moisture;: 3. sampled surveyed ground pedologic parameters; 4. land cover data.

The steps of the present work are: a). geometric and radiometric image preprocessing; b). minimization of soil roughness parameters; c). supervised classifications useful to determine different pedologic classes

A field area has been tested, and the results achieved show a classification accuracy of more than 70 8.525614e-305n different pedologic classes are extracted, giving the possibility to minimize ground surveys and, in the meantime, automatizing thematic maps production.

SOIL MOISTURE MAPPING FROM ASAR IMAGERY FOR THE FLUMENDOSA (ITALY) AND MEUSE (BELGIUM-NETHERLANDS) RIVER BASINS

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ABSTRACT

Soil moisture is a critical and highly variable component of the hydrological cycle. Its effective monitoring can help improve our understanding of subsurface - land surface - atmosphere interactions and can assist in drought analysis, crop yield forecasting, irrigation planning, flood protection, and forest fire prevention. This paper will describe the objectives and methodologies of an Envisat project that will aim to produce maps of seasonal soil moisture patterns at the regional scale based on ASAR imagery. The work will be carried out for two important river basins that have significantly different climatic, geologic, and land use characteristics: the Flumendosa basin in Sardinia (Italy) and the larger Meuse basin that drains large parts of Belgium and the Netherlands as well as portions of France, Germany, and Luxembourg. High resolution ASAR data will be acquired over selected catchment scale test sites within each of these study regions, whereas medium resolution images will be acquired over the entire river basin (or extended region in the case of the smaller basin). A statistical analysis of the information from the processed images at these two different scales will be used to develop an aggregation methodology to generate large scale soil moisture maps. Data assimilation techniques will also be developed for dynamically integrating the high resolution satellite data into catchment scale hydrological simulation models. The project will be placed in the context of recent efforts at validating and applying SAR soil moisture data, which will be briefly reviewed. These include tests of the performance of active microwave remote sensing to measure near-surface soil moisture in controlled experiments involving bare and vegetated terrain, a multi-temporal analysis of SAR images showing the possibility to map soil moisture patterns consistent with the rainfall-runoff dynamics of a catchment (variable source areas occurring along the stream network), and the use of active microwave observations of surface soil moisture content combined with a physically based hydrologic model and a Kalman filtering technique to extend surface observations to accurate retrieval of entire (root zone) soil moisture profiles.

COMBINING THE MICROWAVE MODEL CLOUD AND THE GROWTH MODEL PROMET-V FOR SOIL MOISTURE RETRIEVAL

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ABSTRACT

Soil moisture is an important land surface parameter, which can limit vegetation growth and plays an important role in the development of floods. Many experiments have proven that soil moisture can be detected using ERS data. But most of the experiments are dealing with bare soil conditions. To detect soil moisture under vegetation cover, the influence of the vegetation has to be eliminated. Thus, for deriving soil moisture on a spatial scale the following parameters are important and their influences have to be eliminated:- the soil type- the type and growth condition of the vegetation cover. Within the frame of the project GeoBIRD (ESA contract 12950/98/NL/GD entitled "Retrieval of geo-and bio-physical information from remote sensing data") an attempt was made to derive soil moisture by combining the microwave remote sensing model CLOUD (developed by Attema and Ulaby) and the vegetation growth model PROMET-V (developed by Schneider and Mauser). For this approach three test sites in Middle Europe, which show different dominant vegetation types were chosen. These are Flevoland (Netherlands), where the wheat is on of the leading crops, Freiburg (Germany) where mainly maize is grown and the Bavarian Alpine Foreland (Germany), where grassland is dominating. The CLOUD model was fitted for each testsite. The necessary vegetation parameters which are the plant water content and the growth height are derived from the growth model PROMET-V for each test site and the backscatter values are extracted from corrected and calibrated ERS data.By inverting the CLOUD model, the spatially distributed soil moisture values can be calculated. These modelled results are compared to the in situ soil moisture measurements which were conducted on selected fields in the different testsites. A sensitivity study is carried out and the achieved accuracies are compared and discussed.

MAPPING AND MONITORING OF WETLANDS IN THE LAKE CHAD-BASIN USING ATSR-2 DATA (PROJECT AO3-151)

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ABSTRACT

Wetland-ecosystems are important for bio-diversity conservation and rural development. Wetlands in the Sahel region, and more specifically in the Lake Chad Basin, are very extensive and dynamic. Because of these characteristics, satellite imagery with coarse spatial but high temporal resolution can be used for mapping and monitoring purposes. Even though the ATSR-instruments were originally designed for monitoring sea surface temperatures, ATSR-2 now also carries visible sensors, which should allow for vegetation studies. The proposed approach consists of two parts, the first concerning the channels in the visible and NIR part of the spectrum, the second concerning the thermal channels. First, a soft classification is performed, by applying the Linear Mixture Model technique to a time series of ATSR-2 images and a single SPOT-XS image. The model is calibrated using fraction values calculated from the classified high-resolution image. Subsequently the model is inverted, resulting in a series of fraction images, which represent the partial cover of the specific class for each pixel. The results show that not only visible channels can be used, but also combinations of visible and infrared channels. The accuracy is comparable to those obtained using a combination of coarse resolution SPOT-VEGETATION and high resolution SPOT-XS-images.

The processing of the thermal channel data will be based on the thermal inertia approach, with research focussing on the determination of the appropriate threshold for distinguishing between dryland and wetland. The combination of the information from both visible and thermal channels should allow the discrimination of the major land cover types and will provide a tool for monitoring these dynamic environments. Research on this topic is on going.

SAR-BASED MONITORING OF FLOOD-INDUCED LANDCOVER AND LANDUSE CHANGE IN THE REGION OF THE INLAND DELTA OF THE RIVER NIGER (MALI)

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ABSTRACT

The inland delta of the river Niger is one of the most fragile ecosystems of Sub-Saharan Africa. The permanent and/or periodical availability of water throughout the year makes it one of the most important agropastoral centers in the African Sahel. Patterns of landcover and landuse vary extremely due to the pre-flood and post-flood hydrographical conditions of the Niger river and its tributaries, e.g. the Bani river. ERS 1 and 2 SAR-PRI pre-flood and post-flood data provided by ESA for AO3-363 cover the whole region of the inland delta. Selected subregions are covered by multi-seasonal time series of SAR data. The presented paper deals with some results of a multitemporal/ multi-seasonal analysis of SAR data for a 90kmx60km test site along the Niger and Bani rivers southwest of the town of Mopti. The complex potential of SAR data for detecting and mapping landcover and landuse change is analysed by means of specific methods of image enhancement and image analysis. Median filtered multi-seasonal geocoded data of 1995/1996 are merged in order to increase the efficiency of extracting seasonally flooded versus permanently dry regions (ridges, plateaus) as well as versus permanently flooded river beds and lakes (mayos, mares). Difference imagery of flood versus mid-dry-season SAR-data and mid-dry-season versus late-dry-season SAR data highlights these patterns to a certain extent. Supervised classification of specific combinations of single-date imagery and difference imagery maximize the accuracy of mapping landuse and landcover change. It is nevertheless evident, that the classification value of single-band and single-polarization data of ERS 1 and 2 is limited. Bare soils with high water content, wind-affected water surfaces and certain types of vegetation layers show quite similar backscatter behaviours in monotemporal as well as multitemporal data. Though double pass interferometry of ERS-SAR data shows a certain increase of accuracies of pre-flood and post-flood landcover classification, it is highly recommended to focus on the integration of multi-frequency full-polarimetric SAR data. A cost-benefit analysis should then prove the efficiency of the classification of increasing amounts of SAR data per unit area versus the attainable value of SAR-based landcover and landuse maps for supporting appropriate approaches to regional monitoring and planning.

ON ESTIMATING SNOW WETNESS USING ASAR MEASUREMENTS

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ABSTRACT

The most important attributes of the snow cover for modeling runoff and climate in alpine regions are: snow-covered area, spectral albedo, depth, density, and liquid water content. Because of rough, irregular topography and wind redistribution, all these attributes vary spatial and temporally over alpine areas at both coarse and fine scales. However, these important snow parameters have not been generally used in snowmelt modeling because they are difficult and costly to measure routinely over large areas. ENVISAT sensors offer the means for estimating spatially and temporally distributed snow properties needed for operational hydrological and climatic applications.

This research effort concentrates on developing quantitative algorithm to estimate snow wetness using ASAR measurements. An algorithm which used the C-band polarimetric SAR measurements (JPL/AIRSARs and SIR-Cs C-band image data) for quantitatively measure snow wetness has been developed (Shi and Dozier, 1995). In the case of the polarimetric SAR measurements, we can use the relationships between different polarization to reduce the effects of snow surface roughness and scattering albedo on estimating snow wetness. For ASAR measurements, however, there are only two polarization measurements out of three available. Our study evaluates the possibility to extend our algorithm under the configuration of ASARs dual-polarization measurements.

We have up-graded our polarimetric model (Shi and Dozier, 1995) from the first-order scattering solution to multi-scattering solution in order to evaluate the effect of snow wetness and surface roughness on the cross-polarization measurements. We have established a data-base under ASAR configurations by using multi-scattering model. This data-base includes the most possible snow and surface roughness conditions. Using this data-base, we evaluated the usage of all 3 pairs of ASARs dual-polarization measurements in term of developing the quantitative algorithms. Under the effects of ASAR calibration errors and system noise, our study indicates that the optimal measurement for estimation of snow wetness is the pair of the co-polarization measurements with moderate to large incidence. In addition, we expect the following major problems: 1) The pair of the co-polarization measurements, VV and HH, has a little difference at small incidence angle, which results in that VV and HH measurements are almost identical regardless of snow wetness and surface roughness conditions. Therefore, the measurements of VV and HH only provide the opportunity for estimation of snow wetness where the pixels with the moderate to large incidence. 2) The signals from the cross-polarization measurement VH or HV for a wet snow cover might be too small to be detected under presence of the sensor system noise. This is because the multi-scattering from wet snow cover is generally small. We will demonstrate the newly developed algorithm and its perform with SIR-Cs C-band image data.

REAL TIME SNOWMELT RUNOFF FORECASTING USING ERS SAR PRI DATA

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ABSTRACT

The ERS AO3 project No 156 on "Demonstration of the application of ERS SAR data in snow melt runoff monitoring" aims at the pre-operational use of remote sensing data for hydrological modelling and forecasting. ERS SAR Precision Image (PRI) data were used for real time forecasting of daily runoff in Alpine drainage basins. The four test basins are part of a network of hydropower plants in the valley Zillertal, Central Alps of Austria, covering 66 to 205 km2 in size and ranging from 800 to 3500 m in altitude. Snowmelt provides a significant contribution to runoff in spring and early summer. The runoff calculations are based on the Snowmelt Runoff Model (SRM) of Martinec and Rango, using the snow extent derived from ERS SAR PRI data and daily values of air temperature and precipitation from numerical weather forecast models to derive the equivalent snowmelt depth. For generating snow maps from SAR data an automatic procedure was applied, which is based on change detection technique.

From April to June 1999 and 2000 real time runoff forecasts were carried out daily for the four test basins. Temperature and precipitation forecasts were taken from the numerical weather forecast models Aladin and ECMWF (European Centre for Medium Range Weather Forecast). A fast SAR data processing and dissimination link was set up by DLR/D-PAF and ESA to provide full resolution ERS SAR PRI data in near real time. The PRI data were delivered via Internet. The snow cover products, generated from PRI images, were available as input to the runoff model a few hours after the satellite overflight. The quality of the runoff predictions is assessed by comparison with online runoff measurements. The first pre-operational tests in the melting seasons 1999 and 2000 demonstrate the usefulness of the snow cover information from SAR data for runoff predictions.

SEA ICE 1/2

ARCTIC ICE THICKNESS FROM ERS1/2 RADAR ALTIMETRY

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ABSTRACT

Sea ice thickness is a key parameter in model validation and climate studies. The lack of spatial and temporal data on ice thickness have made it a key target in remote sensing studies. However the derivation of ice thickness from space-borne observations has previously proved an elusive goal. We will present monthly ice thickness maps for the Arctic Ocean derived from ERS-1/2 radar altimetry for the period 1993-1999. Returns from the surface of ice floes are discriminated from open water returns through analysis of echo shapes. Ice elevations are then obtained by differencing height estimates obtained from "ice returns" and estimates of the ocean surface elevation derived from repeat track analysis. Validation of the data against submarine and moored upward looking sonar data shows an agreement in thickness estimates of approximately 50cm. We will consider the effects of snow on the ratio of freeboard to draft and on the return echo surface. Further work is underway to investigate remaining errors and biases in our data. We will present a new time-series of ice thickness based on our data and investigate inter-annual variability and trends observed between 1993 and 1999. Our results show that there is considerable regional variation in trends with ice thickness decreasing in some areas but increasing in others. Comparisons with model simulated ice thickness for the same period will also be shown which indicate that models over-predict ice thickness in some regions. Finally we will explore future prospects for sea ice thickness observations using the Envisat RA-2 instrument and the CryoSat mission.

SAR, SSMI AND NUMERICAL MODEL CHARACTERISATION OF ARCTIC OCEAN COASTAL POLYNYAS

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ABSTRACT

A numerical polynya model (NPM) describing wind-driven coastal polynyas and the effects of brine rejection on the local salinity field is applied for polynya characterisation and compared to remote sensing data from ERS-1/ERS-2 and DMSP special sensor microwave imager (SSM/I). A polynya SSM/I signature model (PSSM) enable identification, shape and size, plus delineation of open water and thin ice in larger sized polynyas. The ERS SAR Browse image product is used for animating the temporal and the spatial extent of the polynyas and the Precision image (PRI) product for high resolution characterisation of the identified polynyas. Based on the PRI images, a SAR classification algorithm defines the size, shape and delineates the open water, new ice and first year ice types. The PRI images are shown to be the most important data set for verifying both the NPM and the PSSM as well as for understanding the polynyas' development processes. The presentation will focus on the SAR classification algorithm as well as the validation of the other models.

SEA AND LAKE ICE STUDIES IN THE NORTHWESTERN RUSSIA USING ERS SAR AND OTHER SATELLITE DATA

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ABSTRACT

Sea and lake ice of the Northwestern Russia is an important indicator of climatic changes. Satellite ice monitoring of this area could be based on ERS SAR data due to their high-resolution and a relatively narrow swathwidth.

Studies of desalinated and lake ice in the Northwestern Russia using ERS SAR and other satellite data were carried out in the frames of the ESA AO3-428 Project "Synergestic use of ERS (SAR and ATSR) and other satellite data for ice studies". During the winters of 1998/1999 and 1999/2000 SAR and ATSR images have been received for the Gulf of Finland, Ladoga and Onega lakes. Their interpretation was done using subsatellite observations, sea ice charts, visible and IR satellite images. Processes of ice freeze-up, melting, evolution, kinematics, and fast ice formation have been investigated. Typical SAR signatures for different ice types and features were revealed and studied.

Synergestic approach for retrieval of ice paramaters was elaborated based on SAR, visible and IR data. This approach includes co-geolocation of images and retrieval of ice parameters using corresponding features in different spectral bands. Neural network algorithm for determining complex of ice parameters, was elaborated.

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ERS SAR DATA APPLICATION USE FOR STUDYING SEA ICE PARAMETERS AND RETRIEVING OF GREENLAND SEALS MIGRATION

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ABSTRACT

Greenland seals (Phoca Groenlandica) is the most numerous representative group of Pinnipedia family. This species of sea mammals is the component of wild nature, base of economics and object of fishery. But the drastic reduction number of population as result of the different factors is fixed. Monitor of biotope media, control of the migration tendency, accurate and efficient registration of population number are the most important tasks for marine biology and oceanic fishery. Present study was done in frame of A03.440 Project "Application of ERS SAR Data for Studying Migration of White Sea Population of Greenland Seals". The objective is the demonstration of SAR practical use. 20 ERS SAR images were received in near-real time. The retrieval ice cover parameters are studied as an abiotic factor of sea mammals ecology. As it has been proved the arrangement of whelping rookeries of seals in White Sea closely relates with certain types of water masses and forms of drifting ice. Signatures of such types of ice are revealed from SAR data and verified by in situ observations. SAR images for areas of mass congestion of seals are compared with the ice that avoided by seals as unfit (or uncomfortable) for pup production. Signatures of brackish water and level lubricious ice are studied in connection with ice floes solidity. Tendency of migration at the different weather conditions was determined with using SAR series. 1998/99 ecological catastrophe was predicted by SAR, next mass destruction number of pup was fixed by marine biologists. Mass death of seals was the result of adverse weather conditions: hard frost covered water area, adverse NE winds "closed" the mammals inside the basin. 1999/2000 SAR images are verified and used and as the principals document for reconnaissance of whelping patches (anomaly warm winter). Visual and IR airborne data were analyzed automatically. Spectral data allows considering shadows and false heat targets, increase accuracy in the count the harp seals (one and all, and separate adults and pups). New level of ice monitoring is connected with ENVISAT: ENVISAT will allow to monitor other representatives of seals (Jan-Majen, New Foundlend and hooded seals). SAR in combination with airborne survey is more prospective for organizing worldwide service of sea mammals control.

MAPPING SEA ICE THICKNESS WITH RADARSAT AND A HELICOPTER-BORNE ELECTROMAGNETIC-INDUCTION SYSTEM

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ABSTRACT

Knowledge of sea ice thickness is important for safe navigation by fishing and commercial vessels and those involved in oil exploration, for the design of offshore structures, and for the understanding of climate change. Sea ice thickness profiles collected with a helicopter-borne electromagnetic-induction system over many tens of kilometers are compared with RADARSAT SAR, airborne SLAR, and video images. The video images were captured in real-time using a downward-looking video camera mounted on the outside of the helicopter. Ice surface roughness profiles extracted from laser altimeter data are also compared with the ice-plus-snow thickness profiles.

Several examples are shown representing different ice conditions in the Gulf of St. Lawrence, Canada in February-March, 1999. These include thick coastal ice rubble, ridges, large composite floes, and ice broken by bridge piers in Northumberland Strait. Deformation features such as ridges and rubble seen in video mosaics are well-represented in the EM-measured ice thickness data, with thicknesses of up to 4 m. Thicknesses of level ice measured with the HEM system and manually through drillholes were generally 30-60 cm. However, fairly uniform thicknesses of approximately 1 m were also measured for large composite floes. The relationship between ice thickness and surface roughness data for thin-ridged ice and for large composite floes is consistent with isostatic equilibrium.

Changes in SAR image tone and texture generally correspond to changes in ice thickness. Thus while satellite SAR data can provide the spatial extent of areas having similar ice thickness distributions, EM-measured ice thickness profiles can provide absolute thicknesses in these areas.

LINCOLN SEA AND NARES STRAIT - A REMOTE SENSING STUDY

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ABSTRACT

On the basis of NOAA AVHRR data an ice-dynamic winter feature in southern Lincoln Sea has been reported by a number of authors and often interpreted as a polynya - an area of open water in an ice canopy. However, passive microwave radiometer data for the period 1978 to present show that the ice concentration in the entire Lincoln Sea seldom goes below 80, all year.

Under an ERS AO project SAR data acquired in the period August 1991 to August 1996 were exploited to study the phenomenon in more detail - and independent of weather conditions. Many scenes have been acquired to give a reasonable coverage in space and time - and especially in the early days of ERS-1.

The study confirms that the ice concentration seldom goes below 80In the period late September to April/early May a large volume of ice is advected from Lincoln Sea into Nares Strait due to a process of break-up of the otherwise continuous ice cover. It also shows that the leads that are created by this dynamic process freeze almost instantly. Exceptions are cases with a strong southern wind that gives rise to relatively large patches of open water along the coast that freeze again when the wind stops and ice transport is resumed. The SAR scenes show that the major ice transport is from north-west with increasing velocities towards the mouth of Nares Strait.

Data indicate that the transport of ice through Nares Strait may cease when an 'ice bridge' is formed in spring in the southern part of the strait (in Kane Basin), as reported by several authors. However, ERS data from this area are unfortunately too scant to confirm this.

In 1990 and 1991 two buoys of the International Arctic Buoy Program happened to pass Nares Strait. ERS SAR data give glimpses of the ice conditions during the pass of the last buoy. It was found that it was up-held for a couple of days at the place of the 'ice-bridge' although no bridge was present.

SATELLITE ICE MONITORING FOR NAVIGATION OF AN ICE-GOING TANKER IN THE KARA SEA

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ABSTRACT

The study of sea ice by satellite radar images is part of the project Arctic Demonstration and Exploratory Voyage ARCDEV (EU contract WA-97-SC.2192) which aimed to investigate the conditions for navigating a tanker vessel from Europe through the Kara Sea to the northwestern Siberian gas and oil fields during winter conditions in April-May 1998.In order to perform such ship navigation operations, an escorting icebreaker support as well as detailed information on the ice conditions is required. It is demonstrated how satellite based microwave radar technology practically can support ice navigation operations to improve the safety and efficiency of the navigation. The ARCDEV convoy was supported by near real-time ice information derived from both ERS-2 and RADARSAT ScanSAR Synthetic Aperture Radar (SAR) information during the most difficult ice conditions for 30 years. Prior to and during the voyage a total of 28 satellite SAR images were acquired, analysed and transferred to the convoy prior to its arrival to the area covered in the image. Detailed analysis and ice type classification of the SAR images were performed. The results of the analysis were used both in the strategic and the tactical planning of the convoy navigation operations. In general, the convoy speed increased by a factor of at least two in the drift ice, and the use of SAR data was even more efficient for the preparation of a sailing channel through the fast ice in the Ob estuary.

OPERATIONAL USE OF SATELLITE SAR FOR SEA ICE MONITORING IN CANADA – PAST EXPERIENCE AND FUTURE POSSIBILITIES

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ABSTRACT

The Canadian Ice Service (CIS) is the Canadian Government Agency responsible for providing ice information over Canada's offshore areas for marine operators. The CIS uses data from a variety of earth observation satellites, both optical and radar, to monitor ice conditions in its operational areas of interest. Beginning with the use of ERS SAR data in 1992 and subsequently with RADARSAT since 1996, SAR data from satellite has become the preferred data source of the CIS for its high quality, large area coverage and low cost. But availability of a source of data alone will not permit its operational adoption.

The experience of the CIS has demonstrated that a fully-operational, end-to-end information system is required. This system starts from satellite tasking, and follows through a chain of data reception, delivery, analysis, and product distribution. It has also been demonstrated that a single wide-swath satellite SAR cannot fully meet the needs of the CIS, and data from multiple sources is still required. The future availability of data from multiple wide-swath satellite SARs with complementary orbits, (e.g. ENVISAT and RADARSAT-2) could reduce, though not eliminate entirely, the need for supplemental data sources. Multiple satellites in orbit would help mitigate the risk of high reliance on a single source of data.

ASAR data from ENVISAT is of particular interest to the CIS as a complementary data source. The CIS is looking forward to the availability of data from ENVISAT and, under an approved AO project, intends to evaluate the utility of Wide Swath data for regional scale ice monitoring in a complementary fashion to RADARSAT-1 and 2. Additionally, the Alternating Polarization mode will be evaluated for information content and potential for enhancing ice/no-ice separation while the Global Monitoring Mode may prove useful for synoptic, non-operational mapping of the entire Canadian Arctic.

SEA ICE THICKNESS FROM SAR-DERIVED KINEMATICS

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ABSTRACT

The RADARSAT synthetic aperture radar is currently providing repeat surveys of the Arctic Ocean sea ice on a near 3-day basis with its wide-swath ScanSAR mode. For the first time, we can produce basin-scale estimates of sea ice age and thickness from observations of ice motion derived from sequential SAR images of the Arctic Ocean. The direct observations we extract from the SAR imagery are the deformation of Lagrangian elements (cells) which are areas enclosed by polygons defined by vertices on the ice cover. The time-dependent deformation of these cells are computed from the motion of the vertices obtained by tracking these points in SAR imagery. From the record of deformation, we estimate the ice age and thickness within each of these cells. Each cell covers an initial area of approximately 10 km by 10 km. More than 60,000 of cells are used to cover the entire Arctic Ocean. These high-resolution observations give us an unprecedented view of the sea ice cover and are suitable for supporting polar investigations as well as operational applications.

We have produced estimates of sea ice deformation, thickness and age from one entire winter of SAR maps of the Arctic Ocean from early November 1996 through June 1997. We are also producing results from the winter of 1997-1998 and the summers of 1997 and 1998. Here, we describe this dataset , their use for studies of the sea ice cover and the potential contribution of ENVISAT in helping to extend these observations into the future. These data products and a description of their format are available at a website at the Jet Propulsion Laboratory (http://www-radar.jpl.nasa.gov/rgps).

EXTRACTION OF SEA ICE PARAMETERS FROM IMAGETTE DATA

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ABSTRACT

From raw ERS wavemode data, complex SAR images of size 5km x 10km, so called imagettes, are computed using the BSAR processor, which have full spatial resolution. As ERS collects wavemode data over sea every 200 km along its track as far as the instrument is not switched to imaging mode, some 1200 imagettes are available each day - some 300 in polar regions - giving a relatively dense coverage of the antarctic and arctic sea ice south of latitude 84 degrees north. ENVISAT will be able to collect wavemode data every 100 km. Due to their independence of daylight, weather conditions and remote receiving stations, imagettes are an ideal data set for the observation of the sea ice cover.

Several statistical measures are introduced for analysis of the imagettes classifying ice free and ice contaminated imagettes together with sea ice parameters such as ice concentration and different ice types. The results are compared to the charts of ice services and SSMI data. Furthermore, a comparison to the Kiel ice model shows the strong relation of the imagette data to the deformation energy. This is due to the fact that regions of high deformation energy show a higher number of ridges, rougher surface and a higher number of small floes.

First encouraging results are presented of a combined analysis of the statistical measures in order to provide an automatic ice parameter extraction system. It is expected that the reliability can be futher improved as soon as calibrated imagette data are available.

In the future, this processing chain is to be extended and applied to provide global statistics of sea state and ice parameters from ENVISAT and historic ERS data.

The work was performed in the framework of the ERS AO3 SOWISAR, the ERS wavemode raw data were kindly provided by ESA.

SIMA - A SOFTWARE SYSTEM FOR MOTION ANALYSIS IN SATELLITE IMAGE SEQUENCES

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ABSTRACT

Detection and tracking of ice floes and icebergs in satellite image sequences is an important field of application in satellite image analysis needed for the saftey of shipping and because changes in the ice drift patterns can indicate changes in the circulation of the global climate system. Nowadays analysis of ice drift in SAR satellite image sequences in most cases is carried out manually. The aim of the SImA (Satellite Image Analysis) project is to examine digital image analysis approaches for object recognition and tracking in SAR satellite image sequences. The focus was put on the development of new software system for the recognition and tracking of ice floes and icebergs. SimA is two-year student project at the University of Bremen, where 14 students are working together under the supervision of three faculty members. It is carried out in co-operation with the Institute of Environmental Physics, Bremen. In order to extract the drift information from the SAR image sequence various image processing steps have to be carried out, i.e. preprocessing, segmentation, object recognition and motion tracking. The system provides miscellaneous filters for image preprocessing, especially contrast enhancement and edge preserving noise smoothing, image segmentation and edge detection methods and various approaches to image motion analysis. By building up an image processing graph, the different operators may be configured and composed together by the user to enhance the quality of the single images and to detect objects and analyse object motion. The results of the motion analysis are motion vector fields, which allow an interpretation of the ice drift. For visual representation of the motion vector fields deformation grids and needle images are available. The system was tested to analyse ice drift on SAR images taken from the Weddell Sea and at the East Coast from Greenland.

SAR SEA ICE CONCENTRATION IN BALTIC SEA VERIFIED BY ALBEDO MEASUREMENTS

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ABSTRACT

A sea ice concentration algorithm for RADARSAT Scan SAR images based on [1] has been developed and adjusted to first year ice of the Baltic Sea. The algorithm builds on local thresholds between ice and open water in order to handle the incidence angle dependency. The sea ice concentration has been verified by albedo data measured by an airborne sensor during the EU-project BASIS/BALTEX winter experiment 1999. The albedo data show good agreement to visible observation of sea ice extent and agreed also to a large amount with the SAR sea ice concentration. The two parameters agree badly over large open water areas with strong wind where the SAR sea ice concentration shows too large extent of ice. Those areas have to be handled manually in the SAR images to avoid misclassification. The SAR sea ice concentration algorithm works best during cold conditions when the contrast is clear in the SAR images and the radar signal is undisturbed by wet snow on the sea ice. Improved results have been shown in heat budget calculations for Gulf of Bothnia in Baltic Sea when SAR sea ice concentration was included.

[1] Dokken, S., Håkansson, B. and J. Askne (1999), Inter comparison of Arctic sea ice concentration using RADARSAT, ERS, SSM/I and in-situ data. In press Canadian J. Remote Sensing, March.

SATELLITE STUDIES OF OCEAN FRONTS AND EDDIES FOR DEEPWATER DEVELOPMENT IN THE NORWEGIAN SEA

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ABSTRACT

The background for this study is the requirements from the oil industry to obtain more knowledge about currents and eddies for the deepwater exploration west of Mid-Norway. In this study more than 70 Synthetic Aperture Radar (SAR) scenes from the ERS-2 satellite, each covering 100 by 100 km, were investigated for low wind conditions allowing observation of current patterns and fronts. Also altimeter data from ERS and TOPEX/Poseidon satellites were analyzed in order to estimate geostrophic currents in the study area. The study showed that SAR and altimeter data can illuminate mesoscale ocean currents in different ways, providing synoptic mapping which is an important supplement to time series of current measurements at single locations. The SAR has capability to map location, size and other geometrical properties of eddies and fronts, provided that the wind conditions are moderate. In at least 50 63742560f the SAR images which were investigated, the wind speed was dominating and masking out eddies and frontal features. The altimeter data from two satellites (ERS and Topex/Poseidon) can be used to calculate seasonal eddy kinetic energy and 10-day averaged geostrophic velocity anomalies. Sea surface temperature from AVHRR can be useful occasionally, but the frequent could cover in his region prohibits regular use of infrared remote sensing techniques. Preliminary comparisons between the SAR and altimeter results indicate that that there is qualitative agreement. The time and spatial scales of the two methods are different, however, which makes it difficult to perform accurate comparisons. The altimeter velocity fields should be compared with eddy-resolving models and both methods should be compared directly with in situ current meter data. The study suggests that both SAR and altimeter should be used in monitoring of mesoscale currents as a supplement to traditional current meter moorings. The study has been supported by the EC OPERALT project (contract no. ENV4-CT98-0739) and Norske Shell a.s.)

SERVICES AND MARKET

THE ERS OIL-SPILL RESEARCH PROJECT IN NEW ZEALAND: DEMONSTRATIONS TO THE COMMERCIAL MARKET

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ABSTRACT

In New Zealand, the best way to show the potential advantages of satellite-based mapping and monitoring is first to carry out applications-oriented research on the problems, thus demonstrating the advantages to the stakeholders. Current research concerns the practicality of using C-band SAR data to map and monitor discharge events, especially oil discharges, in selected New Zealand harbours and shipping lanes. An important feature from the market's perspective has been the possibility of investigating and prosecuting those responsible for illegal discharges. If successful, and once widely known, this monitoring capability could act as a strong disincentive to vessels contemplating discharge within New Zealand waters.

There were two limitations to this investigation. First, there was relative disinterest from those local government authorities responsible for overseeing oil discharges. Although these organisations were enthusiastic about the technology, they were unable to commit resources to its development since they saw their role as following established models of technology defined by a central government agency. Second, even in cases where natural or industrial discharges should have been seen, they were not clearly visible. The viability of SAR for oil-spill detection, therefore, had to rest on surrogate qualitative issues such as the ability to see surface water features, and the response of SAR near shore.

There have been two major successes in the project. First, an in-country capability has been developed to efficiently ingest and process ERS SAR data. This has raised the acceptance level of the data. Second, the project has provided comprehensive baseline mapping of the five major New Zealand harbours most likely to encounter a future oil spill event. Interaction with local and national government agencies during this project has raised awareness of the technology and its potential. These successes will be built on as we progress to planned research on broader scale effects of various land and sea-based discharges on a larger area around one of these harbours using ENVISAT data.

WAVECLIMATE.COM
THE ONLINE OFFSHORE-CLIMATE ASSESSMENT TOOL

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ABSTRACT

ARGOSS has set up an Internet service to provide offshore industry users with state-of-the-art wind and wave climate data based on satellite measurements. The service combines data from three microwave sensors (altimeter, scatterometer and SAR) carried by several different satellite missions (ERS-1, ERS-2, Topex/Poseidon). In waveclimate.com the observations from these different sources are integrated to a single product, that enables users to assess the metocean conditions of an arbitrary part of the world's ocean from behind their desk.

Since the mid 1980s several satellite missions have carried microwave sensors that measure the conditions on the world's oceans. Sensor Parameter Satellite mission altimeter wave height, wind speed Geosat, ERS-1/2, Topex/Poseidon scatterometer wind speed and direction ERS-1/2, Adeos SAR wave spectrum ERS-1/2. Table 1 Overview of the physical parameters measured by the different microwave sensors that are used in waveclimate.com.

This service can be accessed via the Internet at http://www.waveclimate.com. Presently it contains all wind and wave data collected by the ERS-1, ERS-2 and Topex/Poseidon missions to date. A graphical interface allows the user to select his region of interest by pointing on a map. The user can then choose from a number of plots to characterize the metocean climate. In figures 1, 2 and 3 examples are given of the total wave energy, sea and swell along the Indonesian Archipelago. At the workshop more information will be given of the waveclimate along the Indonesian Archipelago to serve applications like planning and design of ports and power plants.

NATIONAL-SCALE DEM GENERATION USING ERS TANDEM DATA IN ALPINE REGIONS

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ABSTRACT

ERS Tandem interferometry has proven its potentialities to generate accurate Digital Elevation Models in several cases, but mainly in limited areas and / or where the topography is not particularly severe. Final results are shown in this paper of a project aiming to generate a DEM over all Switzerland, where steep and varying topography extends over a big part of the whole national territory, covering approx. 40'000 sqkm. The final accuracy of the product has been valitaded by means of comparison with external Ground Control Points and reference DEMs over selected areas. The results allow stating the possibility of generating similar products over similar and larger regions in an operational way, making ERS interferometry a fully commercial technology.

SAGA - SATELLITE DATA AND GEOINFORMATION FOR AGROLOGISTICS

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ABSTRACT

Main target of the DLR funded project called SAGA, which is not yet commercial, is to develop a market oriented application for EO data to optimize the planning and carrying out of the sugar beet campaign from mid September to mid December every year for the harvesting, loading and transport vehicles of two machinery rings in Lower Saxony, Germany. Therefore an actual set of ERS-2 radar (funded by ESA-ERS-AO3) and TM and SPOT optical remote sensing scenes were acquired for the developing (1998) and testing phase (1999), to register all sugar beet fields within the specific transport area.

Prerequisite for the acceptance and the successful use of the data are: 1.) Complete registering of the sugar beet fields as GIS-boundary vectors (not a single missed field or confusion with e.g. maize or potato fields will be accepted) 2.) Data base with name and address of the farmer, name of the field and exact field size. 3.) Delivery of the data until end of August . 4.) Existence of a PC and a GIS-software at the office of the machinery rings. 5.) Large scaled scanned and referenced maps of the entire region 6.) Open minded staff with interest and knowledge, how to use such an Geo-Information System. 7.) Acceptance of PI and therefore good and permanent contact necessary to machinery rings and sugar beet industry.

Because of these requirements, a specific procedure and tact for the farmers is necessary. To complete the database, a prolongation for a third project year (2000) was necessary with regard to central Germans main crop rotation. But even after acceptance and successful registering and convincing the farmer and the machinery ring staff for using EO data and GIS, the cost/benefit relation has always to keep in mind.

SUPPORT TO THE EVALUATION OF THE SHORT-TERM EXPLOITATION OPPORTUNITIES FOR ERS DATA WITHIN THE AGRIBUSINESS MARKET

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ABSTRACT

The main objective of this ESA study was to investigate the use of ERS-2 SAR data (supplemented by one optical image) for producing fully validated regional area estimates of important crops. To monitor large areas on a monthly basis is currently not cost effective, therefore a sampling strategy was developed and area estimates for the region were recalculated using sampled mini-sites and a defined extrapolation method. The crop area estimates extrapolated from the mini-sites were compared to estimates obtained from the whole region. If the results compare well at a regional level, it may also be possible to apply this methodology at a national level. The second objective was to identify short-term opportunities, and make recommendations for increasing the exploitation of SAR data within the Agribusiness market sector. This entailed the identification of the information requirements of the agribusiness sector, and an assessment of the capability of current radar sensors. ERS-2 data were acquired over East Anglia during the 1997/1998 growing season. All radar data were radiometrically and geometrically corrected using NRSC's TSAR software. An IRS LISS-III optical image was also acquired (May 1998) and geocorrected. The ERS-2 data were classified for the winter and summer period using NRSC's SAR CLASSIFIER and the optical image was classified using ERDAS IMAGINE software to produce regional classifications. A sampling strategy was devised and the regional classifications were used to extract data for 30 mini-sites. Area estimates were calculated for the region classifications, and from the mini-sites using a defined extrapolation methodology. The classifications have been validated and the region and mini-site area estimates have been compared to area estimates derived from the MAFF agricultural census for the U.K. (June 1998). The results shall be presented at the symposium. The results to date indicate that the estimates derived from mini-sites area estimates are somewhat varied for the different classifications and crop classes. This project also indicates that current radar sensors cannot satisfy the user requirements of the agribusiness sector. It is suggested that the future sensors including ENVISAT (multi-polarisation data) and TERRASAR (higher spatial resolution, multi-band, multi-polarisation data) will provide better results.

FAST DAMAGES ASSESSMENT FROM EO DATA FOR ASSISTANCE TO RELIEF OPERATIONS AFTER MAJOR NATURAL DISASTERS

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ABSTRACT

Recent major natural disasters have been monitored and studied by GSC using several SAR and optical sensors. The initial scientific purposes of natural phenomenon understanding have been replace by e new objective : assessing damages very fast after the event to help NGO's and relief operators in their rescue and assistance operations. From MITCH hurricane in 1998 to hurricanes in Madagascar in 2000, passing by Izmit earthquakes and floods in Venezuela, we show how SAR and optical data can by suitably interpreted very fast and brought to users on the field or to decision makers to mobilise adequate relief means. On each context the advantage and drawbacks of SAR and optical data are analysed and compared and map codification's are defined according to field operators needs. Complex processing such as interferometry to photo-interpretation on metric resolution optical data provide different level of view and information. Each one has a corresponding user. A first example, Mitch hurricane is specially studied. We focused on several time scale applications. From emergency during the following days to reconstruction and development. We also propose a method for fast damages assessment to agriculture with two simple ERS PRI images. The application remained possible only of certain compatibility conditions are fulfilled between images before and after the event, if the studied phenomenon and local geography and landuse in the affected area are sufficiently known and described. More recent disasters are studied according to data availability which is the main breakthrough that ENVISAT should bring. ARTEMIS/ENVISAT couple should allow a multiplication of applications of SAR in natural hazards damages mapping.

ADVANCED SAR/OPTICAL REMOTE SENSING TECHNIQUES FOR FORESTRY APPLICATIONS: A CASE STUDY IN SARAWAK (MALAYSIA)

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ABSTRACT

For the application of remote sensing techniques to operational forestry, a complete and comprehensive exploitation of multi-sensor synergy and complementarity is needed. New strategies to retrieve information relevant to forestry have been developed and evaluated in a GIS environment. They are now used in commercial projects. Such strategies have been developed according to requirements widely expressed by the community of users, especially in South-East Asia, in South America and in Africa. To achieve the general above-mentioned objectives, existing processing and information extraction methods specific to SAR and to Optical imagery have been revisited and improved. New additional techniques based on control systems principles have been developed. To illustrate the range of techniques that can, and very often must, be used in forestry applications, the results of a commercial project carried out in Sarawak (Borneo island, Malaysia) will be shown and commented. The following technical issues will be addressed and illustrated in this case study: Georeferencing in GIS environment Optical remote sensing images pre-processing, SAR remote sensing images pre-processing, Generation of a DEM, Ortho-rectification of the remote sensing images, Correction of terrain induced effects, Detection of the hydrological network (rivers and water bodies), Detection of the forest communication network (roads, and forest and/or logging tracks), Forest and land-use inventory mapping, Standing timber volume estimation.

Timber volume estimation is made, using a new method developed and validated by PRIVATEERS NV. This method uses both Optical/SAR data fusion technique, and a forest structure model. Validation of the remote sensing operation has been carried out in Sarawak by the commercial customer. Validation results are presented in this paper. It is noteworthy that validation shows that the accuracy of the numerical figures is about ±10, in a standing timber volume range of 0 to 260 cubic meters per hectare.

ESA MISSION MARKETING ACTIVITIES. THE E.M.M.A. OFFER FOR THE DEVELOPMENT OF THE ERS AND ENVISAT MARKET

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ABSTRACT

Since the beginning of the ERS mission with the launch of ERS-1 in 1991, Eurimage has been the exclusive partner for the commercial distribution of ESA's EO mission products. The launch of ERS-2 in 1995 further reinforced the commitment of Eurimage towards the exploitation of ERS-1 & 2 with the generation and successful commercialisation of new and never before available products from space such as the generation of Interferometric DEMs. During this period, spanning more than 10 years, Eurimage has expanded the SAR and LBR market with the co-operation of Value Added Companies, creating a worldwide network of Application Providers. For the exploitation of the next generation of the ESA satellite ENVISAT, Eurimage and a select number of Value Added companies and Space Agencies, have decided to jointly venture for the global distribution of information content derived products. The EMMA partnership, led by Eurimage, will not only deliver to the final client standard data, but will also provide value added information derived from both ERS and ENVISAT, therefore giving users the possibility of having off-the-shelf high level products. The EMMA partnership includes co-operations with international VA companies spanning the complete filed of applications. This co-operation is encouraged to expand in the future with new collaborations, not only with other VA companies but also with International Ground Stations (IGS). Eurimage already has co-operations with several IGS around the world for the provision of global data. Lastly this paper will also show the EMMA plans for the continuation of the R&D program for the development of new applications.

COMMERCIAL DISTRIBUTION OF ERS AND ENVISAT PRODUCTS AND SERVICES

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ABSTRACT

Spot Image is becoming a worldwide distributor of ERS and, later on, ENVISAT products. To implement the distribution and market development activities Spot Image has built up a consortium with several key European and international partners. This paper intends to describe this Consortium and the market development activities: - the current characteristics of the ERS market and the positioning of the ERS/ENVISAT products into the global EO market;- the role and complementarity of the different partners in the Consortium as well as its international presence ;- in particular how the ERS and ENVISAT data will be integrated in a larger multi sources offering and be part of operational products and services including mapping products, displacement mapping services, pollution monitoring and other services.

ENVISAT ESA 1/2

DEMOS

ACE: A NEW 30" GDEM INCORPORATING SATELLITE ALTIMETER DERIVED HEIGHTS

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ABSTRACT

A new Global Digital Elevation Model has been generated at 30" resolution by combining the best available ground truth with a unique global database of satellite altimeter derived heights. This model, ACE (Altimeter Corrected Elevations) demonstrates radically improved spatial accuracy and resolution over large parts of the globe, in particular over Africa and South America. The independent altimeter based dataset, which contains over 100 million individual height estimates, has enabled the identification and correction of gross errors in individual ground truth datasets. Source data of low spatial resolution have been replaced with greatly improved altimeter generated surfaces. Additionally, the use of this satellite derived near-global dataset of very high vertical accuracy, referenced to a single datum, has allowed the identification, measurement and correction of the vertical offsets between adjacent tiles of DTED data, widely reported by users of previous models. The result is a model in which a significant proportion of the earth's land surface is represented by a completely new dataset: this is especially true of areas for which previous models have drawn on Digital Chart of the World. Adjoining ground based datasets of good quality have also been adjusted for vertical and horizontal misplacement. The detailed assessment of dataset quality undertaken as part of the programme to create the ACE GDEM has allowed the inclusion of a unique additional information matrix: a data quality indicator is being constructed for every land pixel of ACE, together with detailed source information. This will allow the user, for the first time, to make an informed judgement on expected performance of the ACE GDEM for the desired application. The ACE GDEM is now in beta release, undergoing validation with selected end users prior to full release at the end of this year.

Domain: TOPOGRAPHY

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SEA SURFACE TEMPERATURE AND CHLOROPHYLL-A CORRELATION INDEX: SEASONAL VARIABILITY ON IBERIAN MARGIN

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ABSTRACT

The research objective is to find a correlation index between sea surface temperature and chlorophyll-a on the north-west of the Iberian Margin. The self-edge is characterised by climatology driven intense seasonal upwelling between April and August along the entire coastline, revealing also frequent alternations between upwelling events and relaxation periods. Surface water in upwelling regions reflects a chronological display, with newer water nearer the upwelling source becoming progressively modified with age as it moves away from the source. This modification occurs as a result of its exposure to light and the ensuing biological production.

Satellite-derived chlorophyll-a from SeaWiFS data, which will be provided by the Remote Sensing Group at Plymouth Marine Laboratory and will be compared with sea surface temperature from AVHRR data processed by the Remote Sensing Laboratory at the University of Vigo, in function to implement "the state of the art of upwelling understanding". There will be a strong positive correlation between sea surface temperature and satellite-derived chlorophyll-a. The studied data will allow us to describe and quantify the key factors regulating primary production and the short-time-scale variability of this ecosystem during this important event and to develop present algorithms for red tides prediction. Tracking an upwelling event may prove possible with the higher resolution of MERIS and development of algorithms that may be especially useful for harmful bloom species. ENVISAT technology involving new sensors is especially attractive as a sampling tool and must be conducted to a better understood.

KEYWORDS: Iberian Margin, satellite-derived data (chlorophyll-a, SST), upwelling, primary production.

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ATSR-SST IN ENCLOSED BASINS - A CASE STUDY IN THE BALTIC SEA

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ABSTRACT

High resolution SST data from the ERS-1,2 ATSR instrument has been used to derive composit images at weekly to monthly time-scales. The technique and results are presented from this AO-3 project. Presently the data covers one year - 1997. The product is developed to meet the needs of SST-users and in particular for prognostic models in oceanography and meteorology.

CONVERSION OF ATSR-2 SKIN SEA SURFACE TEMPERATURES TO BULK TEMPERATURE FOR USE IN CLIMATE STUDIES.

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ABSTRACT

The high accuracy and almost ten year time period of skin Sea Surface Temperatures retrieved from the Along Track Scanning Radiometer (ATSR) series of instruments make them useful observations for climate studies. However, the retrieved satellite skin observations need to be converted to an observation of Bulk Sea Surface Temperature (SST) at a depth of around one metre in order to be consistent with other SST observations used for climate studies such as from ships and buoys. The conversion of skin SST to bulk SST were processed using 3.5 years worth of ATSR-2 cloud-cleared skin SSTs (averaged at a resolution of 0.5 degrees), using a skin to bulk temperature algorithm developed at The Met. Office (UK). The algorithm is based on the physical Fairall model and covers all wind speed ranges. The near surface diurnal thermocline is also modelled with the aim of rejecting those observations thought to have a strong surface thermocline. This poster presents the results from comparisons of bulk SST with climate datasets containing SSTs at 1 and 5 degrees resolution. The datasets are maintained by the Hadley Centre at The Met. Office, and contain SST observations gathered from a combination of data including in-situ and Advanced Very High-Resolution Radiometer (AVHRR) observations. Additionally, we investigate the effect of the skin to bulk conversion and the final bulk product when different SST retrieval schemes are used.

Domain: SEA SURFACE TEMPERATURE

BIOMASS MONITORING WITH SAR

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ABSTRACT

By mapping the aboveground woody biomass in northern boreal forests and the distribution and accumulation of secondary regenerating forests in the tropics, along with the vegetation in the savannah, biomass measurements will provide insight into the size of the carbon sink. The carbon fluxes however are related to changes in the carbon sink and to green biomass activity and therefore monitoring of vegetation changes and activity are needed. By monitoring the changes in above ground woody biomass and estimation of total biomass and its temporal variability, such a mission will contribute significantly to the understanding of the carbon cycle. Furthermore biomass information is also very important to the economies of various countries both in the tropics and in boreal climates. Airborne measurements and in-situ ground campaigns cannot provide a homogeneous and frequently updated data set on a global scale, which is collected independent of national interests. Radar backscatter measurements have proven to be positively correlated with aboveground biomass and this correlation increases with the wavelength. Biomass retrieval algorithms have been developed for airborne P-band data collected over both boreal and tropical forests. Radar measurements are insensitive to cloud cover and can be operated during day and night. Hence a spaceborne radar system, operating at low frequency, will permit the measurement, mapping, and understanding of these parameters with a spatial and temporal resolution suitable for modelling ecosystem processes at regional, continental, and global scales. BioSAR will be a stand-alone mission such that its objective can be met without any additional data, but synergy is expected with using other radar and optical sensors. The main geophysical parameters, which are estimated from the polarimetric radar backscatter measurements performed by this mission, are biomass, flooding condition, and land cover class. Based on experience with airborne campaigns, a polarimetric low frequency SAR has been shown to be the most appropriate instrument to this purpose. The design philosophy behind a P-band spaceborne SAR is based on small size and low-cost, which should be achieved by using available space qualified hardware components. Also a (relative) small antenna is foreseen, for which an adequate performance will be shown. By merging user and scientific requirements with technical constrains the scenario of a SAR instrument has been investigated. It operates as a normal side-looking synthetic aperture radar and images a 50-km swath positioned such that the incidence angle at mid swath is 23 degrees, which also coincide with the ERS AMI SAR swath and the ASAR IS2 swath. This paper will concentrate on the concept of the instrument, the SAR (antenna) design and the potential applications.

AN INVERSION MODEL OF ERS2 RADAR DATA TO RETRIEVE WILD VEGETATION COVER IN SEMI-ARID REGIONS

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ABSTRACT

During the last years, a large number of studies have been achieved to protect water resources and to study erosion in semi-arid regions in particular in the North of Africa. The new physically based models incorporate Geophysical Information System. This incorporation facilitates applications in large catchments and allows remotely sensed to be used. A considerable effort has been devoted to study the sensitivity of radar response over natural surfaces in agricultural sites. For hydrology applications, studies have been focused in particular to retrieve soil moisture and roughness indispensable to describe the hydrological cycle of water. Many other works have been interested in the characterisation of vegetation cover. These models have been often used for agricultural wet watersheds. Our objective, in this study, is to go more in the description of the radar potential to characterise this type of regions and particularly wild vegetation cover. During 1998-1999, a large number of ERS2 images has been taken over Kairouan site in the center of Tunisia. The climate is semi-arid with a run fall between 150 and 350 mm per year. In plain, there is a vegetation type adapted to weak precipitation with a dispersed wild and short vegetation over a very smooth surface. A model is proposed in this paper to retrieve the vegetation cover over soil surface from radar signal for this semi-arid region. Vegetation in these regions is characterised by the presence of clumps, which cover a part of soil surface. Our model described the relation between this covered percentage of surface and radar signal. Soil surface is taken from numerical vertical photos of test fields in the studied site. From these photos, a classification is done to retrieve vegetation percentage for each one. A high correlation is observed between backscattering measure and vegetation percentage. This behaviour is studied for three dates for which moisture is the same in all the site. They correspond to the end of summer and also to April. A model is then developed to characterise theoretically the relation between vegetation cover and radar signal. The comparison between simulated radar signal and real radar data over different test fields shows a very good agreement. A classification is then done over the site to map the vegetation percentage.

Domain: VEGETATION/AGRICULTURE

ON THE USE OF ERS INSAR AND MULTITEMPORAL DATA FOR ECOLOGICAL MONITORING OF THE CHERNOBYL AREA

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ABSTRACT

Study of the ecological situation in the area of prohibited access around the Chernobyl nuclear power plant with a use of ERS SAR in our AO3-246 project is concentrated on the monitoring of the coniferous Forests State - the most sensitive component of the vegetation covers to the radioactive pollution. For our analysis we have selected a series of ERS SAR archival data for the time interval of 1992-1996, obtained at different meteorological conditions and in different seasons of the year. Among the data used in the study are set of 16 ERS PRI scenes and ERS INSAR SLCI pair from a tandem mission. The combination of ERS resulted in multitemporal maps, coherence and DEM for the area of study - the 30 km area around the nuclear power station. The multitemporal maps mentioned above allowed us to classify the next types of the surfaces - deciduous and coniferous forests located on the regular and over moistened soils, open areas with various extent of small-scale roughness and moisture, the area of dry forest on the western trace of nuclear fallout happened in the year 1986 and vast areas of forest fires on the border of the area of prohibited access occured during the period 1986-1992. The ERS INSAR coherence and DEM data allowed to improve classification based on the level of coherence and the altitude of the scattering layers. The use of ERS data in a form of mulritemporal images and INSAR coherence demonstrated applicability of C-band SAR data for forest studies.

HISTORICAL LAND TRANSFORMATION ANALYSIS FOR GEOGRAPHIC HAZARD EVALUATION IN THE ITALIAN COUNTRY

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ABSTRACT

Examples of historical analyses referred to the Italian country are presented. Satellite imagines (ERS 1-2) are correlated with significant morphologic features. Archeological areas, historical land use, hydrological and geological (sismic and volcanic) evidences are analysed. Particular cases of ancient latium (Roman area) are reported: Aniene valley and Ardea coast. In the Aniene valley the verify historical information are demonstration in the evidence.

USE OF MULTITEMPORAL ERS DATA FOR MONITORING OF LANDCOVER CHANGE IN SAHELIAN REGIONS. THE EXEMPLE OF THE DELTA OF THE NIGER RIVER (MALI)

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ABSTRACT

In the Sahelian zone, changes of land cover may not be considered only as a consequence of inter seasonal change. Global climatic changes and mainly the decrease of pluviometry between the 70 and the 90 must also be taken into account to explain annual changes. In the inland delta of the Niger, changes in the land cover is due to pre-flood and post flood hydrological conditions of the Niger and its tributaries. In order to observe with accuracy annual changes as well as seasonal one, we have selected a set of ERS images in the region of Mopti, taken in the pre-flood and post flood periods between 1995 and 1996. We first have reduced the speckle on ERS images by means of appropriate connected filters in order to use edge and region detection for change mapping. Actually, we had two kind of objectives, that is, on one hand to map some invariant patterns and on the other hand to detect changes in the landscape. For a given season, we may consider that land patters such as ridges or plateaus are invariant structures. These structures are detected by means of edge detection methods, applied to multidate data for a given season. Change detection between dry and wet season are then analysed by combining region extraction, obtained with a flat zone approach, with colour making images by RGB techniques from both dates. On the resulting images, major variations in the back scattering of landscape units will appear as coloured flat zones: major decrease of backscatter appears in magenta as major increasing appears in green. With the help of ground truth and aerial photographs of some well-known areas, the coloured zones are interpreted whether as flood, whether as change in the vegetation cover. The same proceeding is then used to detect annual changes from images of different years and of the same season. The results are then superimposed on corresponding maps of the hydrographical network obtained by edge extraction.

STATISTICAL ANALYSIS AND NEURO-FUZZY CLASSIFICATION OF POLARIMETRIC SAR IMAGES OF URBAN AREAS

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ABSTRACT

The use of radar sensors to analyze urban environments has been already widely established in technical literature, even if it is somehow limited by the coarse ground resolution and the limited information contained in single channel images with a fixed off-nadir angle available from commercial satellite sensors. For instance, ERS data have been considered to individuate built-up areas or to describe urbanized texture patterns, but no attempt has been made to provide information about more precise environments, without considering at the same time data coming from multispetral/hyperspectral sen-sors. This paper describes first a detailed statistical analysis of SAR images of urban areas, which aims at investigating the impact of the different polarimetric channels and the different incidence angles on the probability density function (PDF) of the back-scattered intensity. This analysis is be the basis for optimised segmentation and classification of ENVISAT SAR images that fully exploits the statistic of the data. In preparation for the ENVISAT data, a set of SIR-C/X-SAR images of Pavia (Italy) is considered. A number of different areas are identified inside Pavia, which are of potential interest for automatic classification and monitoring. Their PDF and the charts of their moments are separately characterised as functions of polarimetric channels and angles of incidence, and compared. Moreover, the correlation between the different images of each area is studied. This allows us to devise few optimised discriminants to classify the considered areas with statistical methods. Preliminary results of this classification are shown and compared to the classifications obtained with a neural and/or fuzzy approach of the same data set. To this aim, a Fuzzy C-Means approach or a fuzzy ARTMAP spectral/spatial classification tools have been developed and used. Since these algorithms are suitable to jointly consider data coming from different sensors, we compare the results also with classifications obtained considering aerial photographs (suitably spatially degraded) of the same area.

QUANTITATIVE ANALYSIS OF TEMPORAL ESR INSAR DATA OVER THE CITY OF GRAZ

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ABSTRACT

Results of a quantitative analysis of temporal SAR interferometric (InSAR) derived products, namely digital terrain models (DTM), correlation, and amplitude images for cartographic and thematic mapping of the area around the city of Graz in Austria are presented.

ERS-1/2 single look complex (SLC) image data sets acquired over the period August 1995 to May 1999 were compiled and interferometrically processed. The InSAR generated DTMs and the contour lines digitised reference DTM were converted to interferograms in the ERS slant range geometry and compared to the original interferograms. Differences between the original and simulated interferograms were observed, which were attributed to erroneous phase unwrapping and forest heights.

The fusion of the temporal DTMs and the error maps resulted in a detailed high quality DTM with rms. of about 8 m. The comparison of the high quality DTM with the reference one enabled the estimation of heights of some spatially large urban features such as the Graz Airport and some factory buildings.

In addition, the temporal correlation and amplitude images were fused in the RGB colour coding and the seasonal changes were observed. Forested area, urban targets, water bodies, agricultural, and stable fields were clearly detectable between the images acquired in May and August. It was also observed that some shadow areas were of high coherency and classify as stable fields; whereas, overlay regions classify as forest. The results of the RGB image composite agrees with a reference thematic map of the area generated from Landsat TM data.

UTILIZATION OF RADAR REMOTE SENSING AND TEXTURE ANALYSIS FOR URBAN CARTOGRAPHY IN CAMEROON: APPLICATION TO YAOUNDÉ CITY

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ABSTRACT

The goal of this study is to produce a recent cartography of the city of Yaounde in Cameroon, by using a SAR ERS-2 image acquired in 1999. The Yaounde City is growing fast and the urban community is interested in acquiring recent maps. The actual maps are too old and the means to get new ones are very expensive. Radar remote sensing is a very useful technique allowing to produce recent maps with little time delay. Another advantage granted by radar imagery is that, in this particular area clouds are frequently planning above the sky, making acquisition of images very difficult with the optical sensors. Some studies have already been done with radar remote sensing images in Cameroon, particularly in the area of coastal zones mapping. We are now interested in producing maps in some particular urban areas. We started with the area of Kribi, and the study was presented at the last ESA symposium in Liege. We now focus our attention to the city of Yaounde. Many parameters and methods of texture analysis are used here to reach our goal. Texture features issued from the gray level co-occurrence matrix are used, as well as those issued from the run length gray level method. A rigorous selection of the parameters has been done by the sequential progressive and regressive selection method, in order to determine the parameters granting the best rate of textural classification. The norms of Chernoff and Battacharya, and the transformed divergence are conjointly used to evaluate the classes distinction. The multiplicity of texture features and parameters selection methods allow a best choice, and results to a cartography very close to the ground truth.

Domain: LAND COVER/LAND USE

FIRE IMPACT ASSESSMENT IN INDONESIAN RAINFORESTS WITH ERS AND JERS SAR DATA

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ABSTRACT

During the large El-Nino petiod in 1997 to 1998, Indonesia has experienced one of the greatest fire disaster ever observed in a tropical rainforest environment. Following this event ESA and NASDA decided to set up a cooperation project to compare and combine the capabilities of the two SAR satellite sensors systems ERS-1/2 and JERS-1 aiming at an in depth analysis of this disaster.

It was investigated whether these SAR systems can provide high resolution data on the pre-fire vegetation cover, the extent of the fire affected area and the damage to the vegetation. Different processing techniques were applied: 1.) Monotemporal approach deploying texture analysis to identify different vegetation types. 2.) Multitemporal ERS and JERS SAR images were produced from images acquired before and after the fire event. 3.) ERS SAR coherence images were produced from ERS-1 and ERS-2 tandem data. The results of the evaluation were quantitatively compared to a Landsat TM scene acquired during the fires, NOAA-AVHRR hotspot data and extensive field and aerial surveys.

Similar vegetation types were identified in ERS and JERS pre-fire images based on the structure of the forest canopy and moisture content of the leaves. Six classes could be discriminated, there was no synergy between ERS and JERS in this area. Burnt scar detection was based on changes in SAR backscatter when fire had affected vegetation. Burnt scars could be identified with high accuracy in multitemporal SAR images acquired during dry weather, a condition which prevailed during the fires. Furthermore it was possible to estimate the amount of dead, uncombusted biomass thus providing important information on greenhouse gas emission and future fire risk.

Meteorological conditions strongly influenced radar backscatter. An evaluation of orbits acquired during rainy conditions showed that it was difficult to discriminate burnt from unburnt areas in both ERS and JERS images. Similar problems occurred with Interferometric Land Use (ILU) images produced from ERS-1/2 tandem orbits. Forest/non-forest discrimination became unreliable in ILU images acquired during rainy conditions.

ERS COHERENCE AND SLC IMAGES IN FOREST CHARACTERISATION

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ABSTRACT

The coherence of an ERS-1/ERS-2 tandem pair of winter conditions in Finland was studied. Relationships between the coherence and various boreal forest parameters were derived on the basis of standwise (partly pointwise) ground measurements of roughly 1000 stands. The results were compared with a similar study carried out in Sweden (Fransson et al., 1999) using a coherence pair of the same days. Although the stand structure in the Finnish test site is more heterogeneous the results support clearly the results obtained in Sweden: many forest parameters (diameter, height, stem volume, age) are correlated with the coherence. The shape of the dependence does not markedly change if only the 159 stands larger than 5 ha or the 417 stands larger than 2 ha are taken into account. Small stands were excluded because of possible geolocation errors and the large percentage of border areas, where the forest is systematically different from the bulk forest. The detection of clear cuttings was studied both using coherence images and multitemporal ERS SLC images. The ground truth for the clear cuttings was an optical mosaic with a pixel size of 1 m. Clear cuttings of various ages were easily identified in the coherence image. In the ERS SLC-images it was not trivial to distinguish all the clear cuttings, although some of them could be found. One reason is that many of the clear cuttings are in areas of quite rough topography with rocks and cobble deposit. Another reason is that after the tree removal many of the clear cuttings have been tilled with quite a wide spacing. In the optical mosaic, stripes with a spacing of about 5 m are visible in some clear cuttings. So in many cases there was a natural cause to cancel out the decrease of backscattering due to the clearance of trees.

FIRE DAMAGE ASSESSMENT USING ERS-SAR AND NOAA-AVHRR DATA IN EASTKALIMANTAN, INDONESIA

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ABSTRACT

This study is to examine the application of remote sensing (using ERS.SAR.PRI images and NOAA-AVHRR data) and geographic information system for fire damage assessment and to evaluate the accuracy for this study. Eleven ERS.SAR.PRI images and a set of NOAA-AVHRR data, dated just before, during and just after the fire event of 1997/1998 have been used. The study area was located in East Kalimantan, Indonesia near to Tropenbos research station, the Wanariset - Samboja. Extensive fieldcheck was also conducted to collect field information about landcover, landuse, fire damage and when the fire was happening

Adaptive filtering by Gamma Filter and multi-temporal Segmentation were the main technique applied dealing with the reduction of speckle. The maximum likelihood algorithm was used for supervised classification in ENVI (The Environment for Visualising Images). Error matrices, KAPPA analyses were the method applied in accuracy assessment. ERS-Segmentation gave better result than ERS-Filtered, with an overall accuracy of around 82 0.000000 or Error Matrix and around 79 - 8614672221018231831766519901757397219953651233680090158744268556034160937902702961623596653397107735769834952080867831384650556713927811960334366125763585583258053415457500171737201695761589337872230549536029096935150010614415360.000000 or Kappa analysis. Fire damage map was the final result of this study, which visualises the distribution of burnt areas and their extents/ areas.

Further research is needed to improve the methodology to obtain more accurate results as a practical and applicable methodology for fire damage monitoring.

MAPPING CHINA FOREST WITH ERS SAR TANDEM DATA

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ABSTRACT

The need to monitor forest is dramatically increasing in china, particularly after the introduction of new laws against deforestation. The well known potential of ERS SAR to distinguish forest from non forest areas and the interest of the Chinese authorities to perform forest monitoring based on remote sensing data have motivated the co-operation between ESA and the China Ministry of Science and Technology (MOST) in this area. This interest found its expression in the MACFERST project, where the Chinese Institute of Forestry and ESRIN work jointly to generate a forest cover map over China. To generate this forest cover map of the whole Chinese territory, ERS SAR Interferometric Land Use images (ILU) at a quick look level are used. The project is split in four phases, each one covering a quarter of China, starting with the North-Eastern provinces. Considering the size of the area to be covered, the use of medium resolution images becomes mandatory to achieve the result in a reasonable time. The generation of a global large scale forest map requires solving problems such as the mosaicking of coherence from different InSAR pairs in overlapping areas and the adaptation of the classification algorithm as a function of the climatic zones. This paper presents the work carried out from the identification of the most adequate ERS SAR images to the selection of appropriated classification algorithms, including the strategy adopted to resolve problems related to seasonal and geographical differences affecting the radar backscattering.

USEFULNESS OF ERS COHERENCE TIME SERIES FOR MONITORING THE VEGETATION CYCLE OF A MIXED TEMPERATE FOREST

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ABSTRACT

Within the frame of the EMAC campaign, numerous spaceborne remote sensing data including ERS-1/2 intensity images and ERS Tandem couples have been collected over the Fontainebleau forest during the period 1994-1997. The seasonal dynamics of this mixed deciduous forest has been studied using backscattering coefficients time series but no indication on the leafy period was retrieved. This study aims to investigate the capability of INSAR time series for detecting the vegetation cycle of a deciduous forest.

Prior to the analysis, a normalization process has to be implemented in order to compare absolute values of degrees of coherence computed in different acquisition conditions. Using the interferometric software Diapason developed at CNES, we processed 11 ERS tandem couples, acquired over the period of August 95 to July 1996.

The temporal variation of the degree of coherence versus foliage biomass is analyzed for a beech stand during the 1996 vegetation cycle. The interferometric profile is also compared to the s° profile. With the assistance of a coherent model, the seasonal variations of the degree of coherence are simulated and finally interpreted.

PROCESSING AND INTEGRATION OF MULTISENSOR AND MULTIDATE SATELLITE DATA FOR FOREST MANAGEMENT MAPPING IN GABON (APPLICATION TO THE FIRST FOREST ZONE)

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ABSTRACT

The Central African region hosts the world's second largest tropical forest, which constitute a source of wealth: biological, ecological, as well as economic, for the different countries of the region. Given that it is almost impossible to obtain a recent and cloud-free coverage of the region with optical images, and that it is difficult to perform an aerial survey with reasonable delay and cost, radar satellites with their all-weather capabilities has appeared as an interesting source of data to be explored when carrying out thematic mapping. Mapping for forest management has long been carried out using aerial photographs. Satellite images have been used mainly as a complement, like to give an overall view of the study area or to solve some of the geometric problems of map projections. The limits of these data, however, have not been thoroughly explored. The subject of our work is therefore the assessment of the potential of optical and radar satellite images for forest mapping and management, with the objective of evaluating the contribution of multisensor and multidate images in the context of tropical forest mapping. The study is based on data provided by operational satellites (ERS 1 and 2, RADARSAT, SPOT, Landsat) which will be used in preparation of future satellite data such as those of ENVISAT. The methodology used is based on the comparison of manual and automatic approaches. On three test sites, computer-aided photointerpretation, as well as supervised and unsupervised numerical classification have been carried out in order to extract thematic information. GIS tools were then used to perform integration of results with existing vegetation maps so as to assess the processing made. The results show that both approaches give good results when the data include optical images. Also, the manual approach seems well suited in presence of radar images whose speckle noise, even when kept to a minimum is still a handicap. The work will then be focused on the segmentation and classification methods applied to multisource data and on the contribution of radar interferometry data for the caracterization of foret cover. Images provided by:Projet OIBT PD 8/95 Rev.1 (F). Stratification, cartographie et inventaire multi-sourcesen vue de l'aménagement de la première zone forestière du Gabon, phase 1 ;Projet Forêts et Environnement au Gabon (sur financement banque mondiale)Projet ENVISAT ID 539 (demande d'images ERS interférométriques en cours).

USING L-BAND POLARIMETRIC INTERFEROMETRIC DATA TO RETRIEVE ESTIMATES OF FOREST BIOMASS DENSITY

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ABSTRACT

Previous use of SAR to retrieve specific forest characteristics has been limited by saturation of the backscatter over densely forested areas. The backscatter is also affected by the structure of the forest canopy making mixed forests especially difficult to characterize. A number of current airborne, as well as the next generation spaceborne sensors, hope to extend these limits using fully polarimetric L-band sensors. This will allow retrievals of forest parameters up to greater densities and additionally permit an interpretation of the scattering mechanisms through polarimetric analysis. Another source of information will be provided by interfering different polarimetric combinations, where repeat pass systems acquire suitable data, and generating coherence images over the forested areas.

This paper presents a preliminary analysis of two L-band polarimetric data sets from forest sites. The first consists of data from the SIR-C mission (Oct 1994) over Duke Forest, N. Carolina, USA and the second of L-Band polarimetric interferometric (PolInSAR) data from the BNSC SHAC (SAR and Hyper-spectral) airborne mission over Thetford Forest, East Anglia, UK. A Landsat TM image covering Duke Forest, ground DEM and forest database of Thetford Forest were acquired for ground truth. Each PolInSAR image was co-registered and geocoded to the ground database. Specific scattering combinations (HH, HV and VV) were derived from the full scattering matrix and used to derive coherence images between each polarization pair (HH+HH, HV+HV and VV+VV).

Polarimetric decomposition using the Freeman - Durden model shows volume scatter to be the dominant form of scattering over dense forest (typically > 50 t/ha). Single bounce interactions appear to become less significant as biomass density increases. Coherence over the forested areas remains relatively high even over high biomass density stands and the greatest dynamic range was observed in the HV+HV case where the majority of the scattering events occur as volume scatter within the forest canopy. Classification results were increased in both the number of classes and accuracy of class determination using the combined polarimetric and interferometric data. Therefore, by using all the information available from a typical SAR image, that is the backscatter, at different polarizations and phase coherence, we can greatly increase the accuracy of the classification results over higher biomass density forests.

PINE FOREST UNDERSTOREY SENSING WITH ERS-2 SAR IMAGERY

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ABSTRACT

Remote sensing forest studies have mainly concentrated on the overstorey component, continuing to provide innovative approaches, particularly for the quantitative estimation of forest parameters. However, the understorey stratum has not yet received a deserved attention within this technological domain.

On one hand, the understorey has a relevant role both in the structure and functioning of forests, e.g. by being an important layer for wildlife habitats, limiting erosion hazards or providing fuel for fires. On the other hand, the inherent advantages of remote sensing tools can provide new inputs for its monitoring and characterisation, and should be further explored.

Though few, some recent contributions in the optical field have already selected this subject as study object and provided interesting results. However, SAR imagery has remained outside the satellite data choices. A priori, limitation and risks can be highlighted when approaching the use of spaceborne SAR data to understorey studies, but this type of imagery can be sensitive to this forest component, under certain circumstances. The known advantages presented by radar images when compared to optical data - independent of solar light, cloud cover or hazy atmospheric conditions, and increased penetration capabilities - have justified the start of a pathfinder project dedicated to this issue.

The objective of the present document is to explain the strategy followed to dig in the analysis of the understorey forest stratum based on ERS-2 SAR imagery and present the results achieved so far. Maritime pine (Pinus pinaster, Aiton) stands located in central Portugal were used as test areas and ground truth data was obtained through other research projects (Institutional collaboration and synergy).

Domain: FORESTRY

A COMPARISION OF SAR-INTERFEROMETRY- AND CARTOGRAPHICALLY GENERATED DIGITAL ELEVATION MODELS BY ERRORS, ACCURACIES AND EXTRACTED HYDROGRAPHIC FEATURES

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ABSTRACT

Topographic data are critical to the accuracy of a variety of environmental computer models. With rapidly changing technologies in the mapping industries, the quality of Digital Elevation Models (DEM) improved significant. Data from satellite altimetry (SAR Interferometry) as well as data from cartographic sources are compared. This study focuses on errors, accuracies and the extraction of hydrographic features from DEMs.

The SAR Interferometry- models are derived from JERS and ERS with fixed-length 50-meter pixels as well as from SRTM with resampled fixed-length 25-meter pixels. All three models represent different wavelengths and system geometries. The models from cartographic sources base on maps at 1:200,000 (fixed-length 50-meter pixels) and 1:1,000,000 (GTOPO30, fixed-angle 30 arcseconds pixels) scale. The testsites are situated on Lake Baikal, Russia, within the framework of the SIBERIA project. The DEM data contain errors of three types: blunders, which are removed prior to entry in the data set; systematic errors, which follow some fixed system-specific pattern; and random errors, which are of random nature and are completely unpredictable. The horizontal and vertical discretization process generates artifical dams, pits and flats. These local differences among DEM grid cells are analyzed to compute accurate slopes, flow directions and other hydrographic parameters. The relative vertical accuracy, rather than the absolute accuracy, determines the quality of such parameters derived from local differencing computations.

The first phase of analysis focuses on the absolute and relative accuracy in horizontal and vertical dimensions of the DEM data. System-specific errors are described. The next step of calculating flow grids, includes depression filling, indication of flow direction for each cell and computation of flow accumulation, a value equal to the total number of cells that drain to it. Strahler stream orders are used to measure structural complexity of the river networks and classifying the major and minor tributaries for the different DEM's. The higher resoluted SRTM data also provides better identification of the heads of Strahler-first-order channels known as sources.

AUTOMATED TRAINING-SITE SELECTION BASED ON A COHERENCE MODEL FOR FOREST CLASSIFICATION IN THE SIBERIA PROJECT

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ABSTRACT

In recent years SAR Interferometry has proven its value for deriving terrain height information and for detecting movements of the Earth's surface. Quasi as a by-product, SAR Interferometry can be used as an input to classification. In this paper the possibility of using coherence information derived from ERS Tandem Paris for estimating growing stock volume of boreal forest is investigated.

To study the relationship between forest parameters and radar parameters an extensive data set was built up within the framework of the SIBERIA project. Forestry data from 36 testsites, each covering from 20,000 to 100,000 hectares of forested land, were made available. This extensive database provides a good basis for understanding the potential and limitations for using ERS Tandem coherence for forestry applications. A visual analysis of scatter plots of ERS coherence versus growing stock volume showed that the scatter is generally relatively large. However, for test sites with a small degree of scattering, an exponential relationship is evident. To study the behaviour of the coherence model, it was fitted to the scatter plots from all testsites. With some exceptions, the estimated model parameters lay within the expected range.

The exponential coherence model was then used to select automatically training sites (or regions of interest, ROIs) as input for the maximum likelihood classification. The general idea is to determine coherence thresholds for each growing stock volume class using the coherence model, select training sites using this thresholds, and run the classifier using the signatures from the training sites. Growing stock classes for the forested areas are: < 20 qm/ha, 20-50 qm/ha, 50-80 qm/ha, >80 qm/ha. The method works quite stable for different ERS frames of the SIBERIA project area and also different image product (GTC or GEC). This method proved the capabilities of the coherence model described above.

GENERATING A UNIVERSAL FOREST GROUND-TRUTH CATALOGUE FOR REMOTE SENSING APPLICATIONS TO FOREST OBSERVATION

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ABSTRACT

For cost, time and accessibility reasons, the on-ground truth data collection is the usual problem for both research and practical implementation of new remote sensing sensors and technologies. In the framework of the SIBERIA, an attempt to generate a permanent universal system of on-ground truth data for all possible (current and future) remote sensing observations of Northern Eurasia terrestrial ecosystems with a special emphases to forests has been realized. In its current form, the system comprises three levels: 1) federal, 2) (sub) regional and 3) local, which are presented in a form of attributive data bases and connected GIS components. The federal level includes the comprehensive description of entire Russian land by ecological regions (totally 141 for Russia) and administrative units of the federal level. GIS components of this level are presented by a number of digitized maps at scale from 1:1 Mio to 1:4 Mio (including landscape, vegetation, soil, forest, land-use/land-cover maps, relevant layers of the DCW, others). Units of the (sub) regional level called test territories have the average area from 1 to 3 million ha and are designated to describe zonal and altitudinal diversity of landscapes & terrestrial ecosystems. GIS components are at scale 1:200000-1:300000. The local level is presented by test areas of typical landscapes (of the average area from 30000 to 150000 ha) with attributive DBs describing each land-use/land-cover unit (e.g., primary forest inventory & management units are used for forests). Corresponding GIS components have the scale at 1:50000. Two lower levels have been developed for the territory investigated by SIBERIA (of total area at about 100 million ha), and includes 8 test territories and 51 test areas. The system presents possibilities 1) to examine RS images of different types with the resolution from 5-7 m to 150-200 m; 2) to plan an appropriate design of multi-layer observations and 3) to develop appropriate classifications. Problems of spatial accuracy and up dating of the system are discussed.

Domain: FORESTRY 'SIBERIA'

ON THE VARIETY OF IW RADAR OBSERVATIONS IN THE OCEAN 2. RIP-LIKE SIGNATURES

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ABSTRACT

In the accompanying paper (part 1. Slick-like signatures) we describe and present results of a recent classification scheme for synthetic aperture radar (SAR) signatures of internal waves (IWs) that has been proposed based on the analysis of ERS SAR images of the Iberian shelf zone. According to this classification IWs display three different signatures depending on the parameters of surface-active films and wind speed. In particular, it was found that at very low wind speeds IWs display single positive backscatter signatures as a result of the image background falling to the noise floor at such low wind conditions. Here, we present results of observations of predominant single positive signatures even when the background backscatter is well above the noise floor. A variety of observations from different oceanic regions, such as the Strait of Gibraltar, Andaman Sea, Sea of Bali, Gulf of California, central Bay of Biscay, etc.. are presented as evidence of the phenomena. One common factor associated with these SAR observations seems to be that they correspond to comparatively long IWs (their wavelength can be up to several kilometres) which are known to propagate with high phase velocities (C_p>1 m/s). However, analysis of a data set of the West Iberian shelf also shows that predominant positive signatures can occur in this region, where typical values of IW phase speed is C_p~0.5 m/s. This has been made clear from analysis of the mode of signature, which is defined by a parameter that evaluates the IW intensity profiles in relation to the mean backscatter of the image background. The signature mode parameter is found to be correlated with the angle between the IW propagation direction and the wind velocity. A simple model which takes into account modulation of short-scale surface waves by the relative wind velocity to the surface current generated by the IWs is considered and was found to be in good qualitative agreement with the experimental results. While in the accompanying paper (part 1) we found the signature mode parameter to be sensitive to the local concentration of films, in this paper we demonstrate that it can also be sensitive to the relative wind direction to the IW propagation. In addition, we investigate also the signature dependence for moderate wind speed, which was not predicted in the accompanying paper.

ON THE VARIETY OF IW RADAR OBSERVATIONS IN THE OCEAN. 1. SLICK-LIKE SIGNATURES

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ABSTRACT

It was shown recently that three different types of short-period Internal Wave SAR signatures occur on the Iberian Shelf depending on parameters of surface-active films. Large scale modulation of film characteristics by currents associated with internal tidal waves can also produce a signature in ERS SAR images. On the Western Iberian shelf short-period IWs typically propagate in groups of packets that are believed to be generated by the evolution of internal tidal waves over the shelf. Here it is shown that onshore propagating short-period IWs can exhibit different SAR signatures within the same wave packet according to their position relative to the phase of the internal tidal wave. These transitions of signature mode can be explained by large scale variations of film parameters produced by the internal tidal waves. At low-to- moderate winds leading waves in the IW packets usually exhibit double sign signatures, which evolve to negative sign signatures for the subsequent waves in the packets. At very low, near-threshold, winds the IW signatures can be in the form of the double sign type undergoing transition to positive sign signatures when compared to the background behind the IW packet. This is a consequence of different threshold wind speeds for excitation of Bragg waves at different film pressures. It is demonstrated that there is an increase of unperturbed film pressure in the direction of the ranking order of solitons in a packet of short-period IWs, which is predicted by a theoretical model and in agreement with measurements of film elasticity. It is concluded that observations of SAR signature mode transitions are consistent with previous model results, and a diagram describing mode transitions of the IW signatures in relation to film pressure and wind speed is presented. Examples of such transitions in different regions of the global ocean are presented, illustrating where slick-dominated SAR signatures are expected to occur.

DETECTION AND INTERPRETATION OF OCEANIC AND ATMOSPHERIC SIGNATURES IN SPACEBORNE RADAR IMAGERY OF THE NORTH-WESTERN PACIFIC

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ABSTRACT

This work presents the results of analysis of the ERS-SAR images of the Othotsk and Japan seas, which are at our disposal in the frame of ESA, grant AO3-224. The obtained images were used to study three problems.

1) Investigation of internal waves. A detailed analysis of accumulated data has shown that in the Northwestern Pacific there were regions of regular manifestations of internal waves propagating in different directions. The wave surface signatures exhibit clear nonlinear features typical for trains of internal solitons: higher-than-linear group velocities, decreases in wavelength, crest length and amplitude toward the rear of the packet. Interaction of wave structures is a very sensitive detector of both the effectiveness of nonlinear processes and principal physical mechanisms responsible for this interaction. The focus was on specific manifestations of non-linear interaction of internal waves at sea surface. The obtained results were compared with those received by the Space Research Institute in the same region in the 80s using an airborne Ku-band radar.

2) The study of ocean and atmosphere interaction in regions of intensive energy exchange such as the Kuril straits, including the Friza strait, featuring intensive convergent currents and sharp temperature contrasts. First of all, the Friza strait serves as an exchange of waters between the Okhotsk Sea and the Pacific. The strait accommodates a two-directional current system built by tidal flows and characterised by high stability in time and in space. SAR images taken by the ERS-2 on September 25, 1998, at a 12-hour difference permitted to observe the development of vortex structures on the sea surface. Here comparisons were also made with data obtained in the early 80s by means of a set of airborne and spaceborne instruments, which included a satellite-borne SAR of 5cm "Almaz-1", an aircraft-laboratory and a research vessel. The comparisons confirmed the stable character of the observed phenomena, which could add valuable information to the understanding of the long-term oceanic variability in that region.

3) The analysis of the available data made it possible to accurately identify and investigate surface manifestations of gravitational waves in lower troposphere, convective motions in atmosphere, wind fronts, etc.

THE USE OF ERS-1/2 SAR TO THE STUDY OF OCEAN SURFACE FEATURES IN THEGULF OF CALIFORNIA MEXICO

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ABSTRACT

The Gulf of California, a large semi-enclosed sea located in the north-western Mexico between the Baja California Peninsula and the Mexican main land, is a very interesting and complex region, with considerable oceanographic and meteorological interest due to its similarity to other marginal seas, such as the Red Sea, the Adriatic Sea, and the East China Sea (Roden, 1958; Badan-Dangon et al., 1991). Among the outstanding oceanographic features of the Gulf of California are the large annual range of sea surface temperature, its impressive tidal range, that increase gradually from the Gulf entrance up to Tiburon Island and than rapidly toward its head, exceeding 10m during spring tides. There is a seasonally reversing gyre, cyclonic in the summer and anticyclonic in the winter, located in the northern Gulf with speeds reaching 0.7 ms-1. The high tidal range and the complicated bottom topography produce strong currents along the Gulf, especially in the vicinity of Tiburon Island where strong tidal mixing fronts and high internal wave activity are observed. Until now the complex oceanographic processes occurring in the Gulf of California have been investigated mainly by sampling from insitu instruments aided in some occasions by nearly-coincident infra-red derived sea surface temperature images. Unfortunately, in most cases, insitu measurements do not provide adequate spatial and temporal cover of the intrinsic scales of variability associated with these oceanographic features, and due to cloud cover, a common situation to many coastal areas, infra-red imagery is not always a success. In this paper we show evidence that ERS-1/2 SAR can play a useful role in observing the complicated upper-ocean circulation features occurring in the Gulf of California.

Domain: SEA FEATURES

A MODEL FOR WIND SPEED AND WAVE HEIGHT RETRIEVAL FROM RADAR ALTIMETER MEASUREMENTS

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ABSTRACT

A new algorithm for simulation of the measurement of ocean wave height and wind speed by radar altimeter is proposed. This algorithm considers ocean wave spectrum and employs a parametric model for the simulation of the electromagnetic waves diffusion from surface; it offers greater flexibility and realism as to analytical models currently used.

Numerical results give assurance of independence of the measured significant wave height from wave period. They are consistent even if different backscatter models are employed. On the contrary, the numerical results show that wind speed measurements are significantly affected by wave period.

The aim of this work is two-fold: on the one hand to allow a more accurate calibration of altimeter data and on the other hand to develop a model which can be used for simulation of the sea state response as seen by other microwave instruments working at other incidence angles.

CASE STUDIES OF COASTAL OCEAN WIND FIELD RETRIEVALS FROM RADARSAT SYNTHETIC APERTURE RADAR IMAGES NEAR THE ISLAND OF HAINAN, CHINA

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ABSTRACT

High resolution coastal zone wind field estimates may be retrieved from radiometrically calibrated synthetic aperture radar (SAR) images of the coastal zone; the wind field modulates that surface roughness, which in turn modulates the observed radar cross section. Higher wind speeds produce larger cross sections. We consider two calibrated RADARSAT SAR images of the coastal zone near the Island of Hainan, China and used a spectral analysis of the long wavelength structure in the SAR image to estimate the wind direction. The estimated direction and the radar cross section, along with a scatterometer wind retrieval model, were used to estimate the wind speed. SAR images can provide the wind vector with a high spatial resolution; our retrieved estimates are shown to be in reasonable agreement with conventional synoptic weather analyses from the observation times closest to the SAR passes. The images also provide visual evidence of the spatial development and evolution of the marine atmospheric boundary layer. Secondary atmospheric flow phenomena, such as boundary layer rolls and atmospheric internal waves, modulate the ocean surface roughness and may be imaged by SAR.

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VALIDATION OF WIND RETRIEVAL ALGORITHMS FROM SPACEBORNE SAR

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ABSTRACT

The exploitation of Synthetic Aperture Radar (SAR) imagery as a tool to obtain geophysical information of the marine environment has been object of intense studies by the scientific community in the recent years. Several methods have been proposed in the last few years to retrieve quantitative estimates of ocean wave spectra and of wind speed and direction at a given reference height from SAR imagery. These tools appear very interesting in view of the future dual-polarised ASAR instrument onboard the European ENVISAT satellite, whose launch is planned for June 2001.

In preparation of the availability of ENVISAT/ASAR data, we have planned a validation campaign for wind retrieval algorithms from ERS-2/SAR. The main source of reference data is the buoy ODAS Italia 1, located in the North Tyrrhenian Sea at 43.8 N and 9.1 E. ODAS Italia 1 is indeed a real open sea laboratory, equipped with a large set of meteo-marine instrumentation [1], like anemometer, pyranometer, thermometers, current meter, etc.

As a case study, an ERS-2/SAR scene of March 30 (orbit: 25842, frame: 2727) over the North Tyrrhenian Sea was selected and both PRI and SLCI products were acquired. The image shows relevant features due to the the action of the wind on the sea surface. In particular, the presence of wind streaks, which are surface evidence of the wind direction, is clearly visible. However, the ``true" wind direction cannot be immediately recognized because of the 180 degrees ambiguity. We propose to exploit the SAR backscatter spatial structure as a mean to remove the directional ambiguity. The SAR image was analyzed: i) using the empirical backscatter model CMOD4 [2] to retrieve the wind stress; and ii) by means of the VISA method [3] to retrieve the wind direction without ambiguity. Indeed, the VISA procedure allows to discriminate the ``true" wind direction when unstable thermal conditions are fulfilled. All the relevant meteorological parameters (wind intensity, wind direction, air/sea temperature) had been collected by ODAS Italia 1 during a total of 1 hour of acquisition, centered around the time of satellite pass. The comparison of measured wind intensity and direction with SAR retrieved values confirms the soundness of the employed algorithms.

Future plans of validation activities, in connection with the availability of ENVISAT/ASAR data, regard the installation of an ondametric buoy [4] in the vicinity of ODAS Italia 1, in order to jointly validate wind and wave spectra retrieval methods from SAR.

INTERNAL SOLITONS NEAR GIBRALTAR: A MULTI-YEAR STUDY USING ERS-1 & 2 SAR IMAGERY

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ABSTRACT

Synthetic aperture radar (SAR) images are especially useful for observing surface signatures of coherent internal waves in the ocean. A study has been conducted of the dynamics of internal soliton packets in and near the Strait of Gibraltar, using several years' worth of imagery from the European Remote Sensing Satellites, ERS-1 & 2. The study reveals new features of the wave field as well as reaffirming behavior previously reported. It shows the waves may have two modes of propagation out into the Alboran Sea, termed Northeast and Southeast; that they penetrate eastward well beyond 200 km from their source; that they appear to be dependent on fortnightly tides as well as on semi-diurnal and diurnal forcing; and that smaller packets are generated at the Camarinal Sill that propagate into the Atlantic. The data are interpreted in terms of (1) the little-known "dnoidal" solution to the Korteweg De Vries equation for the amplitude and (2) the Taylor-Goldstein equation for the vertical internal modes, using continuously distributed profiles of density and mean flow velocity. Both historical and contemporaneous in-situ data are used. These two equations together capture many quantitative features of the soliton packets. Comparisons between observations and theory will be presented. The study has been supported by the European Space Agency and the U.S. Office of Naval Research.

QUALITY OF LONG TERM SATELLITE WIND AND WAVE MEASUREMENTS

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ABSTRACT

Since the time of the first data from ERS-1, in 1991, the french PAF CERSAT of IFREMER Département d'Océanographie Spatiale has processed and distributed data from ERS-1 and ERS-2. Concurrently the Département was involved in algorithm development and geophysical validation of the products of ERS altimeters and AMI's, and then of other satellites, like TOPEX, NSCAT and, more recently, QuikSCAT. For this purpose, procedures of cross validation of sensors were developed with the aim of building long time series from various sensors and satellites, with homogeneous quality. Here we present long term validation of significant wave height (SWH) and wind speed measurements from altimeters and scatterometers. Two methods are used: global statistical analysis and cross validation at same time and location. The first one is applied to ERS-1, ERS-2 and TOPEX SWH, and shows significant differences, up to more than half a meter for SWH, between the satellite products, over the time period from 1991 to 2000. Furthermore these differences are not constant with time but depend on changes for processing improvement, or on electronics drifts, for instance. The second method, completed by in situ data comparisons, allows to propose corrections for the data, in order to improve their global quality. Results from same technics applied to sea surface wind speed measurements from ERS-1, ERS-2 and TOPEX altimeters are shown and completed with comparisons from scatterometers of ERS, NSCAT and QuikSCAT. Beyond the scope of validation, this work is a step for merging data from various sensors to infer more accurate wind and wave fields.

Domain: WIND/WAVES

EXTENSION AND TYPES OF SEA ICE WITH THE ERS-1 SCATTEROMETRY IN SURROUNDINGS OF THE ANTARCTIC PENINSULA

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ABSTRACT

Sea ice is a most changeable component of the Antarctic ice cover. The ice characteristics are under affect of climatic and weather factors, hydrodynamic, wind and wave variation. Traps of the coast and shallows catch and concentrate broken and drifting sea ice forming multi-year ice. Dynamics and transformation of the sea ice by the scatterometer data were considered for the Antarctic Peninsula region and for the Ukrainian Vernadsky Station area in particular. These data are an importance to the climatic analysis and active ice navigation of the research and tourist vessels in the western Antarctic. The Polar Sea Ice Grids of the ERS-1 AMI provided by IFREMER were used for our research.

SEA ICE INTERPRETATION MANUAL FOR SAR IMAGES

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ABSTRACT

The overall objective of producing a SAR ice interpretation manual is to 1. Support the use of Synthetic Aperture Radar (SAR) images from ERS, RADARSAT and ENVISAT in national Ice Services and other operational users of SAR-derived ice information; 2. Promote and facilitate use of SAR images among end users such as shipping companies, oil companies and other important operators in Arctic regions; and 3. Education and training. There is a demand for a SAR ice interpretation manual which can be used in education at marine colleges and universities and in special training courses for captains, ice pilots, oil companies, oceanographers, meteorologists and other personnel working with sea ice. The manual contains an introduction to SAR imaging of different sea ice types and forms as observed by ERS and RADARSAT images from the European sector of the Arctic Ocean and adjacent seas. The main part of the manual consists of about 50 examples of typical ice types and phenomena as observed by SAR together with interpretation and analysis of the ice features, which are apparent in the images. The manual will be made available for public use both in hardcopy and on Internet.

ANALYSIS OF MULTI-POLARMETRIC SAR IMAGERY FROM THE KARA SEA

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ABSTRACT

Sea ice plays an important role within the global climate system. Knowledge of the Polar Regions is limited due to their size and the hostile environment in which they lie. Satellite imagery can provide synoptic coverage that overcomes these limitations. While single SAR images provide excellent data for monitoring the ice cover in all weather conditions, it is limited due to the ambiguous appearance of the surfaces of ice and water under certain conditions. To address this problem calibrated ERS-2 (C-band, VV polarisation) and RADARSAT (C-band, HH polarization) SAR images were acquired over the Kara Sea on 24th March 1997 to form a composite multi-polarmetric image. Analysis of the synergistic composite can improve the classification of sea ice in satellite imagery, and provide an indication as to how the ASAR sensor on board ENVISAT will respond to sea ice.

SEASONAL CHARACTERISTICS OF ANTARCTIC SEA ICE BACKSCATTER

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ABSTRACT

Sea ice is an important component of the global climate system and is considered as a sensitive indicator of climate changes because it responds sensitively to them as model runs have shown. Besides microwave sensors like SSM/I only scatterometers like the wind scatterometer on board the ERS-1/2 satellites allows for a frequent and complete observation of sea ice in both Polar Regions. In view of a synergetic use of both sensor types a more thorough understanding of the scatterometer signal of sea ice is desirable. As recently reported, the backscatter of sea ice in the Weddell and Ross Sea behaves opposite to the Arctic, where there is a sudden decrease in multi-year ice backscatter once air temperatures approach or exceed zero centigrade. In the Antarctic, there is a pronounced seasonal cycle, with higher backscatter in summer than in winter. In the late austral summer, backscatter decreases again and slowly approaches winter values. The seasonal cycle is interpreted in terms of processes at the ice surface. The spring backscatter rise may be associated with the formation of superimposed ice. In fall, when formation of superimposed ice ceases due to surface cooling, gradual surface flooding with seawater becomes the dominating process and causes the observed decrease of backscatter. In this study, the seasonal cycle of about ten selected Antarctic Sea ice regions are observed with the ERS-1/2 wind scatterometer. The examination will be supplemented with data of the Sea Winds 13.4 GHz microwave radar instrument on board the NASA QUICK SCATterometer satellite (Quickscat), launched in June 1999. Combined with the ERS-1/2 wind scatterometer, the Sea Winds Ku band instrument may provide complimentary information.

SEA ICE ALGORITHM VALIDATION AND IMPROVEMENT BY MULTI SENSOR ANALYSIS

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ABSTRACT

In order to validate and improve sea ice algorithms a hierarchically structured analysis of remote sensing methods was carried out ranging from large scale coverage of satellite passive microwave over intermediate scale of satellite active microwave to small scale aircraft based measurements.

The used dataset was acquired during ARTIST (Arctic Radiation and Interaction Study) which took place around Svalbard in March/April 1998. Airborne measurements were carried out with two research aircrafts of the Alfred Wegener Institute. The aircraft was equipped with well proven devices (e.g. line scanners, radiation thermometer) and new systems (19.35 GHz and 37 GHz radiometers) which were operated for the first time during ARTIST. Several coordinated satellite under flights (SSM/I and ERS SAR) were performed in the vicinity of the marginal sea ice zone.

The dissimilar resolutions and swath widths of different remote sensing systems is a common problem for multi-sensor applications. The newly developed ARTIST Sea Ice algorithm (ASI) combines the NASA team and Svendsens 85GHz methods bringing together the nearly weather independence of the lower frequency SSM/I channels with the high spatial resolution of the 85GHz channels. The goal of the ASI algorithm is to reduce the gap of resolution between ERS SAR and SSM/I. The resolution of the ASI sea ice maps (ASI:about 14km, NASA team:60km) is suitable for mesoscale applications: e.g. the accurate position of the sea ice edge meets the requirements of the mesoscale atmospheric modeling part of ARTIST, the state of the ice edge (diffuse or compact) can easily be identified, and it allows for a higher resolved interpretation of ERS SAR images in terms of sea ice concentrations. Furthermore a texture based classification algorithm for ERS SAR images was developed using co-occurrence texture features and learning vector quantization for supervised learning of the training data. The selection of training samples from the ERS SAR images can thereby aided either by the ASI sea ice maps or the aircraft measurements and observations.

SEASONAL ERS SAR STUDIES OF SEA ICE IN THE PECHORA AND KARA SEA REGION

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ABSTRACT

There is a strong seasonal and regional variability in the sea ice distribution in the Kara and Pechora Seas. It is an important sea ice production region because of very low air temperatures and repeated opening of polynya areas driven mainly by strong winds. With SAR data it is possible to map areas of open water and thin ice for estimation of heat exchange from water to air, which is essential for modelling of the climate system at high latitudes.

This study will focus on characterisation of the different types of first-year sea ice in the Pechora and Kara Sea. Regional and seasonal signatures, during the whole ice season from the early formation of thin ice to the melt period will be investigated. ERS SAR data will be used, as these are especially valuable in the Arctic due to the independence of fog, cloud cover and lack of sunlight. Image data will be examined and parameters for characterising the sea ice will be extracted. Environmental information will be used to get a better understanding of the development of the ice during the year under different weather conditions.

Monitoring of sea ice in the Pechora and Kara Sea region is very important both for economic and environmental reasons. Extensive oil and gas resources are found here, and exploitation of these as well as cargo transport along the Northern Sea Route may cause environmental problems. Also, transport of pollutants from the land areas by the huge rivers that flow into the seas, may contribute to the contamination of the Arctic environment. Sea ice information is important for planning of oil and gas installations, and safe exploitation and transport of these resources.

Domain: SEA ICE

REPROCESSED ERS-1 AND ERS-2 ALTIMETER MEASUREMENTS FOR OCEAN CIRCULATION AND CLIMATE RESEARCH

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ABSTRACT

The estimated accuracy of sea surface height measurements from the NASA/CNES TOPEX/POSEIDON (T/P) altimeter satellite is 2-3 cm. (Fu et al., 1994). As a result of this unprecedented level of accuracy, the measurements from all satellite altimeters have been significantly upgraded by successfully exploiting the results from T/P during the initial phase of the NASA Ocean Altimeter Pathfinder Project (Koblinsky et al., 1998, 1999). This presentation provides an overview of the significant improvements made to the ERS-1 and ERS-2 altimeter data sets and details current research activities and results from the NASA Ocean Altimeter Pathfinder project and collaborative work with other investigations including: Height anomalies from merged ERS -1/2, T/P, and Geosat-Follow-On (GFO)·Mean Sea Level estimates from ERS and T/P·Geostrophic velocity computations from altimetry and in-situ validation techniques·Barotropic de-aliasing: model and removal of the fast response of the ocean to wind and pressure·Global tide model improvements through embedding regional models in shallow and enclosed seas within the T/P based tide model Ionosphere modeling with IRI-2000 for Single Frequency Altimeters GFO improved orbit information·Next generation mean sea surface. Evaluation of NVAP model in Indonesian Archipelago The NOAA/NASA Pathfinder program was created by the Earth Observing System (EOS) Program Office to determine how existing satellite-based data sets can be processed and used to study global change. The data sets are designed to be long time-series data processed with stable calibration and community consensus algorithms to better assist the research community. The Ocean Altimeter Pathfinder Project involves the reprocessing of all altimeter observations with a consistent set of improved algorithms, based on the results from TOPEX/POSEIDON (T/P), into easy-to-use data sets for the oceanographic community for climate research.

A STUDY OF THE MEDITERRANEAN WATER OUTFLOW USING THE ERS AND TOPEX-POSEIDON JOINT ALTIMETRY

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ABSTRACT

After leaving the Strait of Gibraltar the Mediterranean water outflow descends close to the bottom of the slopping topography towards the Gulf of Cadiz, being deflected to the right as a consequence of earth rotation effects, starting its mixes with its surrounding Atlantic waters. Consequently, the termohaline characteristics of the Mediterranean outflow are gradually modified, its salinity decreases and becomes less and less dense reaching, at a certain stage the density values corresponding to the mid-depth layers of the Atlantic Ocean. In the Gulf of Cadiz the Mediterranean water can be described as a gravity current flowing along the Iberian continental slope. Due to a bifurcation, its densest part proceeds westward along deeper isobaths several tens of kilometers offshore from the lighter part. The two cores may become locked together. The presence of these anticyclonic eddies, detached from the main body of Mediterranean undercurrent water, can be detected in the termohaline field, since they form lens-like structures of anomalously high temperatures and salinity, as compared with the surrounding Atlantic waters, and in the velocity field by its vortex rotating structure. This communication presents the results we have obtained in the detection of meddies using jointly the altimetry of Topex-Poseidon and ERS, analysing its sea surface dynamic signals and comparing it with the tracks recorded of several possible meddies off the Portuguese coasts, primarily detected by rafos given us for the Portuguese group of Ioceano. As meddies dynamic signals were in subdecimetric order of magnitude we have to improve both, the accuracy of the satellite orbit and the geophysical corrections applied to the satellite altimeter data.

THE SIGNATURE OF ROSSBY WAVES IN THE ATSR DATASET

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ABSTRACT

The purpose of this paper is to examine the surface thermal signatures of extratropical baroclinic Rossby waves (a special class of planetary waves) in the ocean and measure their propagation speed. We show that longitude-time plots of the global sea surface temperature (SST) record produced by the Along Track Scanning Radiometer (ATSR) on board ERS-1 between August 1991 and April 1996 contain clear evidence of wave propagation in all parts of the world oceans and at many latitudes. The propagation is studied with the help of a 2D Radon transform method in order to analyse more objectively the wave speed and its variation with location and time. The resultant spatial distribution of velocity estimates broadly matches the Rossby wave speeds predicted by the most recent theory and those measured by TOPEX altimetry, but there are some discrepancies, for instance at lower latitudes the waves in the SST field appear to propagate slower than in the altimeter data. We describe in details how the signals vary in both space and time in the data record. Wave signatures are found to be strongest between 25 and 40 S, where the meridional temperature gradient is strongest. Here the observed speeds are 20-30 9.50753e-305reater than theoretical predictions. Planetary wave speed is also found to vary considerably with longitude. In general there is an increase towards the west of ocean basins, consistent with the theoretical findings. Another feature of particular interest is the presence of eastward propagating signatures in the Southern Ocean. We conclude that the ATSR ASST data are a valuable source of information for studying basin scale wave processes as a complement to the use of altimetry. By observing the thermal signature of Rossby waves the method has the potential to clarify their influence on air-sea interaction processes, and contribute to climate modelling studies.

SYNERGISTIC OBSERVATIONS OF ROSSBY WAVES

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ABSTRACT

Baroclinic Rossby waves are large-scale propagating features that transmit information from the eastern side of an ocean basin to the west, where they maintain and may displace the Western Boundary Currents. Satellite altimetry has led to significant advances in the mapping of Rossby wave activity, providing results to challenge the understanding of the theoreticians. Here we look at Rossby waves evidenced in sea surface height, sea surface temperature and ocean colour, using data from ERS-1, ERS-2 and other satellites.

There is good agreement in the Rossby waves recorded by the altimeters on both the TOPEX/Poseidon and ERS platforms, with signals present in all ocean basins and at most latitudes. Westward propagating features are also seen in SST derived from both infrared (ATSR) and passive microwave instruments (TMI). The signature of Rossby waves in ocean colour data is harder to detect and tends to be masked by the strong annual phytoplankton bloom, but evidence has been found in data from both OCTS and SeaWiFS. The interpretation of such a signal is even more challenging. Possibly this is due to thermocline displacement and its effect on biology.

The Rossby waves at any given latitude do not all propagate at a uniform constant speed. In many cases they speed up as they move from eastern basins to the west, in response to changing vertical density structure. Also there may exist several different modes (corresponding to different vertical structures) each of which travels at a different speed. In this paper we will compare the information on Rossby waves derived from these many diverse sensors and look at the added information acquired from synergistic observations, which suggest that whilst altimeters primarily detect the first baroclinic mode, SST and ocean colour are often more sensitive to higher modes.

SEA SURFACE TOPOGRAPHY DUE TO DENSITY GRADIENTS IN THE BALTIC SEA AND KATTEGAT

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ABSTRACT

Data from ERS1/2 and TOPEX/POSEIDON have been used to calculate the sea surface topography in the Baltic Sea and Kattegat. By using data from two different satellites the results can be compared. The difference between the mean sea surface topography and the geoid is obtained by subtracting the NKG96 geoid from the mean sea surface topography. The difference is increasing with approx. 50 cm from Kattegat to the north end of the Botnic Bay. The variation is due to the density differences between the brackish Baltic water and the salty North Sea water. The phenomena have also been observed by oceanographic observations by Ekman and these are used as a check. Fourier transformation of data has been applied to see temporal variations of the sea surface topography.

MONITORING THE EASTERN ALBORAN USING COMBINED ALTIMETRY, IN SITU AND TEMPERATURE DATA

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ABSTRACT

As part of the EU funded OMEGA project a cruise to the Eastern Alboran (Western Mediterranean) was carried out on board RRS Discovery during December 1996 and January 1997. During the cruise, a fine scale survey, designed to be oriented along ERS ground tracks, was repeated several times. Several additional survey legs were carried out, part of which lay along additional ERS or TOPEX/POSEIDON altimeter ground tracks. Hydrographic and current profile data were collected continuously along these survey tracks using an undulating, towed CTD and an Acoustic Doppler Current Profiler referenced to a Global Positioning System. The in situ data have been merged with the along track altimeter data to give profiles of the absolute surface current at several locations across the Almeria-Oran front, which limits the easternmost gyre in the Alboran gyre system. Where a track was repeated, several estimates of the absolute current profile have been made in order to try and understand some of the possible sources of error in the estimates. After the "one-time" calculation of the absolute profiles, several years of repeated altimeter data have been used to monitor the flow across the Almeria-Oran front. At times, the front appears to move to the south, apparently when the eastern Alboran gyre collapses, as observed in previous in situ and remote sensed studies. It is also possible to see times when the front moves northward and intensifies. The coincident altimeter and in situ tracks have high along-track resolution but much coarser track spacing and they also have limited spatial extent. This makes it difficult to gain a complete picture of the state of the Almeria-Oran front from the altimetry alone. In order to try and gain a wider spatial context, and improve the dimensionality of the data, the altimetry data have been further combined with remote sensed Sea Surface Temperature (SST) data, in particular from ATSR. Coincident data obtained during the cruise have been used to determine a relationship between the temperature field and the current structure. This relationship has been used to infer two-dimensional current fields from combined altimeter and SST data.

SAR AND AVHRR IMAGERY USING FOR INVESTIGATIONS OF BIG LAKES PHYSICS AND ECOLOGY - LAKE BAIKAL

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ABSTRACT

Lake Baikal, situated in the centre of Asian continent, is the deepest, the most voluminous, and the oldest freshwater basin on the Earth. These factors are responsible for the formation of its peculiar hydrophysics and ecology. The lake has been the subject of intensive investigations for more then century, however, using of satellite remote sensing for studies of temperature regime, circulation and ecology is on initial stage nowadays. The first opportunity to use SAR imagery for intensive Baikal studies were carried out after European Space Agency mobile receiving station set up in Ulan-Bator, Mongolia during Autumn 1997 and Summer 1998. Courtesy to ESA announcement of opportunity about 80 images proceeding by ERS satellite-born SAR instrument, have been given in our disposal. Simultaneous AVHRR HRPT imagery has been received from NOAA satellites in Irkutsk Centre of Space Monitoring. This information was used intensively for data fusion and better understanding of physical and biological features. When possible, contact data of research cruises was incorporated into analysis. Manifestations of short internal waves in water (with period of 400-800 m) on 1997-98 SAR images of Baikal demonstrate great diversity of direction and transformation in interaction with bottom topography. Some of these wave trains can present high-frequency modulation on the front of coastal-trapped Kelvin wave. Atmospheric internal waves can be also detected on SAR images as well as lee waves, thermal fronts and some other hydrophysical features. Independence of SAR images quality of atmospheric conditions supports their usage for detailed tracing of ice structure. We apply multispectral AVHRR imagery for classification on Baikal ice cover types. Database of AVHRR imagery is used intensively for studies of spatial variability of ice cover and its interannual changes. We apply SAR imagery as well as high resolution "Resurs" satellite images in visual band for calibration and verification of AVHRR-based classification. SAR imagery can be used for novel knowledge on Baikal ecosystem variability. For the late Summer autumn 1998 ERS SAR images show slicks of biological origin on the North Baikal. Probably, intensive bloom of green-blue Anabaena lemmermanii was detected. In situ observations made in the same time in research cruise of r/v "Vereshchagin" show high concentration of this algae in surface layer. This Cyanophita is capable to form patterns of high concentration (5-10 g/m3) in the thin surface layer during low wind conditions. AVHRR-derived surface temperature demonstrate similar structures of circulation field, that determines transport of cianobacteria from warm coastal area into pelagic waters.

REGIONAL LONG TERM SEA LEVEL VARIABILITY FROM MULTI-SATELLITE ALTIMETRY

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ABSTRACT

The monitoring of the long-term sea level variability requires the use of multi-satellite altimetry data. Geosat, ERS and Topex/Poseidon altimeter data are combined to analyse the sea level variability in the Mediterranean Sea over more than ten years. In a first step, the multi-mission data are analysed and unified by a multi-crossover adjustment. The analysis shows a change in the relative bias between the satellites, which is partly due to different corrections used in the pre-processing. In a further step, the main components of the variability are extracted from the unified data using statistical and spectral methods.

RETRIEVAL OF OCEAN CURRENT VELOCITY FIELD USING ERS SAR RAW DATA

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ABSTRACT

It is known that to measure spatial and temporal variability of ocean currents by using contact measurements from ships is very difficult. Principal possibility of ocean current measurements by using spaceborne SARs has been realized only several years ago. In order to study possibilities of spaceborne radars to retrieve mesoscale ocean current fields ERS Synthetic Aperture Radar (SAR) images and raw data has been collected in the framework of the ESA AO3 Project #219 titled "Experimental verification of the method for restoration mesoscale ocean velocity fields using ERS SAR data". The objective of the work was to understand ERS SAR potential for monitoring ocean current fields. The paper reports the results obtained from processing and analysis of the ERS SAR raw data as a step in the investigation the ocean with use a spaceborne SAR. Due to stability of satellite orbit there is a possibility to measure ocean current velocity by using frequency shift of Doppler spectra. Theoretical studies conducted in Institute of Oceanology showed that the Doppler radar method allows to restore only radial component of surface current velocity vector. Radar signals scattered by short surface waves have also parasite Doppler shifts due to phase velocities of short waves and orbital velocities of large waves. Conducted studies showed that shift errors due to those effects are about 3-7 cm/s. The method of processing raw data includes formation of partial Doppler spectra in non-focusing aperture regime, non-coherent accumulation of these spectra for every range element in real aperture, accumulation in respective number of range elements and measurements of averaged spectrum median. Firstly developed method has been applied to Almaz-1 raw data taken over the Gulf Stream when a possibility of ocean velocity field restoration has been shown. For method validation the test site in the Florida Strait between USA and Cuba has been selected. By applying developed method to ERS SAR raw data covering the strait the current velocity field has been retrieved. Obtained results show that current velocity field has been restored and acceptable accuracy achieved. Possibilities and limitations of the methods are also discussed.

SPIRAL EDDIES IN THE JAPAN SEA

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ABSTRACT

This note concerns with spiral eddies, which were overlooked by earlier studies of the Japan Sea. Previous analyses focused mostly on the mesoscale anticyclonic eddies that could be easily identified in the satellite infrared imagery of the Japan Sea (Toba et al. 1984, Isoda and Tameishi 1992, Ostrovskii 1995, Ginzburg et al. 1998, and Takematsu et al. 1999). Two types of cyclonic eddies were also observed: the streets of small cyclonic vortices of the size of about 10 km, associated with the baroclinic instabilities (Takematsu et al. 1999), and cyclonic eddies as the counterparts of anticyclones in the vortex dipoles (Bunimovich et al. 1993). New analysis of the Japan Sea upper layer dynamics is based on the ERS SAR remote sensing during CREAMS-I (1993-1997). This analysis allowed a visualization of various spiral eddies for the first time in the Japan Sea. Eddies appeared in the SAR imagery as a result of wave/current interaction, which outlines the shape of the eddy, or were revealed indirectly by presence of surfactant film trapped within spiralling lines associated with eddy orbital motion that led to backscatter contrasts of up to 10 dB. Spectacular images of the spiral eddies were obtained at the end of October 1992 and in November1993, i.e. in the season when the phytoplankton pigment concentration is high in the Japan Sea (Ishizaka et al. 1997). The eddies were also seen at the end of April 1993. The streaks of the surfactant films always spiralled counter clockwise. The eddy dimension varied from 1-3 km in the Japan Basin interior to 20-40 km south of the subtropical front. Although some of the observed spiral eddies can be explained within framework of recent theory, which dealt with frontogenesis (Munk et al. 2000 and Eldevik and Dysthe 2000), certain features remain unaccounted for by existing models. In particular small eddies of the size of the order of 1 km, located far away from the known strong currents, inside the northern gyre of the Japan Sea, seem unlikely to be related to the frontal dynamics. It is suggested that if such an eddy is cyclonic, its spiral is formed from the eddy centre towards the eddy periphery, so the eddy core serves as a source of a surfactant film that is upwelled to the sea surface from the interior below.

GLOBAL OCEAN TIDES - REVISITED THE IMPACT OF ERS AND ENVISAT

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ABSTRACT

Global ocean tides from TOPEX/POSEIDON and ERS-1 has previously been presented by Andersen, (1995), Andersen and Knudsen (1997) and Smith, (1999). It was concluded that more than 3 years of ERS data available at that time was required if ERS should be able to possible improve the global ocean tide models derived from TOPEX/POSEIDON alone. The possibility of improving the global ocean tide models using ERS data is revisited now that 8 years of observations are available. Especially the issue on improved ocean tide modelling in near coastal regions are investigated as the increased ground track spacing of the ERS and ENVISAT satellites is very important form ocean tide modelling in shallow waters.

SATELLITE ALTIMETER SEA LEVEL VARIATION ANALYSIS OF THE SOUTHERN OCEAN

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ABSTRACT

The spatial and time variations of the Southern Ocean sea level and its possible relationship with the Antarctic sea ice changes and surface geostrophic currents in the area are investigated using altimeter data sets from ERS-1, ERS-2 and Topex-Poseidon between 1992 and 1999. Altimeter data are analysed following an Empirical Orthogonal Function Decomposition (EOFD) suggesting the following results: 1-The sea level variability is complex and bathymetrically controlled. 2- Most of the energy is accounted by the two first modes of the EOFD, that separates the sea level time variability into annual and semiannual cycles. The third mode could be locally related to annual-semiannual interaction processes. 3- The Antarctic Circumpolar Current is dominated by the annual component. In the Brasilian-Malvinas Confluence region the energies in the semiannual and annual components are equally important with a clear spatial variation. 4- The stational sea level variation in the Brasilian-Malvinas and Agulhas current areas are in opposition of phase with the variation in the seasonal sea ice area. 5- An important part of the complex sea level variation in the Southern Ocean seems to be explained by the heat interchange due to ice-ocean water interaction including ice-induced salinity changes and Ocean-Atmosphere processes that affects the dynamic circulation of the Southern Ocean that may have a significant impact both in the regional weather and global climate. 6- Some transference functions that regionally relates bathymetry with altimeter measurements, can be found.

Domain: OCEAN DYNAMICS

INTERFEROMETRIC SAR QUALITY ENHANCING BY SPACE-VARYING SPECTRAL SHIFT PRE-FILTERING

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ABSTRACT

Interferometric SAR data should be pre-filtered in order to remove the geometrical decorrelation by applying the proper spectral shift. This filtering cancels the amplitude components relative to the wave numbers not illuminated in both passes.

Up to now this filtering has been carried out by assuming planar topography and therefore spatial stationarity of the wave number spectra. This approximation is now superseded and two optimum space-varying linear filters are identified. They allow to estimate, from the two takes, the interferogram with the least square error. Obviously, the filter is dependent on the Digital Elevation Model. Therefore, the problem becomes non-linear when the DEM has to be estimated from the data. The optimality is dependent on the computational complexity; simple approximations corresponding to low order kernels are also analyzed.

3-D RECONSTRUCTION OF SOIL SURFACES BY STEREOVISION IN RELATION WITH RADAR BACKSCATTERED SIGNAL OVER THEM

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ABSTRACT

Potential of radar imagery to measure soil roughness is being demonstrated. To overcome limitations in soil geometry descriptions by pin (laser) profilers, three-dimensional (3-D) reconstruction of soil surface by stereovision has been powerful to improve simulation of soil backscattered signal.

In the frame of the European project Flaubert, three campaigns combining satellite and in-situ data have been made in 1999 (April, June, July) to follow the soil degradation under Mediterranean climatic conditions on agricultural sites of North Tunisia. A large number of stereoscopic images have been taken with CCD cameras near Bizerte over a large range of soil roughness. A purpose is to qualifiy 3-D reconstruction and make it of easy use. The algorithm establishes a model, which relates pixel, coordinates to 3-D soil coordinates. It is done by camera calibration which computes the camera projection matrices and by performing disparity map from the 2-D images. Disparity with sub-pixel resolution is calculated by parabola method. To validate our reconstruction method of soil surface we have simulated stereoscopic images of different random simulated soil surfaces with gaussian correlation function and obtained reconstructed 3-D maps. Their comparisons allow us to evaluate the accuracy. We evaluate the filtering of the small-scale fractal soil structure, which is of determining influence on the radar-backscattered signal. We study its relation with the radar signal using the Moment Method to simulate backscattered signal over these reconstructed surfaces. Recent work has also shown that it is possible to recover the projective structure of a scene from point correspondences only, without the need of camera calibration. This approach leads to the calculation of the fundamental matrix from the geometric information contains in the different viewpoints. The two methods (calibrated and uncalibrated) are compared on natural and synthetic targets. Impacts on the radar backscattered signal over soils is also studied using the Moment Method.

SAR PRODUCT CONTROL SOFTWARE (SARCON)

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ABSTRACT

As SAR instruments and their operating modes become more complex, as new applications place more and more demands on image quality and as our understanding of their imperfections becomes more sophisticated, there is increasing recognition that SAR data quality has to be controlled more comprehensively to keep pace. SARCON is a comprehensive SAR product control software tailored to the new generations of SAR sensors. SARCON profits from the most up-to-date thinking on SAR image performance derived from other spaceborne and airborne SAR projects and is based on the newest applications. This paper gives an overview of the structure and the features of this new software tool, which is a product of a co-operation between teams at Marconi Research Centre and DLR. The basic features of the SARCON software include raw data analysis, antenna pattern estimation, point target analysis, distributed target analysis, polarimetric analysis, noise estimation, analysis of wave mode products, target detection, InSAR and analysis of propagation effects. The SARCON software will be initiated under operator control, i.e. the operator will select datasets for analysis, the required quality parameters, type of visualisation of results etc. SARCON contains an internal database to store the derived quality parameters in order to facilitate retrospective analyses and predictions of performance. Visualisation of the results is performed by accessing the database. The database contains the two types of quality measures, applications quality parameters and system quality parameters as well as calibration and characterisation data. Another important function of SARCON is to screen data to identify imperfections such as missing or duplicated lines. With the improvements provided by the SARCON software, it will enable problems in SAR instruments or in the processing chain to be quickly detected and, hence, remedied. It will enable data quality to be monitored over time to warn of problematic trends. Looking at historical data, SARCON can help to trace changes in performance and help to identify the cause. It will enable data sets to be specified more accurately and more meaningfully for the user. And it will help to advance the knowledge on SAR performance and to specify future sensors more effectively and efficiently.

ESTIMATION OF BIOPHYSICAL PARAMETERS FROM TERRA SURFACE REFLECTANCES

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ABSTRACT

Land surface processes are important components of the terrestrial climate system. Accurate descriptions of the interaction between the surface and the atmosphere require reliable quantitative information on the fluxes, mass, and momentum, especially over terrestrial areas, where they are closely associated with the rates of evapotranspiration and photosynthesis. Many of these processes can be related to the spectral reflectance of the surface. The vegetation canopy is classified as a special type of surface not only due to its role in the energy balance but also due to its impact on the global carbon cycle. Its reflection results from bio-physiological, chemical and physical processes, and is characterized by spatial, seasonal and diurnal variations. Modern satellite-born sensors (e.g., MODIS, MERIS) allow for rich spectral and angular sampling of the radiation field reflected by vegetation canopies. While much work on forward modeling of vegetation reflectance has been done, it is only recently, in the context of new satellite sensors such as MODIS, MISR, MERIS, POLDER, etc., that attention has focused on the inverse problem; that is, estimating biophysical parameters from remote reflectance measurements. This presentation will provide an overview of retrieval techniques, which allow us to realize the full potential of the multi-angle and multi-channel satellite-born sensors. An emphasis will be given to the operational algorithm of global leaf area index and fraction of photosynthetically active radiation absorbed by vegetation developed for the MODIS and MISR instruments of the EOS Terra mission as well as an analysis of global leaf area index and fraction of photosynthetically active radiation absorbed by vegetation derived from MODIS and MISR data.

SAR IMAGES DATA BANK FOR LAND USE MONITORING IN CENTRAL AFRICA, AN EFFICIENT DATA STORAGE AND PROCESSING SCHEME

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ABSTRACT

Due to persistent cloud cover over Central Africa, Sar images are preferred to optical data for remote sensing applications. However, land use monitoring with SAR images, which is often based on multitemporal or spatial mosaic data critically, increase, the amount of data requirements. As an illustration, the ERS-SAR mosaic of Central Africa merely consumes more than 50 gigabytes (GB). Managing Data in a long-term cycle is a difficult problem, Land use monitoring require interdisciplinary collaboration and therefore the scientific community and final users expectation is to share and access to online data and metadata. Our objective is to implement a data bank for land use monitoring applications in Central Africa. It is obvious that images have to be stored and handled in a compressed form, which is strongly dependent of the application. Many data compression schemes exists for natural scenes, these, methods are not efficient for SAR images because of the presence of speckle noise, futhermore the quality assessment of the compression techniques goes beyond the commonly use psychovisual quality. In fact bounded errors on edges and textures are needed in order to preserve sufficient quality for land use monitoring. In this paper we propose an efficient transform scheme. A frequency adaptative decomposition of the SAR image based on wavelets and multiwavelets packets functions and a suitable quantization scheme on the obtained wavelets coefficients. Our method out-performs better PSNR ratios, with poor loss of information compared to JPEG or the baseline wavelet coder. A segmentation method in the wavelet domain is developed, so there is no need to use a reconstruction scheme in the spatial domain for land use monitoring applications. Some results are presented with ERS images of Central Africa. Those images are compressed up to a ratio of 30: 1 while still remaining of sufficient quality for visual interpretation, segmentation and land use monitoring. Our future work concerns the indexation of the data bank for queries management.

A BASELINE ESTIMATION METHOD FOR SAR INTERFEROMETRY

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ABSTRACT

Synthetic Aperture Radar Interferometry (InSAR) makes use of the phase difference between two SAR images to generate topographic height information. The height map generation always includes a transformation of the unwrapped phase to the terrain height. To accomplish this operation the baseline, or space difference between the two radar positions, should be estimated. Various methods for carrying out this step have been developed. Among them, we cite the fringe frequency estimation in flat regions, the use of tiepoints, or of an existing Digital Elevation Model (DEM). However, in many cases it is not possible to satisfy the conditions these methods require. For example, when flat regions or tiepoints are not present within the scene, or an accurate DEM is not available. In this paper, we describe a method for the baseline estimation which do not require any of the previously cited conditions. The proposed approach relies on a closed-form geocoding algorithm, which allows to estimate the topographic height corresponding to each interferogram pixel by using only the orbit data and the range/Doppler frequency shift information. These data, joined to that of sensor altitude above the geoid, results in a linear system having as unknowns the two baseline components. A solution can be obtained without the need of tiepoints. Moreover, this algorithm can be applied in rough and hilly regions where the flat terrain approach is useless.

FUZZY SETS FOR CLOUD DETECTION IN ATSR-2 IMAGES OVER LAND

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ABSTRACT

The field of land use studies includes examples of both commercial and scientific uses of low-resolution satellite data. For the effective application of processing techniques used to derive information from satellite data, it is first necessary to determine if the image data contain atmospheric artifacts.

Algorithms used to derive land surface products from satellite data require the pixel in question to be completely cloud. Most current detection methods use crude threshold based algorithms, resulting in the removal of many useful pixels from the available data set.

This paper presents a cloud detection scheme for ATSR-2 data that has been developed using a fuzzy set methodology. Fuzzy sets allow pixel classes to be defined with soft, real-world, decision boundaries, rather than the traditional "yes/no" characterization. Described by a membership function, the grade of membership of a given fuzzy set is assigned for all image pixels.

For this scheme the cloud and surface data sets produced by the International Satellite Cloud Climatology Program (ISCCP) are used as a knowledge base of a priori data. A simple atmospheric model allows the ISCCP data to be reduced to an "as seen by ATSR-2" form, from which bi-variate fuzzy sets for a variety of Earth surfaces and cloud types are calculated, based on their probability distributions. Applied to cloud detection in ATSR-2 images, this varying degree of membership for an image pixel in the cloudy/clear fuzzy sets results in a superior image classification.

The result of cloud detection performed for fifty ATSR-2 images over a variety of land surfaces is presented. The performance of the scheme has been evaluated against the SADIST cloud detection results packaged with the ATSR-2 gridded data products, and against a visual, analyst-based cloud clearance.

MOSAIC GENERATION USING ERS SAR IMAGERY

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ABSRACT

The large archive of ERS SAR imagery can be exploited to generate extensive mosaics. Much of this data has been acquired such that large areas have been imaged over short periods of time. To date three mosaics have been generated - these being of the British Isles, Iceland and northern Europe. For the latter two regions, sufficient data is available that multi-temporal mosaics have been created. These mosaics enable large-scale land features to be visualised and show potential for land use monitoring on a Europe wide scale. The generation of SAR mosaics serves to convert the location of individual 100km by 100-km ERS SAR PRI images to a common map projection and to combine images from adjacent swaths. There is a need to remove the across-track image intensity variations due to the changing radar cross-section of land surfaces across the SAR swath and also to mask out water regions. The localisation information within the ERS SAR PRI product has been found to be adequate for registration of images within the mosaic. For the multi-temporal mosaics, it is necessary to ensure that the time span between the individual mosaics is sufficient to show changes in radar backscatter. This paper will show the three mosaics and describe how they have been generated. It is important to note that large scale mosaic generation should become much easier when wide swath products from the forthcoming ESA ENVISAT ASAR instrument become available.

ELIMINATION OF TROPOSPHERIC ARTEFACTS IN DINSAR IMAGES USING NUMERICAL WEATHER MODELS

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ABSTRACT

Numerical weather models assimilate continuously meteorological measurments and provide a complete state of the atmosphere typically every 6 hours. With these data sets it is possible to calculate the tropospheric delay for each pixel of a differential interferometric SAR image using a ray-tracing procedure. The delay is substracted from the SAR image reducing atmospheric artefacts in the interferogram.

For this investigation we use a global weather model from the European Centre of Medium-Range Weather Forecasts and a mesoscale model from the German Weather Service to test this approach on SAR images in Austria. We discuss the practical and theoretical limitations and compare the results to a similiar project with GPS observations.

GEOLOCATION OF INSAR INTERFEROGRAMS

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ABSTRACT

The development of Interferometric Synthetic Aperture Radar (InSAR) systems for the measurement of highly accurate Digital Elevation Models (DEM's) has already been well documented in the literature. Three measurements are required to reconstruct the topographic information: range, azimuth, and elevation. The first is obtained by timing the return of the radar pulse, the second by observing its Doppler frequency shift, and the last by measuring the phase difference between the signals recovered at the spatially displaced antennae. The phase infromation is taken from the interferogram. Geolocation can introduce significant errors depending upon the choice of method and earth model. Methods to reduce the processing time and provide more accurate results are extremely desirable.

In this paper a new general scheme for the geolocation of InSAR information is presented. It avoids the use of an earth model and exploits the full information of a SAR interferometer: orbit data, range and Doppler frequency shift relative to each SAR image, interferometric phase. Two geolocation algorithms are obtained from this scheme.

The former studies the geolocation as the intersection of three surface defined by the three measurements: range, Doppler frequency shift and interferometric phase. In particular, the three surfaces are: the range sphere centered at the SAR antenna which is also where the Doppler frequency shift cone is located. The cone axis of symmetry is the velocity vector. The interferometric phase adds another surface - a phase cone - whose axis of symmetry is the interferometer baseline and whose apex is the center of baseline. These three surfaces intersect at two locations in space. One of them is the geolocation of image pixel. The last algorithm is based on the solution of a set of four equation: the range sphere and the Doppler frequency shift cone relative to the two SAR images. An exact closed-form solution is obtained. This solution does not use approximations and avoids iterative algorithms. This results in a reduction of the computational load.

Domain: METHODS

DEVELOPMENT OF PRACTICAL ALGORITHM FOR INFERRING COMPONENT TEMPERATURES FROM MULTI-DIRECTIONAL MEASUREMENTS

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ABSTRACT

A mixture of soil and vegetation is an important category of land surfaces on which significant angular variations in thermal infrared radiance exhibits. The variation of thermal structure of the surface with view angles leads to directional effects in observed surface temperature. The directional observations from satellites imply the information of thermodynamic of mixture elements mentioned above. Especially for partial canopies, mixture targets are often characterized by large temperature differences between vegetation and the soil. Studies based on model simulations and field measurements show the angular variations of the brightness surface temperatures, which may be usable to determine vegetation and soil temperatures. The Along-Track Scanning Radiometer (ATSR) on board the First European Remote Sensing Satellite(ERS-1) is the only sensor to be able to capture the directional signatures simultaneously. Thought there is limitation in separating directional signals due to the lower spatial resolution and the heterogeneity of the surface, ATSR provides a possibility to derive components temperatures which is usually applied to dual-source heat fluxes models and improves quantifying of land surface processes. In this paper, the suitable algorithm is proposed to retrieve vegetation and soil temperature over mixture land surface based on the analysis of multi-angle and multi-channel observation made by ATSR-2. Limitation of the algorithm is also discussed when it is applied to various surfaces in range of fractional cover of surface and in conditions of homogeneity/in-homogeneity. Uncertainties in retrieving component temperatures using current algorithm and satellite data are studied further.

Domain: LAND SURFACE TEMPERATURE

MEASUREMENT OF WINDSPEED AND SNOW-HUMIDITY ON THE ANTARCTIC PENINSULA USING ERS-SAR-TANDEM INTERFEROMETRY

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ABSTRACT

The relation between interferometric coherence and meteorological parameters at the snow surface is investigated for three areas on the Antarctic Peninsula. For each area ERS tandem pairs have been processed to provide image sets of ERS-1/2 backscatter amplitudes and coherence. Coherence and backscatter differences are compared to meteorological ground data. As meteorological parameters, appropriate for comparison, we calculate snow humidity at the times of acquisition and mean windspeed during the 24-h periods between tandem acquisitions. For the coastal portions of the ice sheet, backscatter shows large seasonal variations. While smaller, backscatter variations within the 24-h periods of the tandem pairs are also significant. For the vicinity of the weather stations there is reasonable correlation between measured changes in surface humidity and these short-term variations. On the contrary, backscatter variations of dry snow at the high plateau are negligible both over 24 hour periods and seasonally. This demonstrates the absence of significant humidity and surface roughness changes at the plateau over time. Differences in coherence between tandem pairs are therefore expected to stem from one main source only: winddrift. We find a good linear fit between coherence and mean windspeed. For the coastal areas we evaluate the possibility of measuring windspeed and humidity separately with ERS-SAR by combining the observed backscatter changes with the coherence results.

VALIDATION OF ICE FLOW MODELS WITH ERS SAR OBSERVATIONS OF ANTARCTICGLACIERS AND ICE SHELVES

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ABSTRACT

We compared predictions from a coupled ice stream / ice shelf finite element flow model to ERS interferometric observations of glacier andice stream flow in various sectors of West Antarctica. The model requires input information on the ice shelf / stream geometry, which we take from the ERS imagery, ice thickness, which we obtain from ERS radaraltimetry or prior ice sounding radar or gravimetry data, and icerheology which we obtain from the literature. Free parameters include the coefficient of basal friction at the bed and ice softening along the margins of fast-moving ice. Forward modelling shows that it is possible to match with a high degree of precision (less than 10 percent difference in velocity) the results of the ERS interferometric analysis. The comparison in turn provides clues about the physical controls onglacier flow, such as bed processes and ice softening at the margins. Following this validation process, the flow models are then used top redict the future evolution of these glaciers with a changing climate, for instance once the ice shelves that buttress them from flowing fast into the ocean are removed by enhance basal melting.

Domain: ICE

APPLICATION OF ERS-2.SAR DATA FOR SOIL MOISTURE ESTIMATES OVER FLOODED AREAS.

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ABSTRACT

The flood in 1997 has been one of the biggest disasters in Poland in the last two centuries. European Space Agency has provided full set of satellite images ERS-2 over the flooded part of Poland. Some agriculture areas were flooded and in some others soil moisture content was very high exceeding the soil capacity. The information about soil moisture has been important not only for agricultural prognosis, but also could be the essential information for the flood forecast in order to determine the extent of saturation of the watershed and for partitioning of rainfall into surface runoff and infiltration. In July 1998 and 1999 the ground observations have been carried out in order to develop the method of soil moisture estimates. The measurements of soil moisture and vegetation parameters have been done for the area of 100x100 km2 covering the whole ERS-2.SAR scene. On radar images, it is generally difficult to separate the backscattered components related to surface roughness, vegetation cover and soil moisture. To calculate soil moisture the crop type and the crop status must be similar in order to avoid vegetation surface roughness variations. These variations can be expressed by LAI (Leaf Area Index) values, which reflect geometrical properties of an object. It has been assumed that the same type of crop covered agricultural fields in 1997 as in 1999 (crop rotation). It has been also assumed that the vegetation in the same periods of observation has been in the same stage of development. On the basis of these assumptions the developed soil moisture models have been applied for different type of crops using backscattering coefficient calculated from ERS-2 SAR. As the result, soil moisture has been obtained for each of agriculture fields. The research has proved that SAR images (C-VV) could deliver important information about the flooded area and soil moisture for its excessive amount. Extensive cloud cover, usually prevailing during flood periods seriously limits the usefulness of satellite images obtained in optical spectrum. In such cases the evaluation of flood event can only be based on images taken in microwave portion of electromagnetic spectrum.

coherence information was used. It could be demonstrated that forest stand parameters can be derived from coherence information under certain environmental conditions.

By means of model inversion of GeoSAIL, Landsat TM ground reflectance images in the six optical bands were processed into maps of LAI, fraction brown leaves and surface moisture. Here, initial ranges of parameters computed with PROMET-V were used to constrain the model inversion. Updating of PROMET-V local initial plant densities from a retrieved LAI map of one date resulted into highly consistent dynamic and spatial behaviour for most crops, and may therefore result into much more detailed and realistic yield maps than a raster based growth model without updating from remote sensing data can provide.

RETRIEVAL OF GEO- AND BIOPHYSICAL INFORMATION FROM REMOTE SENSING DATA - OVERVIEW OF THE GEOBIRD STUDY

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ABSTRACT

An overview of the results of the GeoBIRD study, a project under ESA contract number 12950/98/NL/GD, will be presented. The goal of GeoBIRD is the improved retrieval of bio-geophysical parameters crop yield, vegetation height, and tree species from multisensoral remote sensing data using ERS and optical sensors (TM, SPOT). This will be achieved through a combined application of the vegetation growth model PROMET-V, which simulates plant growth from environmental information, and remote sensing models (CLOUD and empirical models for SAR data; GeoSAIL and FLIM for optical data), which simulate sensor response from surface properties. For a variety of agricultural and forest test sites in Europe the applicability of the methodology was investigated. ERS-1 SAR images were calibrated and corrected for local incidence angle by means of orbital and digital terrain elevation data. Parameters of the CLOUD model for several agricultural crops and meadows were derived by statistical fitting of gamma values to ground observed parameters. Using information on the spatial distribution of plant parameters (biomass, vegetation water) from PROMET-V the CLOUD model was applied in the inverse mode to determine spatially distributed fields of surface soil moisture. The results were compared to field measurements and water balance calculations. For forests, also texture and

THE CONTRIBUTION OF ERS SATELLITE ALTIMETRY TO HYDROLOGICAL APPLICATIONS

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ABSTRACT

A number of satellite radar altimeters have been launched over the last few decades. Although their primary priorities are aimed at ocean and ice studies, they have had considerable success over inland water bodies. In particular, the ability to monitor level changes in lakes and inland seas has been demonstrated. Unhindered by vegetation or canopy cover, the techniques have additionally been applied to a number of rivers, wetlands and flood plains in several test-case studies. The results demonstrate how sub-monthly, seasonal, and interannual variations in surface water height can be monitored. The instruments are also unhindered by time of day or clouds, sample the surface at pre-defined geographical and temporal resolutions, and the retrieved heights are determined with respect to one common reference datum. These are keen advantages at a time when there is much descoping of traditional gauging stations, and often little or slow dissemination of data.

This study looks at the contribution of the ERS RA data to inland water studies. In particular, results from the ERS-1 phase G will be presented for a selection of lakes in North America and the Florida wetlands. The performance of the instrument over a wide range of target sizes will be discussed paying particular attention to the acquisition time, tracker stability and overall height accuracy for both ocean-like and narrow-peaked echoes. The merits of ocean mode versus ice-mode tracking will also be debated, as well as an assessment of the overall contribution of ERS and ENVISAT altimeric data to several ongoing NASA projects (e.g., the Large-Scale Biosphere-Atmosphere Experiment in Amazonia, Natural Hazards: Flood and Drought in Africa).

MONITORING OF WATER HYACINTH ABUNDANCE AND ITS OCCASIONAL FACTORS IN LAKE VICTORIA AREA (EAST AFRICA) USING ERS-1 AND ERS-2 SAR DATA

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ABSTRACT

This poster shows results of as proposal for the Third Announcement of Opportunity for the Exploitation of ERS Data, section '2.4 New or better Coverage by ERS Receiving Stations', especially for the evaluation of data from the new receiving station in Malindi (Kenya). The overall objective is the detection of water hyacinth in Lake Victoria with the evaluation of ERS backscatter and the phase information of interferometric ERS-1/ERS-2 pairs. Water hyacinth is a weed with enormous growth rates causing serious problems for shipping traffic, fishing, freshwater fish fauna, plant diversity, etc. The aim is now not only the detection of the weed during bad weather conditions, but also to observe the intensive agricultural land use in the surroundings of the lake and to model the solute transport from point and non point sources. The specific objective and focus of the proposal is therefore threefold:

1. Detection of the water hyacinth weed within the beaches of Lake Victoria during bad weather conditions (three rainy seasons) by the use of ERS SAR data. Control mechanisms need to have an areal and actual basis for appropriate management of the problem, therefore long term observations with the 35-day-orbit are necessary to monitor the development of the water hyacinth mats throughout the seasons. The water hyacinth grows on top of the water surface up to several cm heigh affecting the radar backscattering due to an altered surface roughness.

2. Observation of land use in marginal test catchments as an input base for distributed hydrological modelling of water balance and water quality. Around the Lake Victoria intensive agricultural land use (irrigation - plantations of sugar cane, tea, cotton, maize, etc.) is widespread. Each of these different land use types has its specific contribution to erosion and solute transport due to land cultivation techniques and fertilizer input. Areal extent and changes in time are important information sources for hydrological modelling. In particular the Nyando subcatchment, prone to flooding, near the lake could be contributing to high pollution and solute transport rates into the lake.

3. Modelling of solute transport within the test catchments. Remote sensing data serves as input for object oriented hydrological models (OMS) of freshwater pollution by agricultural non point source areas. Results are so called 'what if? - scenarios' of nutrient inputs into the lake and possible extensions of water hyacinth mats, considering growth rates, irrigation amounts, fertilizer inputs, runoff measurements, etc.

OBSERVATION OF THE WETLAND HYDROLOGY IN THE UNSTRUT CATCHEMENT IN THURINGIA (GERMANY) BY MULTITEMPORAL ERS-1 AND ERS-2 SAR DATA

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ABSTRACT

The objective of the ENVISAT ASAR preparational work in Thuringia is the observation of the development of wetlands (i.e. Esperstädter Ried) which could be balanced area covering over the last 10 years using ERS-1 and ERS-2 data. After the reunification of Germany all the pumps were destroyed and the wetlands were flooded. Now there is a continuous dehydration every springtime to use the area as pasture for cattle disturbing the natural water balance. This results in a short term and a long term variation of the water balance which will be observed using the multipolarimetric possibilities of ENVISAT ASAR.

Some of the wetlands in Thuringia play an important role as permanent used grassland areas for cattle farming. These areas would be large water covered lakesides without pumping of water. Since the subsidised market in Europe allows the closing down of large scale agricultural areas, the Federal State of Thuringia has an interest in revitalising these areas in terms of breeding places for water birds or protected areas for salt adapted plants. The multitemporal ERS remote sensing data is used to analyse the seasonal differences between the pumping of water in spring and the rising water table over summer time until autumn. Apart from the seasonal development also the long term alterations after the reunification of Germany are analysed since 1992, when the whole wetlands were full of water up to a fully developed agricultural site today.

The Thuringia Environmental Agency has a strong interest and supports the remote sensing study, since they intend to extend it to further wetland areas within Thuringia. With the multipolarimetric possibilities of the ENVISAT ASAR there are even more detailed informations about the wetland water balances are expected.

ERS-2, RADARSAT SAR BACKSCATTERING CHARACTERISTICS OF THE PARANA RIVER DELTA WETLAND, ARGENTINA

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ABSTRACT

The Lower Delta Islands of the Paraná River in Argentina constitute a major coastal tidal freshwater wetland located at the De La Plata River estuary. It is a complex region where the landscape pattern is characterized by mosaics of natural and man made ecosystems. Since the last few years an increased number of SAR images has been available for monitoring coastal wetlands and deltas, but the complexity of the microwave-vegetation-water-interaction mechanisms taken place needs further investigation. Difficulties arise due to scene factors such as environmental conditions, vegetation phenology, and management practices. Also, differences in the observation geometry (ascending and descending paths) add complexity to the overall interpretation of the radar response. This study was conducted to assess the potential of combined imagery from RADARSAT (C-band, HH polarization) and ERS 2 (C-band, VV polarization) SAR systems for monitoring wetland ecosystems and assess flood condition. This paper discusses the microwave-vegetation-water interaction mechanisms identified in RADARSAT, and ERS 2 SAR images, for three distinct vegetation structures forest, marshes, and rushes, and different flood conditions. TM images of close dates, an existing vegetation map and field data were used as background information. SAR images were carefully calibrated and geolocated. To establish hypothesis about the links between land cover structure, flood condition, sensor characteristics (HH, VV) and resulting scattering process the information extraction procedure consisted on the multitemporal analysis of the backscattering characteristics of well identified samples. Results show significant differences in the way SAR modes interact with woody and herbaceous vegetation, and flood condition. In addition, ascending and descending ERS 2 imagery (day and night) show interesting differences in the radar response due to the vegetation moisture conditions. Current SAR operational satellites are single frequency and single polarization, but the new generation of SAR systems will provide multi polarization measurements. Therefore it is expected that the analysis of combined ERS-2 and Radarsat data, that this paper addresses, may contribute to the understanding of the future ASAR Envisat data.

ASSESSMENT OF THE ERS TIMES SERIES FUSION AND COHERENCE ANALYSIS FOR THE MONITORING OF ENVIRONMENTAL SENSITIVE AREAS IN ALSACE

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ABSTRACT

At present, due to the advantages multi-temporal capability, the high stability of the ERS satellites and the historical data-set archived over many years, it is possible to envisage the monitoring of environmental changes on a medium term basis. This AO3-340 project exploits these advantages and is designed to develop the use of SAR data from both an application and applied research point of view.- the applied research aspects are focused on the assessment SAR time series processing and coherence for hydrological modelling. This is englobed within the framework of the European Project ARSGISIP, Applied Remote Sensing and GIS Integration for Model Parameterization.- the application is developed for wetland monitoring and the control of these sensitive area. It is designed to meet the needs of customers with an obligation to conserve humid area habitats. This falls within the framework of the European Project MANHUMA, Management and Conservation of Humid Areas. The application study zone, a very flat area and an environmentally sensitive biotope which is strongly influenced by hydrological processes is therefore affected by new EU environmental and CAP directives. In this context, the use of new or complementary geo-information products derived from multi-annual EO data is investigated. Multi-temporal ERS SAR fusion techniques and coherence image analyses are used to achieve these objectives. These SAR specific image processing techniques take advantage of the availability of multi-temporal ERS data sets in order to consider both the gain in the quantification of bio-geophysical parameters to be derived, the temporal change detection of these features and the delineation and characterisation of humid areas.

FEASIBILITY OF USING SAR DERIVED SOIL MOISTURE TO ENHANCE THE ROBUSTNESS OF VEGETATION INDEX BASED CROP YIELD MODELS.

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ABSTRACT

Realising the importance of soil moisture for crop survey, soil moisture estimation models using SAR data from ERS and RADARSAT have been used to develop site specific operational models in India.

In the present study, attempts have been made to derive soil moisture status using ERS SAR data of February 8, 1998 and NDVI from IRS data of February 9, 1998 for a mustard and wheat growing area covering parts of Agra, Mathura and Bharatpur district of Uttar Pradesh and Rajasthan states in India. Wheat and mustard fields were categorised as dry, medium moist and moist based on the derived moisture value. Corresponding average NDVI of the same fields were generated. Correlation between NDVI and the field moisture status was carried out. In case of mustard, it was obsefved that very low NDVI were associated with low soil moisture. However, high NDVI values of mustard crop was found to have a large variation in the underlying soil moisture. Further analysis using taluk (an administrative unit with in the district) showed that average soil moisture status was low for low yielding taluks and high for high yielding ones. There was no significant difference in the corresponding NDVI. Similar analysis for wheat fields showed a very low NDVI status for all the fields due to the early crop stage.

This indicates the possibility of deriving a soil moisture index to improve the crop yield forecasting models. This is particularly significant for indeterminant crops like mustard, where NDVI alone was not very effective indicator of crop vigour.

APPRAISAL OF SAR DATA APPLICATION IN ASSESSMENT OF SOIL SALINITY AND WATERLOGGING PROBLEMS IN BAHAWALNAGAR AND BAHAWALPUR DISTRICTS, PAKISTAN

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ABSTRACT

Salinity and waterlogging are highly detrimental to both fertility of the soil and the environment. An accurate assessment of these problems and their physical factors in timely and cost effective manner is one of the prime requirements for reclamation of degraded soil. This study, aimed on appraisal of ERS-SAR data in assessment of soil salinity and waterlogging problems, has been conducted at SUPARCOs Satellite Ground Station, Islamabad, Pakistan in collaboration with European Space Agency (ESA) under AO3 framework. Both optical and microwave data, in separate as well as complemented modes, have been used to demonstrate the potential of satellite remote sensing technology in assessment of soil salinity and associated problems in agricultural areas. SPOT XS and ERS-SAR multi-temporal data (between 1993 and 1999) have been analyzed using digital image processing and GIS techniques to study the areal extent and intensity of the salt affected and waterlogged areas of a small test site. Independent as well as complemented applications of both sensors data have been found useful in mapping of highly saline areas (mostly in crust form). However, both types of data could not provide encouraging results in discrimination between moderately saline and other eroded material like sand silt, etc. Conjunctive use of SAR and optical data provided satisfactory results in salinity mapping during the wet season, as microwave is sensitive to the geometrical characteristics (surface roughness, dielectric properties and penetration through surface layers to some extent) of the ground surface. The authors wish to thank the European Space Agency (ESA) for providing ERS-SAR data and guidance to complete this study.

SOIL MOISTURE MAPPING USING ENVISAT ASAR AND ERS-2 DATA IN THE SOUTHERN GREAT PLAINS REGION OF THE U. S

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ABSTRACT

ENVISAT data will be used to develop a regional soil moisture algorithm for the Southern Great Plains of the United States. This region is characterized by low levels of vegetation for most of the year and variable soil moisture conditions. Data from the ASAR (alternating polarization mode) will be the primary information used. A time series of ERS-2 data is currently being acquired in conjunction with ground observations of soil moisture. The time series is based upon all acquisitions for a specific track and three frames. This data set will be used to establish baseline conditions and to better understand the annual temporal backscatter coefficient signatures of grasslands and winter wheat. The time series would be continued for one year after the beginning of data collection by ENVISAT and will include the ASAR data. Alternative modeling approaches are being evaluated using this data set as well as other data already available within this region (AIRSAR, SIR-C and Radarsat). There are significant limitations in using a single channel synthetic aperture radar for soil moisture estimation. It is expected that the multipolarization data of ASAR will greatly improve these techniques. The results of the first year of ERS-2 observations will be presented. Backscattering coefficients will be compared with ground based soil moisture and land cover information for twelve sites. Land cover information is based upon interpretation of Landsat Thematic Mapper images acquired close to the date of each ERS-2 acquisition. Since the inception of the series in June of 1999, two acquisitions have not been useable due to ongoing rainfall at the time of the overpass.

SOIL MOISTURE ESTIMATION WITH SAR.PRI ERS IMAGES

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ABSTRACT

The estimation of the water content in the root soil zone is of fundamental importance for crop management and yield forecast. This subject requires a periodic and extended monitoring along wide surfaces, which can only be achieved by means of remote sensing.

The active microwaves sensors operating in C band, such as the Synthetic Aperture Radar (SAR) of ERS, have demonstrated to be a useful tool for monitoring the level of surface soil moisture, ensuring also the systematic availability of information under any meteorological or light condition. SAR backscattering depends on the surface roughness, slope and its physical-chemical characteristics. Indeed, the backscatterered energy is a function of the dielectric constant of the soil, which depends on the water content.

This paper presents the first results of humidity estimation on soils dedicated to agriculture, with fallow cover, located in the Llanura Pampeana (in the Centre-South of the County of Buenos Aires, Argentina). Campaigns of soil sampling simultaneously with the satellite acquisition were carried out in 12 places. Samples were extracted with drill between 0 and 10 cm of depth and were processed following the gravimetric method, obtaining the corresponding values of volumetric moisture. In the first stage of the project, three images ERS-2 SAR PRI were used. The images were georeferenced and radiometrically calibrated in order to retrieve the values of sigma nought over the sampling places, using the software SAR Toolbox (ESA) and PCI (RSI Inc.). The correlation between sigma nought s0 (expressed in dB) and the measured volumetric humidity HV (expressed in) is presented. It shows an acceptable coefficient of lineal correlation (r2 = 0,65) for a linear adjustment HV = a + b . s0.

The images were classified applying this correlation function, obtaining maps of humidity for the parcels of interest. These results are compared with the values obtained estimating the humidity by hydric balance. These first experiences, limitations and the future plans for the project are presented in this paper.

Domain: HYDROLOGY

SUBSIDENCE MONITORING USING SPARSE SAR DIFFERENTIAL INTERFEROMETRIC MEASUREMENTS: THE BOLOGNA CASE STUDY

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ABSTRACT

From differential interferometric synthetic aperture radar (SAR) data it is possible to measure small deformations of the terrain occurred between different acquisitions. In this paper, we use ERS 1 and ERS 2 data, covering a time interval spanning from March 1993 to June 1999, to study terrain displacements occurring in the area of Bologna, Italy, and its surroundings.

According to previous studies, based on both in-situ and SAR differential interferometry measurements, the considered area has been affected by subsidence phenomena, probably caused by extraction of water from subsoil. The interferometric measurements performed up to now have been limited to Bologna's urban area, due to the limitations of traditional phase unwrapping techniques. As a matter of fact, temporal decorrelation causes a nearly complete loss of coherence over most part of the imaged scene, and good quality data are available only on sparse areas (urban areas and/or isolated buildings, other stable objects, arid terrain). This prevents unwrapping the good quality phase by means of algorithms requiring that input data are on a regular rectangular grid. Here, we make use of a new generalized technique, presented in [1], that is able to deal with sparse data. Therefore, we are able to extend the analysis to the Bologna's surrounding area.

The displacement maps corresponding to the obtained unwrapped phases are then properly combined to perform a temporal analysis of the subsidence phenomena occurring in the considered area, thus obtaining a complete space-time description of the terrain movements. Temporal analysis of data is also useful to minimize the impact of atmospheric artifacts and inaccurate satellite orbit knowledge. Finally, in order to test the effectiveness of the method, the obtained results are compared with in situ measurements.

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STUDY OF SURFACE DISPLACEMENTS IN URBAN CONTEXT WITH SAR INTERFEROMETRY: APPLICATION TO THE CITIES OF PARIS (FRANCE), AND TAINAN (TAIWAN)

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ABSTRACT

Differential SAR interferometry allows detection and mapping of slow deformations, especially in urban areas, where coherence remains high over long time scales. One limiting factor is then the variation of atmospheric conditions between the acquisition of images, which can introduce large artifacts on interferograms. On Paris city (France), atmospheric heterogeneities were clearly detected on all differential interferograms we have generated. A method for automatic characterization of displacement fringes, free of atmospheric artifacts, based on complex correlation of interferograms was used, and allowed us to reveal two subsiding zones. These centimetric subsidences are associated with the construction of an underground station (Haussmann-St.Lazare) for the Eole subway, beginning in 1995 and ending in 1997. They result from the lowering of the piezometric level, due to phreatic water pumping. The spatial subsiding extent may be mapped, and the temporal evolution of the subsidences is carefully examined. We also studied Tainan city (1.2 millions of inhabitants), located in the southwestern part of Taiwan. Tainan is built on a small elongated hill, 35 m high, towering above the surrounding coastal plain. The ten processed differential interferograms show deformation of this relief on the range of 3 cm during the period 1996-1998. This validates a recent geological model (Deffontaines et al., 1997) which interpret this area as an uplift resulting from the westward propagation of the Taiwanese orogene deformation front, linked to the active collision of the Eurasian and Philippine plates. Such study leads to revalue the natural hazard mitigation in Tainan. These studies highlight the potentiality of SAR interferometry for detection, in urban context, of slow deformation (few centimeters per year) of small or larger extent (e.g. 2 km and 50 km² for Paris and Tainan respectively), related to human or natural causes. This project is supported by ESA (ERS AO3-350 / Envisat AO-441).

Domain: EARTH MOTION

SURVEY OF LARGE DEFORMATION IN THE CHILE-PERU SEISMIC GAP (SOUTH AMERICA) USING SAR INTERFEROMETRY: THE LOADING AND TRIGGERING OF GIANT EARTHQUAKE

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ABSTRACT:

The 1995 M=8.1 Antofagasta earthquake ruptured the southern segment of Chile-Peru seismic gap located on one of the fastest plate boundary, the subduction of the oceanic Nasca plate beneath South America (nearly 80 mm/yr of relative convergence). Studies of this earthquake corroborate that the conditions of applying SAR technique are exceptionally good in this region due to the extreme aridity of the Atacama desert. Combined with GPS and seismic modelling, SAR interferometry has proved to be essential to constrain the surface deformation, and to characterize the mechanics and kinematics of the earthquake: the area of co-seismic deformation is very large (200km x 300 km) and reach 60 cm of range increase; the variation of slip distribution on the fault plane indicates non homogeneous strain release; blocked in the north, by the presence of the geometrical asperity of Mejillones penninsula, the rupture propagates toward the south. The 1995 may be a foreshock of a huge earthquake that pending in the Northern Chile Gap (20°S). This region offers the unique opportunity to tackle the understanding of the mechanical processes that take place during the elasting loading (inter-seismic phase) and the triggering of earthquake (pre-seismic phase). We processed ERS scenes centred o the North Chile gap (20°S), on an area of 250km x 200km, that consist of 8 scenes on 3 parallel orbits over a period of 2 to 4 years. The map of inter-seismic deformation reveals 10 to 14 mm/yr of range decrease, consistent with uplift and eastward displacements measured by GPS. The maximum of gradient is located on the first 100 km from the coast. Modelling the inter-seismic displacement using back-arc dislocation model indicates high value of coupling (70-100), and a depth of locking of 40-50 km. To study post-seismic deformation in Antofagasta area we processed an interferogram that include 3.5 years of displacement after the event. The image of post-seismic deformation reveals a superposition of inter-seismic loading along the coast and post-seismic signal in the area of the 1995 earthquake. This can be modelled as after-slip on a fault larger and deeper than the fault, which was activated during the earthquake.

MINING INDUCED SEISMIC EVENTS - IMAGING SURFACE DEFORMATION OF DEEP MINE ROCK BURSTS AND FAULT MOVEMENTS

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ABSTRACT

Seismic events, some exceeding Richter magnitude 6, caused by rock bursts and fault movement induced by deep mining (around 2.5 km), are being studied with data from European Space Agency satellites ERS1 and ERS 2. The satellite synthetic aperture radar (SAR) data is applied by interferometry (InSAR) and used to image surface deformation caused by such events, with the objective of aiding mine seismology and safety. Results are presented.

Domain: EARTHQUAKES

WATCHING FOR THE HAZARDOUS SPRING 99 FLOODING IN THE CHERNOBYL ZONE IN UKRAINE WITH THE ERS SAR IMAGES

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ABSTRACT

The basin of the Pripyat River is located within a high radioactiveness zone what was occurred after the Chernobyl catastrophe. There are radioactive marshes and many burial-places of the radioactive waste materials near by the Chernobyl Nuclear Power Station (building rubbish, trees subjected by radiation, machines and equipment used for clearing and disactivation). These dangerous objects are fenced in polder dams. But overflow the dams can be happen in case of a high flood. A following return of radioactive water to the Pripyat and Dnieper Rivers bears a hazard to the densely populated areas located along the rivers. Such situation has been warned at the spring 99. To obtain a real situation the ERS-2 SAR data was required within the framework of the ESA AO3.358 Project. Forecasting by means of the domestic hydrological model on the critical high water time has been compared and defined more precisely with the ERS SAR image. Comparison with the normal situation during the previous dry autumn was carried out with another SAR image.

A RAPID MAPPING SYSTEM FOR HURRICANE DAMAGE ASSESSMENT

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ABSTRACT

After the catastrophic damage caused by the hurricane Mitch in Central America, the subsequent intervention of the French Civil Defence Agency DDSC, and the work carried out by ESA and the CNES, ESA and the DDSC had agreed to co-operate during the following, end of 1999, cyclone season. The objective was to assess the contribution of space techniques to perform disaster management in an operational context. Within this framework, ESA granted a contract to a consortium between SPOT IMAGE, SERTIT, PRIVATEERS and IGN Espace. The experiment was focusing on risk management in relation to hurricane threats in inter-tropical regions, the French West Indies and La Réunion Island. The main objective is to design a rapid response mapping system in order to quickly provide the DDSC with adequate cartographic and damage assessment map products. On the 16th of November 1999, the hurricane Lenny was brewing in the Antilles and therefore started the procedure. During this event, archive data from ERS, Radarsat, SPOT were processed and new acquisitions planned. Then, on the 18th of November the hurricane reached and damaged Guadeloupe. At first, a basic cartographic product was produced in less than 24hrs after a Radarsat data acquisition, the 22nd of November. This information overlaid on IGN maps and SPOT data shows the main areas affected by the hurricane. Then, high level cartographic products called damage assessment products were produced by applying radar change detection techniques. These high resolution thematic products detailed the areas affected by the hurricane and indicates potential damage levels. All the cartographic products were up-loaded to an interactive Web Intranet server which enables the partners and the DDSC to visualise and request advanced geographical and thematic mapping from the online database. The experiment demonstrates the ability to rapidly delimit potentially damaged areas using EO satellites complemented with cartographic maps. It provides feedback for assessing the contribution of EO based products and services to risk management in an operational context. The different constraints imposed by operational EO systems, the required level of processing plus thematic analyses and time aspects of the data and information provision chain are exposed. Acknowledgements: The experiment was performed with support of ESA, CNES and CSA which provided respectively ERS, SPOT and RADARSAT data.

MAPPING AND EVALUATION OF "MITCH" HURRICANE DAMAGES IN CENTRAL AMERICA USING ERS SAR AND SPOT IMAGES

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ABSTRACT

In November 1998, Central America was devastated by the hurricane "Mitch". Never before, had this area suffered such total devastation combining wide flooding, huge forest destruction, landslides, and large-scale destruction of housing and infrastructures. A project was immediately put up to carry out a wide area / high spatial resolution evaluation of these damages, using SPOT and ERS satellite imagery. The aim was to deliver as quickly as possible accurate high spatial resolution maps of the damages that could be used by local photo-interpreters. To reach this goal, the following data processing procedure was applied: - The ERS SAR data were used to detect the damages. In the change detection process, the ERS SAR archive data acquired before "Mitch" were compared to the ERS SAR data acquired just after "Mitch". - Combined speckle filtering and super-resolution techniques have been applied to the ERS SAR data, to detect and map existing targets at a spatial resolution of 10 meters (SPOT-P resolution) before and after "Mitch", with particular emphasis to housing and infrastructures. - Change detection techniques appropriate to SAR images have been applied to detect and map the damages. - SPOT-P archive data were used as mapping background. The final product is the result of a common-sense data fusion process integrating ERS SAR change detection and SPOT-P archive data, to facilitate photo-interpretation of the final product. - Finally, two sets of cartographic UTM maps of "Mitch" damages have been produced, on 10 and 20 meters grids.

The SPOT and ERS satellite images were made available respectively during November and December 1998. Altogether, these data allowed to study about 120.000 km2 in the most devastated areas of Honduras, Nicaragua and El Salvador. All the cartographic high spatial resolution products were delivered in the first days of 1999.

This efficiency in operating the project enabled rapid validation of the results (El-Salvador in January/February 1999, Nicaragua in February 1999 and Honduras in March 1999), with satisfactory results. Validation results in Honduras are presented.

FLOOD MONITORING IN THE SENEGAL RIVER VALLEY: FIRST RESULTS BASED ON SAR PRI DATA

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ABSTRACT

The traditional flood recession agriculture in the Senegal River valley in West Africa relies on adequate inundation of the valley, adequate with respect to areal extent and duration of the flood. In the recent decades, the river flow has been regulated through operations of dams in the river basin in order to provide a steady water flow in the river for use in irrigated farming. This in combination with a general decline in precipitation in the 70's and 80's in the Sahel, has resulted in a lower potential for flood recession agriculture. In 1999, the western part of Sahel, has experienced higher precipitation rates, and thus larger inundations than during the last 30 years.

Remote sensing is currently the only means for mapping the extent of the flooding in the very complex landscape, and SAR data is in particular useful. This study focuses on a small test area in the middle part of the river valley around Podor in Senegal. Four ERS2 PRI SAR scenes have been used in the analysis for delineation of flooded areas. Transects of the inundated areas measured by differential GPS, have resulted in profiles of the surface elevation across the area of flood recession agriculture. The combined use of surface elevation measurements and satellite data enabled a contour mapping of the flooded cuvette, and a rough estimation of the amount of flooding. The duration and extend of the flood could be estimated, and the result may thus serve useful to local decision-makers in crop yield estimation etc.

Domain: FLOODS/STORMS

ANALYSIS OF THE PALEODRAINAGES OF THE NORTHWESTERN SIMPSON DESERT, AUSTRALIA FROM ERS1-2 IMAGES

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ABSTRACT

The Simpson Desert is located in the arid center of the Australian continent and is part of the largest internally draining basin, Lake Eyre, in the Southern Hemisphere. To date paleoclimatic, geomorphic and sedimentologic investigations in the basin have been concentrated in the eastern river catchments and the Lake Eyre Playa itself. By contrast, the equally ancient northwestern alluvial systems, which are hypothesized to have once drained into Lake Eyre, have not been mapped or adequately studied as they are now buried by the Simpson Desert. Relative to the ancient drainage systems, the modern rivers in the basins northwest are smaller and tend to disappear in the dune swales, a short distance from the mountain ranges. Recent fieldwork in the region has revealed that this ancient channel pattern may be a strong control on the location of catastrophically avulsed channels during the late Pleistocene and Holocene. Little is known or understood about this surface which is believed to have been formed by large drainage systems during more pluvial climate regimes. Sediments in the region are variable but depositional environments are distinguishable by texture variations. The Pleistocene dune fields overlie older fluvial gravel deposits, which are often exposed in the dune swales or lie at shallow depth. Aeolian sediments tend to be fine grained, well-sorted, quartz sand with red hematite coats yielding a reddish-orange color. Fluvial sediments are coarser (medium sand to coarse gravel) and are arranged in channel fills and bar forms, and tend not to be red. The analysis of radar data for this region reveals important information on the channel location, channel scale and channel patterns which form this ancient alluvial surface. The channel patterns are essentially single thread, straight or gently winding with localized anabranching and changes to distributary patterns in the intermediate and terminal floodouts. A combination of multispectral and ERS 1-2 radar images has been used to reconstruct the past hydrological and climatic variations of the study area. This is part of the ESA project AO3-348.

EXPLORATION FOR IMPROVED QUALITY GROUNDWATER IN SEMI-DESERT NAMAQUALAND, SOUTH AFRICA

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ABSTRACT

Synthetic aperture radar (SAR) data from European Space Agency satellites ERS1 and ERS2 is used to help test a hypothesis that may improve ground water quality in Namaqualand, South Africa. Precipitation in this semi-desert is mainly from sea mist, which condenses on exposed granite domes, feeding the extremely limited aquifers. It is hypothesised that finely fissured granite domes feed the aquifers more effectively than smooth granite domes. Fissured and smooth domes are being classified by SAR speckle analysis. Results are presented.

SYNERGISM OF OPTIC AND RADAR DATA TO OPTIMIZE LITHOSTRUCTURAL MAPPING AND MINERAL EXPLORATION IN SOUTH-EAST SENEGAL AND MALI (WEST AFRICA)

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ABSTRACT

Satellite remote sensing data, thanks to their synoptic view and their visible, infrared and microwave information content, are valuable geological information sources, particularly for lithostructural mapping and mineral exploration in remote regions and in terrains characterized by important vegetation, alluvial and laterite covers. We developped our research activities in two directions: (1) merging of optic and radar data, and (2) assessment of the potential of interferometric data. A composite image where spectral and textural information are combined, has been computed from Landsat-TM and radar SAR ERS-1 data covering the area of the Boboti granitic massif (South-East Senegal), by applying Principal Component Analysis and Intensity-Hue-Saturation image merging techniques. The IHS technique appeared as the most impressive, giving the possibility to weight the radar contribution in the resultant image. We interpreted this ERS-1/TM merged image and got a more accurate cartography of the Bambadji granitic massif and its fracture pattern. This is of major interest as far as the unexplored contacts of the batholite with the intruded rocks may be proposed as exploration targets for additional iron reserves and the fracture nods, as potential gold metallotects. A field trip has been conducted from 18 to 24 February 2000 in the areas of Kedougou (Senegal) and Kenieba (Mali), with a set of ERS and RADARSAT amplitude and coherence images. It demonstrated the usefulness of coherence images in understanding surface characteristics and changes, and also their capacity to enhance the expression of lithologic differences, when merged with amplitude images. In fact, thanks to their great sensitivity to vegetation types, coherence images allow to follow easily the talweg network outlined by forest galleries, and to discriminate subtle differences among vegetation covers on major river beds and plateaus zones, which may be related to the nature of underlying rocks. These results clearly indicate the possibility to optimize lithostructural mapping and mineral exploration in poorly outcropped terrains, by adding merged optic/radar images and interferometry derived products to the package of geological information sources.

NUMERICAL AND ANALOGUE MODELLING OF LARGE FLANK COLLAPSE AT MOUNT ETNA

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ABSTRACT

Previous works have proposed that the dynamic of Mount Etna is dominated by large scale collapses. A recent study, based on INSAR data, has shown an active spreading of the flanks of the volcano. Two main sectors of instability, which have different spreading process, have been identified. An eastern sector bounded by the Pernicana faults system to the north, by the North and the South Rift Zones to the west and by the Mascalucia-Tremestieri-Trecastagni faults to the South East, slides to the east. A southern sector, limited to the south by an active anticlinal ridge, is driven by southward gravity spreading over a basal decollement. The onset of the sliding coincide with a new cycle of volcanic activity in summer 1996. We have used both numerical and analogue modelling in order to better constrain the geometry and the kinematic of the collapse processes of Mount Etna. The scaled analogue experiments take into account the E-W extension and also the weak Plio-Quaternary basement. The analogue models emphasises that both the E-W extension and the southward gravity spreading drive the evolution of the volcanic edifice. Numerical modelling with a boundary element method was used to explain the displacement field, observed by radar interferometry, and to estimate the stress field. It shows that stability of Mount Etna is subcritical and a perturbation like dyke's injection may be enough to destabilise the whole edifice. This work points out the interest of coupling analogic and numerical study to the understand the evolution of a volcanic edifice.

Domain: GEOLOGY/VOLCANOES

OPERATIONAL ALTIMETRY AT GFZ - FROM ERS-2 TO ENVISAT

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ABSTRACT

As part of the German Processing - and Archiving Facility for ERS (D-PAF), the Altimeter Data Processing System (ADP) at GFZ is responsible for the systematic acquisition and processing of ERS-2 altimeter data, the quality control, the generation of upgraded geophysical data products and its distribution.

The quick-look products are based on standard ERS-2 fast-delivery data, which are upgraded by merging the GFZ preliminary orbit, by recomputing corrections for atmospheric path delay, by applying the tides and additional altimeter range corrections, e.g. USO drift and SPTR correction. Three product types are provided and are available within 6 to 12 days, the along-track Quick-Look Ocean Product (QLOPR), the Quick-Look Ocean Crossovers (QLOPC) and the Quick-Look Sea Surface Height Model (SSHQL).

The precise products are derived from upgraded Level-2 altimeter data. Herein, the precise orbit, generated at GFZ, is merged and the altimeter ranges are corrected similar as for the quick-look products. Two gridded data sets are provided, the Short Period Sea Surface Height Model which is based on the complete altimeter data sequence of one ERS-2 cycle (35 days) and the Long Period Sea Surface Height Model which is produced each half year by accumulation of all data since launch.

The experience in operational altimetry with ERS-1/2 will be continued for the Envisat era. Based on Envisat level 1b and level 2 data products, ADP will generate various value-added ocean and ice data products. Standard geophysical data products will be provided as well as user-specific data products which will fulfill the requirements resulting from two user inquires which were initiated by GFZ in 1994 and 1995.

A RECIPE FOR UPGRADING ERS ALTIMETER DATA

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ABSTRACT

ERS-1 altimeter data have a history of product and algorithm definitions dating back to 1990, and not surprisingly these were soon surpassed by TOPEX-aided knowledge and models. In addition no measurements re-calibrations have been applied since, to safeguard the homogeneity of the data sets. It was only in 1995, after the launch of ERS-2, that the altimeter product generation was upgraded. Still, older ERS-1 data were never reprocessed, and more precise orbits were never incorporated. But also the ERS-2 altimeter data require upgrading by applying some instrument corrections and replacing a number of geophysical corrections by more recent models. The combination of a long list of re-calibration algorithms, updated geophysical corrections and precise orbits has led to a harmonised and accurate ERS-1/2 altimeter data set that allows the reconstruction of many ocean parameters with equal efficiency as other modern altimeters, but with denser spatial (35-day) coverage. In this poster we provide this upgrade recipe and present some new data analyses that demonstrate the quality of the new data set that is now part of the DEOS' Radar Altimeter Database System (RADS). Despite the suggested recipe, it is recommended that ESA reprocesses all ERS waveforms with the latest insights.

ERS ORBIT DETERMINATION AND GRAVITY FIELD MODEL TAILORING: RECENT DEVELOPMENTS

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ABSTRACT

In the last ten years significant advances have been made in gravity field modelling, culminating in general purpose-models like JGM-3, TEG-3 and EGM96. Significant defects remain in the quality of the models when applied to orbit determination of some altimeter satellites, leading to large orbit errors, characterised by the geographically correlated nature of the altimeter crossover height differences. However, we have used these data effectively in the adjustment of JGM-3 and EGM96 to models tailored to ERS-1 and ERS-2. Many gravity field coefficients are "invisible" to altimetry, but still cause radial orbit errors through misfits with the basic tracking data: SLR and PRARE. We have now incorporated these observations in the tailoring process, and the adjustment is carried up to degree and order 70. This led to significant improvements to the EGM96 model, reducing the radial orbit error from 7 to 4.5 cm and cutting the tracking data residuals by 3 cm in RSS sense. With the availability of altimeter crossovers over the ice-covered Arctic (courtesy of UCL/MSSL) we now have valuable new information on the behaviour of the gravity field induced orbit error over this remote area. This independent source of information is used to validate several gravity field models and orbit products.

THE PRARE SYSTEM ON BOARD ERS-2: STATUS AND RESULTS

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ABSTRACT

The PRARE system onboard ERS-2 is the primary tracking system of the satellite. Throughout the past 5 years this system has proven to be a reliable and highly precise range and range rate measuring instrument operating under all weather conditions in even rough climatic regions. Through various revisions the quality of the data has steadily been improved. Since 1996 the PRARE data are used by GFZ in the operational ERS-2 POD, replacing the radar altimeter crossovers. Additionally normal equations for Earth gravity coefficients and station coordinates recovery were created. The gravity and PRARE station solution of the joint GFZ/GRGS model GRIM5-S1 has been compared with external solutions, which confirm the high quality of the solution.

The poster will present the system status and the achieved scientific results.

NON-PARAMETRIC ESTIMATION OF THE WET TROPOSPHERIC CORRECTION, CLOUD LIQUID WATER CONTENT AND SEA SURFACE WIND SPEED IN ERS CONFIGURATION.

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ABSTRACT

Traditionally, geophysical parameters are estimated using parametric regression on an appropriate database. This estimation method is accurate in the densest region but often fails for less dense data region. In this work, we have compared performances of parametric and non parametric regression. For the wet tropospheric correction (dh in cm), the cloud liquid water content (clw in kg/m2), the atmospheric attenuation of the backscattering coefficient in Ku band (att in dB) and the sea surface wind speed (us in ms-1), estimations are made using the 2 brightness temperatures (TB24 at 23.8 GHz and TB36 at 36.5 GHz) and the backscattering coefficient in Ku band (s0Ku). This last term is used instead of a term in us_altimeter-7 m/s like in ERS2 standard products. It appears that this modification improves the atmospheric parameters retrieval since the sea surface roughness is taken into account more directly than using the sea surface wind speed calculated from s0Ku by the Witter and Chelton algorithm. Nonparametric regression (NPR) is a method to statistically smooth a data set such that a valid estimate of a variable (geophysical parameter) can be found in measurements space (TB and s0). The database consists of 12 global meteorological fields, containing both analyses and guesses of surface and atmospheric parameters. These parameters are given in 1.125x1.125 degree meshes (Bourras et al, 99). In each mesh, geophysical parameters are associated to brightness temperatures and backscattering coefficients simulated by a radiative transfer model. For a given set of ERS2 measurements the estimation of a geophysical parameter at this point is a combination of this geophysical parameter at each point of the database with the associate weight. This last is a function of the distance between the set of measurements and each set of simulations. For our non parametric regression, we take a spherical Epanechnikov kernel associated to the appropriate bandwidth in each direction, and we prefer a local linear regression estimator to the classical Nadaray-Watson regression estimator which induces bias where data density varies a lot. This retrieval method is tested first over the database itself to conclude on the regression quality and then is validated using radiosounding measurements.

Domain: GEODESY

NDSC SUPPORT TO THE DEVELOPMENT OF ERS-2 GOME GEOPHYSICAL DATA

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ABSTRACT

Operating aboard the ESAs ERS-2 heliosynchronous polar satellite since 1995, the Global Ozone Monitoring Experiment (GOME) measures the solar irradiance and the Earth radiance from 240 nm through 790 nm, at 0.2-0.4 nm spectral resolution. The atmospheric abundance of several trace species - such as O3, NO2, BrO, OClO, CH2O and SO2 - is derived from GOME spectra using differential absorption spectroscopy techniques. GOME has proven to be a major component of the global observing system and is the successful prototype of a series of new-generation spaceborne sensors.

The ground-based Network for the Detection of Stratospheric Change (NDSC) is another major contributor to the global observing system for atmospheric composition. Started in 1991, at the present time the NDSC includes five primary and two dozen complementary stations distributed from the Arctic to the Antarctic. The column abundance and vertical distribution of key atmospheric constituents are monitored at NDSC stations by a variety of complementary techniques and instruments such as UV-visible spectrometers, Fourier transform infrared spectrometers, lidars, millimeter wave radiometers, and ozone sondes. A main goal of the NDSC is to provide an independent calibration and validation of satellite measurements on the global scale as well as in the long term.

Through the geophysical validation of GOME data products and retrieval algorithms, ground-based observations associated with the NDSC have played a unique role in the further development of GOME. The NDSC provided an extensive, high-quality database to the GOME validation campaign conducted during the ERS-2 commissioning phase. It has generated well-controlled correlative data records needed for the quality assessment and the long-term verification of operational GOME data products. It has provided experimental support to advanced studies focusing on specific aspects of data retrieval. Furthermore, the synergistic use of GOME, NDSC and other correlative data has enhanced their geophysical exploitation.

The present paper highlights several contributions of the NDSC to the further development of GOME data products. Focusing on the integrated exploitation of multi-technique network data records, it also illustrates NDSC capabilities for the pseudo-global and long-term validation of future GOME-like spaceborne sensors.

UPPER ATMOSPHERIC NO FROM SCIAMACHY: SIMULATIONS AND INSTRUMENT CAPABILITIES

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ABSTRACT

The SCanning Imaging Absorption spectroMeter for Atmospheric ChartograpHY (SCIAMACHY) operates in eight channels covering the UV, the visible and two infrared regions. Recent developments in the testing of the instrument now enable not only the full use of channel 1 (240 nm-314 nm) at a required high level of performance but in some special cases its extension to 220 nm. This instrumental improvement allows new objectives to be addressed in the upper stratosphere, on top of the already proposed mesospheric and thermospheric investigations of nitric oxide. Simulations will show the instrument capabilities for these studies and will be compared with the latest instrument test data obtained before instrument delivery. The operation modes corresponding to these NO observations will also be described. The capabilities of SCIAMACHY for mapping the total column of upper atmospheric NO will be investigated as well as possibilities to infer NO vertical distribution and transfer properties between the different atmospheric regions. Nitric oxide signal will also be discussed in the present ERS-2 GOME observation.

GROUND BASED HIGH RESOLUTION FTIR MEASUREMENTS OF STRATOSPHERIC MOLECULES ABOVE HARESTUA, NORWAY, DURING 1995 TO 2000.

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ABSTRACT

Groundbased high-resolution Solar FTIR measurements have been conducted at the complementary NDSC (Network for Detection of Stratospheric Change) site Harestua in southern Norway (60oN, 11oE, altitude 590 m) since 1994. Measurements has primarily been focused on molecules of interest for stratospheric ozone depletion research, HCl, HF, HNO3, ClO, ClONO2, N2O, COF2, and O3 as part of the field campaigns SESAME and THESEO. A primary goal of NDSC is satellite validation and the site is part of three accepted ENVISAT AO-proposals:

Validation of ENVISAT-1 level-2 products related to lower atmosphere O3 and NOy chemistry by an FTIR quasi-global network. Global study of inorganic chlorine and flourine loading in the earths atmosphere, based on correlative measurements by ENVISAT-1 and 12 NDSC sites. Isotopic ratios of water and methane for the study of stratospheric oxidation processes.

In order to increase the capabilities of the technique in the above mentioned applications substantial work has been devoted to development, application and validation of algorithms for retreival of vertical concentration profiles from the pressure-broadening of the absorption lines.

The FTIR measurements are performed using a Bruker 120 M high-resolution (0.0035 cm-1) FT spectrometer connected to a coeliostat. Total columns are retrieved using the softwares SFIT and MALT. In addition vertical concentration profiles of some species are derived from the pressure broadened absorption lines. Two methods for the profile retrieval have been employed: i.e. the Chahine Twomey technique which is an iterative search method and the optimal estimation technique (SFIT2) which uses a statistical approach. The retrieved profiles have been compared with other measurement data. In general the comparisons show good agreement when comparing total columns, while differences of up to 20 13620336s seen when comparing partial columns.

Results from 5 years of measurements will be presented and discussed in relation to other observations and modelling data.

TOOLS FOR THE ANALYSIS OF RESIDUAL SPECTRA AFFECTING MIPAS LEVEL 2 PRODUCTS

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ABSTRACT

One of the atmospheric payload instruments of ENVISAT is MIPAS, an infrared Fourier spectrometer operated as a limb sounder. MIPAS level 1 products consist of sequences of calibrated emission spectra covering the range from 4.15 to 14.6 micrometer; level 2 products are vertical profiles of pressure, temperature and selected trace gas VMRs derived from sequential level 1 scans. The retrieval of the level 2 products is based on the use of initial guess data, forward modelling and iterative improvements of the assumed parameters until convergence to a stable solution has been reached.

The attainable profile quality will be affected by random as well as by systematic effects that result in differences between measured and simulated spectra remaining after the level 2 retrieval iterations. Time averaged residual spectra should average out random noise and be close to zero. Deviations from zero can be due to imprecise spectroscopic data or instrument parameters, shortcomings of radiative transfer modelling, or inappropriate retrieval techniques and parameters.

The level 2 data will be generated as near real time as well as off-line products. For both types of data our work aims at the identification and subsequent minimisation of level 2 residual spectra. To this end, a number of analysis techniques and tools have been designed and implemented allowing the detailed analysis of spectra, profiles, Jacobians and quality metrics. Some of these tools can be operated automatically, while others require interactive investigation and parameter modification.

Concepts and typical examples will be presented, where the manipulation of simulated instrumental parameters, of spectral measurements and of retrieval parameters leads to degraded profile quality. The application of the proposed tools allows the identification and quantification of separate error terms and hints to their origin.

During the mission, when we cannot rely on simulated data with known degradations, data of increasing atmospheric complexity shall be used. Thus, our first analysis steps will be the identification of instrumental features, followed by the determination of general spectral characteristics and special meso-scale effects. This rationale and the available tools will help to verify the selected approaches during the level 2 processing including the choice of the proposed emission line windows, the retrieval approaches and parameters, and the knowledge of the attainable level 2 data quality. Special emphasis has to be given to the sequential application of the various tools.

SAFIRE-A MEASUREMENTS DURING THE APE-GAIA CAMPAIGN

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ABSTRACT

Results of measurements obtained by SAFIRE-A (Spectroscopy of the Atmosphere by using Far InfraRed Emission - Airborne) during the APE-GAIA (Airborne Polar Experiment Geophysica Aircraft In Antarctica, Ushuaia, Argentina, 15th September 15th October 1999) campaign are presented, providing an assessment of instrument performances in view of its participation to the planned M55-Geophsyica activities for ENVISAT validation. The SAFIRE-A Far Infrared FT spectrometer was operated onboard the Geophysica stratospheric platform during the five scientific flight which the aircraft performed over the Antarctic Peninsula, aiming at investigating the chemistry and dynamics across the boundary of the southern polar vortex. The instrument provided limb sounding observations of atmospheric emission spectra over two frequency intervals: [22-23.5 cm-1], and [123-125 cm-1] where spectral features respectively of O3, ClO, N2O, HNO3 and HCl, H2O are displayed. Volume mixing ratio vertical profiles of the observed species are retrieved from limb-scanning sequences by data analysis and inversion. Variability of O3, ClO, N2O and HNO3, along the flight track, has been studied as a function of altitude and latitude and results of measurements obtained in some of the APE-GAIA Antarctic flights are displayed.

COMPARISON OF GROUND BASED FTIR MEASUREMENTS AT HARESTUA TO SPACEBORNE MEASUREMENTS

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ABSTRACT

Ground based high resolution Solar FTIR measurements conducted at the complementary NDSC (Network for Detection of Stratospheric Change) site Harestua in (60oN, 11oE, altitude 590 m) are here compared to spaceborne measurements from various instruments, such as HALOE, CRISTA (on the space shuttle) and MOPITT.

The two first above-mentioned instruments are focused on detecting stratospheric species of large relevance for the ozone depletion chemistry, such as HCl, HNO3 and O3. The Moppitt instrument also covers the troposphere measuring CO and methane. These species are of high importance for tropospheric as well as stratospheric atmospheric chemistry. Both gases have a strong anthropogenic component and especially CO with its relatively short lifetime (3 months) is likely to show a considerable variation in time and space.

In the present paper partial and total columns retrieved from spectra at the Harestua site in southern Norway (60oN, 11oE, altitude 590 m) during 1994 - 2000 will be compared to coincident measurements in time and space with the above-mentioned space borne instruments. The results will be discussed and related to the uncertainties of the FTIR measurements.

PASSIVE CALIBRATION TARGETS WITH A LARGE, STABLE AND CONTROLLABLE RCS FOR SPACEBORNE SAR

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ABSTRACT

The series of calibration experiments with ERS-1/2 SAR was conducted in 1995 and 1999 at the Bear Lakes calibration site near Moscow. Since a very beginning in the number of calibartion scenarios along with standard targets (corner reflectors) new passive calibration targets based on parabolic antennas were investigated. Main tasks - study of the scatterers stability and a way to broaden scatterer pattern were made and reported earlier.

Experiments of the year 1999 were conducted under AO3-343 project and devoted to the continuation of the study of the parabolic antennas scattering stability and a way to control their radar cross section. Three parabolic antennas, used in the experiment, were located at the corners of the rectangular triangle with 50 m legs. Two antennas were used as a reference, and another one was a calibration target with polarisation grid in focal area. The use of the polarization grid allowed us to modify scattering matrix of the antenna. Final scattering properties of the structure become similar to that of the dipole. As a result, setting the angle q between the SAR polarization plane and the grid polarization plane, we were able to change the targets RCS for a single polarization system, like as ERS SAR.

The SLCI data obtained under AO3-343 project were used for the measurements of the antennas RCS. The measurements show, that reference antennas have very stable and very large, with ~ 52 dBm2 radar cross-section. The cross-section of the last one was controlled by the orientation of the polarization grid with respect to ERS-2 polarization plane. The results are in good agreement with theoretical predictions except for orthogonal orientation, where observe 4 dB higher scatter than it was predicted.

The study conducted with a use of ERS SAR data confirms high stability of the parabolic antennas and the possibility to control the polarization plane (radar cross section) of the backscattered signal, what is of special value for multipolarization SAR systems like as Envisat ASAR.

CALIBRATION AND EVALUATION OF ENVISAT TEMPERATURE AND OZONE DATA USING STATISTICS FROM THE UK MET OFFICE NWP SYSTEM

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ABSTRACT

Temperature and ozone data from the GOMOS, MIPAS and SCIAMACHY instruments aboard Envisat will be assimilated into the UK Met Office Numerical Weather Prediction (NWP) system. The operational data routinely used by the weather agencies will be assimilated together with the Envisat data. This assimilation system seeks to combine in an optimal manner atmospheric observations with data from a general circulation model of the atmosphere. The statistics generated by the assimilation procedure on the difference between the Envisat observations and the data assimilation analyses, and between the Envisat observations and forecasts using the analyses as initial data, will be used to calibrate and evaluate the Envisat data. The approach will follow that applied to temperature and ozone data from instruments aboard NASA's Upper Atmosphere Research Satellite (UARS) and from ESA's GOME instrument. Observation processing datasets generated by the statistics will be used to identify potential biases in the data. In collaboration with the Envisat instrument teams, biases in the observations will be estimated. The impact of the Envisat datasets will be tested using Observation System Experiments (OSEs) in which different sets of data are systematically removed from the assimilation. Wherever possible, the meteorological analyses incorporating Envisat data and operational data will be evaluated against independent observations (i.e. observations not used in the assimilation). The error characteristics provided by the instrument teams will be assessed. An attempt will also be made to identify shortcomings in the UK Met Office assimilation system.

THE DEVELOPMENT OF AN ADVANCED CALIBRATION TRANSPONDER FOR QUAD-POL SAR AND SCANSAR

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ABSTRACT

For future SAR systems with increased complexity, number of modes and number of beams the calibration requirement is significantly greater than that for ERS. For example, calibration of SAR instruments with multiple polarisations is difficult with conventional transponders and corner reflectors because of the problems in controlling the channel responses and separating them in the final image. Similarly, it is no longer possible to rely on a single well prepared and characterised calibration site and transponder to conduct a cost-effective calibration campaign. The advanced SAR transponder design described in this paper addresses both of these issues - additional functionality and multiple deployment. The transponder features separate pulse coding for each of the polarisation channels. This has two main benefits. The images from the different channels no longer interfere since the decoding processing only focuses one channel at a time. Also the background level variance in the image is reduced allowing more accurate measurements to be made. The technique has the added benefit of allowing operation without the use of specially prepared sites. The transponder also features digital pulse replication, which allows improved calibration statistics without saturating the radar receiver. This will be of particular benefit for calibrating low-resolution modes such as SCANSAR. This transponder builds on the original ESA design used for ERS but cost-effectiveness is improved by using smaller Potter horn antennas and a simplified internal calibration system. The technique has been successfully demonstrated previously using experimental C band equipment. A prototype transponder is now being developed under GSTP funding. This implements a single channel of the full quad-pol system and is being used to demonstrate the technology.

ALTIMETRIC MEASUREMENTS AT L, S, C AND KU BANDS FROM AN OPEN SEA PLATFORM

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ABSTRACT

Altimetric measurements have been carried out using coherent and impulsive radars at L (1.25 GHz), S (2.5 GHz), C (5.4 GHz) and Ku (15.4 GHz) bands, from the Italian Oil Company (AGIP) platform "Barbara C", in a deep-water site in the Central Adriatic Sea. One of the aims of the experiment is to study the properties of the sea surface obtainable from the specular reflection of the e.m. waves. This is possible due to the coherency of the radars, which allows to measure the sea surface displacement along with the radar backscatter. The instantaneous properties of the radar backscatter, as a function of the wave isplacement and of the wind, are studied using the continuous wavelet analysis, a technique which allows to distinguish between the different roles of wind and waves in the determination of the radar backscatter. Besides this, the measures allow the determination of the electromagnetic bias, which is one of the most important parameters in altimetry. The implications of these measurements, hopefully continued in the future, with the satellite altimetry, concern the e.m. bias as well as the dependence of the radar backscatter on wave age and turbulent properties of the atmospheric boundary layer.

IN-SITU VALIDATION OF THE AATSR SKIN SST PRODUCTS WITH THE SISTER RADIOMETER

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ABSTRACT

The ENVISAT AATSR (Advanced Along Track Scanning Radiometer) is a filter radiometer capable of measuring infrared brightness temperatures (BTs) to very high accuracy. The principal derived AATSR product is a skin sea surface temperature (SSST), calculated from the BTs with a physically based retrieval algorithm.

Convection within the sea is inhibited at the air-sea boundary, so the transport of heat through the surface layer is relatively inefficient and the SSST is often decoupled significantly from the bulk sea surface temperature (BSST) immediately below. As a result, it is not adequate to validate the AATSR SSST product against buoy measurements of BSST alone.

The authors plan to collect in-situ measurements of SSST with the SISTeR (Scanning Infrared Sea surface Temperature Radiometer), a compact and flexible chopped, self-calibrating infrared filter radiometer specially designed for research in a maritime environment. All external radiance measurements are referred to two internal black bodies, operated at ambient temperature and at a programmable increment (typically 10K) above ambient temperature.

Measurements of the upwelling sea surface radiance are made at an angle as near as practicable to nadir, where the emissivity of the sea surface is highest. A second interlaced set of downwelling sky radiance measurements are made at the complementary angle so that a deficit due to the reflected sky signal can be corrected and the true SSST calculated.

The SISTeR will be deployed on research ships and other ships of opportunity to collect sea-level radiometric data co-incident with ENVISAT/AATSR overpasses. The SISTeR has previously been deployed in support of ATSR-2 both in coastal waters and over the open ocean. Illustrative results from some of these campaigns are discussed.

STUDY OF THE GEOMETRIC PROPERTIES OF ENVISAT ASAR PRODUCTS

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ABSTRACT

The base for the interpretation of remote sensing data is the calibration of the data to be analyzed. ESA is taking into account this fundamental needs by including also the ENVISAT sensors into its long tradition of high precision calibration and validation. DLR-DFD participated in those activities as one of the Processing and Archiving Centers of the ERS ground segment and consequently intends to contribute to the calibration of ENVISAT-ASAR data, too. Additionally the institute has long experience in the definition, exemplary implementation and operation of processing chains for the generation of higher level SAR products. This service shall be extended to support ENVISAT-ASAR data as well. A basic requirement is the suitability of the input standard products.

Therefore the geometric properties of the precision image, the single look complex and medium resolution products shall be checked and reported regarding product annotation, timing parameters, orbit precision, parameter stability by considering repeat acquisitions and processing artifacts. The products shall be terrain corrected and interferometrically processed. During the orthorectification procedure the ASAR data set is combined with ground control points as well as digital elevation models serving as external references. Possible processing artifacts as well as geodetic inconsistencies would be identified. Interferometric processing is a sensitive tool for the identification of several error sources like timing and orbit precision and phase behavior. The analysis of the coherence allows a fine scale investigation.

The proposed presentation will describe the intended procedures. It will be complemented with results achieved during the calibration and validation of ERS-SAR-data.

GERMAN CONTRIBUTION TO SCIAMACHY VALIDATION WITH GROUND-BASED FTIR OBSERVATIONS FROM THE NDSC NETWORK: PREPARATION PHASE

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ABSTRACT

Within this German SCIAMACHY CAL/VAL project columns of O3, NO2, N2O, CO, CO2, CH4, H2CO, and profiles of O3, N2O, and CH4 shall be validated with ground-based FTIR measurements. The German NDSC-FTIR-Validation Network includes sites covering 28 - 68 °N: Zugspitze (NDSC Primary Site, run by IFU-Garmisch), and Kiruna and Izana (NDSC Complementary Sites, run by IMK-Karlsruhe). In the ongoing preparation phase, existing expert know how will be exploited to guarantee an optimum consistency and quality control of the ground-based FTIR measurements and retrieval techniques. Examples of the current work will be discussed.

OPERATIONAL LONG TERM MONITORING OF THE SCIAMACHY INSTRUMENT ON ENVISAT

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ABSTRACT

We outline the concept, including functions and responsibilities, for the operational instrument monitoring for SCIAMACHY. According to agreements between ESA and the Announcement of Opportunity Provider (AOP), the operational long term monitoring (OLTM) is a function which has to be provided by AOP. Its technical and scientific implementation will be realised as part of the tasks of the SCIAMACHY Operations Support Team (SOST). Monitoring the behaviour of SCIAMACHY in-orbit is an essential function during the Commissioning and Routine Operations Phase. OLTM ensures that the actual instrument status is known, that countermeasures preventing instrument malfunctions can be initiated, and that data processing can incorporate the most up-to-date instrument characterization. Thus for the full complement of OLTM tasks, both housekeeping (HK) and science data have to be evaluated. Modifications to instrument characterization will be provided by OLTM in order to account for degradation of optical components of the instrument over the mission lifetime. These are achieved by the so-called "m-factors", which ratio the actual radiance at a specific time during the mission, obtained under well defined measurement conditions, and a reference radiance determined at a phase when the instrument status could be described by the original calibration parameters. In a complementary sense also the behaviour of single optical components is monitored. OLTM based on HK data will mainly deal with long term trend analysis of parameters: extrapolation of the temporal behaviour to estimate the occurence of specific events (e.g. heater power to learn when de-contamination has to be scheduled), extrapolation of the temporal behaviour to avoid occurences of out-of-limit events, correlation of specific events with measurement parameters, investigation of out-of-limit events (e.g. frequency, triggering events; etc.) orbital dependencies. According to the presently identified orbit scenarios and their planned execution pattern in-flight calibration & monitoring data will be generated on a regular basis. Among the numerous analysis methods and purposes for these data a well-defined subset will be used to achieve the monitoring goals as described above, based on the current knowledge of the instrument and on lessons learned from GOME on ERS-2.

THE ENVISAT EXPLOITATION PROGRAMME

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ABSTRACT

The UK EnviSat Exploitation Programme (EEP) has aimed to encourage the EO communities concerned with policy, research, applications development and operations to work closely together on common objectives. This has been to stimulate the use of data and products that will be available from the EnviSat mission not only in the large public and science sectors but also in the wider commercial base. The programme has concentrated on the applications and potential products of the land, ocean and atmospheric instruments. This includes: - ASAR (Advanced Synthetic Aperture Radar) - MERIS (MEdium Resolution Imaging Spectrometer) - AATSR (Advanced Along Track Scanning Radiometer) - RA-2 (Radar Altimeter) - MWR (Microwave Radiometer) - GOMOS (Global Ozone Monitoring by Occultation of Stars) - MIPAS (Michelson Interferometer for Passive Atmospheric Sounding) - SCIAMACHY (Scanning Imaging Absorption Spectrometer for Atmospheric Cartography)

The following areas have been addressed that include information provision and gathering, data handling development, technical meetings and the provision of reports and publicity material. The results of these activities can be viewed from a Web site, address: www.eoboard.co.uk. The potential of EnviSat instruments for sea state and marine monitoring through the use of demonstrators has been included on this site. To stimulate land applications and geocoding of ASAR and MERIS data, a world wide DEM catalogue has also been produced, address: www.demcat.co.uk. For the Advanced Along Track Scanning Radiometer and the Medium Resolution Imaging Spectrometer, application studies were undertaken that produced either sample data or demonstrated higher level products. These are available on CD-ROM. There is now a comprehensive set of information leaflets that cover the EnviSat satellite, atmosphere, land, marine, global, agriculture and forestry as well geological applications.

CONCEPT FOR USING GPS-BUOYS FOR RA DRIFT MONITORING

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ABSTRACT

Radar altimetry is a valuable tool for measuring instantaneous sea levels or mean sea surface heights. Until today a long series of measurements from different altimeter missions exist. A main problem in using these data for determination of sea level changes are the biases between the missions and a only weakly determined drift of the different sensors. For the past and current missions different strategies are used for calibration and drift monitoring, e.g. using crossovers or tide gauges as a height reference. The disadvantage of all calibration methods is, that no direct measurement beneath the sub-satellite tracks are available and, therefore, models have to be used to account for e.g. the sea surface slope or time varying signals. A more reliable method exists, when using oil platforms equipped with GPS and tide gauges beneath the sub-tracks. Unfortunately, only a few of them are probable located. With the availability of GPS a different strategy can be applied. As shown for ERS and Topex/Poseidon, a GPS-equipped buoy, anchored beneath a sub-track, can be used as a height reference. Since GPS-derived coordinates are ITRF-referenced, an absolute calibration is possible. Until today only lightweight buoys were deployed. Therefore, no long-term sensor for the calibration and drift monitoring exists. A ruggedized GPS-buoy will be deployed in the North Sea in the context of a large German sea level monitoring project. An ENVISAT crossover, which intersects with a Topex/Poseidon and GFO sub-track, will be chosen. The lifetime of the buoy is expected to be several years, therefore, a long-term calibration, drift monitoring and inter-calibration of different missions will be possible. A second buoy will be deployed in the Gulf of Mexico. In addition, the buoy will be equipped with supplementary sensors, like wind speed, gyros and air pressure sensors, allowing a broader use for calibration, e.g. of wind speed or significant wave heights.

parameters, a common agreed set of real MIPAS measurements is used for further testing. Residuals between measured and best-fitting modeled spectra are analyzed for systematic patterns. Emphasis is put on candidate explanations such as inappropriate predictions on instrument characteristics; different use of initial guess and a priori data; over-or under-regularization of the retrieval, and possible deficiencies in spectroscopic data. Furthermore, GOMOS, SCIAMACHY, and other data are used for validation.

ADVANCED MIPAS-LEVEL-2 DATA ANALYSIS (AMIL2DA)

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ABSTRACT

Changes in atmospheric composition are important in the context of stratospheric ozone depletion, global change and related environmental problems. The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS), which is a core instrument of the Envisat polar platform to be launched in 2001 by the European Space Agency (ESA), is a powerful tool to measure vertical profiles of trace species on a global scale. While operational data processing by ESA covers only analysis of pressure, temperature, and the mixing ratios of the species O3, H2O, HNO3, CH4, N2O, and NO2, MIPAS infrared spectral limb emission measurements contain information on a bulk of further important species. The goal of AMIL2DA is to generate data analysis tools for these supplemental species along with thorough validation of these algorithms. Instead of merging the contributions of all participants to one data analysis algorithm which fits all purposes, the AMIL2DA strategy is to maintain the diversity of different computer codes by each group which are custom-tailored to their specific scientific needs. First, forward radiative transfer algorithms and retrieval processors are adapted to the physical and computational needs of the MIPAS experiment. These codes then are cross-validated by intercomparison to reveal potential weaknesses of the assessed computer models. Spectroscopic line data not included in the current databases but important to MIPAS applications are generated. After cross-validation of forward radiative transfer models and subsequent upgrading, these are operated in the context of an inversion computer code, which infers atmospheric constituent abundances from measured spectra. The different inversion algorithms are applied to a common set of synthetic measurement data in a blind-test validation mode. After upgrading the inversion models and fine-tuning of processing

ANALYSIS OF THE EFFECT RAIN ON ENVISAT ALTIMETER: DEFINITION OF A RAIN FLAG

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ABSTRACT

Attenuation of the signal and distortion of the waveforms by oceanic rain can significantly degrade the quality of altimeter measurements. Several studies have analysed in details the effect of rain on the dual-frequency (Ku and C bands) Topex altimeter (NRA) data. They showed that the frequency dependence of the electromagnetic signal attenuation by rain can be used to define a rain flag based on the detection of departure from a rain free relationship between the two frequency backscatter coefficients. This kind of rain flag proved to perform better than the operational one based on coincident passive microwave data. The future Envisat altimeter will also have a dual-frequency capability and will operate in Ku and S bands. The aim of the present study is to analyse in detail the distortion of the altimeter waveforms to define a rain flag. For this purpose, an analytical model has been developed to compute Ku and S band waveforms in presence of a rain cell. It has been used to quantify the deformation of waveforms for a wide range of rain rate and rain cell diameter. The results of the modelling are used to define a rain detection criterion based on the attenuation of the Ku band signal compared to the S band one. The results are also used jointly with a cloud liquid water estimate based on Marshall-Palmer drop size distributions within rain cell to propose an inversion technique to retrieve rain rate and rain cell diameter from attenuation and passive microwave cloud liquid water estimates.

Domain: ENVISAT

SAR PRODUCTS FOR ALL: RENT-A-RAPIDS

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ABSTRACT

Through the new SARCOM consortium, a mobile receiving station can be rented. This unique service enables users to get access to timely, low cost ERS-SAR data products world-wide. SAR products for all: **anybody** (low cost), **anytime** (up to near real-time), and **anywhere** (station can be deployed worldwide).

For this service, NLR's mobile receiving station RAPIDS is used. RAPIDS is a cost-effective PC-based ground receiving station, capable of local acquisition and processing of satellite data from ERS and also Spot. Further, the station will be upgraded to receive ASAR data from the future ENVISAT. Due to the low complexity and small size of RAPIDS, the station can rapidly be deployed anywhere in the world. The turn-around time (break-down plus build-up) of RAPIDS is less than 24 hours. RAPIDS is transportable by car, ship and wide-body aircraft. The station can be operated by NLR staff or by the customer (the customer will then be trained by NLR staff). More information about RAPIDS is on the Internet: www.rapids.nl

The SARCOM consortium has been selected by the European Space Agency to distribute data products worldwide from the ERS and ENVISAT satellites. Because of this worldwide license, the Rent-a-RAPIDS service is inclusive the license for data reception. The SARCOM consortium is a group of major players in the satellite imagery market: Spot Image (France), Geoserve (the Netherlands), Nigel Press Associates (UK), NLR (the Netherlands), RADARSAT International (Canada), Satellus (Sweden) and Tromsø Satellite Station (Norway).

The Rent-a-RAPIDS service can be a solution for applications for which currently no (timely) ERS-SAR data is available. Examples applications include flood monitoring in Bangladesh, forestry and bathymetry in Indonesia and volcano monitoring on Montserrat.

KEYWORDS: worldwide, mobile receiving station, low cost, rapid deployment, commercial service.

GAMMA SAR AND INTERFEROMETRIC PROCESSING SOFTWARE

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ABSTRACT

The Gamma Modular SAR Processor (MSP), Interferometric SAR Processor (ISP), Differential Interferometry and Geocoding Software (DIFF&GEO), and Land Application Tools (LAT) are modular software packages useful to process synthetic aperture radar (SAR) images. Data of both spaceborne and airborne sensors including ERS-1/2, JERS-1, SIR-C, SEASAT, RADARSAT StripMap mode, and the single-pass Dornier DOSAR interferometer have been successfully processed interferometrically. Up-to-date algorithms were implemented to achieve accurate processing of the data while permitting timely processing of large data sets. Recent projects completed with the software were the SAR and interferometric processing of more than 700 JERS scenes in the frame of the SIBERIA project and the generation of subsidence maps for Bologna, Abano, and Mexico City. User-friendly display tools and full documentation in HTML language complement the software. Both binary and source code licenses are provided.

Recent development included the adaptation of the software to PC operated under LINUX or NT operating systems and the improvement of the functionality for differential SAR interferometry. Furthermore, as part of our ERS AO3 project (ERS AO3-175), software demonstration, training, and testing examples which can be distributed to the users were generated. Development in the near future will include the adaptation of the software to the processing of ENVISAT ASAR (with data provided through ENV AO-210) and ALOS PALSAR (ALOS AO proposal submitted) data.

Domain: SERVICES AND MARKET

WATER DYNAMICS IN THE KURIL STRAITS AREA: STUDY WITH ERS SAR

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ABSTRACT

Synthetic aperture radar (SAR) images obtained from the ERS-1 and ERS-2 satellites are analyzed together with NOAA AVHRR imagery, weather maps and hydrographic CTD data to study peculiarities of water dynamics in the southern Okhotsk Sea. The mesoscale features such as eddies of 100-150 km in diameter and fronts associated with the main currents were detected on the AVHRR, while the SAR data provided evidences on the smaller scales of ocean structure.

Characteristic outlines of anticyclonic rings were clearly defined at wind speed of 3-10 m/s and were likely associated with a modulation of the surface capillary-gravity waves by the current shear. Some small-scale features of circulation were also found due to the presence of surface films. Spatially organized compact vortex structures of 7-15 km in diameter were especially well visible in spring and fall periods, which correlates with a biological activity in the area. Among them cyclonic eddies are dominant outside of strong flows.

Rough bottom topography and strong tidal currents in the area of Kuril Islands are responsible for formation of rips, wakes and headland vortices, and packets of internal waves. Pattern of the shear fronts on the SAR images varies with a tidal phase. However the main areas of tidal energy dissipation are tightly related to the bottom topography and are likely stable. Typical spatial patterns of water dynamics and new fine details of the surface water structure are discussed.

OIL SPILL MONITORING IN THE MEDITERRANEAN SEA USING ERS SAR DATA

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ABSTRACT

Although SAR imagery is widely accepted as a valuable method in detecting oil spills, its operational use largely adopts subjective criteria to discriminate between slicks and other similar natural features. In the present paper a set of image features are tested in order to select those useful in detecting the oil spills.

Two different statistical approaches have also been developed in order to evaluate the probability for a dark area to be a slick on a SAR image. A comparison of the results of the two methods is provided. The advantages and the drawbacks of both are presented and discussed. Based on the previous algorithms a SAR post processing imagery system has been developed. It can analyse both in automatic or manual modality the ERS SAR PRI images in order to identify the slicks and to produce a detection report. The system functionalities, its performances and the operational framework are described. The system validation activity has been carried out on two data sets, the one used to statistically characterise the slicks and on a new one. The results obtained are very encouraging, showing about 85101153650 of correct classification in both the situations.

Last but not least, a comparison on the detection capabilities is performed, using as input to the system images with different spatial and radiometric resolutions. This analysis is devoted to identify possible system parameters to reduce the time gap between the image acquisition and the detection report availability.

CHINESE PROGRESS TOWARD COASTAL AND MARINE APPLICATIONS OF SPACEBORNE SAR

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ABSTRACT

Images from the synthetic aperture radars (SARs) aboard the European Remote Sensing Satellites ERS-1/2, the Canadian Radarsat and the first Japanese Remote Sensing Satelllite JERS-1 have been used by Chinese marine community since 1991. This paper presents the recent progress toward coastal and marine applications of the SAR images in China. Particular attention has been paid to mapping of coastal zone, observations of internal waves, and measurements of ocean surface winds.

ENVIRONMENTAL REMOTE SENSING SYSTEM FOR COASTAL WATER MONITORING (ENVISAT AO 560)

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ABSTRACT

Human activities that take place in the coastal zones (industry, tourism, fishing, aquaculture, etc) are affecting the environment. Also, human activities effects on the coastal environment can have a remote origin, and the observed effects are often difficult to relate to the causes, as they may do not appear immediately. The strong seasonal variations in tourist activity and in the associated environmental pressures makes complicate the management of the coastal zones.

Finally, as a result of taking these interactions into account insufficiently or too late in the planning processes, human activities handicap each other and damage the environment.

The main objectives of the system are: - Integrate and assemble all environmental researches in the Black Sea zone on the purpose of achieving a superior understanding of physical, chemical and biological phenomena;- Create the structure of an operational system, partially independent of budget funds, having as inputs local measurements and researches and as output, specialized reports for different users (industrial, tourist industry, government);- Ensure the use of edge technologies in environmental monitoring, shortening the way innovative technologies have to travel to the commercial applications.- Create an environmental monitoring system that would comply and support the European and international environmental legislation;- Provide an operational system as decisional support for disaster and environmental monitoring.

An operational system, near real time effective can solve a great deal of these problems, especially when related to early response. A structure of such a system is presented, adapted to the social-economic realities of Romania, together with some methodological aspects of the use data provided by ERS-1&2 and Envisat on-board sensors.

PRELIMINARY STUDIES FOR ENVISAT PROPOSAL (AO-ID-542): DETERMINING OFFISHERIES AND COASTAL MANAGEMENT PLAN BY USING REMOTE SENSING TECHNIQUES IN LAKE VAN, EASTERN TURKEY

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ABSTRACT

Lake Van is largest Soda Lake on earth. The lake covers a surface area 3574km2 and its volume 607 km3, its elevation is 1650 m and average depth 171 mand the deepest point 451 m and its pH is 9.8. It is very suitable both in the feeding and living habitat for Chalcalburnus tarichi (local name Vanfish) that only one species lives into Lake Van and taken second row with a portion 31after carp in the inland water fish production of Turkey. This project have been intended to investigate of following elements: Fisheries monitoring, understanding of lake coast process, sea surface temperature (SST), detection of pollution and coastal processes, identification of area for Van fish distribution, chlorophyll concentration and coastal dynamics, creating of new lake batyhmetric map. In this project will be used ENVISAT data from AATSR, ASAR, MERIS and RA-2 sensors. Its also investigates a methodology by using a multi-stage approach and state of the art of the space technologies especially for SAR. This will increase the level of understanding and by applying the ENVISAT data used in Turkish research and academic institutions.

RESIDUAL CURRENTS MOVEMENTS AND OIL SPILLS TRANSPORT

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ABSTRACT

Oil Spill trajectory could be detected from radar data. Radar data such as Radarsat are good tools for oil spills movements. In this study the finite element model was applied with Doppler frequency shift to model surface water currents on the coastal water of Malacca Straits, Malaysia. This study was used the probability density function and time series analysis to predict oil spill movements due to the effects of residual currents componets.

The results show that the water current on Malacca Straits moved in elliptical shape. The Major axis are parrallal to the coastline of Malaysia. The minor axis have a right angle with the coastline of Malaysia. It is clear that the oil spills moved towards the coastline with constant current velocity of o.23 m/s and spread in small parcales along the coastal water of Malaysia. The time was required for oil spills spreading was 12 hours.

In conclusion, the average current velocity of the time period play significant role for oil spills spreading. The extraction of oil spills with current speed make Radarsat as good tools for modelling oil spills movements in coastal zone.

WAVE REFRACTION PATTERN AND COASTAL EROSION

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ABSTRACT

Waves play an important role for shoreline configuration. Wave pattern could induce erosion and sedimentation. The main objective of this study to model the wave refraction effects on shoreline change. Polarised TOPSAR data and ERS-1 data are used for this purpose ERS-1 data are taken in 8 th August 1993 and polarised TOPSAR data was taken in 6 th December 1996. For this purpose, 2-DFFT was applied with selective window size of 100 x 100 pixels and lines to present wave spectra refraction patterns. The simulation of quasi-linear model was used to model the rate of shoreline change. The vectors of shoreline were used to compare with wave spectra model in order to exam the accuracy of coastal erosion model. The results show that the wave refraction pattern modeled from TOPSAR data have a good correlation with the quasi-linear model compare to one extracted from ERS-1 data. The dominated feature from TOPSAR data and ERS-1 is the wave spectra tend to converge along the Sultan Mahmud Airport, which means erosion event. The shoreline rate modeled from vectors data of TOPSAR data and ERS-1 have a good correlation with a quasi-linear model. In addition, L-band polarised data were more sensitive to detect shoreline change compare to C-band. In conclusion, wave refraction patterns are good index for shoreline erosion. The integration between polarised SAR data consider as a good tools for investigation of wave effects on shoreline change.

NUMERICAL MODEL OF WAVE SPECTRA REFRACTION BY TOPSAR POLARISED DATA

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ABSTRACT

This paper presents work done utilizing TOPSAR data to detect wave refraction patterns along Terengganu coastline. TOPSAR data was used to extract information on wave spectra. This wave spectra wave used to model the wave refraction patterns. For this purpose, 2-DFFT was applied with a selective window size of 100 x 100 pixels and lines to present wave spectra refraction pattern. The quasi-linear model was used to model the real wave spectra into TOPSAR wave spectra. A composite image of wave spectra summation was used to detect the wave refraction pattern. The gamma filter was then applied to detect the area of wave convergence and wave divergences. The density spectra for the convergence and divergence waves were used to model the energy spectra along the wave orthogonal.

The results show that L-band is more suitable for detecting wave spectra refraction pattern compare to C-band. The maximum convergence spectra energy is found near to the Sultan Mohamed Airport. The wave spectra model had a good correlation with L-HH polarised band compare to L-HV band and C-VV band. This means that the L-HH polarised band are suitable to detect the wave refraction pattern.

It can be concluded that wave refraction pattern could be detected by polarised data. The polarised data of L-band has a more potentials for monitoring wave spectra refraction pattern.

MONITORING BLUEFIN TUNA HABITS WITH THE HELP OF SATELLITE ENVIRONMENTAL DATA: ERS EXPERIENCE WAITING FOR ENVISAT.

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ABSTRACT

Many studies have provided evidence of a deep correlation between several parameters (notably climate, physical and chemical conditions of the marine environment and food-chain processes) and tuna fishes spatial distribution and displacements.

Some theories suggest that tunas follow the warm water fluxes in search of food. Actually, even though the upwelling (deep water rich in minerals and nutrients rising to the surface) takes place in cold waters, secondary production organisms (zooplankton and micronekton) which feed tunas are pushed from the cold waters where they are generated to the warm pools.

Objective of European Community project "Study of Eastern Atlantic and Mediterranean bluefin tuna migrations using Pop-off satellite tags" (Fair CT97-3975) is to get more precise information about bluefin tunas migration patterns and spawning areas, in order to supply ICCAT (International Commission for the Conservation of Atlantic Tunas) with detailed stock assessment information and EC with tools for a better management of resources.

On one side, tunas are tagged and their route is followed thanks to tags transmitted signals received from the ARGOS satellite system. On the other side, the analysis of oceanographic data (Ocean Colour and Sea Surface Temperature) in the tunas crossed areas gives some hints at correlation between environmental parameters and fish behaviour.

In order to monitor environmental parameters ATSR, AVHRR data (SST) and SeaWiFS level-2 geophysical data (in particular chlorophyll concentration) have been chosen. The criteria for data acquisition have been changed during the project together with those for working out other planned activities. Many unforeseen problems have troubled the first project phase, giving hints at new research procedures.

TOPOGRAPHIC MAPPING OF THE GERMAN TIDAL FLAT AREAS USING ERS-SAR IMAGES

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ABSTRACT

The tidal flats of the Wadden Sea along the coast of northwest Germany are highly dynamic areas whose topography changes on timescales from a few hours (storm events) up to several months (sediment ablations and disposal). Conventionally generated maps based on echo sounding and geodetic leveling techniques often do not represent the actual situation because it takes several years to map the complete Wadden Sea. With the help of remote sensing data, especially ERS-SAR images, it is possible to achieve a more frequent updating of the topographic maps of tidal areas between high and low water level using the 'waterline method'. For this purpose waterlines in ERS-SAR images acquired at different tidal levels are extracted. After geocoding the SAR images, each point of the extracted waterlines is assigned to a water level provided by a water level model to represent the height of the sea bottom. The operational model of the German Maritime and Hydrographic Agency (BSH) calculates currents and water levels based on forecasts of wind and air pressure above the North Sea. The heights of the points along each waterline form a random grid of topographic points with a wide spacing when the gradient of the sea bottom is flat and a narrow spacing when the gradient is steep. A digital elevation model is derived from this irregular grid by triangulation and interpolation using the software package TASH (Topographisches Auswertesystem der Universitaet Hanover) which is based on the Delaunay triangulation method. The results of the 'waterline method' are evaluated by comparing the interpolated topography to data aquired by echo sounding and geodetic data and can be included in conventionally derived maps.

CLEAN SEAS: A NORTH SEA TEST SITE

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ABSTRACT

Over three years, the Clean Seas project team focused on the problem of monitoring marine pollution and the role that existing earth observing satellites might play. Here we present some results from the North Sea test site, examined in detail during a two-year acquisition campaign. We have examined synergy within the data from radar, optical and infrared sensors, in conjunction with hydrodynamic models. The North Sea test site is a region where river discharges can be seen from satellite imagery to have an influence on the local sea conditions. The Rhine discharge into the continental coastal waters can be clearly seen in satellite imagery. These waters remain as a distinct water mass around the west and north coasts of the Netherlands, continuing east to Denmark. We chose to look at sediment dispersal patterns from the Rhine discharge, as an indicator of the types of pollution that the Clean Seas approach of combined remote sensing and modelling might tackle well. We present results from two test periods, August 1997 and May 1998, during which several interesting hydrodynamic and turbidity patterns were observed in SST, colour and SAR images. AVHRR data were used for model boundary conditions, whilst the higher accuracy ATSR data were used for validation of the model results. Sediment distribution patterns from the model were verified using "chlorophyll concentration" data from MOS and SeaWiFS. In turbid coastal waters such as those along the Dutch coast, the chlorophyll algorithms are corrupted by high sediment loads and become indicators of suspended sediment. In conjunction with the visible channels of AVHRR and ATSR, they give an uncalibrated measure of the sediment load. During the test periods studied, there was good correlation between the data sources, e.g. between SST and ERS-2 SAR images for August 97. Both data sets showed the development of fine plume structures close to the Rhine outflow, apparently associated with the outflow, and possibly caused by tidal pulsing of the Rhine Plume. Although the model reproduced the general temperature and sediment distributions well, these fine structures were not reproduced. In the North Sea test site, we see the importance of using a model to alleviate the problems of remote sensed data in temperate coastal climates, where both cloud cover and wind speed act to restrict the amount of useful data. Future missions with coincident infrared, visible and active microwave data will improve the options for combining data. However, using the model we will still be able to see a more complete picture of the way the Rhine plume disperses over time than will be evident from the remote sensed data alone.

COASTAL CHANGES AND THE ROLE OF MANGROVE AND MORPHOLOGICAL FEATURES ON THE DYNAMICS AND PRODUCTIVITY OF THE NE-BRAZILIAN OCEANIC WATERS

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ABSTRACT

The coast of Pernambuco in Brazil is drained by several small rivers, all surrounded by mangroves. Due to the small load of continental sediments and characteristics of the area (wave regime, climate, topography, etc) this coast is vulnerable to erosional process. At the last few decades, erosional problem has largely increased, in part due to the lack of planning of coastal occupation and in part due to the construction of pier, sea walls, etc, by private initiative. This construction while aimed to resolve point-problem has caused disturbances in much larger areas. Analysis of SAR images have been proved useful for monitoring coastal dynamics and studies of sedimentation and erosion zones. ERS images, C-Band, VV Polarization in ascending orbits have been used. The SAR scenes correspond to ERS-1 (orbit 25240, 13 May 1996 and orbit 25469, 29 May 1996) and ERS-2 (orbit 05295, 25 April 1996 and orbit 05796, 30 May 1996). Also one RADARSAT image, C-Band, HH Polarization, of the NE-Brazilian coast has been used. It was taken on 8 September 1997 on a descending orbit. The beam mode was ScanSar Wide. The goals and results of the study have been related to the use of SAR ERS images to position morphological features, to trace coastline evolution and detect changes in mangrove coverage. Particular attention has been applied to: 1) Identify and map coastal features such as reefs in Recife and Olinda, sandbars, banks and marine structures as Suape Harbour, 2) Characterize mangrove vegetation as in the Itamaraca island. Finally the results have been compared with RADARSAT image.The work has been made in the framework of ERS AO3-137 project(C. Medeiros, PI, J. M.Benjamin,Co-I).

ON THE USE OF ERS INSAR DATA FOR CLASSIFICATION OF COASTAL COVER TYPES AND DETECTION OF FAST VARIATIONS OF WATER LEVEL

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ABSTRACT

The AO-3 project "Observation of Caspian coastal evolution caused by rise of the sea level" included the use of ERS INSAR data for classification cover types. Single-look complex data obtained in tandem mission on 2 May and 3 May 1996 were used to study a possibility of classification of coastal cover types and the detection of the coast modifications between the sessions. Combined pseudo-color images consisted of multitemporal images plus coherence maps have been generated and used to classify the coverage types and to study fast modifications of their state. Numerous types of surface coverage have been classified. Among them are open water surfaces of sea and internal reservoirs, water surfaces covered by vegetation, reed growth, meadows, fields, plowed lands, forests, flooded lands, urban zones, salt-marshes etc. A series of the fast variations such as appearance new plowed lands, modifications of soil moisture and modifications in reed growth drainage zone were detected.. The interferogram, representing the surface topography and surface dynamics have been generated. Analysis of combined pseudo-color images and interferogram results in new information. The level of islands borders and some shore borders covered by reed growth was displaced up to 15 cm within one day between observarions. We suppose that a reason is a drop of the scattering surfaces level followed by a fast drop of sea level. This may be results of siccus, occurred in Caspian sea at that time. We suppose that interferometry may be used to classify a density of coastal covers and detection of fast variations of water level.

OBSERVATION OF SEASONAL VARIATIONS OF THE NORTH CASPIAN COAST VEGETATION COVERS BASED ON ERS-2 SAR MULTITEMPORAL DATA RECEIVED IN 1999 YEAR

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ABSTRACT

This work has been carried out as a part of AO-3 project "Observation of Caspian coastal evolution caused by rise of the sea level" because the study of the evolution of this nature complex from year to year is not possible without a consideration of seasonal variations of the coastal vegetation covers. Analysis of the multitemporal (May, June, July) ERS-2 data on the area of interest has been carried out and dynamics maps of vegetation covers have been generated. Three coastal areas were researched - Kalmykia coast and Damchiksky and Obgeorovsky regions of Astrakhansky Biosphere Reserve. Seasonal dynamic differences allowed us to classify three zones on the maps of estuary parts, there are marine part of estuary covered by water vegetation, reed growth drainage zone and dry land that is an alluvial plain, cut by rivers arms and covered by meadows and fields. One more zone is detected in the Kalmykia coast, it is a zone of semi-desert vegetation. Dark spots in the images received in June pointed places of underwater vegetation which will appear only in July in the north of estuary, but in the south of one such vegetation (lotus etc.) appears in June on the water surface (sigma-naught is increased). The reed growth drainage zone has close values of sigma-naught on all these images because backscattering properties of reed growth are stable from May to July. The meadows vegetation on alluvial plain appeared in the May, and the sigma-naught increased in June and in July along the rivers arms but in the distance of the rivers sigma-naught of meadows and semi-desert vegetation decreased in July. Numerous agricultural lands have their original seasonal dynamics.Use of ERS SAR multitemporal data allowed to differ seasonal dynamics of the coastal vegetation covers.

ERS SAR IMAGING OVER THE BRAZIL-MALVINAS CONFLUENCE AND ARGENTINE COASTAL WATERS; ITS USEFULNESS FOR DIFFERENT OCEAN ACTIVITIES

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ABSTRACT

Argentina is one of the South American countries with a very long coastline, of approximately 4725-km, extending from the southern coast of the La Plata estuary down to Cape Horn. This coastline includes one peninsula and a considerable number of bays, gulfs, and straits. The dynamics of the water masses bordering these coasts consist of different littoral drift currents influenced by the flow of the La Plata River, other secondary river affluents and the Magallan strait. Further offshore, the Western South Atlantic Ocean is dominated by the encounter of the poleward-flowing Brazil Currents and the ecuatorward Malvinas (Falkland) Current. This encounter occurs near the entrance of the La Plata River estuary, roughly between 35° and 40° S and is referred to as the Brazil-Malvinas Confluence. Multiple meanders, eddies and filaments may appear in this area, resulting in an extensive mixing zone with SST gradients that can exceed 10° C over a distance of only a few kilometers. The argentine Comisión Nacional de Actividades Espaciales inaugurated its satellite receiving station in Falda del Carmen, Cordoba, in 1997. From then on, a large volume of data of the coast and the Western South Atlantic Ocean is being acquired. In this paper, a selection of ERS SAR images from this source and from two ESA Pilot Projects, are presented and discussed. They provide a variety of radar backscatter patterns over the Brazil-Malvinas confluence and argentine coastal waters. The sensibility of microwaves to a number of atmospherics and ocean phenomena are shown, among them: wind fronts, atmospheric gravity waves, rain cells, current boundaries, eddies and internal waves. Also, the capability of this type of information to reveal natural films, oil spills, ships and ship wakes and bathymetric features is shown. This set of images is a good example of the usefulness of this type of information for different activities in the region, such us: fishery, transport, petroleum and gas extraction, recreation, scientific, etc.

Domain: COASTAL ZONES

GOME OBSERVATIONS OF FORMALDEHYDE

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ABSTRACT

Formaldehyde indicates and supports photochemical activity in the atmosphere. Large amounts are expected to found in industrial areas and during biomass burning. HCHO is a major intermediate in the degradation of methane (and many other hydrocarbons). In the absence of heterogenous losses, essentially every methane is molecule is converted to HCHO. Therefore it is found throughout the troposphere. It is destroyed via photolysis and reaction with OH.

GOME is the first instrument that allows measurements of Formaldehyde on a global scale. This study presents the seasonal and regional variation since launch of ERS-2 in 1995.

During large biomass burning events in Indonesia, South Africa and South America vertical columns of up to 2*10exp16 molec/cm2 are found. Other regions with high excess of HCHO are the Southeast of the United States, Eastern Europe, Southeast Asia and India depending on the season. Possible sources and the influence on the tropospheric photochemistry and in particular on the ozone production will be discussed in this study.

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TROPOSAT: THE USE AND USABILITY OF SATELLITE DATA FOR TROPOSPHERIC RESEARCH

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ABSTRACT

While the measurement of stratospheric gases was the primary goal of the current satellite instruments, the newly-gained capability of observing tropospheric trace gas distributions (such as NO2, O3, SO2, HCHO, BrO, or water vapour) with space-borne sensors can truly be regarded as a revolutionary step in the technical development and will lead to a significant enhancement of our capability of investigating the chemistry and physics of the troposphere. To explore and encourage the use of satellite data for tropospheric research a new subproject, TROPOSAT, has been formed within EUROTRAC-2, the EUREKA project studying the transport and transformation of pollutants in the troposphere. The aim of TROPOSAT is to determine two- and three- dimensional distributions and time series of trace gases and other parameters in the troposphere and so facilitate future research and environmental monitoring on regional and global scales, in particular through:* the development of algorithms for the retrieval of tropospheric species and parameters; * the use of satellite data for understanding atmospheric processes; * the synergistic use of different instrumentation and platforms for tropospheric measurements; * the development of validation strategies for tropospheric satellite data products. In addition TROPOSAT will undertake other underpinning and derived activities such as the development of appropriate data assimilation techniques combining satellite measurements with modelling, and the specification of the requirements for future satellite instruments for tropospheric work. The poster describes the organisation and scientific work of the project and will present recent results on regional tropospheric distributions of NO2, BrO and SO2.

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SURFACE UV FLUX ESTIMATION FROM GOME: IMPACT OF CLOUDS AND WAVELENGTH DEPENDENT EFFECTIVE ALBEDO

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ABSTRACT

GOME satellite measurements deliver global top of the atmosphere sun normalized radiances in the spectral range of 240-790 nm with a spectral resolution of 0.2-0.4 nm. Using ozone and cloud information from spectral inversion, surface UV flux and actinic flux can be determined. Current UV satellite methods (e.g. TOMS derived UV-B irradiances) usually employ only one discrete wavelength assuming a constant effective albedo for the entire spectral UV range. The reflectivity at 360 or 380 nm is considered to be representative.

In this study an attempt is made to take into account the wavelength dependent UV surface albedo to derive the surface flux. For various surface properties as vegetation, soil or ocean, preliminary results of estimating a typical wavelength dependence are given. Relating the cloud effective albedo to cloud optical depth makes it possible to obtain an improved cloud transmission estimate as a function of wavelength. Preliminary results from the comparison with ground-based UV surface flux measurements will be presented.

TROPOSPHERIC OH PRIMARY PRODUCTION FROM ERS-2 DATA

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ABSTRACT

In order to calculate the OH production rate from satellite measurements, one has to estimate the following quantities:o Profile of the photodissociation rate of ozoneo Tropospheric ozone profileo Tropospheric water vapour profile. The estimation of tropospheric OH primary production rate from ERS-2 data is demonstrated. The tropospheric ozone profiles retrieved by RAL from GOME narrow-swath mode (40 km by 80 km) available via BADC were used. The tropospheric actinic flux profile and photodissociation rates of ozone are calculated from GOME and ATSR-2 measurements using the TUV radiation model with the DISORT radiative transfer code. For partially cloudy GOME ground pixels the photodissociation rates are approximated as a linear combination from the clear-sky and the fully cloudy cases according to an independent pixel approximation. Total ozone, ozone profile, NO2 column, spectral albedo at the top of the atmosphere (TOA), UTC date and time of pixel at the end of integration time, and ground pixel location coordinates are used in the TUV model from the GOME measurements. Thick cloud, thin cloud and cloud free fractions for GOME FOV and the thick and thin cloud top height are used from the ATSR-2 measurements processed by RAL and available via BADC. Additionally, the mean reflectance of ATSR-2 555 nm and 659 nm channels for thick cloud, thin cloud and cloud free are used to determine the cloud optical thickness using the radiative transfer model. Next, the fitting of simulated GOME albedo spectra at the TOA with the measured ones is performed. The effective wavelength dependent surface albedo for GOME pixel is determined, cloud optical thickness within the error bars is optimised and for cloud free GOME pixels the aerosol extinction is changed if needed to fit with the albedo at TOA measured by GOME. The water vapour content from the ATSR Microwave Sounder is used to estimate the tropospheric OH primary production rate. The estimates are made as well using the NOAA-14 RTOVS layer precipitable water for 3 layers between 1000 and 300 mb, and DMSP F14 SSM/T-2 water vapour mixing ratios at 15 levels from 1000 mb to 300 mb.

GOME DATA ANALYSIS AND GROUND-BASED IN THE MEDITERRANEAN AREA DURING ETNAVOLCANO ACTIVITY

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ABSTRACT

The ozone decline at mid-latitude can be explained by three different and concomitant mechanisms: - loss inside the arctic vortex and subsequent transport of low-level ozone air masses to mid latitude - local process - chlorine activation on extra-vortices PSCs

A collaborative study is started with the aim to address the first two questions by means of analysis of satellite (GOME) data, integrated by ground-based (DOAS) and balloon measurements. Furthermore we are verifying the use of GOME data for measuring volcanic (and possibly anthropogenic) emission of SO2 in the Mediterranean area, in order to estimate climatic impact of volcanic emission and monitor potentially dangerous eruptive activity. The preliminary results are presented.

MEASUREMENTS OF LIGHTNING-PRODUCED NO2 BY GOME AND LIS

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ABSTRACT

The budget of the nitrogen oxide (NOX) production by lightning is difficult to establish because the dynamics of a thunderstorm disturb NOX-measurements from both in-situ and remote-sensing techniques. Also, the interpretation of the measurements is complicated by the in homogeneity of clouds and transport effects. Therefore, only a rough estimate of 2-20 TgN/a of global NOX-production by lightning is possible up to know. In this study, some examples of NO2-production in thunderstorms are analysed using NO2-measurements from the European satellite spectrometer Global Ozone Monitoring Experiment (GOME). Lightning data measured by the NASA-satellite project Lightning Imaging Sensor (LIS) are used to identify lightning events coinciding with GOME measurements.

Domain: ATMOSPHERE
UV Radiation, Trace Gases Other Than Ozone

A NEW RADIATIVE TRANSFER MODEL FOR A SPHERICAL PLANETARY ATMOSPHERE

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ABSTRACT

A new radiative transfer model suitable to calculate the radiation field in a spherical planetary atmosphere has been developed. The developed approach involves the Picard iterative approximation to solve the radiative transfer equation in its integral form. The radiation field calculated by solving of the differential radiative transfer equation in a pseudo-spherical atmosphere is used as initial guess for the iterative scheme. This approach has on the one hand the same advantages and is on the other hand much more computationally efficient as compared to the Monte-Carlo method. The developed radiative transfer model has been verified using a Monte-Carlo radiative transfer model. The relative difference between the radiance at top of atmosphere calculated by both models has a typical value of less than 1.

PRECISION ESTIMATES FOR TRACE GAS PROFILE RETRIEVALS FROM SCIAMACHY LIMB MEASUREMENTS

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ABSTRACT

The limb measurements of SCIAMACHY provide a unique opportunity to retrieve stratospheric concentration profiles for atmospheric trace constituents. For a strong absorber like O3 profile information can be derived for the free troposphere and the lower mesosphere.

The precisions of the anticipated profile retrievals are studied using a fully spherical radiative transfer model, which computes weighting functions for the trace gas profiles quasi-analytically. This model is combined with an instrument model incorporating realistic signal/noise and field-of-view integration of SCIAMACHY to produce retrieval variances according to the optimal estimation formalism by Rodgers.

Thus the precisions of retrieved profiles of O3, NO2, ClO, BrO, SO2 and OClO in several measurement scenarios, i.e., mid-latitude, polar and ozone-hole polar, are estimated. These estimates describe the theoretical limits for the SCIAMACHY limb data products. The influences of other potential error sources like data processing uncertainties have to be investigated after launch.

By comparison of SCIAMACHY's retrieval precisions to those of other instruments aboard Envisat overlaps can be identified which enable a validation of both instruments by a cross-comparison of their retrieval results.

RETRIEVING SPECTRAL REFLECTIVITIES FROM EXTRACTED GOME INSTRUMENT HEADER DATA

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ABSTRACT

The Extracted GOME Instrument header (EGOI) data, which are available near-real time and contain parts of the UV-Vis spectra, are used in the retrieval of ozone columns and profiles. This work is done in the framework of the ESA-DUP project GOFAP.

The level 0-1 algorithms used are based on the GOME Data Processor (GDP) algorithms of DLR, but there are several differences. The corrections for straylight and polarisation sensitivity differ from the GDP algorithms in order to account for the limited spectral information in the EGOI data (only nine small spectral windows are available).

Detailed validation studies have resulted in several improvements in the level 0 to 1 algorithms. These comprise the wavelength calibration, correction of Peltier cooler interference, correction for polarisation sensitivity and correction of the effective reflectivity degradation. This paper gives an overview of the level 0-1 processor.

RING EFFECT STUDIES FOR A CLOUDY ATMOSPHERE USING GOME DATA

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ABSTRACT

Filling-in of spectral features observed in scattered sunlight lead to what is known as the "Ring Effect". The Ring Effect can have significant consequences for the retrieval of atmospheric constituents if not adequately corrected. As clouds also have strong impacts on the radiative transfer in the UV/visible spectral range, possible changes of the Ring Effect due to clouds have to be considered. Such investigations require radiative transfer modelling including both cloud and Ring features. This is provided by the radiative transfer model SCIATRAN, developed at the Institute of Environmental Physics/Remote Sensing (IUP/IFE), University of Bremen. UV/visible measurements from GOME and also ground-based measurements, both taken under cloudy conditions, have been used to validate model spectra, adequately calculated with SCIATRAN by including Ring and cloud modelling. A number of different cloud scenarios have been taken to simulate measured radiances in both ground and satellite geometry. Retrievals of NO2 from these spectra have been investigated using the differential optical absorption spectroscopy technique. Resulting errors using different Ring spectra in the retrieval have been derived. Results of the validation and the model study will be presented, which are used to clearly explain the sources of variable filling-in of Fraunhofer and absorption structures in the presence of clouds.

DEGRADATION OF UV EARTH RADIANCE OBSERVATIONS BY GOME

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ABSTRACT

Degradation of optical components in space is a problem affecting many remote sensing intruments. The degradation of the Global Ozone Monitoring Experiment (GOME) is monitored in-flight by observing either the sun or, occasionally, the moon. The solar measurements are acquired daily and therefore best allow to monitor the degradation of GOME. The light backscattered by the Earth's atmosphere follows however a different optical path through the spectrometer than solar irradiance. Because of the absence of a reference source for Earth radiances, the effect of the instrument degradation on the accuracy of Earth albedo is difficult to determine. In this paper we will show how the accuracy of Earth albedo measurements can be determined by identifying a range of Earth radiance targets suitable for monitoring degradation in the UV. The choice criteria, and their uncertainties, will be determined by means of a doubly adding radiative transfer code. These targets, with identical solar illumination and similar ozone columns, will yield information year after year on the degradation of the instrument along the Earth radiance path. Moreover, this information can be directly compared with the degradation observed for Moon radiance measurements, which are acquired with a different angle of the scan mirror but otherwise follow the same optical path in the instrument. In addition, the GOME instrument is polarization sensitive: the measurement of the degree of polarization of the incoming light is necessary for the radiometric calibration of earth radiance, but not for solar irradiances, which are not polarized. It follows that the sun is not a viable calibration target for degradation phenomena which might affect polarization measurements.Zonal averages of the Earth radiances measures by the Polarization Measuring Devices will also yield additional information on the way that Earth albeod measurements are affected.

QUALITY ASSESSMENT FOR GOME/ERS-2 LEVEL 1 AND LEVEL 2 PRODUCTS

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ABSTRACT

The ERS-2 Satellite Payload includes the Global Ozone Monitoring Experiment (GOME) designed to measure a range of atmospheric trace constituents with particular emphasis on global ozone distribution. Good data quality assessment (QA) is essential for the scientific acceptance of the GOME data products. This paper presents the QA system used during the operational processing of GOME data. A set of QA indicators of key GOME Level 1 and Level 2 parameters has been carefully selected. The Level 1 indicators are based on instrument performance and physical constraints like mean values of science data, ratios of PMD and science channel readouts, start and end wavelength of each channel and ratios of GOME sun spectra compared to a reference spectrum. The Level 2 indicators show climatological constraints in the form of ozone and NO2 vertical columns histograms for each orbit with their corresponding errors and monthly climatologies for ozone and NO2. The QA indicators as well as statistics on the viewing mode of GOME and quicklooks showing the ground-track for each orbit are stored in a QA database. The QA database is accessed through a QA tool implemented as a Java applet that runs on standard browsers. The QA tool can plot time series of QA indicators, showing possible limit violations, and it has several additional features like for example the possibility to select a specific product using orbit number, acquisition time or geographical coordinates. The routinely GOME QA processing runs automatically. Human intervention is limited to checking of the QA indicators and flagging of the products with low quality. Such an automatic QA system is especially important during the reprocessing period where up to 200 orbits can be processed per day. The GOME QA system demonstrated to be very useful for finding and for the detailed investigation of "anomalies" not only with the data products, but also with the GOME sensor itself.

A PARAMETRISATION OF THE EARTHSHINE POLARISATION IN THE UV

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ABSTRACT

Since many satellite remote sensing instruments (e.g. GOME, SCIAMACHY, OSIRIS) are sensitive to polarisation, we may expect to improve the quality of calibrated earthshine radiances through theoretical knowledge of the behaviour of the Stokes vector of atmospheric radiation. In particular, earthshine spectra show strong variation of their polarisation characteristics in the wavelength range of 290-340 nm, which is used for both ozone column and profile retrieval (ozone Huggins band).

We have constructed a database of calculated earthshine spectra for a variety of viewing angles, solar angles and surface albedos. The first three Stokes parameters I, Q and U for part of the UV (290-350 nm, at 0.2 nm intervals) were calculated using a plane-parallel polarised radiative transfer code developed at the KNMI (DAK, using the doubling-adding algorithm of de Haan et al. 1987). Only ozone absorption and molecular Rayleigh scattering for a set of standard atmospheres were considered. Surface reflectance was assumed Lambertian in nature. This database allows us to construct spectra for large ground pixels (40 x 320 km2) as observed by e.g. GOME, by interpolation to and addition of subpixel spectra.

We show applications of this database, in particular the improvement of the polarisation correction for GOME radiances. For example, the largest wavelength for which the polarisation may be determined from single Rayleigh scattering theory (around 300 nm) can be parametrised in solar zenith angle. A combination of similar parametrisations of the polarisation in the Huggins absorption band leads to significant improvement of the calibrated GOME radiances.

SCIAMACHY OPTICAL PERFORMANCE CHARACTERISTICS

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ABSTRACT

The Scanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY) is a contribution to the ENVISAT-1 satellite, which will be launched in mid 2001. The SCIAMACHY instrument is designed to measure sunlight transmitted, reflected and scattered by the Earth's atmosphere or surface simultaneously from the UV to the NIR spectral region (240 - 2380 nm) in various viewing geometries, namely nadir, limb, and both solar and lunar occulation.

From these measurements atmospheric concentration distributions of O3, NO, NO2, NO3, BrO, OClO, SO2, H2CO, H2O, CO, CO2, N2O, and CH4 will be deduced globally. SCIAMACHY is the only instrument on ENVISAT, which is able to detect the concentrations of O3, NO2, BrO, SO2, H2CO, H2O, CO, CO2, N2O, and CH4 down the boundary layer or the cloud top.

The accuracy of the envisaged data products depends on a) the instrument performance and characterisation, b) the algorithms used for inversion of the data (data processing), c) the validation of the data products. Instrument performance is now well characterised and the calibrated instrument was delivered to ESA-ENVISAT in early 2000. The development of scientific and operational algorithms is progressing. The SCIAMACHY validation campaign embedded in the ENVISAT validation campaign is also under preparation.

In this contribution the as-build status of the optical performance of SCIAMACHY is presented and compared with the required performance.

Special emphasis will be placed on performance aspects relevant for data processing and validation.

Domain: ATMOSPHERE
Calibration, Radiative Transfer, Assimilation

CLOUD PROPERTIES DERIVED FROM ATSR-2 AND AEROSOL OPTICAL THICKNESSES DERIVED FROM GOME IN CO-LOCATED CLOUD-FREE SCENES

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ABSTRACT

A scheme to derive cloud-top height, reflectance and coverage has been developed at the Rutherford Appleton Laboratory. The scheme was developed specifically to characterise cloud in pixels used for height-resolved ozone retrieval from the ERS-2 GOME instrument and to identify cloud-free GOME pixels unambiguously for retrieval of aerosol. The scheme operates by (a) co-locating the GOME and ATSR-2 fields-of-view (FOV); (b) classifying (from visible channel reflectance ratios) all ATSR-2 pixels within each GOME pixel according to surface/cloud type; and (c) generating histograms of occurrence of each ATSR-2 pixel type vs infra-red brightness tempertature, visible-channel reflectance and parallax-height (derived by stereo-matching forward and nadir ATSR-2 views). Infra-red brightness temperature is related to cloud height by reference to the nearest temperature profile from the appropriate UKMO analysis. Cloud and surface parameters representative of the GOME pixel are derived from the histograms: e.g. total, "thick" and "thin" cloud fractions; mean and standard deviation of cloud reflectance, mean and standard deviation cloud height (from both temperature and parallax approaches). The scheme has been applied in parallel with the GOME ozone profile algorithm (see parallel paper) to a significant sub-set of the GOME/ATSR-2 data-set and the derived information is available via the British Atmospheric Data Centre (http://www.badc.rl.ac.uk)

A scheme to retrieve tropospheric aerosol from GOME measurements in the O2 A-band (near 760nm) has also been developed and applied to pixels identified as "cloud-free" by the above ATSR-2 scheme. Aerosol optical thicknesses retrieved from the A-band have been compared systematically with those obtained for the same pixels by a completely independent method developed by IMGA which uses GOME measurements in the visible and near-IR. Potential for further development of the A-band scheme will be discussed.

DETECTION OF CLOUD COVER FRACTIONS BY GOME POLARISATION MEASUREMENT DEVICES AND VALIDATION BY SURFACE OBSERVATIONS AND METEOSAT DATA

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ABSTRACT

Photodissociation rates of species in the atmosphere are strongly influenced by the presence of clouds. In order to determine the actinic flux and photodissociation rates from GOME measurements, the knowledge of cloud characteristics is of crucial importance. GOME Level-2 data contain cloud fractions from the Initial Cloud Fitting Algorithm (ICFA). The ICFA gives effective cloud fractions for cloud optical thickness of 20. Additionally, errors are introduced by using monthly mean cloud top heights from the ISCCP climatology. It is shown that the errors on surface photodissociation rates calculated using the ICFA cloud fraction of up to 20 are introduced due to unknown cloud optical thickness. Other methods for determining the cloud fraction have been developed using data from the broadband Polarisation Measurement Detectors (PMDs). This allows the estimation of cloud optical thickness and top height from the oxygen A-band (CRAG algorithm), which are important for actinic flux profile estimation. The aim of this work is to validate a method that produces cloud cover fractions from GOME PMD data. By using the PMDs of GOME we divide the wide swath (320x40 km) seen by the spectral detectors into smaller parts (20x40 km) at the cost of a lower spectral resolution. The PMD detected albedo of the earth can be used to distinguish between cloud and surface if the reflectance of the surface remains constant. A lookup table for each 0.5x0.5 degree grid box was generated by processing all PMD data for one month and storing the minimum and maximum value of each of the three PMD devices which represent a cloud free and a completely clouded situation respectively. All values in between are interpolated linearly to a fractional cloud cover. All GOME pixels over the Netherlands are selected for the test month and the cloud fraction per PMD sub-pixel is calculated. Observations from surface weather stations, collocated within the PMD sub-pixel, are compared with the calculated cloud fractions. Results of the comparison show that the PMD cloud algorithm has difficulty representing small cloud fractions correctly and has a wide range of solutions for higher cloud fractional covers.

PMD CLOUD DETECTION SCHEMES FOR GOME: COMPARISON WITH ATSR-2 DATA AND ICFA DATA REGARDING THE IMPACT ON GOME OZONE VCD

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ABSTRACT

In order to determine the ozone and other trace gase amounts more accurately, it is clear that column densities achieved by DOAS fitting have to be corrected for cloudy and partially cloudy scenes. Therefore, cloud parameters are needed. At present, the fractional cloud coverage is only retrieved in GDP (GOME Data Processor) by ICFA (Initial Cloud Fitting Algorithm). ICFA extracts information about clouds from GOME measurements both outside and within the O2 A-band. In the project CRAG (Cloud Retrieval Algorithm for GOME) a two-step procedure based on the PMDs and the GOME measurements of the O2 A-band, has been introduced. Since there have been two PMD algorithm available, we present a comparison of both in this paper.

Both PMD algorithm retrieve the fractional cloud coverage. One of these schemes is based on a threshold technique, the other on "cloud-free composite" technique. Since both algorithms work on a heuristic base, their results have to be verified with respect to the existing cloud retrieval algorithm for GOME, ICFA (Initial Cloud Fitting Algorithm), and to the cloud recognition results of other sensors. Therefore, a comparison of ICFA results will be presented. Furthermore, the impact on GOME ozone vertical column densities (VCD) by all cloud detection schemes, ICFA and both PMD algorithms, will be compared. Therefore, a computation of a broad set of orbits covering data from 1995 until 1997 has been performed.

In addition, a comparison with results of several ATSR-2 (Along Track Scattering Radiometer) swathes for the computation of the fractional cloud coverage will be shown. Finally, a discussion of both PMD algorithm will be presented including also operational aspects.

DISCRIMINATION BETWEEN WATER AND ICE CLOUDS USING NEAR-IR AVIRIS MEASUREMENTS

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ABSTRACT

Around 1.6 micron, the spectral shape of the absorption bands of water and ice is different: the water absorption spectrum exhibits a local minimum whereas for ice there is a negative gradient. This difference is exploited to develop a water/ice-cloud discrimination algorithm for top-of-atmosphere reflectivities. The algorithm is based on radiative transfer modelling using the doubling-adding method to describe multiple scattering. The single scattering properties of cloud particles are calculated by means of Mie theory for water droplets and ray-tracing techniques for imperfect hexagonal ice crystals. The central theme of this paper is the testing of the algorithm using airborne spectral radiance measurements made over clouds. The algorithm has been developed for the analysis of measurements to be made by SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY). This spectrometer has been designed to measure radiances in the ultraviolet, visible and near-infrared wavelength regions (240-2380 nm) at moderate spectral resolution (0.2-1.5 nm). It will be flown on ENVISAT, which is planned to be launched in 2001. In order to test the concept described above, measurements made by NASA's Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) are used. The relatively low spectral resolution of AVIRIS (10 nm) is still sufficient for detecting spectral structures related to differences in water/ice absorption around 1.6 micron. Three cloudy AVIRIS flight lines are used for the analysis of the algorithm. The flight lines contain measurements made over different types of water and ice clouds over ocean. Several clusters of AVIRIS spectra acquired over these clouds are analysed with respect to their 1.6 ?m spectral gradient. On the basis of this analysis the water/ice-cloud discrimination algorithm is examined in detail and conclusions are drawn with respect to the applicability of the algorithm to future SCIAMACHY measurements.

RETRIEVAL OF CLOUD PROPERTIES FROM OXYGEN A-BAND SPECTRA MEASURED BY THE GLOBAL OZONE MONITORING EXPERIMENT

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ABSTRACT

With the launch of the Global Ozone Monitoring Experiment (GOME), a UV-VIS spectrometer operating on board the ERS-2 satellite since April1995, the first global space-based measurements of the oxygen A-band (758-775 nm) have become available at a moderately high spectral resolution of 0.35 nm. These spectra offer a unique possibility to derive cloud properties, because the depth of the oxygen A-band is sensitive to cloud top pressure, whereas the reflectivity at continuum wavelengths is sensitive to cloud fraction and cloud optical thickness. Therefore, we developed a fast retrieval method, called FRESCO (Fast Retrieval Scheme for Clouds using the Oxygen A-band), to derive simultaneously cloud fraction and cloud top pressure. The FRESCO algorithm makes use of radiances measured in three narrow wavelength intervals inside and outside the oxygen A-band, namely at 758 nm (no absorption), 761 nm (strong absorption), and 765 nm (moderate absorption). The cloud properties derived using FRESCO are used as input for near-real-time ozone column retrievals from GOME, but are also important to study cloud properties on the global scale. Global monthly average FRESCO cloud fractions and cloud top pressures have been compared to ISCCP-D2 data, showing good overall agreement both for cloud fraction (0.01 average difference, 0.10 standard deviation) and cloud top pressure (35 hPa average difference, 105 hPa standard deviation). In addition, a detailed validation of FRESCO using collocated ATSR-2 data has been performed. To this end, a cloud detection algorithm is used to separate clear and cloudy pixels inATSR-2 images. The brightness temperatures of the cloudy pixels as measured by ATSR-2 are related to cloud top pressures using ECMWF profiles. Generally, the results from GOME and ATSR-2 agree well. The average difference in cloud fraction is 0.05, with a standard deviation of 0.09. The average difference in cloud top pressure is 65 hPa, with a standard deviation of 91 hPa. The comparison of FRESCO cloud properties to those of ISCCP-D2 and ATSR-2 indicates that problems with FRESCO occur mainly due to absorption within the cloud and uncertainties in the surface albedo. We will make suggestions about possible improvements to our FRESCO retrieval algorithm.

Domain: ATMOSPHERE
Clouds/Aerosols

SOFTWARE FOR EXTRACTION OF GOME DATA FROM LEVEL-2 TO -3 FOR TOTAL COLUMN OZONE AND OTHER PARAMETERS

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ABSTRACT

The Global Ozone Monitoring Experiment (GOME) has been launched on board the second European Remote Sensing Satellite (ERS-2) designed to measure a range of atmospheric trace constituents with particular emphasis on global ozone distribution. GOME is a spectrometer which measures the solar radiation scattered from the Earth's atmosphere and reflected by the Earth's surface in nadir viewing geometry in the wavelength range of 240 - 790 nm with a spectral resolution of 0.2 - 0.4 nm. For a 960 km swath width GOME achieves global coverage in three days. Global Total Column Ozone maps are provided in near real time shows actual situation of Stratospheric Ozone layer. It is difficult to ascertain the actual total column ozone values for different locations from these maps as they are based on color code. GOME level 1 to 2 software is provided for extraction of GOME Level-2 data in ASCII readable format from Level-2 binary data .In this paper, Level 2-to-3 Processing software is developed for obtaining actual concentration of total column ozone and other trace gases in numerical format. This software has different module for extraction of information and for each forward scan pixel, latitude, longitude and corresponding total column of ozone, vertical column density, DOAS slant column of ozone and other trace gases and also cloud top pressure and surface pressure, etc.

GOME FAST DELIVERY AND VALUE-ADDED PRODUCTS (GOFAP)

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ABSTRACT

In the framework of the ESA Data User Porgram a Fast Delivery processor has been developed to provide GOME ozone products within 3 hours after observation. This service meets the growing demand for ozone products for purposes like assimilation in numerical weather prediction models, radiation forecasts, and planning of experiments related to atmospheric chemistry research.

By making maximum use of the existing ERS ground segment and European Internet links the retrieval of ozone products can be performed within 3 hours after observation from the Extracted GOME Instrument Header (EGOI) Data. This data contains parts of the ultra violet spectrum applicable for the retrieval of ozone columns and stratospheric ozone profiles. The EGOI data is calibrated and processed to a level 1b product.

For the total ozone column retrieval a very fast processor has been developed. The retrieval technique is based on the Differential Optical Absorption Spectroscopy (DOAS).

Data assimilation software has been incorporated in the automatic GOME fast-delivery processing to provide global maps of ozone. In the data assimilation a transport model (TM3) and wind fields provided by ECMWF describe the atmospheric flow of ozone.

An existing off-line profile retrieval algorithm has been adapted to produce reliable stratospheric ozone profiles within the strict time constraint with a spatial resolution sufficient for numerical weather predictions.

The processed level 1 data is also used for the computation of additional NRT products like cloud and aerosol information. The cloud fraction and cloud top pressure are calculated with the FRESCO algorithm. The aerosol absorption index is computed to have an indication for areas with heavy aerosol pollution.

The near-real time processor and the presently delivered ozone products will be presented. Details of the work can be found in dedicated poster presentations.

INTERCOMPARISON OF GOME OZONE PROFILES

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ABSTRACT

A number of groups have started producing ozone profiles from the ERS-2 GOME radiance data. At the request of the GOME Science Advisory Group, this group was formed to compare the results from the different ozone profile algorithms. The intercomparison will be done in three phases:

1) Level 1 Radiance adjustment

The first area will be GOME calibration and how each group adjusts (or not) the GOME radiances. There are known wavelength dependent errors in the Band 1a calibration, there is a calibration offset between Band 1 and Band 2, there are probably other errors as well. The details how each group adjusts the level 1 radiances, all bands, before running their ozone profile algorithm will be presented.

2) Synthetic Data Retrieval

Synthetic spectra willl be generated over the GOME wavelength interval. The spectra with the appropriate meta-data will be distributed to the participating groups. The retrieved profiles will be compared will be compared with the input ozone profiles.

3) Validation with NDSC ozone profile data

The ozone profiles over NDSC sites will be compared with NDSC ozone lidar and ozonesonde profiles.

FAST AND ACCURATE OZONE PROFILE RETRIEVAL FOR GOME-2 USING 4-STREAM LIDORT

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ABSTRACT

The retrieval of vertical profile information of ozone from nadir viewing UV/VIS sensors, such as GOME and GOME-2, requires the calculation of radiances for any given ozone profile as well as the derivatives of the radiance to the ozone at specific atmospheric layers (weighting functions). The LIDORT scheme solves for both quantities by utilizing the well-known discrete-ordinates method expanded by a scheme to calculate the derivatives in a computationally economical manner. In view of the requirements on the speed of the ozone profile retrieval algorithm resulting from the high data rate of the instruments, a fast version of LIDORT has been developed: LIDIRT4A. The number of streams has been limited to four thereby allowing analytic solutions to replace certain numerical steps in the LIDORT scheme. Only the sparse linear system that has to be solved to fix the boundary conditions still requires a numerical module. The low number of streams results in a small degradation in accuracy (about 0.5). However, this is still acceptable in view of the uncertainties inherent to the calibration of the instruments. This will be shown by comparing profile retrievals using LIDORT4A and LIDORT with sufficient streams for different atmospheric and viewing conditions. Apart from its use for the NRT retrieval for GOME, the algorithm development is part of the preparations for the NRT GOME-2 processing within the EUMETSAT Ozone SAF project.

GOME SATELLITE DETECTION OF OZONE VERTICAL COLUMN OVER A SNOW/ICE COVERED SURFACE IN THE PRESENCE OF BROKEN CLOUDS

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ABSTRACT

In the presence of broken clouds over snow or ice covered surfaces it is quite difficult to distinguish between clouds and surfaces.

A new approach has been developed, which treats the cloud as a Lambertian surface and characterizes the inhomogeneous pixel area (with broken clouds) by deriving an effective albedo and cloud-top-height. These parameters are determined by minimizing the difference between GOME measured sun-normalized radiances and corresponding model spectra in the spectral range of O_4 absorption near 370 nm. Extrapolation of the effective albedo to short wavelengths enables to improve the ozone vertical column retrieval in the 315-335 nm range.

It will be shown that this method can clearly distinguish between clouds and snow-covered (bright) surfaces, which improves the accuracy of the retrieved ozone column.

SCIENCE OBJECTIVES OF EOS-CHEM'S OZONE MONITORING INSTRUMENT (OMI)

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ABSTRACT

The Ozone Monitoring Instrument (OMI) will fly on NASA's satellite EOS-CHEM, which will be launched in December 2002. The EOS-CHEM satellite is focussed on atmospheric chemistry and climate issues. The main science objectives of the EOS-CHEM mission are: (1) Is the ozone layer recovering as expected? (2) What are the sources of tropospheric pollutants, their chemical transformation and their transport? (3) What are the roles of upper-tropospheric water vapor, aerosols and ozone in climate change? The EOS-CHEM satellite consists of 4 instruments, which are the Microwave Limb Sounder (MLS), the High Resolution Dynamics Limb Sounder (HIRDLS), the Tropospheric Emission Spectrometer (TES), which is a nadir and limb sounder, and OMI.

OMI is a UV/VIS nadir solar backscatter spectrograph, which reaches global coverage in one day with a 13 x 24km^2 footprint. OMI is derived from the European satellite instruments GOME and SCIAMACHY. OMI is capable of measuring (ir) radiances of the sun and earth in the wavelength range of 270 to 500 nm, from which ozone column and profile, NO2, SO2 and BrO as well as aerosols, cloud coverage and cloud top pressure can be derived. OClO and HCHO are in principle also possible data products of OMI.

OMI's unique capability in measuring column amounts of ozone, NO2 etc. with a small footprint and daily global coverage will enable EOS-CHEM to monitor tropospheric pollution on a regional scale. The design and capability of OMI will be explained. The contribution of OMI to answer the above mentioned science questions and the resulting science requirements of the instrument will be discussed.

VALIDATION OF OZONE PROFILE RETRIEVAL AT KNMI

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ABSTRACT

At the KNMI ozone profiles are retrieved from GOME observations using the optimal estimation method. A-priori ozone profiles and temperature profiles are taken from climatologies. The radiative transfer is modelled using the MODTRAN code which includes the multiple scattering based on DISORT. Prior to the retrieval a correction is applied to the level 1 product to account for the wavelength calibration and the degradation of the sun-normalized radiance.

Ozone profiles have been retrieved from GOME overpass observations at De Bilt (Netherlands) and Paramaribo (Surinam). These sites represent urban mid-latitude and rural tropical situations. These overpass data are compiled for the period 1996 up to 2000. These results are compared with local ground measurements of ozone profiles and with total ozone measurements at these locations.

ON THE VARIABILITY OF TOTAL COLUMN OZONE DERIVED FROM ERS-2 GOME AND TOMS

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ABSTRACT

ERS-2-GOME has been successfully operating in space since April 1995 in a near polar orbit. Total column ozone has been derived since then on an operational basis almost continuously.

Temporal and spatial variability of the total column ozone is analysed over a wide range of scales covering smaller scale structures such as streamers, medium scale structures such as planetary waves and interannual variations. For the long-term studies also TOMS total ozone data is taken into account.

In recent years it became evident that the distribution of ozone is also characterised by small-scale structures. Examples are the so-called streamers, finger-like structures of ozone-low air masses reaching out from tropical latitudes towards northern latitudes. They turned out to be highly variable on time scales of a few days. For the longer-term studies the total ozone column is used as a dynamical tracer, supplying information on the dynamical activity of the atmosphere and its development.

Different spectral schemes such as Kalman Filter, Harmonic and Wavelet analysis based methods are used as well as sequential data assimilation techniques such as advection and wind driven 3D chemical transport modeling. Aimed is to get the maximum information content by a combination of measurement and model at best.

Results, model result intercomparisons and comparisons to climatologies will be presented. The benefit of the utilization of ENVISAT data will be addressed.

EXPECTATIONS FOR GOME-2 ON THE METOP SATELLITES

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ABSTRACT

The first Global Ozone Monitoring Experiment (GOME) was launched in April 1995 on ERS-2. The objective was to measure the global distribution of ozone and other trace gases; an objective which has been achieved.

GOME has demonstrated its capability to measure total column ozone, ozone profile, nitrogen dioxide, sulphur dioxide, formaldehyde and halogen oxides. Furthermore, cloud parameters and aerosol properties have also been successfully retrieved. Both KNMI and DLR provide total column ozone data in near real time.

Building on the success of GOME, GOME-2 has been selected to fly as part of the payload of the first three METOP satellites, thereby ensuring operational monitoring of Ozone for a fifteen-year period.

GOME-2 has a number of improvements over GOME, including improved calibration capabilities by addition of a new on-board white light source, and better characterisation of the Polarisation State of incoming radiation from new polarisation measuring devices.

The expectations for GOME-2, its role as an operational instrument will be discussed.

Domain: ATMOSPHERE
Ozone Total Column, Profiles

POSTERS

Note: Posters are grouped by Application Domain for easy retrieval. They are in display in the exhibition area all week during the Symposium.

ERS GEOREFERENCING PRECISION

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ABSTRACT

Remote sensing applications are increasingly dependent upon the integration of image data sets from different sources and sensors. This integration can only be achieved if a coordinate system common to all data sets can be defined to an adequate accuracy. Historically SAR data sets have been georeferenced through the identification of ground control points. In this paper we discuss the practical limits on the accuracy with which SAR data can be automatically georeferenced from analysis of orbit and timing data, and present experimental results both from a series of ERS acquistions over well surveyed corner reflectors and from comparison of digital road vector map datasets with automatically geocoded SAR products.

AUTOMATED TIEPOINT RETRIEVAL THROUGH HETEROMORPHIC IMAGE SIMULATION FOR SPACEBORNE SAR SENSORS

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ABSTRACT

The nominal radar geometry available from header information accompanying a satellite radar image is often accurate enough to generate an image simulation based on topographic information. given that an accurate DEM is available.

In mountainous regions, the importance of taking the topological inequivalence of radar and map geometries into account cannot be overemphasized. Without such consideration, foreshortened areas and especially layover are rendered improperly, and necessary correlation to the true radar acquisition is lost. Simulation algorithms need to account for the lack of homomorphism (also known as heteromorphism) between radar and map geometries.

The image simulation product may be used for radiometric normalization, enabling multi-mode image comparison, but it is also useful as a component in an automated terrain-geocoding system. In mountainous regions, topography alone determines the distribution of backscatter in the radar image, and one can even neglect thematic land-cover considerations in a first approximation. More refined models integrate land cover information into the simulation process as well.

Correlation of image simulations to real radar imagery can be used to refine the nominal geometry accompanying the radar image. The correlation acts as a source of hundreds or thousands of ground control points, which are used to adjust the orbit information and or the range and Doppler parameters.

RADARSAT and ERS imagery acquired over Switzerland are used to illustrate automated tiepoint retrieval over a range of incidence angles, image resolutions, and DEM spacings. Significant run-time improvements are documented through the use of context-sensitive digital elevation model oversampling.
Keywords: tiepoint, refinement, DEM, geocoding, simulation, calibration

GEOMORPHOLOGICAL AND GEOLOGICAL VALIDATION OF DIGITAL TERRAIN MODELS PROCESSED FROM SPATIAL IMAGERY. APPLICATIONS IN THE PYRENNEES (S FRANCE) AND E SÉNÉGAL (W AFRICA)

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ABSTRACT

Within the following association ISR-THOMSON-SYSECA, CEGN, and Marne-la-Vallée University, we analysed and compared differents Digital Terrain Models (below DTMs) acquired from spatial images (SPOT-P, SAR-ERS1/2, radarsat) using the existing techniques (optical and radar stereo techniques and interferometry). Our aim is herein to compare the different resulting DTMs in order to select those highlighting topographic, geological and geomophological characteristics and minimizing artefacts on the same areas. Two different applications had been selected corresponding to different geological, geomorphological, climatological and topographical environments. The first studied area corresponds to a peneplain lying below a low dipping monocline cuesta, 100m high, situated close to the political boundary between western Mali and eastern Sénégal (W Africa). The flat lowlands corresponds to metamorphic rocks (anchizone to green shists facies) intruded by different leucogranites, covered by locally thick lateritic and alterite formations. The southwestern cuesta is composed of slightly folded and faulted sandstones. The second studied area presents a contrasting relief and correponds to the northern Pyrenees (southern France) within a temperate climate showing three different test sites: 1 corresponding to a proximal alluvial fan in the almost flat foreland basin composed of alluvial conglomerate low dipping deposits (Lannemezan cone); the second one corresponds to siliciclastic deposits folded and faulted, of the pyrenean foothills close to the Boussens oil field ; the last one corresponds to the axial Pyrenean range (NE of the Pic du midi de Bigorre) where metamorphic rocks occur. Despite some low frequency and easily avoidable atmospheric artefacts, the DTMs extracted from interferograms techniques are of as high quality than the SPOT-P stereo technique especially in the flat lowland and the plateau. In the hilly area, DTMs extracted from SPOT stereo techniques are of better quality than interferometric ones. On the same areas, the radarsat (R3, R5, R7 and combinations) extracted DTM are generally of low and raw quality. To conclude, the geomorphological, geological characteristics are useful to establish the coherent parameters to test DTMs qualities. This study highlights the strategic importance to produce high quality DTMs from space imagery all over onshore areas.

DTM PRODUCTION BY FUSION OF MIXED SAR AND OPTICAL IMAGE DATA

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ABSTRACT

This paper presents a methodology for the fusion of image-based three-dimensional data in order to generate Digital Terrain Models (DTMs). For example, interferometric, radargrammetric or photogrammetric data may all be involved in this process. However, the proposed methodology also allows any kind of three-dimensional data to be processed, including existing DTMs or ground control points (GCPs). In this paper, we deal with three-dimensional data coming from images of different origins : optical images provided by SPOT, SAR images provided by ERS and RADARSAT. The fusion algorithm is derived as an inverse problem using a Bayesian framework. The purpose of such a fusion process is to obtain a comdined DTM which is more reliable than the individual components (a stereoscopic DTM or a radargrammetric DTM or an interferometric DTM) in terms of both accuracy and density of reliable data. In addition, we focus on the evaluation of the quality of the DTM produced, using two approaches: a quantitative one based on statistics, and a qualitative one based on visual analysis using geomorphological criteria.

USING THE LANDMAP BRITISH ISLES 1" IFSAR DEM FOR HYDROLOGICAL NETWORK DERIVATION.

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ABSTRACT

A Digital Elevation Model of the British Isles has been produced at 1"(~30m) pixel spacing by the Landmap project. This DEM has been created from multiple passes of ascending and descending tandem ERS Synthetic Aperture Radar data using commercially available software from Phoenix Systems. A quality assessment is shown for several areas of the IfSAR DEM when compared against DTED-1 (100m resolution, courtesy of MCE Feltham, UK) and the Institute of Hydrology's hydrological DTM (IHDTM), a 50m DTM derived from contours and water features from Ordnance Survey 1:50,000 maps. One of the many uses of such a high resolution DEM is for overland flow hydrological modelling. This type of modelling requires an accumulation (stream) network, which represents the overland flow paths of water across the land surface. Accumulation networks can be easily derived from suitable DEMs by several methods. The suitability of a DEM for this purpose is denoted by its coverage (areal extent), resolution, relative vertical accuracy, roughness and the presence of artifacts such as sinks or pits. IfSAR DEMs are inherently noisy due to the nature of the radar data used in their production. This vertical noise needs to be smoothed out in order to fill sinks and allow proper routing of the derived networks. Several methods, such as median filtering, are available for this task and will be discussed here. Any smoothing will also change the vertical accuracy of the DEM and an assessment is made of the effect on accuracy of these smoothing methods. A second issue with IfSAR DEMs is that of low coherence areas which can leave large holes in the DEM. The combination of ascending and descending pass ERS data minimises this effect as well as any atmospheric effects but some mountainous areas will retain holes. Small holes can be interpolated over and larger holes can be substituted with a lower resolution DEM(s). The effectiveness of these techniques with respect to generating fully connected accumulation networks is shown by comparing derived networks against cartographically available networks. An assessment is also made of the potential value of such IfSAR-DEMs for global high resolution hydrological network extraction, particularly in the light of the NASA SRTM mission and the global coverage of the ERS tandem mission.

EVALUATION OF METHODS USED IN ASSESSING THE ACCURACY OF INSAR DERIVED DEMS

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ABSTRACT

Interferometric SAR has been widely used as a source of data for construction of Digital Elevation Models (DEMs) especially since the operation of ERS-2 (launched in July 1995) in tandem wit ERS-1. In most publications describing the accuracy of such DEM, is a single figure, the Root Mean Square (RMS) error, irrespective of the extent and terrain characteristics of the study area. System characteristics are also important factors to be considered in reporting the achievable accuracy of InSAR DEM. Some reports mention the system parameters and the terrain characteristics, but the spatial distribution of the error with respect to any influencing factor, such as coherence and terrain slope, were not reported. Understanding the spatial distribution of the elevation error is important in assessing the quality of InSAR DEMs in order to avoid any misrepresentation of the potentials and limitations of the technique.

In this study, different methods of reporting the RMS error are attempted and assessed. RMS error for a regular grid gives an idea of different accuracy level one would achieve if different image sizes or different test site location for same image size were chosen for the study. Since it is critical to understand the factors influencing the height error, the spatial distribution of error is analysed to determine its correlation with terrain slope and spatial coherence of the interferometric data. A stratified RMS approach is used to evaluate the spatial relationship of the height error with slope and coherence. Surprisingly, neither the slope-stratification nor coherence-stratification shows any relation with the spatial distribution of the height error.

InSAR DEMs were derived from datasets with three different baselines. The individual DEMs and multi-baseline DEMs derived from simple additive method and baseline weighted method were analysed for their height accuracy using proposed evaluation methods, such as regular-grid-RMS error method and stratified-RMS error method. The multi-baseline DEMs revealed that the major contribution to error was due to the phase noise and uncertainties in the orbital position of the platform.

THE LANDMAP PROJECT FOR THE AUTOMATED CREATION AND VALIDATION OF MULTI-RESOLUTION ORTHORECTIFIED SATELLITE IMAGE PRODUCTS AND A 1" DEM OF THE BRITISH ISLES FROM ERS TANDEM SAR INTERFEROMETRY

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ABSTRACT

A Digital Elevation Model (DEM) of the British Isles at 1" (~30m) and a set of orthorectified satellite image data products (from 0.3" to 1") were created by the LANDMAP project over a year starting in June 1999 using a multi-processor Solaris machine with some 0.5TB of on-line disk-space. The unique DEM has been created from multiple passes of ascending and descending tandem ERS Synthetic Aperture Radar data using commercially available software from Phoenix Systems Ltd. and GIS software developed to maximise ERS-tandem strip coverage. The 1" DEM was validated using (i) kinematic GPS profiles around the British Isles and (ii) airborne laser scanning altimetry kindly provided by the Environment Agency (N. Holden) and NRSC Limited (N. Veck) both of which have up to an order of magnitude higher vertical accuracy. Dead reckoning was used with precise PRCs together with the CEOS GLOBE 30" global DEM to provide very accurate DEMs for individual strip without the use of any Ground Control Points (see Smith et al., this proceedings). These strips were then checked for planimetric error using automated DEM-to-DEM matching and then block adjusted to minimise sidelap/across-track errors. A consensus algorithm was developed to minimise artefacts due to atmospheric effects, phase noise errors and phase unwrapping errors. The resultant 1" DEM was then used to orthorectify all the IfSAR products (amplitudes and phase coherence) and these were then mosaiced into seamless image map products. Automated feature extraction operators were employed to register SPOT, LANDSAT-5 and LANDSAT-7 images to the orthorectified phase coherence. The resultant orthorectified images were then mosaiced into a final image map product. The resultant LANDMAP data products (including all data produced at individual stages) are available to anyone in the British academic community at no license fee cost for any purpose related to teaching, learning and/or research. The software developed for the LANDMAP project is also being made freely available (at Manchester University / MIMAS) to anyone in the UK academic community who is interested in mapping large areas using this approach. The LANDMAP approach heralds a new age for remote sensing research whereby geocoded and orthorectified image maps can be produced for anywhere on the planet WITHOUT the need for any Ground Control Point acquisition.

ENVISAT RA-2: POTENTIAL FOR LAND TOPOGRAPHIC MAPPING

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ABSTRACT

The ERS-1 and ERS-2 missions have generated a huge database of returns from the earth's land surfaces. The inclusion of an ice mode has allowed, for the first time, detailed height information to be obtained over much of the complex topography overflown by these missions. However, the inability of the altimeter to maintain lock over extreme terrain has constrained to some extent the scope of land surface mapping, and, critically, has prevented assessment of the quality of existing ground truth datasets in these regions. This paper presents a global analysis of the performance of ERS-1 and ERS-2 altimeters (in both ice and ocean mode) for land height determination, with a detailed analysis of the extent of good coverage, and investigation of those areas where only intermittent data are currently obtained. The distributions of complex echo types are also presented, and the role of an expert system in identifying and optimising these echoes is discussed. This analysis is then extended to assess the potential contribution of the ENVISAT RA-2 to topographic mapping, highlighting those areas (for example at high northern latitudes not overflown by the Shuttle Topographic Mission) where significant enhancement of existing data is anticipated. It is also foreseen that a very valuable contribution will be made in the assessment and correction of spatially correlated errors in the current generation of Global Digital Elevation Models (GDEMs). This is especially true of those mountainous parts of the world where assessment is not currently viable with altimeter derived heights, but where analysis of adjoining regions has raised grave doubts about the validity of the GDEM data. The potential augmentation of current altimeter height datasets over extreme terrain is also assessed in the context of assessment and correction of detailed DEMs, such as those obtained from InSAR techniques.

TOPOGRAPHY

SMALL AND MESO-SCALE FEATURES OF THE MARINE ATMOSPHERIC BOUNDARY LAYER ETECTED BY SATELLITE MICROWAVE SENSORS

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ABSTRACT

Microwave sensors such as scatterometer and SAR have been used to investigate the spatial characteristics of the winds offshore and along coast, in selected areas of the Mediterranean Sea. The paper will show the results concerning the Adriatic Sea bora wind, an orographic northeasterly wind particularly strong in winter and spring. Scatterometer wind fields provide a clear evidence of the spatial modulation produced by the Balkans Alps on the flow, with important consequences on the structure of the atmospheric Ekman pumping. SAR provides instead a detailed map of the variability of this wind close to coast, as well as of its small scale structure (wind rolls and transversal modulation). The latter has been investigated using both spectral methods and applying new techniques as the conditional sampling and the continuous wavelet analysis. The spatial information obtained by using the satellite data are combined with those yielded by the analysis of the wind time series collected offshore during bora events. The result is an exhaustive description of the main characteristics of this regional wind, from the mesoscale down to the microscale. The example described above stresses the importance of using data from different sensors in the study of the marine atmospheric boundary layer.

DEPTH ESTIMATION OF INTERNAL WAVES IN SOUTH CHINA SEA FROM SAR IMAGERY

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ABSTRACT

Imagery from ERS-1/2 and Radarsat SAR had been studied to estimating the depth of internal waves in South China Sea. It is assumed that the observed groups of internal wave packets in SAR imagery were generated by local semidiurnal tides. The mean distance between the leading crest of two successive wave packets was used to derive the group velocity of the internal waves. The depth of internal waves was then calculated from a two-layer finite depth internal wave model, by assuming the group velocity measured from the SAR images was equal to that calculated from dynamics. Results show reasonably good agreement with in situ measurements.

Keywords: Internal wave, SAR, Two-layer model.

MULTI-YEAR ERS OBSERVATIONS OF OCEAN CIRCULATION FEATURES ALONG THE COAST OF NORTHERN NORWAY

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ABSTRACT

The coast of Northern Norway from Troms to Trøndelag is nearly parallel to the descending tracks of the ERS satellites, thus enabling acquisitions of 7-8 image frames over the continental shelf. Given the high latitude location this can be done at relatively short intervals, enabling frequent observations of the dynamic coastal environment.

The Norwegian Defence research Establishment has acquired images along these paths since the early part of the ERS-1 mission. The primary applications for these images have in the past been oil spill and vessel detection.

The observations have, however, revealed many interesting features of both oceanographic and meteorological origin. Here we present a summary of the observations, and comment on signatures and observability of various features throughout the various seasons of the year.

INTERNAL WAVES IN THE ANDAMAN SEA, NEW RESULTS FROM ERS SAR AND OTHER SENSORS

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ABSTRACT

Daily sequential ERS-1/2 Tandem mission SAR scenes (ordered via project AO3-177) indicate the existence of fronts and internal waves in 1km water depth within the south Andaman Sea. From ECMWF winds, a local cyclone storm leads to a significant stirring of the water column and to the setup up of regionally contrasting stratification regimes. The implication is that the storm induces both horizontal and vertical Ekman currents. Such currents may be strong enough to modulate the tide-topographic interaction and initiate the development of a transcritical resonant flow regime leading to the generation of internal waves.

In situ observations in deep water show that anomalous IW amplitudes occurred during a spring tide regime and by possible link to remote equatorial forced downwelling Kelvin waves that may act to change the large scale stratification within the generation region. It may also be linked to anomalous current fluctuations between the Andaman Sea and Indian ocean associated with propagating mesoscale features. To investigate this hypothesis, ECMWF winds are analysed with Topex-Poseidon SSH and ATSR SST data to infer generation environmental conditions for observed times of internal waves seen in SAR images. An important consequence of this work is that it highlights the special role that SAR image data have for synoptic understanding of the environment of internal wave generation and evolution through different depth and stratification regimes. Internal waves have wide ranging influence on underwater communications, mixing and transport of energy and their associated current shear can affect commercial offshore engineering structures.

MANIFESTATIONS OF SEA CURRENTS AND EDDIES IN ERS-SAR IMAGES OF THE BERING STRAIT

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ABSTRACT

This work presents the results of analysis of the ERS-SAR images of the Bering Strait which are at our disposal in frame of ESA grant AO3-451. An analysis of ERS-SAR data of the Bering Strait, obtained in June - September 1995, and in July - August 1998 has allowed to observe many important ocean processes. Such as: meandering fronts and eddy activity (well pronounced in the eastern part of the Strait), strong jet-like current at the Prince Wales Cape (on 2 August, 1998), intrusions of the cold Chukchi Sea water (extensions of the Siberian Coastal Current) in the western part of the Strait. According to these images one may conclude that typical for the Bering Strait north current predominated in the whole Strait on 11th July 1995, while on 31 August 1995 there were some evidences (bright bands) of the rather wide southward stream between the Peek Cape and Diomede Islands. The flow direction in the central part of the Bering Strait can be revealed from the wake-like features mentioned above. Especially impressive is a chain of vortexes (Karman vortex street) north from the Rock. The structure and evolution of the Karman streets and other features visible in the SAR images around these obstacles can be used for monitoring of the currents flowing round the islands and the Rock.Specific arc-like features north of the Strait seem to be manifestations of the bottom relief irregularities produced by sea currents, although reliable distinguishing between signatures of the relief and eddies requires further investigations including concurrent sub-satellite observations in the Strait. This research was supported by Russian Foundation for Basic Research, Grant 98-05-64489.

IDENTIFICATION AND CLASSIFICATION OF MESOSCALE OCEAN FEATURES ON ERS SAR IMAGERY

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ABSTRACT

Since 1997 Russian Institute of Fisheries and Oceanography performs regular collection of ERS-1/2 SAR data over Norwegian and Okhotsk seas regions of the most active fishery in Russia. The goal of this activity is to explore the possibility of identification of frontal regions and current shears (meanders, eddies, upwelling) from space. The data collection is complex, i.e. in addition to SAR data various data allowing to facilitate SAR imagery interpretation were collected. The most important of them are 1-km and 4-km NOAA AVHRR SST data, altimetry data on sea surface dynamic topography, satellite wind speed data from DMSP SSM/I and all accessible in situ data on SST, salinity and dynamic topography. About 40 standard ERS scenes acquired in various weather conditions were analyzed. All images are subdivided into regions where some specific structures of either oceanic or atmospheric origin are identified, described and measured. The available information from other satellites and research vessels is involved into SAR features description. It turned on that during the summer regular monitoring less than in half cases in Norwegian sea (7 days of 17) the wind conditions were favorable for our signatures of interest identification, and only in 3 cases they were ideal. On the other hand, the easy for interpretation thermal images are mostly useless due to very often cloudiness in that region. The similar situation takes place in the sea of Okhotsk. Therefore the problem of statistics collection and formalization of features identification is quite actual. The observed specific radar features form the electronic catalog which will be updated regularly using new SAR image acquisitions.

MULTISENSOR OBSERVATIONS OF INTERNAL WAVES AND THEIR EFFECTS IN THE BAY OF BISCAY

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ABSTRACT

Observations of internal solitary waves (IWs) with ERS SAR and other satellite sensors in the Central Bay of Biscay are presented and discussed. The existence of the IWs as locally large features here, about 140 km from the nearest shelf break topography, was predicted and studied with in situ ADCP measurements by New and Pingree (1990, 1992). Here we will present a series of ERS SAR observations from 1993 until 2000 which extend southwards from the shelf-break region in the Northern Bay of Biscay into the central Bay. An initial study of some of these images has been undertaken by New and da Silva (2000). These observations provide conclusive evidence that the internal waves in the central Bay are generated locally where the beam of internal tidal energy reaches the ocean surface, after generation at the shelf break and reflection from the sea-floor. The SAR observations are matched and compared with SeaWiFS and AVHRR image data. These show the well known surface cooling effect at the Armorican and Celtic shelf edge which results from mixing originated by the IW activity. Corresponding phytoplankton blooms are also observed on SeaWiFS images. Mixing originated by the large-amplitude IWs in the central Bay has also been predicted to occur by New and Pingree (2000). In this paper we characterise the signatures of these IWs in the central Bay of Biscay, and seek evidence of their mixing effects, such as decreased surface temperature and increased phytoplankton abundance, using satellite multisensors (radar, ocean colour and thermal sensors). The radar signatures are characterised according to our knowledge of the IW in-water characteristics and of the sea-surface microlayer.

SEA FEATURES

CHANGES IN SEA LEVEL, SEA SURFACE TEMPERATURE AND SEA SURFACE PRESSURE FROM SATELLITES - THE IMPACT OF ERS AND ENVISAT

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ABSTRACT

In studies of Global Change, sea surface temperature data may provide valuable information. Global sea surface temperature data may indicate changes in the heat budget of the oceans. Seven years of sea surface temperature data and sea level height for the same period is analysed. Altimetry from the TOPEX/POSEIDON and ERS satellites will be used along pressure observations and sea surface temperature data from the ATSR 1 and 2 sensor onboard the ERS satellites and AVHRR data from the NOAA satellites. Due to the inclination of the TOPEX/POSEIDON orbit only 93 percent of the worlds oceans are covered by altimetry. With the ERS satellites 98 percent of the worlds oceans are covered. The impact of this increased coverage in particular the Arctic ocean is addressed. The changes in the sea level are compared with changes in sea surface temperature to decide whether the changes in sea level are related to changes in the heat content of the ocean. Spatial and temporal correlation between the signals are investigated, and a bivariate coherency analysis of the sea level together with the sea surface temperature is carried out at different spatial scales.

ATSR MAPS CORAL BLEACHING ON AUSTRALIA'S GREAT BARRIER REEF

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ABSTRACT

The Australian Great Barrier Reef (GBR) experienced its most intensive and extensive coral bleaching event on record in early 1998. This period also saw extensive damage to other reefs around the globe. There is concern among environmental scientists and GBR-based industries, especially tourism, that widespread death and bleaching of corals caused by extremely high temperatures during 1997-98 may occur more frequently on the GBR if global climate change unfolds as predicted during the coming decades. Currently NOAA/NESDIS are developing "coral bleaching hot-spot" maps based on AVHRR data, but coral bleaching temperature thresholds are highly sensitive depending on species and geographic location, and AVHRR absolute accuracies may not be adequate for this task. The sea surface temperatures provided by ATSR and AVHRR data are compared with in situ measurements from several buoys located on the GBR. Maps of coral-bleached areas are also compared with sea surface temperature maps obtained from the satellite data. Although the ATSR has limited coverage due to its narrow swath, the advantage of accessing global high spatial resolution data in reef and coastal areas may give a better means of monitoring the water temperature of reefs at risk of coral bleaching. The potential for ATSR to provide improved temperature maps over sections of the GBR is under investigation and progress and results will be reported in this paper. ATSR data have also been used to confirm that core samples taken from coral reefs can provide a long-term record of local water temperature.

THE RELATIONSHIP BETWEEN IN SITU AND SATELLITE SEA SURFACE TEMPERATURES IN THE SOUTHWESTERN ATLANTIC OCEAN

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ABSTRACT

Sea surface temperature (SST) data are used in this work to investigate the differences between in situ measurements and satellite estimations of SST in the Southwestern Atlantic Ocean. The in situ data were obtained between March 1993 and July 1994 from ships of opportunity and drifting buoys. High resolution satellite data were obtained from the AVHRR (Advanced Very High Resolution Radiometer) and ATSR (Along Track Scanning Radiometer) sensors for the same period and area of study. Match-ups between in situ and satellite SSTs were performed for a maximum period of ± 3 h from the image acquisition time. Temperature difference (deltaT) between the in situ and AVHRR data indicated that the NOAA algorithms overestimated the atmospheric attenuation occurring in the Southwestern Atlantic Ocean in the study period. 'deltaTs' were higher between buoy and AVHRR data than between ships of opportunity and AVHRR data. 'deltaT' between ships of opportunity and satellite are usually higher than 'deltaT' between drifting buoys and satellite data because ships generally provide less accurate SST data in relation to buoy data. However, drifting buoys have a natural tendency to concentrate in regions of thermal gradients. In the Brazil-Malvinas Confluence (BMC) zone the buoys are not able to sample SSTs across the front. However ship routes are not dependent on the distribution of the thermal fronts in the ocean so ships offer a more reliable way of sampling SST in this case. The spatial behaviour of the 'deltaTs' suggests that the higher values are related to the positions of the frontal systems. The very active nature of the advection processes occurring on very short timescales is a possible cause for the higher 'deltaT' values being encountered in the frontal regions. The drifting buoys that are used in validation programmes (especially the NOAA ones) have the tendency to concentrate in regions of strong thermal gradients at the sea surface so their temperature measurements are inevitably subject to colocation error with satellite data because of the frontal motion. This effect is strong in the western boundary currents and in regions of convergence.

SEA SURFACE TEMPERATURE

A MODEL-BASED LAND SURFACE TEMPERATURE RETRIEVAL ALGORITHM

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ABSTRACT

The general land cover are neither isothermal nor homogeneous which are necessary requirements of Planck's law and Kirchhoff's law, however, most of the current algorithms are based on the assumption of homogeneous and isothermal land cover to retrieve land surface temperature (LST), as a result, most of them are failed to consider the directionality of thermal emission. We have developed a new thermal model to describe the directional thermal emission of nonisothermal vegetation canopy, this model is capable of LST retrieval by model inversion. Instead of an effective averaged temperature, our model-based inversion algorithm can retrieve the component temperatures of the vegetation canopy which are important parameters across wide range of applications ranging from estimation of soil moisture to inversion of sensible and latent heat. Based on analyses using forward simulation and inversion, our method is shown to be stable in the presence of observation noise. Ground-based multiangular observation has been carried out in YuCheng Remote Sensing Experimental Station at ShanDong province of China in April, 1999. Important biophysical parameters were also measured in detail in this experiment. Comparisons between the measured and reconstructed directional brightness temperatures show that the maximum error is roughly equivalent to the uncertainty in the observations. The sensitivities of ATSR's two observation angles are also analyzed in detail to surface structure and component temperatures, the result will be very helpful in further application of ATSR thermal products. Our model and inversion algorithm can be easily extended to different types of vegetation canopies, further combined with other agricultural models will be able to predict the soil and plant moisture even the accurate yield.

accuracies are obtained for water vapor dependent algorithms than for that ones that include a quadratic dependence with (T2-T1) (**) if both methods are used under the best conditions, i.e., no errors on water vapor and emissivity.

In the validation process, in situ data for a grassland site in Australia covering the period from January to December 1999 have been used. ATSR-2 data have been exploited in order to apply the algorithms studied. After calculating LST's starting from these algorithms and comparing the values obtained with the in situ ones, values of total error of 1.2 K and 1.7 K were attained for the dual angle and split window methods respectively. This best behaviour of the bi-angular (or dual angle) algorithm corroborates the conclusion obtained in the theoretical study.

The algorithms permit, due to the similarities between ATSR-2 and AATSR sensors, preparation for exploitation of AATSR data on the ENVISAT platform.

* Sobrino, J.A., Li, Z-L., Stoll, M. P., and Becker, F. 1996, Multi-channel and multi-angle algorithms for estimating sea and land surface temperature with ATSR data. International Journal of Remote Sensing.** T2 and T1 are the brightness temperatures given by the sensor ATSR-2 at channels centered at 11 ?m and 12 ?m respectively.

SURFACE TEMPERATURE FROM ATSR-2 DATA: ALGORITHMS AND VALIDATION

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ABSTRACT

The retrieval of land and sea surface temperature (LST and SST respectively) using thermal infrared satellite data is of considerable importance for many applications such as oceanography, global climate studies, geology, hydrology, meteorology and vegetation monitoring. The radiance measurement given by the sensor must be corrected for: (1) the perturbation produced by the atmosphere and (2) the fact that the emissivity of the surface is less than one. The ATSR is a new generation instrument that incorporates improved technology over the AVHRR which makes it very suitable for surface temperature applications, and permits, for first time bi-angular observation. Sobrino et al. (1996) (*) proposed a single-channel double viewing angle method for deriving surface temperature from ATSR-1 thermal infrared measurements, and compared this method with the split window technique, arriving at the conclusion that the double angle method gives better results than the split window method when the emissivity is known.

The present work is focussed on the following purposes: firstly, to extend the studies to the ATSR-2 sensor to a series of algorithms to obtain SST and LST, and secondly, to compare different models for estimating surface temperature, evaluating the accuracy given by each one of them, and giving to the user the possibility of choosing the most appropriate method depending on the availability of input data (water vapor and emissivity values). Finally, a validation with in situ data of some of the methods studied has been included.

In order to reach these goals, a wide simulation data base has been built using the MODTRAN 3.5 (version 1.2) radiative transfer program. In this data base, a large gradient of temperatures between the near surface temperature and ground surface has been included. Furthermore, nine different emissivities (grass, dry grass, conifer trees, deciduous trees, sea, sand (2 types),and lime (2 types)) obtained from Salisbury spectral emissivity data base have been included. Consideration of the angular variation of emissivity is achieved using our field measurements. The types of surfaces chosen are representative of 9065731520f the earth's surface. Starting from this data base, the coefficients of the proposed correction algorithms (the theoretical ones and the statistical ones) have been calculated. A sensitivity study, including the effects of noise, and emissivity and water vapor content uncertainties, has been done.

The results of the comparison of the sensitivity of the different algorithms permit us to conclude that, for error free data, the dual angle methods give better accuracy than split-window ones. Split-window methods for nadir view give better results than for forward view, and finally, dual angle methods for 11 μm channel give lower deviation than the ones for 12 μm channel. The use of 3.7 μm channel data for night provides an important improvement of the accuracy in the estimation of surface temperatures. Moreover, when water vapor content dependence is included, better

COMPONENT TEMPERATURE RETRIEVAL FROM ATSR-2

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ABSTRACT

The reliability of Numerical Weather Predictions (NWP) is known to be severely dependent on the description of land surface hydrology. Current and especially future satellite sensors can provide a suite of observations useful to overcome this problem. In this contribution, we describe an ambitious project of which the objectives and approaches are: 1) Work towards the improvement of interactive land surface atmospheric models, such as used for climate modelling, via the implementation of improved land surface models in NWP models; 2). To develop improved methods for remote observation of land surface properties and processes, taking advantage of available airborne/space-borne sensors systems in view of the planned sensor systems in the IEOS (International Earth Observation System) era.

An important aspect herein is the development of algorithms using the Along Track Scanning Radiometer (ATSR) in preparation of AATSR-ENVISAT. ATSR allows to analyse the applicability of multi viewing satellite systems to land surface processes in order to improve the accuracy of NWP models and to investigate its' applicability to the future ENVISAT system. The potential of ATSR's directional observations in the thermal infrared region is a relatively new area of research. In this paper, the application and validation of an algorithm to retrieve component temperatures from ATSR observations is discussed. Separating component temperatures is important as it enables the application of advanced algorithms such as dual source models for land-atmosphere interactions (especially at the scale suitable for NWPs).

Several case studies are dealt with, comprising ATSR datasets and field data of selected regions with different landcovers. Directional measurements of surface temperature from ATSR are inverted to estimate vegetation and soil temperature of mixed (heterogeneous) targets. In addition, participation in a large field campaign in N-W China (Gobi) in June 2000 covering several ATSR-2 overpasses is planned for validation of the algorithm.

SYNERGISTIC USE OF ATSR-2 MULTISPECTRAL AND DUAL-ANGLE DATA FOR LAND SURFACE STUDIES

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ABSTRACT

The second Along-Track Scanning Radiometer (ATSR-2) onboard the European Remote Sensing satellite (ERS) is presently the only one available to provide quasi-simultaneous multispectral data from visible to thermal infrared bands at two view angles. In addition to three thermal infrared channels centered at 3.7 micron, 11 micron and 12 micron and one channel at 1.6 micron, ATSR-2 has three additional visible-near infrared channels centered at 0.56 micron, 0.67 micron and 0.87 micron intended for vegetation analysis. Such data represent an opportunity to explore the potential information on both spectral and directional observations, in view of the preparation of a new generation of multi-angle satellite sensors. Improvement of land surface processes are feasible through the use of the improved visible and near infrared atmospheric corrections and the separate retrievals of different component (soil and foliage) temperatures in a pixel which may be achieved in principle with ATSR-2 two angle views. In this study, we first intend to develop a method using all three visible and near infrared channel data at two-angle views to perform atmospheric corrections in those channels, which allows simultaneous retrieval of aerosol opacity and land surface bidirectional reflectance. Then, on the basis of the radiative transfer theory in a canopy, we develop a model to retrieve separately soil and vegetation temperatures from two-angle measurements using the five channels of ATSR-2 (three visible and near-infrared channels plus two thermal infrared channels at 11 micron, 12 micron). The three visible and near-infrared channels are used to determine the fraction cover of vegetation in a pixel with help of a modified atmospherically resistant vegetation index we proposed. While the two thermal infrared channels data are used to determine with split window the ground surface brightness temperatures at two view angles. Several case studies are undertaken with ATSR-2 data, the results indicate that (1) The simultaneous retrievals of aerosol opacity and land surface bidirectional reflectance are possible with acceptable uncertainty.. (2) The separate estimate of foliage and bare soil temperature from satellite data improves the quantifying and modeling of land surface processes, such as CO2 assimilation and sensible heat transfer. (3) The modified index we proposed takes into account the combined correction of the atmospheric effects and the optical properties of bare soils, and has considerable potential for characterizing sparse and moderately dense vegetation environments.

LAND SURFACE TEMPERATURE

SPATIAL AND TEMPORAL ERRORS IN ERS-2 RADIAL POSITIONING

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ABSTRACT

Precise orbit determination of ERS-2 has been undertaken using the FAUST multi-arc multi-satellite software and the AGM98 gravity field. Tracking data comprises satellite laser ranging (SLR), PRARE and single satellite crossovers. Results will be given for orbits utilising SLR and PRARE data illustrating the impact of PRARE on ERS-2 orbit determinations. Quality control has been undertaken through both the tracking residuals and through investigation of the temporal and spatial analysis of dual crossover (DXO) residuals with TOPEX/Poseidon. In particular, the rms SXO residuals will be seen to increase with solar activity. The geographical distribution of the radial error on ascending and descending passes and the geographically correlated and anti-correlated errors have been quantified through binning the DXO residuals. Spectral analysis of the DXO residuals in the Southern Ocean identifies deficiencies within a particular order of the gravity field. Temporal analysis of the DXO residuals reveals signatures in the differences between the centre of figures for ERS-2 and TOPEX/Poseidon altimetry. These effects are more marked as the solar activity increases from the minimum around 1996 towards the solar maximum. Additional temporally varying terms reveal variation in the time tag bias, the geophysical corrections and the altimeter bias. ERS-2 is well known to exhibit jumps in the altimetric range associated with the altimeter being placed in its stand-by mode and quantified through the single point target response. Analysis of the bias signatures will be presented from launch. Results show that the bias drift can lead to an aliasing of the sea-level change at the level of about 2 mm/yr over the first 45 cycles.

ORBIT CONTROL OF ERS-1, ERS-2 AND ENVISAT TO SUPPORT SAR INTERFEROMETRY

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ABSTRACT

For some types of SAR interferometry applications images of the same area should be obtained at two different times from practically identical orbits. An example of this is the images acquired over Izmit with ERS-2 1999/08/13 (before the earthquake) and 1999/09/17 (after the earthquake). The interferometric fringes that are obtained are then due to the deformations caused by the earthquake.

For other interferometric applications the SAR images should be made from different orbits with a sideway shift of typically 150 - 400 m. The interferometric fringes are then essentially due to the shift in view angle. The target for the ERS-1 &2 tandem mission that started with the launch of ERS-2 in the year 1995 and ended with the loss of ERS-1 in the year 2000 was to maintain an interferometric baseline of about 250 m between the ERS-1 and the ERS-2 acquisitions of a target area at consecutive days.

The considerable advantage of the Tandem Mission to obtain image pairs with the desired interferometric baseline was the short time difference of only one day between the acquisitions. The secular orbital perturbations due to air drag and luni/solar gravitation were therefore in first order affecting both orbits in the same way and the baseline that depends on the difference between the orbits could rather well be predicted in advance and quite accurately controlled. It would not be possible to obtain as good results between acquisitions made with a time difference of n*35 days (the repeat cycle of both ERS and ENVISAT is 35 days) because of the varying air-drag and the changing orientation of the orbit relative to the Sun-direction (in spite of that a Sun-synchronous orbit is used).

In this paper an account will be given of what has been achieved with the ERS-1 and 2 orbit control for SAR interferometry and what could be obtainable for the single spacecraft mission ENVISAT.

THE PERFORMANCE OF THE ERS-2 SYNTHETIC APERTURE RADAR

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ABSTRACT

The ERS-2 Synthetic Aperture Radar (SAR) mission has been in operation since April 1995. To ensure maximum use is made of the data produced by this instrument, it is necessary for quality assessment and both internal and external calibration to be performed on a regular basis. The parameters measured for these activities include the various impulse response function (IRF) parameters (such as spatial resolution), radiometric calibration constant, radiometric stability, image localisation and image noise estimates. The quality assessment measures and radiometric stability have been derived using the ESA SAR transponders deployed in Flevoland, The Netherlands and to a limited extent by using the IRF parameters of ERS ground stations. The transponders have also been used to derive an ERS-2 SAR calibration constant while the transponders and the ground stations have been used to assess image localisation. Internal calibration is assessed via calibration and replica pulse powers; monitoring of the calibration pulse power (the best guide to the transmitter pulse power) has shown a steady decrease of 0.63 dB per year. As the replica pulse power (used in the SAR processing) is also decreasing by the same amount, the impact on image calibration has been minimal. The only impact has been on the noise equivalent radar cross-section of the ERS-2 SAR images; this has been increasing from -26 dB at the start of the ERS-2 SAR mission by the same rate as the decrease in calibration and replica pulse powers. The paper will give details of the ERS-2 SAR performance based on the quantities discussed above and will compare these with those from the ERS-1 SAR which ceased operating in March 2000.

ASSESSMENT OF THE NEW ERS-2 MONO-GYRO PILOTING MODE ON THE QUALITY OF ERS SAR DATA AND ERS SAR APPLICATIONS PERFORMANCE

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ABSTRACT

ERS-1 and ERS-2 have been piloted with 3 gyros since the beginning of the ERS mission, showing extraordinary attitude stability around the orbit.

However, several problems that occurred with ERS-2 gyros since the beginning of the ERS-2 mission have motivated the development of a new on-board software to pilot ERS-2 with one unique gyro. This mono-gyro configuration should ensure the continuity of ERS-2 operations even in case of further gyro failures. The drawback of this new configuration was an expected degradation of the attitude stability.

A special validation campaign (7th - 23rd February 2000) took place for the installation and qualification of the new piloting mode. In particular, the impact of this new configuration on the quality of ERS-2 data and on ERS-2 applications had to be carefully assessed before taking the decision to leave ERS-2 operating in mono-gyro mode.

One of the most critical points was the impact of the loss of attitude stability on the SAR Doppler Centroid frequency, since larger and more rapidly varying Doppler Centroid values around the orbit were expected. Applications such as ERS interferometry could be affected if the new observed Doppler frequencies were considerably different from the ones observed for ERS-1 and ERS-2 since the beginning of the mission.

This paper presents the main SAR related activities carried out during the validation campaign and assesses impact of the new mono-gyro piloting mode on the quality of ERS-2 SAR data and on the ERS SAR applications performance, particularly on InSAR.

ERS AND ENVISAT ORBIT DETERMINATION AND PREDICTION AT ESOC

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ABSTRACT

For ten years now, the European Space Operations Centre (ESOC) in Darmstadt has been responsible for the operation of the highly successful ERS satellites. Determining, predicting and controlling the orbits of ERS-1, ERS-2 is one of the tasks of ESOC. The same will be required for Envisat, preparations for which have already been on-going for several years now.

The routine determination, prediction and control of the ERS orbits, with accuracies well inside the initial requirements, has been presented at previous occasions, but this is only one aspect of the work done at ESOC. The high-precision orbit determination of ERS-1 and later ERS-2 is another relatively routine activity.

Further ERS and Envisat orbit support required from ESOC ranges between totally different extremes. On the one hand, preparations are on-going for the high-precision absolute calibration of the Envisat RA-2 instrument, requiring short-arc laser orbit restitutions with sub-centimetre accuracy in the radial direction. Napeos, the newly developed orbit software at ESOC shall be able to provide this support. On the other hand, immediate support of the ERS-1 flight control team on the day of the satellite's demise, and the following days could be given, despite the drastic and unpredictable change in the orbit and the loss of all tracking data. A seamless transition was achieved and the satellite's orbit is still monitored using the same software.

The year 2000 marks a year of many transitions in the ERS and Envisat orbit determination system at ESOC. Napeos is being phased in and will replace the proven software used for ERS-1 and ERS-2. Most developments have been in this area, rather than in upgrades of the existing system. This paper will therefore concentrate mainly on the new system, briefly indicating its performance in routine orbit determination during the current solar maximum and precise orbit determination using SLR and Doris, but mainly concentrating on the two special topics of the orbit of ERS-1 in its final days, and the high-precision calibration of the Envisat RA-2 instrument.

FIVE YEARS OF ERS-2 LOW BIT RATE MISSION: ROUTINE CAL/VAL AND LONG LOOP SENSOR PERFORMANCE MONITORING

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ABSTRACT

In July 1991 the European Space Agency (ESA) launched the first European Remote Sensing Satellite (ERS-1), a forerunner of a new generation of satellites for environmental monitoring. Following five years of successful in orbit exploitation, a second satellite (ERS-2) was launched on April 21st, 1995 and it is still overflying our planet. ERS-2 is carrying the same payloads as ERS-1 plus a spectrometer instrument: the GOME.

The ERS-2 Low Bit Rate (LBR) Mission includes the Active Microwave Instrument (AMI) operated in wave and scatterometer mode, the Radar Altimeter (RA) instrument, the ATSR and one spectrometer instrument (GOME). This set of instruments enables the determination of geophysical and physical parameters such as the wind speed and direction, the wave height, length and direction, the distance between the satellite and the earth surface (sea, ice or land) and the presence of ozone and other trace gasses in the stratosphere.

The LBR data are processed at the ESA ground stations and the products are delivered within three hours from sensing to the major meteorological centers (via the Global Telecommunication System) and research institutes as well as to the Product Control Service in ESRIN.

To ensure the quality of these data, the Product Control Service (PCS) performs the long loop performance monitoring of the instruments since the beginning of the ERS mission. This activity includes several tasks such as the monitoring of the instruments calibration and instruments ageing, the monitoring of the processing stations and the quality control of the products.

The paper describes the results of this monitoring activity. In particular the major events that occurred during the ERS-2 mission (Flight and Ground segments), the calibration status of the ERS-2 instruments and the evolution of the key parameters affected by the ageing are reported. The quality of the products delivered is also analysed and discussed.

The conclusion summarises the lesson learnt during these five years of operations and addresses some guidelines for future missions (ENVISAT, METOP).

PERFORMANCE

ANALYSIS OF GEOPHYSICAL CORRECTIONS APPLIED TO ERS ALTIMETER DATA

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ABSTRACT

DUT/DEOS have developed the Radar Altimeter Database System (RADS) containing GEOSAT, TOPEX, and ERS altimeter data in a common format and with common and/or cross-calibrated measurements and geophysical corrections. Important geophysical corrections are due to ionospheric delay, wet tropospheric delay and ocean tides. This paper compares the application of two ionospheric models (Bent and IRI95) and several tide models (CSR3.0, CSR4.0, FES95.2, GOT99) and their application to ERS altimetry. Single and dual satellite crossover height differences serve as analysis tools.

Near the coasts it is not only the tidal correction that plays an important role. Also the wet tropospheric correction causes some complications. Whereas the value for water vapour measured directly by the microwave radiometer is more precise than the one based on global models, it is sparsely available due to contamination of the measurement by land in the radiometer footprint. We studied to possibility of extrapolating the radiometer measurements in a sensible way.

IDENTIFICATION AND CORRECTION OF CLOCK ASYMMETRY IN THE ERS-1 AND ERS-2 RADAR ALTIMETERS

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ABSTRACT

During the Commissioning Phase of ERS-2 many groups measuring the relative range between ERS-1 and ERS-2 noticed irregular step-like changes. The most obvious of these was a jump of 3-4 cm, observed on 1 August 1995;closer examination of the data revealed others.

These jumps in bias were traced to a known asymmetry in the mark-space ratio of the altimeters reference clock, which had been discovered prior to the launch of ERS-1. This asymmetry varies from cycle to cycle over groups of four cycles, then repeats. Although its magnitude was ameliorated by modifying the circuitry, the effect did remain but it was believed to be stable.

This timing error slightly increases the noise of the height measurement but also affects the actual delay of the signal used for internal calibration. Since the effect was supposed to be stable this was unimportant as it effectively became part of the range bias, calibrated during the Commissioning Phase.

The asymmetry had been originally discovered by using a special operation sequence in the instrument which can also be performed in orbit. This had been done regularly for each satellite since launch so it was possible to reconstruct the asymmetry pattern, the resulting change in the internal calibration reference and thus the associated shift in range.

The range jumps were found to be coincident with occasions when the instrument (on either satellite) had been switched off, although not all switch-offs had jumps. It became apparent, during the analysis of the one year of Tandem operations of the two satellites, that the probability of a jump was linked to the temperature to which the instrument dropped during the time it was switched off, with a threshold at about 2°C above which jumps were unlikely.

Following the ERS-2 Commissioning Phase a process was established at ESRIN to provide, on-line, a file containing the new value of range shift for each switch-off. Recently a significant improvement in the analysis technique has been developed and an operational processor embodying this is now in the testing phase. Validation of the correction against geophysical data should start in May 2000.

THE TIME TAG BIAS OF ERS ALTIMETER DATA

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ABSTRACT

The time stamping of measurements of ERS-1 and -2is performed by the on-board clock. This clock contains an oscillator with a fixed frequency that triggers a counter to be increased by one on every cycle of the oscillator. To correlate the clock count to UTC (Universal Time Coordinate) the clock count is compared to an accurate atomic clock at the Kiruna ground station in Sweden while the satellites are dumping their data. Errors in the time stamping may result from errors in this clock correlation or from unmonitored variations of the oscillator frequency around the orbit. The time tags attached to the altimeter measurements of ERS-1 and -2 are systematically early by over a millisecond. Apart from a mean offset, the timing error also exhibits an annual variation. Although this timing error was discovered already some years ago, an explanation was never found. It is shown that the timing error and its variation can be attributed to a combination of processing errors and instrumental deficiencies. The mean timing error of about 1 ms is likely to be due to different effects, among which the intrinsic bias of the timing system due to the low resolution of the satellite time used in the correlation process plays a major role. An around-the-orbit variation of the on-board clock frequency appears temperature induced and has a seasonal modulation.

BLACK SEA GEOID AND SEA SURFACE TOPOGRAPHY WITH THE ERS-1 ALTIMETER DATA

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ABSTRACT

Determination and research of the sea surface topography and geoid of the Black Sea and Azov Sea was carried out with the ERS-1 OPR data observed for period 1993-1996. The main purposes of this investigation was to bring the new information in the fields of Geology, Oceanography and Geodesy of the Black Sea region.487 tracks including 25168 measurements were selected primarily. Finally 462 edited tracks (23781 measurements) were used to calculate a detailed topography. Geoid heights decrease from the west to east from 36 to 12 meters. Average differences and standard deviations between altimeter and gravity OSU91 geoid are -1.32 m and 1.56 m accordingly. Topography of a differential geoid (after elimination of the spherical harmonics from altimeter geoid) shows a good information on the geological structures to study tectonic and geodynamic features of the region. Hydrodynamic analysis of the sea surface topography along collinear tracks was carried out and compared with in situ data. This work is dedicated to the excellent scientific service of the ERS-1 satellite during 1991-1999.

IMPROVED MODELLING OF EARTH GRAVITY AND IMPACT ON ERS POD

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ABSTRACT

Since spring 1995 (launch of ERS-2) the models for the routine ERS-1/2 precision orbit determination at D-PAF have been kept unchanged in order to provide a long homogeneous orbit series for detailed user investigations.

Meanwhile a number of new geometric and dynamic models have been made available or will become available in near future, which will lead to considerable improvements in the estimation of the ERS ephemerides. Besides effects such as ocean and atmospheric tide modelling, especially improvements in the Earth gravity modelling resulting from the joint GFZ/GRGS GRIM5 solutions can be mentioned. The impact of the latest GRIM5 models will be presented. The CHAMP satellite mission (launch July 2000) will provide Earth gravity information with an order of magnitude improvement for the ERS POD relevant spatial structures. Initial solutions from the commissioning phase of the mission will be discussed.

The impact of latest models on the ERS POD will be discussed and a proposal for a change in the operational ERS POD products will be presented.

THE KMS99 GLOBAL MARINE GRAVITY FIELD FROM ERS AND GEOSAT ALTIMETRY

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ABSTRACT

With the ERS-1 and GEOSAT geodetic missions 50 mill 1hz radar altimetric observations have become available. The resolution of the KMS gravity field is 1/30 degree corresponding to 2 minutes or 8 km at the Equator. In order to improve the spatial resolution of the gravity field it is necessary to investigate more data and alternatively data having a higher along track sampling can improve the spatial resolution of the gravity field. For the KMS99 gravity field data from the ERS-1 and ERS-2 Exact Repeat Mission have been used to improve the Gravity field at high latitudes, where previous no altimetry was available from neither GEOSAT nor ERS-1 geodetic missions. This presentation describes recent improvements in the KMS99 global marine gravity field, and presents extensive testing and comparison with other gravity field in regions of different gravity. The improvements in the gravity field are presented and validated using marine observations.

GEODESY

SHRINKING OF THE ARCTIC ICE COVER OVER THE LAST TWO DECADES

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ABSTRACT

The global sea ice cover is considered to be an indicator of global warming. Satellite observations from passive microwave sensors has established that the ice area has decreased with 6 64032010ver the last 20 years, while the multiyear ice has decreased with 14 0ver the same period implying that the Arctic ice cover is in transformation. If this trend continues the Arctic Ocean could be ice-free during summer in 50 100 years, which will drastically change the albedo and the oceanic uptake of CO2 from the atmosphere. The melting of ice will also cause increased stratification in the Greenland and Labrador seas, slowing down the deep water formation and the conveyor belt circulation. Recent results of trend analysis of ice extent, ice area and multiyear ice area from ice-ocean coupled modeling at the Nansen Center using synoptic forcing over the last 20 years is in good agreement with satellite observations laying the ground for improved predictive capability.

Furthermore, recentice thickness analysis from US nuclear submarines have shown dramatic decrease of 1.3 m over the last 30 years, averaging 4 cm thinning per year. This is in large contrast to Russian spatio-temporal ice thickness estimates retrieved from the dispersion relationship of surface-gravity swells propagating in the Arctic Ocean in the period 1972 1991. These estimates show a decrease of 0.5 cm per year, one eighth less that the US submarine data. This discrepancy underline the urgent need for proper spatio-temporal monitoring of the ice thickness of the Arctic Oceans in addition to satellite observations for global warming detection.

FEATURES OF TOPOGRAPHY AND DYNAMICS OF GLACIERS OF THE WESTERN ANTARCTIC PENINSULAR BY THE ERS SAR INTERFEROMETRY

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ABSTRACT

The region of the western Antarctic Peninsular near by the Vernadsky Ukrainian Antarctic Station was observed with several ERS SAR images obtained in 1995, 1996 and 2000. Changeability of dynamics and topography of the Girard, Weddington and Collins Glaciers flowing to the correspondent Bays at the Graham Coast were studied. Interferometric processing was carried out with the POLIMI ISAR software. This research is within the framework of the AO3.358 Project.

EQUILIBRIUM AND FIRN LINE DETECTION WITH MULTIPOLARISATION SAR

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ABSTRACT

We examine the capability of multipolarisation SAR for glacier monitoring on Austre Okstindbreen in mid-Norway and Kongsvegen glacier on Svalbard. The state of a glacier within a particular massbalance year is determined by the relative size of its accumulation area, i.e. the area gaining snow mass, and its ablation area, i.e. the area losing mass. Accumulation and ablation areas are separated by the equilibrium line. Monitoring the location of the equilibrium line over a long time-span provides information about glacier retreat or advance and thus about climatic trends.

SAR provides images independent of clouds or night-time conditions and is therefore an ideal tool for glacier monitoring. Results from Austre Okstindbreen show that the crosspolarisation SAR images (HV and VH) contain more backscatter variation and reveal more details of the glacier surface than the HH and VV polarised images. The present year's equilibrium line cannot be seen on the SAR images, however a distinct line is visible on the C-Band SAR images. Evidence shows that this line is the firn line created by old snow layers from previous years, being therefore related to the average equilibrium line altitude (ELA). Using firn-line altitude as a climate indicator and for monitoring of mass balance with remote sensing techniques is discussed.

GLACIOLOGICAL INVESTIGATION OF MERTZ GLACIER, EAST ANTARCTICA, USING SAR INTERFEROMETRY AND FIELD OBSERVATIONS

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ABSTRACT

The Mertz glacier in East Antarctica is one large glacier of the drainage area surrounding the Dome C. This glacier terminates in the southern ocean with a 100 km long ice tongue. The ERS1 and 2 satellite SAR instrument helped us to recover the grounding line of the glacier using 2 tandem interferograms with different ocean tide amplitude. The 2 interferograms are not computed on the same ERS track, but adjacent ones. We developed a method to differentiate the interferometric information and infer the grounding line position. Further glaciological investigation are made on this glacier and tongue using both the interferometry results and ground data acquired during the expedition GANOVEX VIII (German Antarctic North Victoria Land Expedition) in 1999-2000. The result of these investigations and the method for grounding line recovery using non-repeat interferometry will be presented.

SURFACE MOTION AND GROUNDING LINE DETECTION, MEASURED BY DIFFERENTIAL ERS-SAR INTERFEROMETRY, THWAITES GLACIER, WEST ANTARCTICA

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ABSTRACT

The surface motion of Thwaites Glacier, one of the fastest ice streams in the Antarctica, was studied by differential SAR interferometry using more than 40 interferometric ERS-1/2 pairs. The scenes cover an area of 300 x 200 km, stretching from the source of the glacier to its floating tongue, including the neighbouring Pine-Island Glacier. We used tandem pairs as well as ERS-1 pairs of the 3 day repeat orbits. The interferometric pairs have baselines between 0 and 240 meters, the total region was covered by at least two image pairs. This dataset allowed us to separate the topographic phase from the motion. On the floating part of the glacier the combination of interferograms from ascending and descending orbits (crossing at approximately 90o) constrains the glacier's velocity vectors in 2 dimensions. Interferometric velocities agree well with results from feature tracking methods. We found maximum horizontal velocities of 3.5 km/year near the ice cliff of the western part of the floating tongue. Using double difference techniques we separated the steady flow horizontal motion from the vertical tidal motion, which varies over time. In this way we were able to map the grounding line as well as the ice flux of the glacier. Furthermore we were able to monitor a time-variable rotational movement of the floating tongue.

EIGHT Y*EARS OF ERS1/2 OBSERVATIONS OF THE EVOLUTION OF WEST ANTARCTICGLACIERS: WHAT HAVE WE LEARNED ?

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ABSTRACT

Since 1992, the ERS SAR series has provided extensive interferometric coverage of West Antarctic glaciers. Spectacular results have been obtained from this long series of data, well beyond our wild expectations. ERS interferometry has provided highly detailed measurements of the glacier velocities and of their line of grounding (where they detach from the bed and become afloat in the ocean) at anunprecedented level of precision. The results have been employed to estimate their mass budget and their state of mass balance. Pine Island Glacier and Thwaites Glacier stand out as being significantly out of balance at present. Repeated imaging of these glaciers revealed that the grouding line retreated significantly (km) in 1992, 1994, 1996 and2000, which in turn translates into ice thinning rates of several meters per year. These rates of ice thinning cannot be explained by annual changes in accumulation or ablation and therefore suggests that the two glaciers are flowing too rapidly and are down drawing their drainage basins. ERS data acquired in 2000 further indicate that their ice velocity increased by 10 percent in the last 4 years, which is a large signal. Taken together, these observations suggest that this sector of West Antarctica, deep inside the continent, is slowly collapsing,thereby confirming an hypothesis formulated by Hughes 20 years ago that this sector is the "weak underbelly of West Antarctica" most likely to trigger its collapse.

FLOW SPEED IN THE FRONTAL AREA OF THE FILCHNER ICE SHELF DERIVED FROM INTERFEROMETRY AND NUMERICAL MODELLING

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ABSTRACT

We estimate the flow dynamics along the calving front of the Filchner Ice Shelf located between Berkner Island and Prinzregent-Luitpold-Land east of the Antarctic peninsula. In particular we concentrate on a comparison between results out of 60 interferometrically processed ERS scenes and modelling studies and discuss the restrictions of each method under special considerations of the glaciological situation in the investigation area. The INSAR processing system was developed at the Institute of Navigation with the capability to handle large data volumes. Coherence is present over a time interval of up to 18 days. The three-dimensional numerical ice shelf model takes into account the influence of shear zones on the flow regime. A special feature of the Filchner Ice Shelf is a partly 150 m thick marine ice layer, extending over an area of more than 4000 square kilometres in the north-western part of the ice shelf. From the velocity field of the ice masses we estimate the basal melt rate and the accumulation rate of marine ice. A large calving event in 1986 lead to the loss of three tabular icebergs. Possible effects of this event on the ice shelf will be discussed as well.

GLACIOLOGICAL INFORMATION DERIVED FROM COMBINING INTERFEROMETRIC SAR WITH OTHER REMOTE SENSING MEASUREMENTS

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ABSTRACT

The focus of the AO3 study "Radar Mapping of Greenland using the ESA ERS-1/2 satellites" is mapping of elevation and velocity of ice covered areas in Greenland by using interferometric techniques. The purpose is to improve mass-balance assessments of the ice sheet and local glaciers and to study their dynamics. Measurements of both surface elevation and velocity are useful for achieving this purpose. Elevation measurements are important e.g. for assessing ice volume change, modelling ablation rate, and developing hydrological models of run-off from ice margins. Measured ice velocities give information about the balance of the ice sheet upstream of the measurement site if compared with balance velocities, and also provide important boundary conditions for ice-dynamics models. Interferometric SAR (InSAR) measurements of ice-sheet elevation and velocity are useful in themselves. However, if combined with other remote sensing or in-situ measurements, the potential of InSAR increases substantially. InSAR, for example, provides measurement of surface elevation with high spatial resolution in two dimensions, with good relative but moderate absolute vertical accuracy. Other techniques, such as radar- and laser-altimetry, provide absolute elevations with high precision, but along profiles, only. Using altimetry measurements for absolute vertical adjustment of SAR surface-elevation maps, detailed maps of ice margins, required e.g. for melt-rate or hydrological modelling, can be obtained. Displacement measurements of low contrast glacier areas are unique to InSAR. For ERS, direct measurements of displacements in up to two directions are available, providing at most two independent relations between the three components of the surface-velocity vector. Different methods, based on different assumptions, can be used to establish the one or two missing relations between the velocity components. Examples are horizontal flow in the maximum slope direction, surface parallel flow, vertical flow determined by surface parallel component and the specific mass balance, etc. The paper reviews the different assumptions and the glaciological information that can be derived by combining the various assumptions with SAR velocity measurements. Also, a method for deriving melt-rates by combining InSAR measurements with ice-radar measurement of ice thickness and repeated laser-altimetry measurement of surface elevation change is described.

INVESTIGATION OF CORRELATIONS BETWEEN TEMPORAL VARIATIONS OF RADAR BACKSCATTER AND ALTIMETER-DERIVED ICE SHEET ELEVATION CHANGES

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ABSTRACT

Temporal and spatial variations in radar backscatter, as shown by variations in the altimeter waveform shapes, are investigated to determine their possible effects on ice elevation changes derived from 7 years of ERS-1 and 2 data. Variations in the strength of the radar backscatter affect primarily the waveform amplitude and subsurface volume scattering affects primarily the shape of the waveform ramp. The effect of such variations on the derived surface elevations depends on the retracking point chosen on the waveform to represent the surface elevation. Our GSFC V4 functional-fit retracking algorithm selects the mid-point of the ramp, the 20threshold retracker selects the point on the ramp at 2065244310f the maximum amplitude, and the OCOG selects a threshold point calculated from the centroid of the waveform area. Ninety-day averages of normalized ramp amplitude, sigma0, AGC, and other pertinent waveform parameters are calculated for 50 km grid squares over the Greenland ice sheet for seven years of data. Time-series of the parameter averages at each grid point are analyzed by calculating linear trends with least-squares fits. Elevation change maps for 7 years are derived by analysis of H(t) time-series created from the elevation differences at crossovers also in 50 km grid squares. For both the GSFC V4 and the 20threshold retracking algorithms, we find no significant correlations between any trends in the waveform parameters and our elevation changes derived using time-series H(t) analysis of elevation differences at crossovers. We also find no significant spatial correlations between the 7-year temporal means of these parameters and the elevation change grids. Of particular importance is the absence of correlation between the ice elevation changes and the temporal trend of the90-day averages of the amplitude of the waveform ramp. Double-ramped waveforms, caused by multiple near-equidistant topographic surfaces, also affect the algorithm track points. No significant time-dependent trend was found in the number of double ramps in locations that showed either high or low elevation changes,nor were any correlations found between the percentage of double ramps spatially and elevation change. We are continuing this investigation over Antarctica where previous studies by Wingham and associates using the OCOG algorithm found that changes in surface backscatter required corrections to their derived elevation changes.

THE EVOLUTION OF A GLACIER SURGE OBSERVED WITH THE ERS SATELLITES

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ABSTRACT

Surge type glaciers are characterized by long periods (20-200 years) of slow flow punctuated by short periods (1-10 years) of fast flow during which substantial volumes of ice are transferred to lower altitudes causing a temporary acceleration of the overall melt-rate. Glacier surges may provide useful insight into the expected behaviour of ice-streams under the influence of a changing climate. However, the causes, mechanisms and precise occurrence of surging are not completely understood and there is a need to acquire more information about this type of glaciers. ERS SAR data has provided invaluable tools of remotely study these relatively rare events.

A time series of ERS-1/2 SAR data from September 1991 to October 1997 was used to monitor the complete surge cycle of Monacobreen in Northwest Spitsbergen. Significant information for the study of this surge type glacier was provided to glaciologists by the analysis of the backscattering coefficient images (in particular for the position and the crevasses of the front of the glacier), by the use of differential SAR interferometry in descending and ascending mode to retrieve displacement and height maps, and by applying coherence and feature tracking where surge velocities exceeded the regime within which interferometric phase could be usefully interpreted. The result for Monacobreen is a complete map of temporal and spatial velocity structure from the beginning of the surge to its end.

SAR INTERFEROMETRIC ANALYSIS OF DAVID DRYGALSKI GLACIAL SYSTEM AND NANSEN ICE SHEET (ANTARCTICA)

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ABSTRACT

We used ERS-1 ERS-2 SAR tandem pairs of the David Glacier and Nansen Ice Sheet in the vicinity of Terra Nova Bay Antarctica, for the purpose to outline the flow dynamics, and ice-flow velocity of the area and contemporary start an evaluation phase to assess the best processing procedure before to extensively apply differential interferometrical analysis on the whole Pacific Sector of East Antarctica. The reconstruction of the ice velocity field in a large scale over Antarctica is one of the main goal of the VECTRA project, therefore we focused our attention to this test site that was objective of many previous studies and investigations. We test the possibility to determine information about the glacial setting of the area directly from amplitude, raw interferogram and coherence images. The SAR images cover the David Drygalski glacial system and Nansen Ice Sheet where we performed a glacial analysis based on interferometric and amplitude products. The glacial features interpreted using amplitude, coherence and ice flow velocity derived by interferometry have been submitted to a validation procedure. The validation approach insight the comparison between Landsat TM (Tematic Mapper) satellite images, SAR data and ground truth data. The interferometric products well describe the ice flux difference and the stress fields related to the confluence of the two ice fluxes of the David Glacier and to the grounding-floating zone. Deformation pattern related to marine current activity can be outlined in the Nansen Ice Sheet as well in the Drygalski Ice Tongue. The amplitude image and interferometric coherence maps describe the distribution of different type of ice and crevassing pattern.

INTERFEROMETRY AND ALTIMETRY ABOVE DOME C, ANTARCTICA

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ABSTRACT

Ice flows very slowly around dome regions and thus the dynamic of dome structures is difficult to measure and/or to characterize. Since EPICA projected to perform a deep drilling at Dome C, in East Antarctica, it is of particular interest to study the ice dynamics around that region. Up to now, little is known about ice motion near Dome C. Here, we tentatively study this problem using remote sensing tools. One is the high-resolution, high-precision topography obtained from the ERS1 geodetic mission. This allows to point out surface anomalies related to bedrock anomalies Another tool is the measurement of ice velocity using satellite SAR interferometry, namely using ERS data collected during the tandem mission of 1995/1996 with a 1 to 35 days repeat cycle, and using Radarsat RAMP SAR data collected in Sept/Oct 1997 with a 24-day repeat cycle. Finally arborne low frequency radar survey help map the surrounding berdrock topography. The interferometry results are compared with balance velocity and deformation velocity calculated with the topography and thickeness.

ERS ALTIMETRY IN ANTARCTICA

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ABSTRACT

The geodetic orbit of ERS-1 (168-day repeat) between 1994 April and 1995 March provides altimetric observation of the Antarctica surface with a high resolution. We have analysed the waveform altimetric data from this orbit to compute global maps with 1/30 grid size. We develop a retracking technique that allows the restitution of three waveform parameters related with surface and subsurface snow characteristics that are mapped by the same way. The map of the four parameters shows a lot of surprising features. The surface topography map exhibits many scars due to local flow anomaly. Several physical processes can be identified and studied: abrupt transition from strong friction to weak friction and inversely, strike-slip, en echelon crack.. This map allow to estimate balance velocity that exhibits impressive streams up to few hundred kilometers.. The maps of the parameter deduced from the waveform shape and intensity of the backscattering also show surprising details: abrupt change of waveform shape and backscattering coefficient of up to 4 dB in few tens of kilometers in the central part, abrupt increase of surface roughness after the slope break and in convergence area. These high-resolution maps allow a better understanding of both dynamics and climatological phenomena acting at the 10 km scale. These are necessary to apprehend mass balance study.

UNSTEADY FLOW IN THE ANTARCTIC ICE SHEET REVEALED BY SAR INTERFEROMETRY AND RADAR ALTIMETRY

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ABSTRACT

A combination of ERS satellite radar altimetry and interferometry shows that inland sections of Pine Island Glacier, West Antarctica, thinned by as much as ~1.6 m/year between 1992 and 1999, and that the pattern of elevation change is largely coincident with fast ice motion. The rates of thinning, which are causing the glacier to retreat inland, cannot be explained by fluctuations in the surface mass budget, and we attribute them to a change in the dynamics of the streaming ice. If the ice thinning continues unabated, the entire grounded section of Pine Island Glacier will be destroyed within ~400 years, resulting in a net contribution to eustatic sea level of ~7mm.

PROCESSING INTERFEROMETRIC ERS-1/2 TANDEM DATA COAST TO COAST IN GREENLAND

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ABSTRACT

We are conducting an AO3 study "Radar Mapping of Greenland using the ESA ERS-1/2 satellites." The study aims to develop accurate and high-resolution ice flow estimates and elevation maps for all of the Greenland ice sheets and glaciers based on ERS-1/2 interferometric SAR (InSAR) data.

Present digital elevation maps of Greenland are of varying accuracy and resolution. Our primary approach is thus to use a differential interferometric technique to estimate elevation and glacier displacement simultaneously to the extent that the available data supports this approach. Otherwise we will rely on elevation data from the National Survey and Cadastra of Denmark. The data requirements are on the order of 1700 standard frames to cover all of Greenland with two tandem pairs from one look direction (descending). As only 6065516240 of Greenland is covered by ascending tandem pairs, the data requirement is thus unfortunately correspondingly smaller. To reduce the number of individual data sets processed, and avoid along-track data mosaicking, we are setting up a strip processing chain. This reduces the number of individual data sets required by approximately a factor 10. We also anticipate that processing of strip pose less stringent requirements on the number of ground control points (GCPs). Ideally, only tie-points are required on the coasts, but we anticipate that changes in tropospheric and ionospheric conditions, SAR system drift etc., will degrade the accuracy significantly if GCPs from the interior are not used. Worst case we anticipate that it will be necessary to use both available elevation data and other ice flow estimation techniques (e.g. mass balance flow) to "adjust" the InSAR data for slowly varying effects.

This paper describes considerations for interferometric processing algorithms capable of processing long strips. A preliminary coast to coast digital elevation model will be presented. The paper also describes our experiences with respect to the significance and characteristics of errors with long spatial correlation, originating from changes in the troposphere, the ionosphere, SAR system drift, and penetration in the dry snow zone.

ICE 1/2

INSAR IMAGING OF LONDON SURFACE MOVEMENT FOR STRUCTURAL DAMAGE MANAGEMENT AND WATER RESOURCE CONSERVATION

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ABSTRACT

Synthetic Aperture Radar (SAR) Interferometry (InSAR), using data from the European Space Agency (ESA) satellites ERS-1 and ERS-2 (ESA project AO3 258), is being used to image, survey and map surface movement in the London region. Local and regional movement due to shrink and swell of the London Clay geology, tunnelling, and possibly ground water abstraction has been imaged for the first time by InSAR and results are presented.

The geology of London is predominantly clay, which shrinks in summer drought and swells with winter rain causing cyclic annual vertical movements of around 50mm, with extremes during repeated dry summers and winters. This movement causes structural damage to buildings and infrastructure. It is thought to be a major cause of water main bursts in the region. Structural damage to houses is widely experienced, an expensive burden to the community and to insurance companies. Although the phenomenon is well recognised, variability of the actual surface movement across the London Clay has not been comprehensively surveyed before. Apart from the variable properties of the clay itself, tree cover, soil exposure, urbanisation and surface drainage factors significantly contribute to highly localised variability, which can be identified in the images. Some of these other factors are also studied by satellite imagery, towards a causal explanation of the shrink/swell variability. Tunnelling and water abstraction features are clearly distinguishable on the images from subtle regional surface change.

Ongoing research is underway to produce the first regional shrink/swell maps and to model the phenomenon. Mapping and feedback to geological models could benefit a diversity of end users and improve the region's economy. In particular, engineering solutions may be focused where high shrink/swell susceptibility is identified to efficiently target water main bursts and so conserve water resources.

TEMPORAL ANALYSIS OF TERRAIN MOVEMENTS BY MEANS OF SAR DIFFERENTIAL INTERFEROMETRIC MEASUREMENTS ON SPARSE COHERENT AREAS

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ABSTRACT

Synthetic aperture radar (SAR) differential interferometry is a powerful technique that allows, in principle, to measure from satellite small (of the order of one centimeter) deformations of the terrain occurred between different acquisitions. Main limitations include decorrelation noise and atmospheric artifacts that can affect SAR differential interferograms. Also, availability of precise satellite orbit data and digital elevation model (DEM) of the observed scene can be other issues. Due to decorrelation noise, good quality data are often available only on sparse coherent areas (e.g. urban areas and/or isolated buildings, other stable objects, arid terrain). This is relevant mainly to phase unwrapping, which is a necessary step to measure without ambiguity the terrain deformation. The problem can be overcome by using a new phase unwrapping approach [1] that allows to process sparse data, and therefore extract the available information from noisy data sets. The impact of atmospheric artifacts and inaccurate satellite orbit knowledge can be minimized by performing a temporal analysis of the successive observed deformations. In particular, if the terrain movement time evolution is almost ever sufficiently smooth when observed at the time intervals of the successive SAR data acquisitions, the contribution of the these error sources to the measured terrain displacements can be filtered out. Problems due to potentially inaccurate satellite orbit knowledge can be also solved, together with determination of absolute terrain deformation, by making use of ground control points. Finally, SAR acquisitions with small spatial baselines can be selected, thus reducing the need for a high precision DEM in order to remove the topographic phase term. The area of Naples, Italy, is a particularly interesting test site for the above outlined procedure, due to the occurrence of subsidence phenomena, volcanic activities, landslides. Using ERS data, we analyze the terrain movements happened in Naples and in the surrounding area in the last decade.

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VALIDATION OF THE PERMANENT SCATTERERS TECHNIQUE IN URBAN AREAS

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ABSTRACT

Most of the earth surface has been monitored systematically first by ERS-1, then by ERS-2 and it will be with ENVISAT, thus creating long and consistent series of data. In urban areas and where exposed rocks are visible, it is possible to identify numerous back scatterers that do not change their signature with time (the Permanent Scatterers) and therefore they can be used as natural monuments to estimate the progressive motion of the terrain. The precision of the measurement is a small fraction of a wavelength (5.6cm) and millimetric motions are appreciable with good reliability. The Atmospheric Phase Screen (APS) contribution is rather smooth spatially and independent from take to take, so that it can be identified and removed from the data using a proper processing, provided that the density of the PS is high enough as it happens in urban areas. Then, it is possible to obtain maps of subsidence with very high spatial sampling rate (as an example, we counted more than 40000 in Paris, Roma and Milano) and high quality. The sub-millimetric accuracy of this technique has been checked by means of a comparison with GPS measurements where available and by cross-correlating dilation of metallic structures in Paris and Milano with temperatures over a six years period. Other non-linear motions have been easily identified after the APS removal. Many examples will be discussed.

ERS AND ENVISAT DIFFERENTIAL SAR INTERFEROMETRY FOR SUBSIDENCE MONITORING

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ABSTRACT

In recent years significant progress was achieved in SAR interferometry. In this paper we report on the potential of differential SAR interferometry to map land subsidence. After a presentation of the methodology the focus will be on feasibility demonstration and accuracy assessment. The theoretical considerations are verified with the selected cases Ruhrgebiet, Mexico City, Bologna, and Euganean Geothermal Basin, representing fast (m/year) to slow (mm/year) deformation velocities. The accuracy of the generated deformation maps and the maturity of the required processing techniques lead to the conclusion that differential SAR interferometry has a very high potential for operational mapping of land subsidence. The high reliability of the ERS satellites with the huge data archive starting in 1991, strongly support this application. The planned ENVISAT ASAR has the potential to maintain good data availability into the future. This will, nevertheless, strongly depend on the sensor operation strategy. The operation of the ASAR in a single interferometric mode for most of the time and the acquisition of a large data archive are essential prerequisites for the subsidence application.

ERS-1/2 SAR INTERFEROMETRY FOR URBAN SUBSIDENCE DETECTION IN CHINA

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ABSTRACT

It is now possible to detect subtle changes in the Earth's land surface over periods of days to years with a scale (global), accuracy (millimeters), and reliability (day or night, all weather) using satellite SAR interferometry. Since the 1980's the excessive ground water exploitation in many cities in China has resulted in significant subsidence that has damaged buildings, roads, and pipelines. It has also changes the areas affected by flooding. And in recent years the subsidence of megalopolis has been increasingly serious. In this paper the potential of ERS-1/2 SAR interferometry for mapping of subtle land subsidence has been investigated. Several test sites were selected, including Suzhou (jiangsu province), Tianjin. In situ measurements on actual subsidence were gathered. Differential interferograms were generated using ERS-1/2 SLCI data and combined with Digital Elevation Models (DEM). The time series of results were shown that under favorable conditions detection of land subsidence were feasible. Atmospheric effects together with temporal decorrelation were the major limitations to the accuracy of the technique for this type of long-term measurement. Those results provided a good way for mapping subtle surface deformations in urban areas and for testing the quality of theoretical models of subsidence. An interactive D-INSAR data processor was developed and applied to demonstrate the monitoring of subsidence for these test sites. The aim of the demonstration was to assess the vertical accuracy and precision with which subsidence could be measured.

ASSESSEMENT OF SAR INTERFEROMETRY WITHIN OPERATIONAL APPLICATIONS: MAPPING AND MODELING OF PERI-URBAN SUBSIDENCE

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ABSTRACT

Differential SAR interferometry might be considered as a surveying technique for land-subsidence. Unlike some applications such as landslides with high deformation gradients associated with short-time evolution on steeply sloping terrains, subsidence is more suitable for interferometric constraints of feasibility. In terms of deformation gradient, relative movement associated with the subsidence phenomenom usually does not exceed some fraction of a wavelength across one radar pixel. The assessment of interferometric possibilities for land-subsidence monitoring is derived from time series analysis of interferometric maps. We focused on sites affected by subsidence caused by human activities: underground mining or ground water pumping. In the first case, some of the subsidence occurs gradually, associated with the collapse of cavities previously filled with ore. In the second case, subsidence is the result of large-scale abstraction of water in a confined aquifer-aquitard system largely composed of unconsolidated sediments. Different test-sites were studied: Vietnam, France, Mexico, and Indonesia. End users targeted by the studies (i.e. cities departments and agencies responsible for risk management, urban planning and environmental management) were involved in the projects. A methodology has been developed in order to simultaneously model at a regional scale the transient ground water flow in leaky aquifer systems and total subsidence due to the compaction of aquitards as a result of aquifer over exploitation. The application on a complex ground water system led to the construction of a quasi-tridimensional model at a regional scale (1,500 km2). The calibration process is done through the available data (piezometry and levelling). The comparison between the quantitative investigations performed with the model and the interferometric measurements will be presented. The ongoing studies provide an opportunity for a broad spectrum of users to assess the opportunity presented by SAR Interferometry within the context of their operational programs. The demonstrations open up wide application prospects, not only in the scientific field but also for industrial use. The project was supported by ESA(A03-191).

CLIMATE CHANGE - HIMALAYAN PERI-GLACIAL LAKE, MORAINE DAM BURST SURVEILLANCE

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ABSTRACT

The stability of glacial moraine, forming the dams of peri-glacial lakes in the remote Himalayas of Bhutan, are being monitored with data from European Space Agency Satellites ERS1 and ERS 2. Climate change is increasing the Himalayan glacial melt water, causing occasional moraine dam bursts, with resulting down river flooding and structural damage. Synthetic Aperture Radar (SAR) satellite data is used experimentally to image changes to the moraine by SAR interferometry (InSAR) and coherence mapping. Results are presented.

EARTH MOTION

THE DEVASTATION OF VENEZUELA BY HEAVY RAINS IN DECEMBER 1999: ASSESSMENT OF THE SITUATION USING ERS INSAR TANDEM DATA AND SPOT IMAGES

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ABSTRACT

After the devastation caused by two weeks of torrential rain in Venezuela in December 1999, it is estimated that up to 50,000 people have died in floods and landslides; a further 200,000 people have been left homeless as whole towns along the Caribbean coast have been washed away. Concerned about the extent of this human tragedy, Privateers N.V. has immediately offered its support to Venezuela. In cooperation with CNES and ESA who provided the sets of SPOT and ERS images acquired before and after the disaster, this project aims to the rapid provision of cartographic maps designed to assess the situation and to help with the rehabilitation of the country. To reach this goal, the following data processing procedure was applied:- Based on the calibrated radar reflectivity, the ERS SAR data are used to detect the damages. In the change detection process, the ERS SAR archive data are compared to the ERS SAR data acquired just after the rains. A combination of speckle filtering and super-resolution techniques is applied to the ERS SAR data, to detect and map existing targets at a spatial resolution of 10 meters, before and after the rains, with particular emphasis to housing and infrastructures.- To complete the detection of damages and changes using ERS SAR images, interferometric ERS tandem pairs acquired before and after the disaster are used. Coherence maps, radiometrically restored using new filtering techniques developed by Privateers N.V., enable the identification of landslides and - Independently, change detection is carried out; using SPOT-P archive and present data, to get a more complete detection of the changes.- SPOT-P archive data are used as mapping background. The final product is the result of a common-sense data fusion process integrating ERS SAR change detection and SPOT-P archive data, to facilitate photo-interpretation of the final product.- Finally, a set of cartographic UTM maps of the damages have been produced, on 10x10 meters grids. Evaluation of results will be carried out in the next months, and presented in this communication.

FOREST STORM DAMAGE ASSESSMENT WITH ERS TANDEM DATA

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ABSTRACT

In winter 1999/2000 two heavy storms caused extensive damage in Europe. Especially forests were affected, but also buildings and power lines. The economic damage in several European states is enormous, especially in France and Switzerland. Space-borne remote sensing is one possible information source to assess the extent of the forest storm damage. SAR sensors with its "all-weather" capability and a very good potential for change detection are particularly useful for this application. For the time period of interest ERS-1/2 SAR data were acquired of the affected areas including Tandem acquisitions shortly after the storms. In this paper we will discuss the potential of ERS Tandem data for forest damage monitoring. Recent studies showed that forest can reliably be distinguished from other land types based on the degree of coherence and the backscattering coefficient. The degree of coherence (short coherence) is a measure of the phase noise of the interferogram. It depends on sensor parameters, parameters related to the imaging geometry and the acquisition interval, and target parameters, and is therefore a good parameter for change detection. For forest the coherence is low. The geometry of the storm damaged forest is changed dramatically as compared to the situation before the storm. Parts of the ground surface as well as the more stable parts of the trees, namely the trunk and strong branches, become directly visible for the fallen and broken trees of storm damaged forest stands. These changes have a strong impact on the coherence and, to a much lesser degree, also on the backscattering coefficient. The comparison of coherence images before and after the storm shows that the increase of the coherence is correlated with forest damage allowing to derive damage mapping algorithms. Results for test sites in France, namely Yvelines and Correze, and Switzerland will be shown confirming the high potential of the presented methodology for forest damage assessment.

MAPPING STORM FOREST DAMAGE USING SAR COHERENCE DATA. THE CASE OF THE HAGUENAU FOREST - FRANCE

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ABSTRACT

The devastating storms, which struck France in December 1999, destroyed the equivalent of several years of forest normal exploitation. It is of ultimate importance to map the damages for short-term actions as well as for long-term reforestation. While it is accepted that coherence images derived from SAR may discriminate accurately forest and non-forest area, this novel work based on a multitemporal approach of coherence images demonstrates that coherence can be related to various levels of damage to the forest. This work was carried out over France's second largest plain forest, the forest of Haguenau, 30 km North of Strasbourg based on the exploitation of the coherence product developed by Spot Image with the support of ESA. Two coherence products derived from two ERS1/ERS2 tandem pairs acquired before the storm, the 31 October and 1 November 1999 and after the storm, the 9 and 10 of January 2000 have been used. Thus, the coherence product from archive data allows to separate forest/non forest areas whereas the coherence product realised after the storm shows a strong increase of the coherence degree within forested areas linked with an increase of soil's contribution in the signal due to the fall of trees. Plus a "damage" image was produced based on the rationing of the two coherence channels, associated with an averaged intensity image and the after-storm coherence. Damage maps were produced at a scale of 1:25,000 scale. These maps show that 5064055160 of the forest has been devastated which is in total agreement with the damage amount reported by the forest service. After this rush results, a focussed analysis taking in account the influence of tree species, secondary species, tree density is on going. The obtained results will emphase the potential of these new coherence products and allow to set up a production chain of damage products in order to be able to provide, in a very short time in case of future catastrophes, valuable information to the forest and security services.

VALIDATING SOIL MOISTURE ESTIMATION WITH ERS PRI DATA: OPERATIONAL USE IN DECIDE, A DECISION SUPPORT SYSTEM FOR FLOODS

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ABSTRACT

Preventing damages due to floods as well as control and management of floodwaters are now problems of vital necessity as demonstrated by recent, world-wide, events. This situation is expected to rise in the years to come, as a consequence of climate changes, land-use modification, growing population and concentration in larger urbanised areas. In response to a specific ESA/ESRIN invitation to tender, a Consortium with VITROCISET as prime contractor, and Datamat and LaMMA as subcontractors, has developed DeciDe, a system able to address these problems by merging of satellite data, in-situ data, atmospheric and hydrological model results. Its capability has been tested over the river Arno basin, specifically to foresee floods in the city of Florence (Italy). A crucial point of the system is the soil moisture estimation, as directly related to the rainfall runoff quantity, critical parameter for hydrological models. Evaluating distributed rainfall fields from satellite, atmospheric model and rain-gauge data is generally a complicate task, more difficult (i.e. more uncertain) is the estimation of the moisture content of the soil, based on the amount of precipitation. At this level satellite SAR data reveal to be a valuable tool: deeply linked to the soil moisture content, they allow to tune the technique for soil moisture retrieval. In the DeciDe system soil moisture estimations are obtained:* hourly with a weighted sum of the amount of rain precipitated during 5 days before,* off-line correcting the sum-weight values by means of SAR measurements, each time an ERS PRI image is available for the target basin. A specific technique has been developed to use couples of ERS PRI images from the same frame and track for comparison with corresponding moisture maps from rainfall fields. Couples of data sets are used to neglect, in the SAR data processing, the contributions of the observation geometry and soil roughness. The relationship between dielectric constant and volumetric soil moisture established by Hallikainen et al. is used in the process.

APPLICATION OF SAR-DATA FOR FLOOD MODELLING IN SOUTHERN GERMANY

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ABSTRACT

An Integrated Flood Forecast System (IFFS) which uses synergistic remote sensing data with special focus on the possibilities of SAR data will be presented.

As a first data source, which is based on SAR analyses, an interferometrically derived elevation model of the watershed is used. From this, information layers on watershed boundaries, subwatershed definition, slope and flow paths are derived. These layers are used to automatically generate the hydrological structure of the runoff model. Since the hydrological structure is not changing rapidly, the analyses of one pair of ERS-tandem scenes is sufficient. Additionally land use information from classification of TM data is further applied to characterise the watershed.

The second SAR derived data source for flood modelling is the surface soil moisture. Soil moisture information is of relevance for runoff modelling because it determines the partitioning of rainfall into surface runoff and infiltration. After the ERS-SAR data were radiometrically and geometrically corrected using DEM information, surface soil moisture was derived under crops using a semi-empirical model, which corrects the influence of the soil texture and the canopy contribution to the SAR signal. This information is then used to describe the moisture conditions of the watershed prior to a flood.

A demonstration run of the Integrated Flood Forecast model in the Ammer watershed (700 sqkm) in Southern Bavaria will be presented. As a test case an extreme flood which was the most sever since 150 years is selected.

Further, the planned application of the methodology in an operational flood forecast system for the Neckar, a major river in Baden-Württemberg, South Germany will be presented. For such an operational application the use of SAR data with a high temporal resolution, which will be provided by ENVISAT ASAR data wide-swath mode, is mandatory.

CONTRIBUTION OF ERS SAR IMAGES AND ERS COHERENCE DATA TO A FLOOD INFORMATION SYSTEM ON THE MEUSE BASIN - FRANCE

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ABSTRACT

Within the framework of an agreement between ESA, CNES and the French Civil Defence Agency concerning the assessment of the contribution of space techniques to effective disaster management in an operational context, a demonstrator had been set up for plain floods monitoring and management. The test site corresponds to the French Northern part of the Meuse basin. The topics of this demonstrator were to produce a set of maps to be included in an operational GIS being prepared for the Regional Security Service. The first produced map corresponds to a "map of maximal extent of Flood". Its was derived from ERS data acquired during the floods of 1993 and 1995, the largest events of this century after the 1926 flood. In an operational context such document will be use in order to visualise potential flooded areas. Its will also be useful to update the "historical map of flood" an essential document used in the flood protection administrative procedure.

A dynamic monitoring of the 1993 event had been done over the plain area, i.e. Sedan -Charleville area, and over the gorge between Charleville and Revun in the Ardennes steeply region, based on the exploitation a ERS time-series acquired within a 3 days repeat pass mode. Its points out sector of long term flood and part affected only for shorter period. Plus, from this data set, as the knowledge of natural wetlands is of critical importance to the understanding of flood mechanisms, the evolution of soil wetness, during and afterwards the flood, will be assessed.

In parallel, from ERS coherence data, ILU image from ESA, and a high resolution coherence product, a land cover map will be generated. Combination of the obtained land cover and the flood extent maps will allow the identification of the damaged area. Locally, very high-resolution optical data would be combined with the maximum flood extension map in order to illustrate at a higher scale the potential impact of floods on the landscape.

The obtained results demonstrate an effective contribution of EO data to the set up of a flood information system on the Meuse basin.

EVALUATION OF MULTITEMPORAL RADAR DATA FOR THE MAPPING OF INUNDATION DYNAMICS IN THE SAVE-FLOOD PLAIN (CROATIA)

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ABSTRACT

The study presented is contributing to the ESA ERS-AO3 project "Mapping the inundation dynamics and plant communities in the Sava-river wetlands (Croatia) by synergy of multitemporal radar and multispectral image data. The main topic of this part of the study focuses flood dynamics by use of the ERS-sensors, in combination with an analysis of the vegetation types that depend upon these flood dynamics in the Save-flood-plain around the area of Lonjsko Polje Nature Park. The study was carried out using standard remote sensing methods to (georeference, processing) the "raw" satellite images (GEC-format). The further evaluation (segmentation, classification) was made with the software eCognition, a new technology for object-oriented and multi-scale image analysis. The thematic map of vegetation communities from 12.09.1997 (IRS 1-C) is used as a basic (LÖFFL, 1999) for the evaluation of the ERS-data (20.9.98, 21.9.98, 26.10.98).

Therefore the objective in this study was to construct a monitoring-system about inundation dynamics in the area of the Nature Park. If flood dynamics is the driving force behind the vegetation succession dynamics, so it is necessary to know which areas (plant communities) are very frequently flooded and which areas are only sometimes or never flooded. The management of Nature Park need information about extension and duration of flooding events (e.g. usable pasture places, succession-changes of plant communities). The maximum high waters (during last years) were been in 1998. As well ground truth were only available from 1998 with basis of IRS 1-C (12.09.1997), for this period of time an extensive evaluation of applicable ERS images (20.09.98, 21.09.98, 26.10.98) and mapping of flooding dynamics was possible. However to have a meaningful monitoring-system (GIS) further research and monitoring with new data will be necessary. In addition with a high quality DEM it would be possible to determine not only the area (in hectares / km^2) but also the quantity (in m^3) of water in flooding periods of time. As a DEM is lacking, an alternative solution would be interpolation of surveyed height transects in combination with vegetation types that depend on moisture differences (= height differences in decimetre). As well each observation give us an other flood-line connecting with a specified altitude. By collecting "flood-lines" over time an accurate contours-map can be built up. Normalized by 3 to 4 transects measured by the topographic survey (different plant communities = different altitudes) a fast and efficient mapping seems to be possible to determine not only the area but also the quantity of water in flooding periods of time.

FLOOD MONITORING IN BANGLADESH. AN APPLICATION OF SAR IMAGERY FOR IMPACT ASSESSMENTS OF FLOOD EXTENT, FLOOD DEPTH AND DURATION

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ABSTRACT

Inundation of the floodplains of the Brahmaputra, Ganges and Meghna rivers is a yearly occurring phenomenon during the monsoon (June-October). Floodings are essential for maintaining the floodplain system and making agricultural production and fishery possible. Nevertheless, the duration and extent of the inundation varies largely between different years and about once every ten years excessive floods occur. Especially these extreme floods result in large damages and many problems for agriculture and infrastructure.

In order to predict and minimise flood damage and potential adverse effects of water resources projects, infrastructure development and other interventions, there is currently a need for a better understanding of river dynamics and the complex floodplain processes that determine the extent of flooding. For the purpose of emergency response and assessment of flood damage there is especially a need for improved data handling procedures and decision support systems for short-term response applications. Detailed knowledge on flood dynamics and good accessibility to data will support policy makers in planning and taking action.

In the SPIHRAL project (ESA DUP project) a methodology was developed to determine flood extent, flood depth and duration using SAR imagery. Especially the kind of information regarding depth and duration of a flood is of vital importance for estimations of the impact of a flood on the environment and the socio- economical system. Therefore, in the SPIHRAL project the information on flood characteristics as was obtained from SAR imagery, was used in several applications in order to assess the impact of the flood of 1999 on infrastructure, rice production and fishery in the floodplains of Bangladesh.

For demonstration of applications the SPIHRAL project used ERS SAR images from 1999 as were received and pre- processed by the mobile ground receiving station RAPIDS. This station was installed in Bangladesh under another ESA DUP project. Currently, further preparations are made to enhance the data preparation and application possibilities. Further, the potential of ENVISAT imagery will be explored. The ultimate goal is to develop a processing chain which can deliver products like flood maps and derived products like drainage maps, crop suitability maps and infrastructure damage maps, on a near real time basis.

CHINA REMOTE SENSING SATELLITE GROUND STATION AND ITS FLOOD MONITORING WITH ERS IN CHINA

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ABSTRACT

It is well known that China is a country which suffered frequent and heavy flood in recent years, especially in 1994, 1995, 1996 and 1998. The most serious floods occur often at some rivers, such as Yangtze and Songhua River, and large lakes, such as Poyang and Dongting Lake. Large agricultural and settled area are flooded and the loss is about several-tens billion US$ in each of these years. The reason to cause serious flood lies not only natural disaster but also environment destruction by people. So it is very important for China to monitor the flood disaster and assess the flooded area every year. The advantage of ERS SAR, all-weather and all-day, makes it play a very important role in flood monitoring. With the successful system upgrade in 1993, China Remote Sensing Satellite Ground Station (RSGS) started to receive, archive and process ERS SAR data. And in the following years, RSGS generated a large number of ERS images which cover the flooded area. And flooded area was calculated as well by method of multi-temporal and multi-sensor data fusion. These images and analysis results were sent to some central and local governments to help them assess the disaster. In this paper, some interesting images are given to show the work which was done by RSGS to monitor the flood. And brief introductions to these images are also presented to help people get the idea about the flood in China.With the launch of ENVISAT, its advantage of wide swath coverage will be more beneficial to flood monitoring. It is expected that RSGS will do better and better once it becomes the ENVISAT network station.

FLOODS/STORMS

OPERATIONAL USE OF INSAR FOR VOLCANO OBSERVATORIES: EXPERIENCE IN LOCAL RECEPTION AT MONTSERRAT

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ABSTRACT

A volcano observatory that is monitoring an erupting volcano (es) needs as much relevant data as it can get in a timely manner. InSAR has, potentially, a major role to play in delivering information on ground deformation and topographic change that can feed into the crisis management process. The Montserrat Volcano Observatory (MVO) has been observing the ongoing eruption of the Soufriere Hills Volcano since 1995. We have been studying the ERS-derived InSAR data acquired for Montserrat by the Cotopaxi ground station. These data, mostly from mid-1997 onwards, are exclusively from ascending passes. This is because the satellite(s) is just out of range of the Cotopaxi ground station in the descending pass. Also these data are only usually available at MVO about 3 weeks or more after acquisition. In March-May 2000 we mounted an experiment to test the capabilities of local ground reception of both ascending and descending pass ERS SAR data at MVO and their immediate processing as InSAR products. This used a BURS/RAPIDS system that was shipped to the island and set up in the observatory grounds. Here we report on the success of that deployment and the problems encountered.

FIRST RESULTS FROM OPERATIONAL VOLCANO MONITORING IN THE CANARY ISLANDS

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ABSTRACT

Indra Espacio and the Spanish Volcanic Research Network have started a project for operational volcano monitoring demonstration in the Canary Islands in the frame of an ESA contract using ERS interferometry. The new service shall complement the information derived from field deployed instrumentation in the archipelago and shall be used for decision making in volcanic risk linked to the Civil Protection Authorities.

The Canary Islands are best suited for operational differential INSAR application because of its volcanic land cover -long term coherence stability has been assessed- and availability of systematic field measurements. Furthermore, the sparse volcanic features to be monitored make this technology most cost-effective when designing a volcanic monitoring system.

The preliminary results from the service, those obtained from the processing of a selection from the ERS historical archive of the last decade, have unveiled unknown displacements out of the areas traditionally being monitored by field instrumentation. These results have conditioned the development of new surveying campaigns and are revolutionising the way the volcano monitoring is being performed in the archipelago and of course shall pave the way for the achievement a self-sustained service beyond the ESA funding.

The next step in the operational service covers the systematic processing of new images acquired by the ERS-2 over the archipelago every 35 days. The historical archive enables adequate baseline companion image availability.

A crisis monitoring scenario -where the satellite coverage is maximised- has also been defined and shall be tested as an exercise coincident with fieldwork campaigns.

LARGE FLANK COLLAPSE AT MOUNT ETNA IMAGED BY ERS SAR INTERFEROMETRY

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ABSTRACT

Large flank collapse has been proposed by many recent authors as a major process in the dynamics of Mount Etna. However several aspects of the process are still unclear, such as the collapsing area boundaries and the driving force of the instability. Here, we present the results of six years of interferometric survey of Mount Etna (September 1992 to January 1999). With a dataset of 238 interferograms calculated from 38 ERS images, we detect for the first time active spreading on the eastern and southern flanks of Etna. Two sectors of instability have been identified where the spreading process differs. An eastern sector is bounded to the North by the Pernicana fault, to the West by the North Rift Zone and the South Rift Zone and to the South by the Mascalucia-Tremestieri-Trecastagni fault system. Interferograms provide new data on the activity and extent of the southern boundary that was previously underestimated. In this sector, the structural features indicate an eastward sliding driven by the E-W regional extension. A second collapsing sector exists along the southern flank of Etna. The interferograms evidence an active anticlinal ridge at its southern base. It is assumed to be the result of southward gravity spreading over a basal decollement between Etna and the Hyblean plateform. The two sectors started active spreading in the summer 1996, after the beginning of a new cycle of eruptive activity at the summit. The spreading was ongoing until January 1998 with deformation rates ranging from 0.4-0.6 cm/yr for the Mascalucia-Tremestieri-Trecastagni faults to 1.2 cm/yr for the anticlinal ridge. The collapse of Southeastern Etna appears to occur by sporadic increment rather than by a continuous process. This observation could be explained if we consider that Etna is in a sub-critical state of stability under the stress field induced by regional E-W extension and N-S compression. Small perturbations such as dyke injection in the Rift Zones could be responsible for the destabilising of the volcano. We consider this study as a good demonstration of the potentiality of SAR interferometry for the understanding of the long-term evolution of strato-volcanoes.

STUDIES OF VOLCANOES OF ALASKA BY SATELLITE RADAR INTERFEROMETRY

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ABSTRACT

Satellite radar interferometry has provided a new geodetic technique to measure the deformation of volcanoes at tens-of-meter horizontal resolution with centimeter to subcentimeter vertical precision. The two-dimensional surface deformation data enables the construction of detailed numerical models allowing the study of magmatic and tectonic processes beneath volcanoes. Using this technique, we studied the 1997 eruption of Okmok. We have measured ~1.4 m deflation during the eruption, ~20 cm pre-eruptive inflation during 1992 to 1995, and >10 cm post-eruptive inflation within a year after the eruption, and modeled the deformations using Mogi sources. We imaged the ground surface deformation associated with the 1996 seismic crisis over Akutan volcano. Although seismic swarm did not result in an eruption, we found that the western part of the volcano uplifted ~60 cm while the eastern part subsided. The complex deformation field at the Akutan volcano was modeled by dike intrusion and contraction. Radar interferometric results indicate that that the northern flank of the volcano has been unstable since 1992, and the surface material is moving by~3 cm per year. Finally, we applied satellite radar interferometry to Westdahl volcano which erupted 1991 and have been quiet since. We discovered this volcano has been inflating about 15 cm since last eruption. In summary, satellite radar interferometry can not only be used to study a volcanic eruption, but also to detect a seismic deformation at quiescent volcanoes preceding the seismic swarm; it is a useful technique to study volcanic eruptions as well as to mitigate volcanic hazards.

ERS SAR DATA AND DEM ANALYSIS TO COMPLEMENT THE GEOLOGICAL INTERPRETATION OF THE KALECÝK-HASAYAZ BASIN, ANKARA, TÜRKÝYE

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ABSTRACT

The geomorphology of Türkiye is characterized by an active plate boundary where two continental blocks are colliding. Continental collision formed an accretionary terrane, welding together several smaller micro continental blocks. Presently, convergence continues forcing pie-shaped Anatolian plate westward along the North and East Anatolian transform faults. The study area, the Kalecik Hasayaz Basin comprising 1530 km2, is located between these two continental blocks, approximately 80 km northeast of the capital city of Ankara. It is mainly characterized by fluvio-lacustrine, gypsum and alluvial fan deposits, and contains certain structural typologies and landforms produced by the post-collisional tectonic regime. In this study, the SAR (Synthetic Aperture Radar) aboard the ERS (European Remote Sensing) spacecraft, was used as a new tool for the interpretation of the geology of the region. ERS-1 SAR scenes were used as a complement to available ground truth and laboratory results for a detailed interpretation. The objectives of this study with SAR imagery are: 1) to determine litho-physical characteristics and for surface mapping, hence for recognizing geologic formation, 2) to detect structural and lithological features by using spatial signatures of the Radar imagery. The Imaging Radar of the ERS-1 has provided new information of surface characterization of the study area considerably. This technique has proven to be very useful for delineating and identifying spatial surface indicators, and a direct correspondence with certain kinds of surface lithology, tectonic structures and as well as with geomorphologic landforms could be found. After interpreting ERS-SAR imagery data the geology of the study region had to be revised. Improved understanding of the surface processes during late Miocene-early Pliocene has been gained. The sensibility of the Radar for surface expressions is used to understand present and past tectonic activities. Its potential for three-dimensional sensing allows an enhanced analysis of surface forms and to locate and map additional geologic features even in poorly developed relief. Surface back-scattering profiles including roughness changes, as well as 3-D models, which are derived from the digital terrain, data including SAR data were used to better determining lithologic units and tectonic features. Finally, ERS-1 viewing geometry is suitable for the delineation of fluvial clastics, alluvial fan and gypsum deposits, geological structures, surficial materials.

RECONSTRUCTION OF THE PALEODRAINAGE AND GEOLOGIC EVOLUTION OF LAKE ABHE, EAST AFRICA

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ABSTRACT

The arid zones of the Earth are key elements to understand the geological behavior of large-scale sedimentary processes occurring on the planet. We analyzed the geomorphology, tectonic and sedimentary evolution of Lake Abhe, East Africa, using different remote sensing data (ERS 1-2 radar, LANDSAT and CORONA) in order to obtain a complete and multitemporal data set of the study area. Lake Abhe extends over a large tectonic depression of the southern part of the Afar Depression of the east African rift system. The paleodrainage and paleomorphologies show that the lake covered an area at least four times bigger in the late Pleistocene. The retreat of the lake is continuing nowadays: the present lake has an extension of 155 km2 whereas it was 350 km2 in the '60s. The shorelines of the lake receded of two km in the last forty years, unveiling an intricate relict of fluvial pattern mainly dry presently. This helps in calculating the amount of water discharge in the lake during the humid climate and its variation through time. The main tributary of Lake Abhe is the perennial Awash River which shows several avulsions close to the lake and also forms a few abandoned deltas. This area is very peculiar in terms of tectonic and depositional pattern relationships. A few conoids and young lacustrine deposits appear to be cut by new fault system. Although the fall of the Lake Abhe level has been found related to the regression which also affected the central Africa lake systems in the late Pleistocene, we are also evaluating the possibility that the rapid variation of the lake level may be related to recent tectonic activity that has changed and strongly affected the drainage of the headwater of the lake. This is part of the ESA project AO3-348.

COMPARING SPACEBORNE ERS-SAR AND AIRBORNE GEOPHYSICAL DATA: APPLICATION TO GEOLOGY IN THE FRENCH GUIANA RAINFOREST LANDSCAPES

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ABSTRACT

Since the beginning of the ERS program in 1991, a great range of thematic results applied to the French Guiana has been demonstrated (PPF-12, etc.). The accuracy of the radar signal has notably provided a renewed morphological view of this part of rain-forest close to the equator. Schematically the French Guiana geological setting comprises deeply-altered magmatic rocks with sedimentary units in the north and in some places in the central-southern part. In July and December 1996 the French Geological Survey (BRGM) working for the Ministry of Industry supervised an airborne geophysical survey combining magnetism and spectrometry measurements, operated by CGG (Compagnie Générale de Géophysique). The objectives were (i) the realisation of a global geophysical mapping to consolidate the geological background, (ii) an aid to the elaboration of a strategy for the mineral exploration of the French Guiana, especially for gold, (iii) the synthesis and the amalgamation of former geophysical surveys realized in the 70's. Magnetism and SAR data provide information about the basaltic veins which cut through the Proterozoic terranes. Those veins reveal the onset of the Atlantic ocean, about 180 Ma ago. The magnetic results should be deeply influenced by the alteration under a tropical climate, which has induced the formation of lateritic deposits. Radiometry is undoubtedly more interesting, notably because the contribution of three different elements has been distinguished: on the one hand, uranium (U) and thorium (Th) abundant in the northern part of the French Guiana and especially in the eastern part, and on the other hand potassium (K) highly concentrated in the Upper Detrital Group, namely Orapu, at the border between the sedimentary and the magmatic rocks. This geological unit is characterized by high gold rates. Some geophysical features could be compared with the ERS-SAR lineaments revealing faulting, schistosity or lithology, for example by alignment of the hydrographic network. The remote sensing backscattering mainly due to the shape of the canopy (C-band) modulated by regional morphology and surface roughness, and the geophysical data corresponding to characteristics of the rocks themselves are highly complementary.

GEOLOGY/VOLCANO MONITORING

ENVISAT: THE AATSR VALIDATION PROGRAMME

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ABSTRACT

Validation is an essential component in the successful operation of any satellite mission, designed for Earth observation. It is the means by which data collected by the sensors are assessed independently for their quality. Not only is validation a precursor for the application of satellite data but the process of validation itself, brings up many scientific issues as it involves all aspects of the process of making a geophysical measurement. One of the instruments on board ENVISAT is the Advanced Along Track Scanning Radiometer (AATSR). Continuing from its predecessors, ATSR and ATSR-2, the prime objective of AATSR is to provide accurate measurements of global sea surface temperature, which will be used, for climate research, including change detection. AATSR will have three visible/near infrared channels, and four infrared and mid/thermal channels. Plans for updating each data product from AATSR are already well underway. This paper will present an overview of the AATSR validation plan, providing information on the different validation activities that make up the plan as a whole. Measurements cannot be made of every surface viewed by the sensor, at all times throughout the year, and decisions concerning priority areas must be made. Standard measurement procedures are also important, and reference will be made to the AATSR validation measurement protocol. As well as specific validation projects and collaborative activities with other validation teams of other instruments, it is anticipated that additional data will come from the wider scientific community.

THE VALIDATION OF ENVISAT ORBITS

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ABSTRACT

ESA has the responsibility for precise orbit determination (POD). The POD verification activity relies on a cooperative investigation among the ENVISAT project POD team and investigators working in this area. The verification activities will be conducted both during production process (operational verification) and afterwards (expert verification). The goal of the operational verification is to ensure that the orbits to be included in the RA-2 products (or any other product) meet mission accuracy requirements. Results of the operational verification are summarized in a verification report which is provided along with the orbit. The expert verification focuses on a more detailed understanding of the nature of the orbit error. This verification is performed both by the project POD team and by members of the POD Working team. The project POD team expert verification starts during the orbit production process. Additional selected members of the POD Working team also have access to the orbit data before delivery, for verification purposes. Others conduct their verification efforts once the orbits are officially available. Results from all verification centers are collected for publication in a verification report. The orbit verification tools are traditionally divided among internal and external tests. Internal tests do not need any data other than those used for orbit production; they are performed during the orbit production process itself. External tests are based on the use of data not included in the orbit determination or on orbits produced by different groups using different software and/or configuration. In addition to precise DORIS (+SLR) orbit ephemeris, all other types of orbits will be considered: medium-accuracy DORIS orbit ephemeris, and also the DORIS real-time navigator orbit and FOS orbits. The POD Working team will focus on key topics: prelaunch verification of project POD procedures, assessment of POD models and standards, post-launch orbit accuracy evaluation. It will issue an orbit verification plan. A postlaunch verification report will be prepared with a detailed assessment of the orbit accuracy. A POD verification activity based on a short-arc evaluation of regional ENVISAT orbits, especially over the Mediterranean Sea, so that results may be used for the purpose of RA-2 calibration.

THE RA-2 AND MWR VALIDATION AND CROSS-CALIBRATION

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ABSTRACT

ENVISAT will carry a radar altimeter of new generation named RA-2 and a microwave radiometer (MWR). The RA-2 provides improved measurement performances and many new capabilities which will benefit the science and application community. With almost two decades of altimetric measurements acquired by ESA, long term evolution of glaciologic and oceanographic parameters playing a key role in climate change can be addressed. This requires homogeneous data sets inter-calibrated within a few millimeters. The ENVISAT RADAR ALTIMETRY CROSS-CALIBRATION and VALIDATION TEAM has been set up to cross-calibrate the RA-2 on ERS, calibrate the MWRinstrument and validate the user level geophysical products. Details of the objectives, strategy and methodology will be presented.

RA-2 ABSOLUTE RANGE AND SIGMA-0 CALIBRATION AND IN-FLIGHT VERIFICATION

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ABSTRACT

The RA-2 altimeter is intended to continue an uninterrupted series of measurements of sea level and ice-sheet elevation started by ERS-1 in 1991. To fully exploit these measurements, an absolute reference in the time series, and a distinction between instrumental artifacts and significant geophysical signals, is necessary. Therefore, the range bias and instrument drift shall be determined with a accuracy of 1 cm and 1 mm/year respectively. Such accuracies can only be achieved by using: * a large number of measurements to reduce random errors; * a diversity of measurement techniques and independent data analysis to reduce susceptibility to systematic errors. Due to the limited temporal sampling of the 35-day repeat orbit of EnviSat, the resulting overall concept is a regional calibration which makes use of the north-western Mediterranean basin as a reference surface, with a number of particular of high-confidence super-sites.

Measurement of the vertical-incidence backscatter coefficient, sigma-0, by radar altimeters has been used for the determination of wind-speed over the ocean. The models used are empirical and so it has been sufficient to perform relative calibration between missions. These are traced back to GEOS-3 resulting in a minimum uncertainty in the absolute sigma-0, for all altimeters, of 1 dB. Recent applications of the altimeter sigma-0, such as physically based models of sea-state bias and wave period, require an absolute sigma-0 measurement. The measurement technique makes use of a newly developed transponder, using a delay-line for clutter suppression. The altimeter will operate in a preset mode, and will acquire individual echoes over the transponder. Special data-processing techniques are also being developed.

During the six month of commissioning an in-flight instrument verification activity will also be performed, with the following main objectives: * Instrument verification of main capabilities and operations in all its modes. * Instrument parameter tuning and optimisation: verification of optimum setting of the instrument parameter performed in the lab on-ground can only be done in-flight, once the instrument is acquiring scientifically meaningful data. Algorithm parameter optimisation, and verification of the auxiliary data retrieval and use in these algorithms. This verification is crucial for any calibration to be accurate. Therefore, despite the 6 months saturation of the overall verification activity, sometime after the RA-2 switch-on the data shall be such that is accurate enough for calibration purposes.

THE SCIAMACHY VALIDATION PROGRAM

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ABSTRACT

The SCIAMACHY instrument on board ENVISAT will measure high-resolution spectra of the atmosphere. Concentrations of various atmospheric constituents will be derived from this. Validation is essential to ensure the quality of these derived parameters. The validation activities are co-ordinated by the SCIAMACHY validation and interpretation group (SCIAVALIG), a sub-group of the SCIAMACHY Science Advisory Group (SSAG). Validation of the SCIAMACHY measurements is a significant challenge, due to the broad range of data products from nadir, limb and occultation measurements. In addition to the validation of the calibrated spectra it is necessary to assess the performance of the processing algorithms in converting radiances into atmospheric parameters, and to determine random and systematic errors associated with every resulting data product. This will be achieved by the collection of suitable validation data from different ground-based, airborne and satellite instruments. With the use of appropriate tools and models, the SCIAMACHY and validation data sets will be analysed and compared. An accurate assessment of errors is essential for the use of such data in both scientific and general applications. The validation activities consists of two complementary parts: 'Core' validation, which provides a minimal but essential validation of SCIAMACHY and validation based on selected AO proposals. Moreover the validation of SCIAMACHY is divided in three phases. In the commissioning phase the preliminary validation will be performed. This is followed by the main validation phase, which provides the error assessment for the first official data release of validated SCIAMACHY products. Subsequently the long-term validation of data products aims to ensure their quality -- independent of degradation of the instrument - throughout the lifetime of the instrument.

THE VALIDATION OF THE PRODUCTS DERIVED FROM THE ATMOSPHERIC CHEMISTRY INSTRUMENTS

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ABSTRACT

Geophysical validation is a process whereby the geophysical data products derived from the measurements made by the satellite sensors are checked against independent (in-situ) measurements of the same parameter. The parameters provided by the Envisat Atmospheric Chemistry Instruments are vertical profiles of pressure, temperature, O3, H2O, NO2, NO3, CH4, HNO3; columns of O3, NO2, H2O, N2O, CO, CH4, OClO, H2CO, SO2, aerosol absorption indicator; cloud-cover fraction and cloud-top height/pressure. The algorithms designed to derive estimates of the above parameters need to be verified. For this a large number of correlative observations under a wide range of conditions is needed to arrive at a representative and statistically relevant data quality assessment, and to provide insight into sources of error both in the Envisat data and the correlative data sets. Correlative atmospheric measurements are planned using satellite instruments, balloon-borne instruments, airborne instruments and ground-based instruments. Satellite data will be used for global intercomparisons. The nearly global coverage of most of these provides many collocations under a wide range of conditions. Balloon-borne instruments are to be flown on large stratospheric balloons and in addition, ozone sondes are routinely launched from a large number of sites. Airborne instruments are to be flown on a stratospheric aircraft capable of cruising at altitudes up to 21km and covering a radius of 3600km allowing several Envisat vertical profiles to be validated per flight. Ground-based instruments include different types of spectrometers, radiometers and lidars. Many of them are operated on a routine basis, and quality control procedures that have matured over many years are rigorously and routinely applied. In order to increase the number of coincident data points, assimilation models and trajectory analysis calculations are used to extrapolate observations in time and space. The validation of the products derived from the Atmospheric Chemistry Instruments is coordinated by the Atmospheric Chemistry Validation Team (ACVT) a group of investigators involved in algorithm verification, data acquisition, data assimilation and data analysis.

GOMOS CALIBRATION AND PROCESSOR VERIFICATION

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ABSTRACT

The GOMOS Commissioning phase can be summarised in three main objectives: a) verification of instrument health and operational capability, b) instrument calibration as per level-1b processor needs and c) end-to-end validation of level 1b (engineering) and level 2 (geophysical) processor. The GOMOS commissioning phase planning is described in a single document, 'GOMOS Commissioning Verification Scenario' and is a joint effort of ESA, the GOMOS science institutes and industry (ESA Support Laboratory, ESL). Following the initial instrument checkout by the flight operation centre, the instrument will start to collect occultation and calibration data using targets defined in the calibration mission plan, optimised to verify the on-ground performance and calibration database. The GOMOS Instrument Engineering Calibration Facility incorporates a stand-alone calibration processor, CALEX. The functionality of this processor reflects the content of the calibration database; satisfying all needs of the level-1b processor. In addition, CALEX will include added functionality useful for the instrument performance evaluation during and after the commissioning phase. A palette of tools necessary to process and visualise the CALEX computation-files is presently under development. Once the instrument calibration database has been updated and verified the level 2 validation will commence and will particularly focus on the internal consistency of the geophysical algorithms, products and error assessment thereof. The calibration versus processor validation is executed in an iterative manner and will result in a tuned level-1/2 processor, updated calibration and configuration database and error budget assessment. The GOMOS commissioning planning is well under way with calibration exercises taking place for all major performance drivers. The paper presented reviews and demonstrates the appropriateness the GOMOS specific calibration and validation plan.

MIPAS CALIBRATION AND PROCESSOR VERIFICATION

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ABSTRACT

The Michelson Interferometer for Passive Atmospheric Sounding will be one of the atmospheric payload instruments on board ESA's polar orbiting ENVISAT. Sensing the Earth's limb emission in a wavelength range 4.15 ... 14.6 micrometers it will allow detection of a large number of middle atmospheric constituents of primary interest for various disciplines of atmospheric research. Besides generation of geolocated, fully calibrated limb radiance data (Level 1B products), abundancy profiles of a set of high priority target species, O3, H2O, CH4, N2O, HNO3, together with atmospheric pressure, temperature (Level 2 products) will be systematically processed and disseminated in near real time. Whereas the development of the essential MIPAS ground processor elements has been finalised activities are in progress aiming at the optimisation of the overall algorithm performance, and to enhance primary auxiliary data and instrument settings. Moreover, specific software tools are under development supporting the in-orbit calibration of the instrument and the validation of critical Level 1B/2 algorithm components. Current analyses focus on the simulation and optimisation of calibration and scene measurement scenarios as required in conjunction with the various post-launch verification and characterisation tasks. Actual performance parameters as measured with the MIPAS flight model and expected variabilities in the target atmosphere are taken into account, as well as the results of various dedicated support studies, e.g., on the definition of spectral intervals (`microwindows') used in Level 2 profile retrievals. The work is performed in a coordinated effort involving both industrial and scientific expert teams. This paper will summarise activities related to pre-launch validation of critical components of the ground segment algorithm. The approach adopted for the early in-flight operation of MIPAS as well as the role of primary ground segment facilities (e.g., Payload Data Segment, Instrument Engineering Calibration Facility) will be highlighted. Finally, the overall strategy for the in-flight characterisation and verification of instrument and ground processing chain will be outlined.

MERIS VALIDATION PLAN

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ABSTRACT

The validation of the Meris products is based on the proposals from a number of investigators to exchange MERIS data acquired during the commisioning and validation phases against data that will be deposited in a central archive.

Strictly speaking the validation exercise can only take place after the calibration of MERIS been successfully established, that is after the commissioning phase. However, the collection of data for validation purposes, particularly for marine products, will start as soon as MERIS starts acquiring data, to take advantage of better visibility in the Northern Hemisphere summer.

The products of the marine branch will be validated using measurement campaigns using fixed buoys, ships of opportunity, dedicated cruises and the AERONET network. Coordination of the proposals for the validation of marine products will be achieved in part by the issue of requirements by the institutes responsible for the development of the MERIS ground segment algorithms.

The validation of the products over land will address the determination of aerosol type and optical thickness over dense dark vegetation patches using the AERONET network.

The MERIS cloud products (cloud top pressure, cloud albedo and cloud optical thickness) will be validated through dedicated flight campaigns that will take close remote sensing measurements of cloud radiative properties, achieve in situ measurements of cloud dynamical and microphysical properties, and assess the ground albedo and the transmitted light through the cloud layer. Water vapour over land will be validated over limited areas, through a network of ground stations.

Preliminary validation results will be presented at a workshop that will be held three months after the end of the commisioning phase.

MERIS INSTRUMENT CALIBRATION

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ABSTRACT

Preflight characterization results and the in-flight calibration plan are described for the MEdium Resolution Imaging Spectrometer (MERIS) to be launched in 2001 on board ESA's ENVISAT spacecraft.

The MERIS instrument consist of 5 push broom cameras, each with 15 spectral bands in the visible and near-infra red.. The cameras point in different directions across track covering a swath of 1150 km and providing a global coverage in less than three days. The instrument has been successfully built to challenging geometric, spectrometric and radiometric performance specifications - i.e. radiometric accuracy must be within 2 accuracy.

Onboard calibration will provide fortnightly updates of the instrument gain coefficients. Solar illuminated Spectralon diffuser panels are used to provide a uniform target across the complete MERIS swath. A second Spectralon diffuser panel will be deployed every three months to monitor the degradation of the regularly used calibration panel to the harsh space environment. An Erbium doped Spectralon diffuser will also be deployed every three months to monitor the evolution of the spectral characteristics of the instrument.

During the mission, ground data processing to accomplish radiometric calibration, geometric rectification and geophysical retrievals will proceed in an automated fashion. This paper will describe the preflight characterization results, the method used to exploit this data in the ground processing and the in-flight calibration plan including the validation of the MERIS Level 1b product.

ASAR GROUND PROCESSOR VERIFICATION AND WAVE VALIDATION

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ABSTRACT

The European Space Agency has selected an Advanced Synthetic Aperture Radar operating at C-band (5.331 GHz) as a payload for the forthcoming ENVISAT mission. The sensor ensures continuity of ERS SAR and features enhanced capability in terms of coverage, range of incidence angles, polarisations and modes of operation. The key features of the ENVISAT ASAR system and instrument modes of operation are detailed in the companion parent paper [Torres et al]. The ASAR Ground Processor will be presented highlighting the concepts for its development and the performance achieved versus the ESA specifications. The new ASAR products and their image quality will be detailed including angles of incidence, Equivalent Number of Looks, resolutions and estimated noise equivalent sigma0. The selection of the processing algorithm for each product is discussed based on the image quality requirements and the throughput. A pre-validation of the processor has been done using ERS data. This allows ESA to verify the quality of the products with large datasets before the launch and to dispose of simulated ASAR products with the ENVISAT format. Examples of these simulated ASAR products will be presented, with their quality measurements. The ASAR Generic processor is already integrated in the ESA Payload Data Handling Station and will be procured to the to the ENVISAT Processing and Archive Centers (PACs) and National Stations offering ESA ASAR services. The use of an ASAR Generic Processor will ensure product compatibility between the different centers (same format and processing algorithm) and will simplify the product validation. The processor is capable of processing medium resolution products and their correspondent browses in near real time and high resolution on request products off-line. It can operate in stripline mode without geometric and radiometric discontinuities between slices, allowing medium resolution products containing data up to 10 minutes of acquisition. The validation plan of the newly developed Cross Spectra and Wave Spectra Algorithms (NORUT) for the generation of the Wave Mode Level 1b product (ASAR Cross Spectra and imagette) and the Wave Mode Level 2 product (ASAR Wave Spectra and Wind retrieval) will be detailed. Pre-launch validation results using ERS measurements, wave models and collocated in-situ (wind and wave field) data from platforms and ships will also be presented.

ASAR INSTRUMENT CALIBRATION

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ABSTRACT

This paper presents the approach to be taken during the commissioning phase for the in-flight calibration of the ENVISAT-1 ASAR instrument. The philosophy presented is a logical progression from the experience gained during calibration of the ERS SARs. The ASAR has a comprehensive internal calibration loop which is described distinctly from the external calibration and characterization. The antenna patterns of the various beams have been fully measured during on-ground flight-model testing and have been used for initial performance predictions. In the first instance these patterns will also be used by the ground processor although in-flight characterization of the mainbeams will be made over the South American rainforest. In a similar way to ERS, radiometric calibration will be achieved using precision calibration transponders situated in the Netherlands for ASAR there are a total of four, three fixed and one transportable. These transponders can operate in both horizontal and vertical polarizations and are also capable of recording the azimuth beam patterns and supporting the external characterization mode of ASAR. The techniques and the performance objectives are also reviewed. The instrument calibration activities will be centred around the Instrument Engineering Calibration Facility (IECF) which has been especially developed, principally to support the commissioning phase activities. The paper concludes with an overall view of the status of the preparatory activities.

THE ENVISAT CALIBRATION AND VALIDATION PROGRAMME

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ABSTRACT

The paper presents an overview of the Envisat Calibration and Validation programme. The paper focuses on the organisational aspects and on the presentation of the overall approach.

The Calibration and Validation activities are organised around 11 Cal-Val teams, each composed by ESA staff, industry cognisant engineers, ESL representatives and a large number of PI's, most of which have been selected through the Envisat Announcement of Opportunity for the Exploitation of the Envisat data.

The objective of the Cal-Val teams is to authorise the release of the many Envisat products after the six months of the Commissioning Phase (for Level 1b products) and by the Validation Workshop (9 months after the launch, for the Level 2 geophysical products).

THE ENVISAT MISSION

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ABSTRACT

This paper provides an overview of the Envisat Mission, the largest-ever Earth Observation European mission. The paper lists the payload composition (a total of 7 ESA developed instruments and 3 Announcement of Opportunity instruments), the platform characteristics and capabilities (8 tons and 6 KW power). An overview of the distributed ground segment and its services is given. The data recovery strategy is emphasised (Envisat will embark 2 solid state recorders). The Envisat products are presented (in terms of format structure and main characteristics) along with the way of retrieving/ordering them.

Domains:

- **OCEAN DYNAMICS**
- **SEA ICE**
- **ENVISAT**
- **SEA FEATURES**
- **METHODS**

CERSAT ACTIVITIES

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ABSTRACT

Since 1991 CERSAT has been the French processing and archiving facility for the low bit rate processing of ERS1 and ERS2 radar altimeter and scatterometer. Since 1996 CERSAT has extended its activities to other scatterometers (NSCAT, QUIKSCAT launched by NASA), and also started providing the users with value added products such as the Mean WIND FIELD Atlas and the SEA-ICE atlas derived from ERS and NSCAT scatterometers. These atlases are respectively distributed to 1800 and 200 laboratories.

In 1996 we also started collocation activities providing the users with collocated database between all the sensors archived at IFREMER (ERS 1 and ERS2 radar altimeter and scatterometers, NSCAT and Quikscat scatterometers, SSM/I Radiometer for F10/F11/F13/F14 and Topex). The news sensors should be rapidly integrated in the system after their launch On the stand CERSAT will present all these data, its WWW server, its collocation database, and the future developments for the new sensors such as Envisat, SeaWinds, METOP.

A VISUAL ARCHIVE SYSTEM OF SEA ICE PARAMETERS DERIVED FROM SYNERGISTIC ATSR, AVHRR, SSMI AND ERS-1 SAR DATA

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ABSTRACT

Layers of information derived from coincident and co-located data of Arctic sea ice, acquired from different sensors, are presented within a display and browsing system that has unique users interactive features. Sea ice surface parameters are calculated from the following sensors: (1) surface temperature from the IR channels of AVHRR and ATSR independently; (2) surface albedo from the AVHRR visible channels, (3) thickness of thin ice (recently growing) from integration of SSM/I and AVHRR, and (4) major ice types (thin, first-year, and multi-year) from ERS-2 SAR. All parameters along with the original observation parameters from each sensor are combined in a visual display system in which each parameter (or a group of observation parameters) is presented as a layer of information. The entire information hierarchy can be displayed, browsed and animated in a very fast manner. The data from all sensors are co-located using a technique that defines the contours of the footprint from a coarse-resolution sensor (such as SSMI or AVHRR or ATSR) and overlays it on an image from a finer resolution sensor. These contours can also be displayed to examine the heterogeneity of ground cover within a footprint of a coarse-resolution cell using the coincident samples from the corresponding fine-resolution cell. The thermal history of Arctic sea ice in the study region will be presented. This approach allows the user to absorb huge amount of imagery data in an intuitive way.

DESIGN OF THE NETHERLANDS SCIAMACHY DATA CENTER

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ABSTRACT

The primary goal of the Netherlands SCIAMACHY Data Center (NL-SCIA-DC) is to provide data services and processing facilities to Dutch users of SCIAMACHY data beyond those offered by the ENVISAT ground segment and German D-PAC. The NL-SCIA-DC will offer data services for GOME and SCIAMACHY data. In the future more instrument data may be added to the data center. As the NL-SCIA-DC is a joint effort of KNMI and SRON, the data center will be distributed over these two institutes.

The need for a NL-SCIA-DC came from the atmospheric researchers in the Netherlands who needed faster access and more flexibility in accessing and processing GOME data. From experience in previous projects the need for close cooperation with the future users was recognized. Therefore the users do not only define the User Requirements, but also need to be actively involved in the development of the NL-SCIA-DC. The users got access to development versions of the data center, thus allowing them to evaluate their requirements and allowing new requirements to be incorporated in the design. For these reasons it has been decided to apply an evolutionary life cycle approach for the development of the NL-SCIA-DC. The evolutionary approach consists of multiple waterfall cycles with an overlap in development. All documents and project plans are made according the ESA PSS-05-lite standard.

While the described development was based on GOME data and data processing, it is intended to operate these facilities from 2001 onward and continue the development with new data from SCIAMACHY on ENVISAT.

Features: * Access the NL-SCIA-DC through the Internet at any place on any computer.
* Interactive access to satellite data located at the NL-SCIA-DC. * Generic, dynamic and platform independent GUI. * Three data selecting mechanisms:1. Catalogue search enables file level search for data. 2. Query search enables data selection on meta data parameters. 3. Browse search enables a graphical entry to select data. * Downloading of selected data. * (Re) processing of selected data. * User settings are saved and used in the next session. * Distributed architecture not visible for the user. * Facilities to test new data processors.

ERS SAR VIEWS THE TROPICAL AND SUBTROPICAL OCEAN: A NEW WEBSITE

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ABSTRACT

ERS SAR images acquired over mid-latitude ocean areas have been used quite extensively to study mesoscale phenomena in the ocean and in the marine atmospheric boundary layer, but not so in tropical and subtropical ocean areas. In order to improve this situation the European Space Agency (ESA) has funded a project to set up a website aimed at informing a broad readership about the potential of ERS SAR imagery for studying these phenomena also in low latitude ocean areas. We have searched the archives at ESA as well as at the Singapore and the Taiwan ERS ground stations for ERS SAR images showing pronounced radar signatures of mesoscale oceanic and atmospheric phenomena like, e.g., oceanic internal waves, ocean current fronts, underwater bottom topography, river plumes, oil pollution, atmospheric internal waves, coastal wind fields, atmospheric boundary layer rolls, and tropical rain cells. From these images we have selected more than 200 ERS SAR images and put them on the website. For most of them we have added supporting data like NOAA AVHRR images, SPOT images, bathymetric maps, or weather maps and have added comments on how geophysical parameters can be extracted from them. In the presentation, which requires an LCD projector, the most spectacular ERS SAR images together with supporting data will be presented and their usefulness in scientific investigations will be pointed out.

ENVIVIEW: AN ENVISAT PRODUCT TOOL

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ABSTRACT

The Envisat mission, to be launched next year, is the largest European remote-sensing mission ever flown. It will deliver a very large number of data products from its 10 instruments. The Envisat products will use a specific data format, where each product is orbit based, binary encoded and contains several geophysical quantities in the same product file. With the aim of improving and widening the access to the Envisat products, the European Space Agency is developing a product tool (called EnviView) which is characterised by the following main properties: it is platform independent (developed in Java); it can access any Envisat product; it can display the content of any field in the product (image or graphs); it can be run in manual or batch mode; it can display the value of any field in any product along with its format definition and with its scientific definition; it includes the product handbook of all Envisat products. In addition, EnviView can convert part or all of an Envisat product into a number of different formats, such as HDF. Users who are already familiar with HDF products or that have already developed application software for HDF products can use EnviView to bring the Envisat products directly into their working environment. EnviView can also be used to allow immediate access to the Envisat products by all those commercial software packages, which are able to read and manipulate HDF files.