



The ESA SAR missions and their Exploitation for Science and Applications Development



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ESA-ESRIN Frascati Italy



ERS Missions



ERS mission overview

- 15 years of ERS-1/2 data in the archive
- (suitable for applications requiring long term series products)
- ERS-2 achieved 11 years in orbit in April 2006
- (was designed for 3 years nominal lifetime)
- Some problems with the platform
- (gyroscope in 2001, tape recorder in 2003)
- but all instruments still functioning well
 - engineering solutions have been developed:
 - new 'gyro-less' working mode
 - set up of a station network for Low Bit Rate data recovery
- Operations funding until 2008



ERS-2 satellite and payload status

<i>Mission elements</i>	<i>Expected evolution</i>	<i>Comments</i>
Service Module	Good	Relaxed attitude control +/- 2deg, all other sub-systems with full redundancy. SPOT-1 platform flown for 17 years before de-orbiting.
Propulsion and Hydrazine	Excellent	1/3 of hydrazine has been consumed within 11 years
Payload Equipment Bay	Fair	Tape Recorders Failed , Realtime mission only with some 40% global coverage. Transmission Tube redundancy available.
SAR Image Mode	Excellent	
SAR Wave Mode	Excellent	
Scatterometer	Fair	Sub System on redundant side
RA & MWR	Excellent	
ATSR	Good	Scan Mirror problem has been overcome by patches on ground
GOME	Good	Calibration lamp problem overcome by using sun measurements
PRARE	Excellent	Reduced surface transponders covering North & South Poles and Europe only; no redundancy

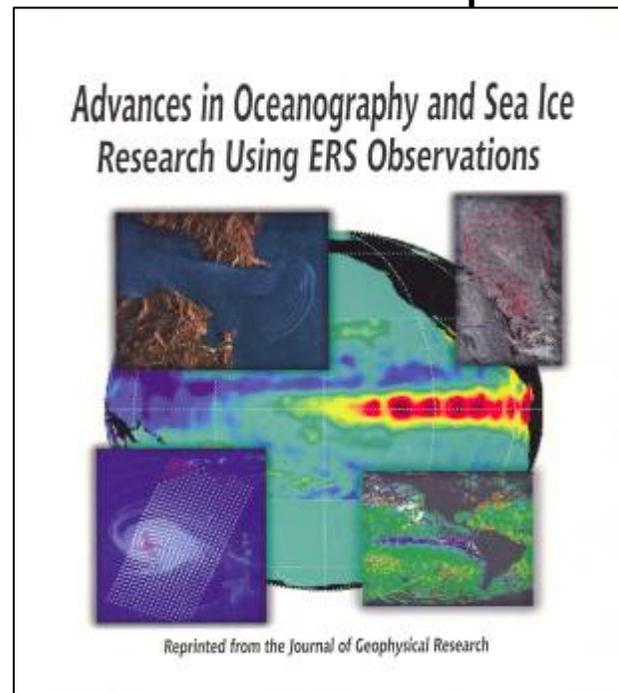


ERS AMI SAR exploitation

ERS Achievements - Science

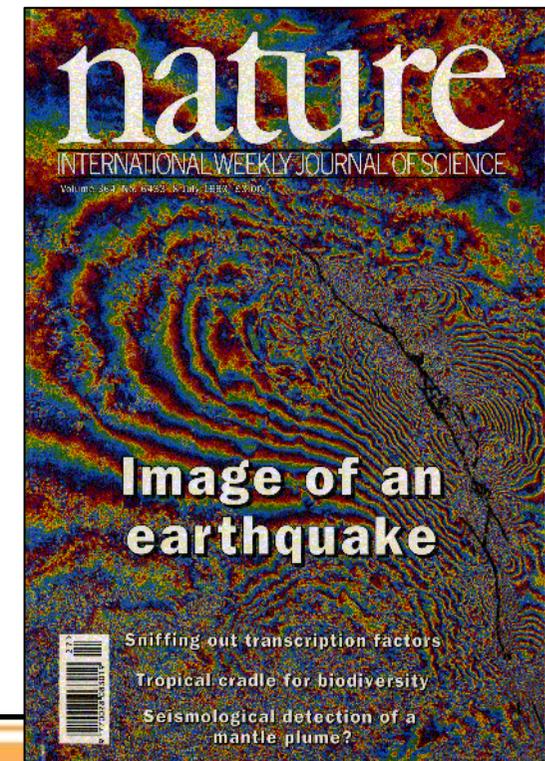


ERS and Volcanic activities



Oceanography and sea Ice

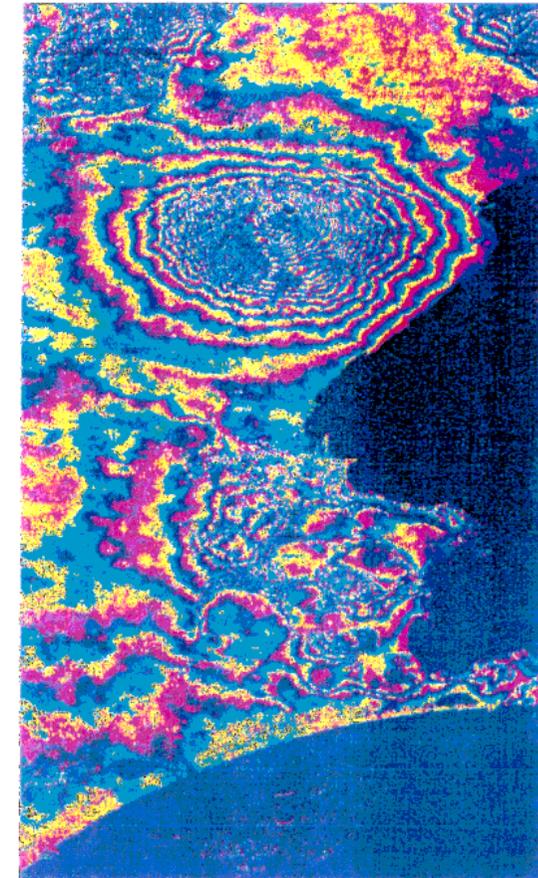
ERS and SAR Interferometry



Yves-Louis Desnos

FRINGE-1992

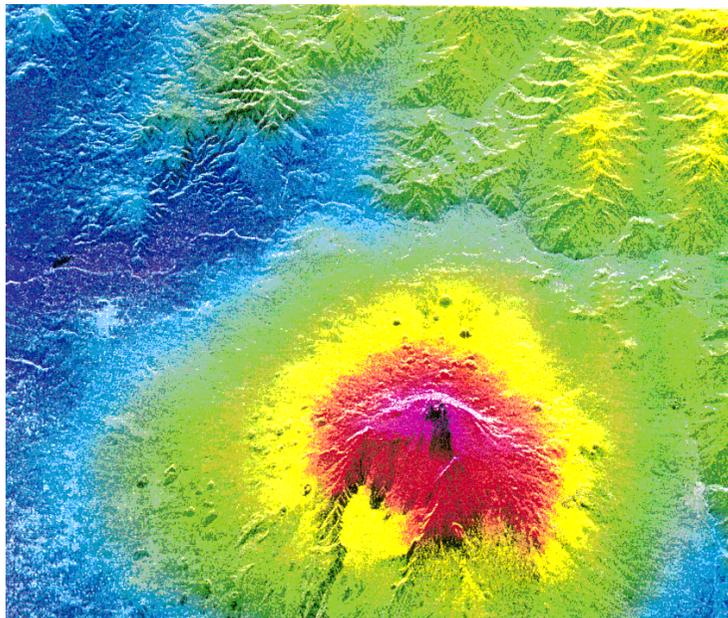
- Originally not anticipated in the ERS-1 specifications
INTERFEROMETRY was pro-actively supported by ESA
- ERS-1 INSAR activity is co-ordinated within the framework of a mission-dedicated Working Group, called FRINGE,
- set up by ESA/ESRIN at the beginning of 1992 and currently comprising about 200 groups world-wide:
 - Scientific exchange
 - Access to test data
 - Development of first tools





ERS-1/ERS-2 Tandem 1995

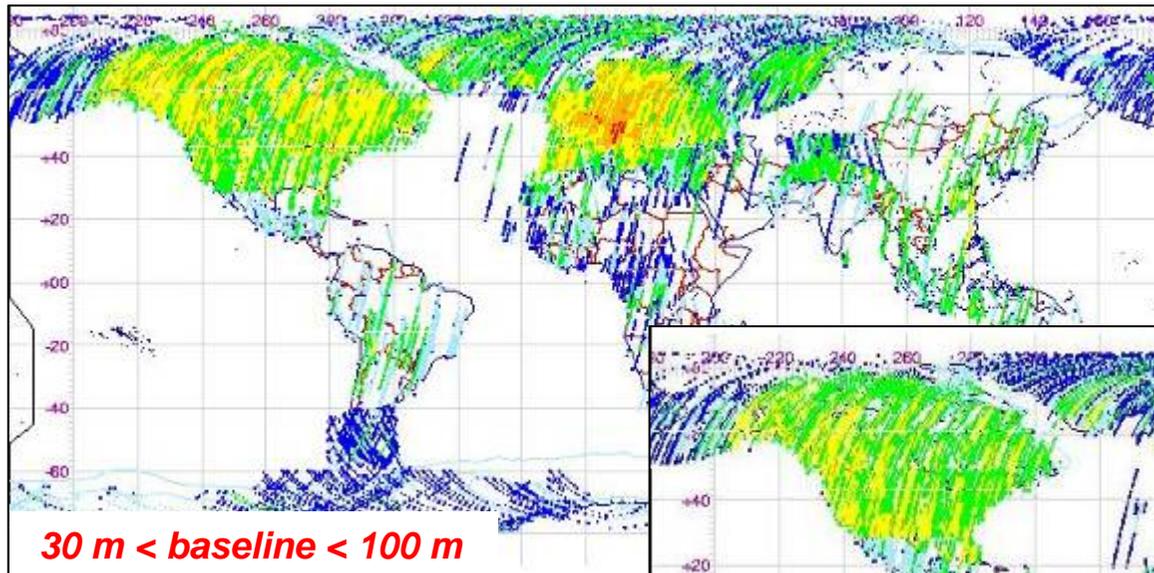
- The successful launch of ERS-2 in 1995 opened the opportunity to fly both ERS-1 and ERS-2 in tandem as a single Interferometer.
- The ERS Tandem mission began in September 95 and will last for a period of 9 months in a configuration such that there a 1-day interval between ERS-1 & ERS-2 observing the same area of ground.
- “Fringe members reported high values of interferogram quality”



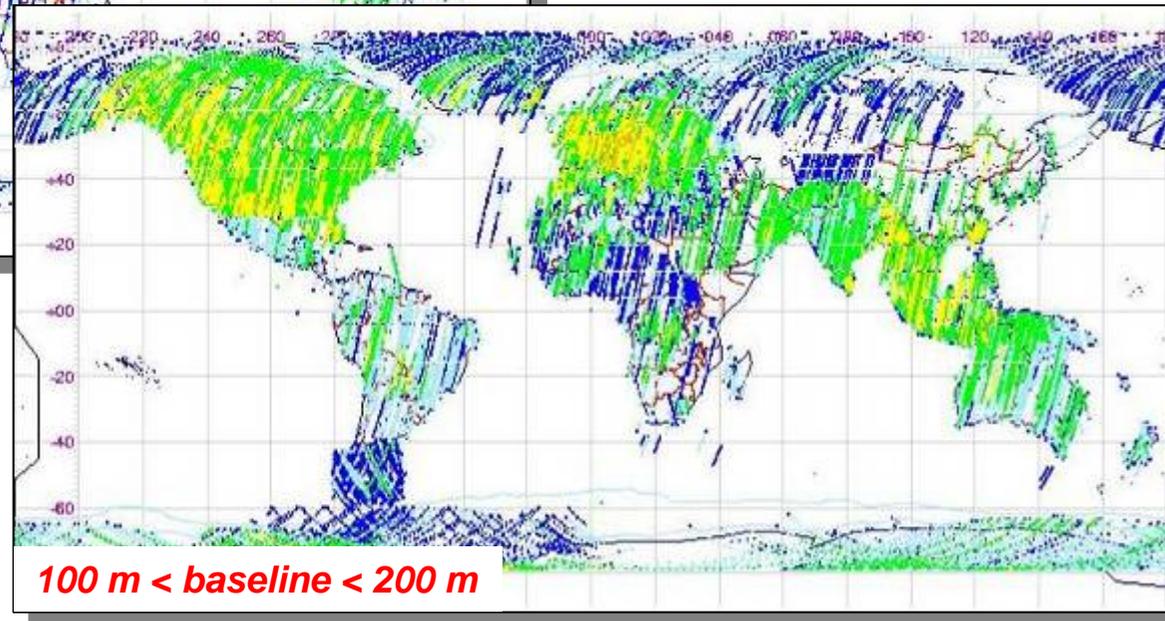
ERS-1/ERS-2 phase interferogramme for the region of Etna in Sicily produced by the group of Ph. Hartl at the Insitiute for Navigational Studies (INS)

Data catalogues

ERS SAR data: Tandem ERS-1/ERS-2



*ERS SAR tandem :
a unique dataset!*



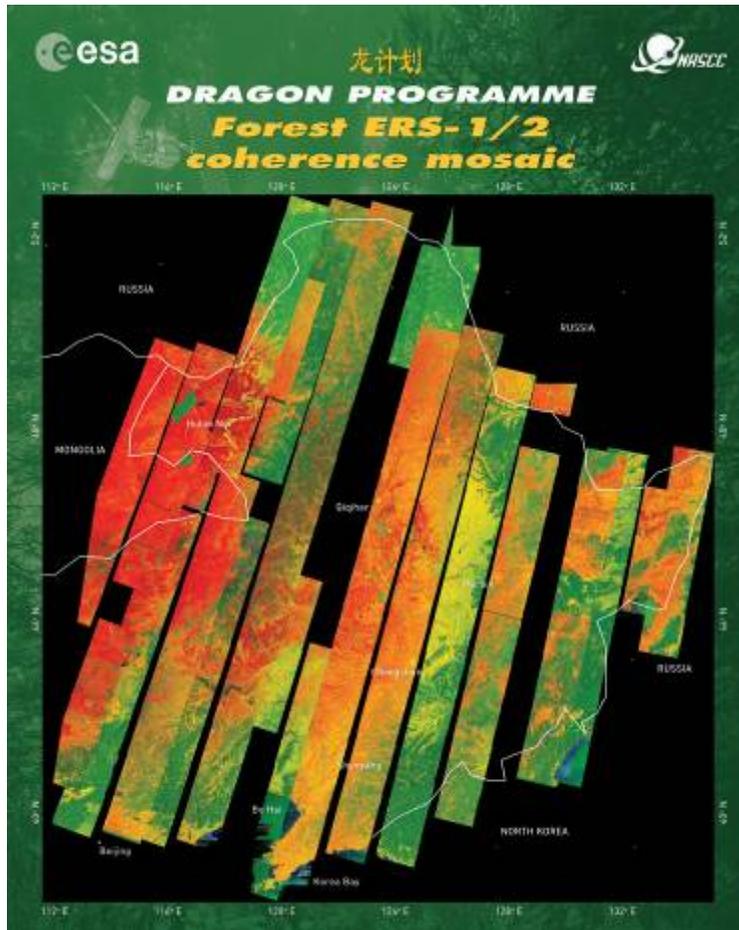
73% of the tandem data meet the optimal baseline requirements for DEM generation of 50 to 300 m



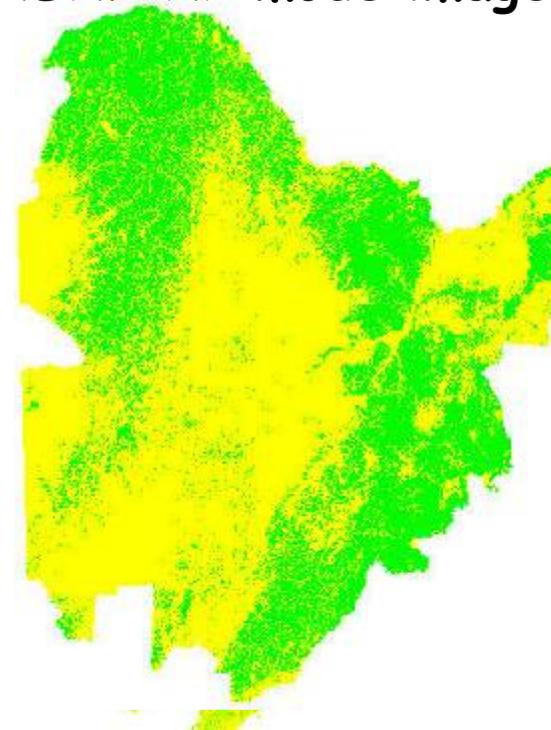
ERS & ENVISAT exploitation

Forest Mapping in NE China Using ERS InSAR and ASAR AP data

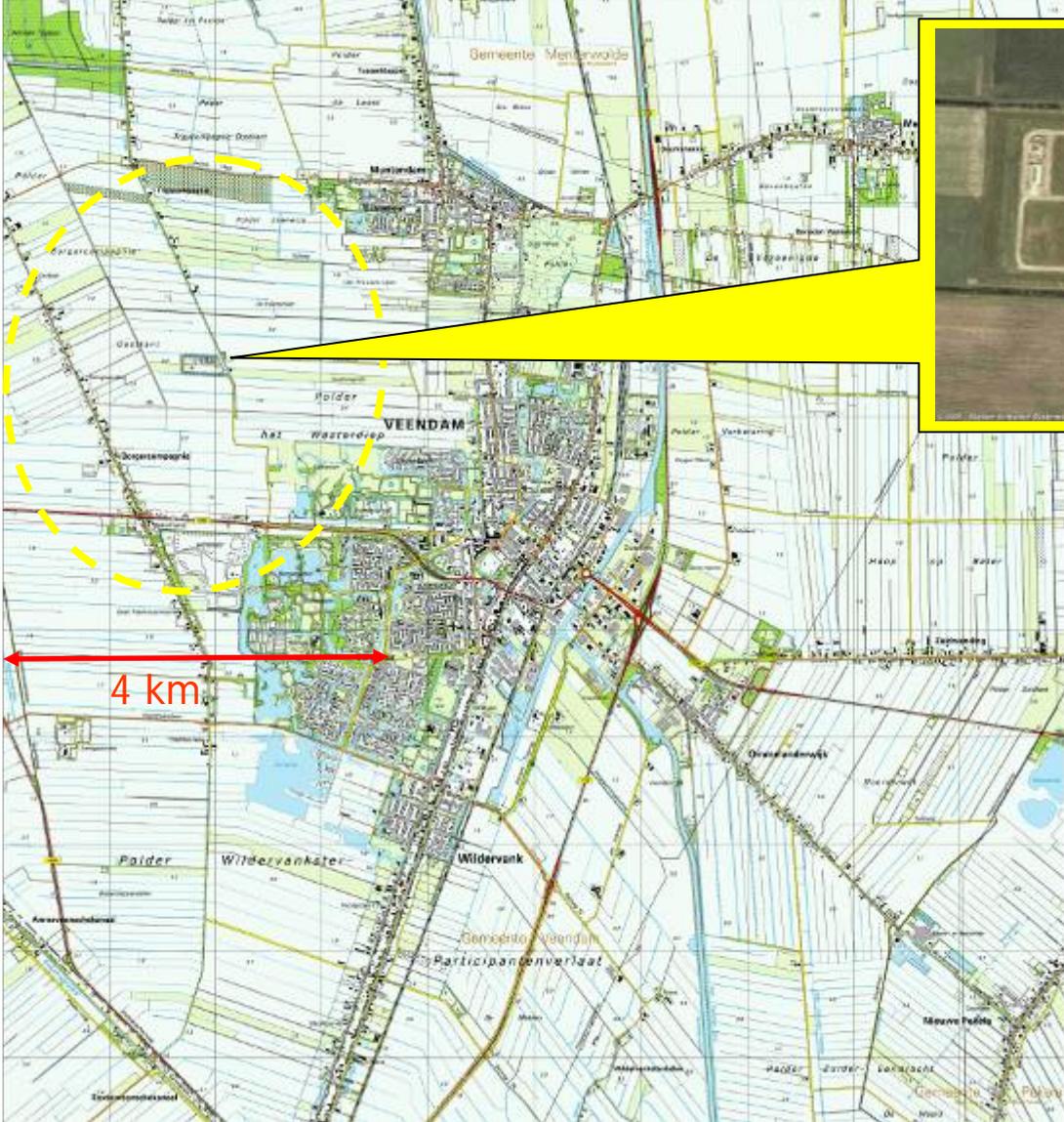
ERS SAR Tandem mission '95/'96



ASAR AP mode imagery 2005/06

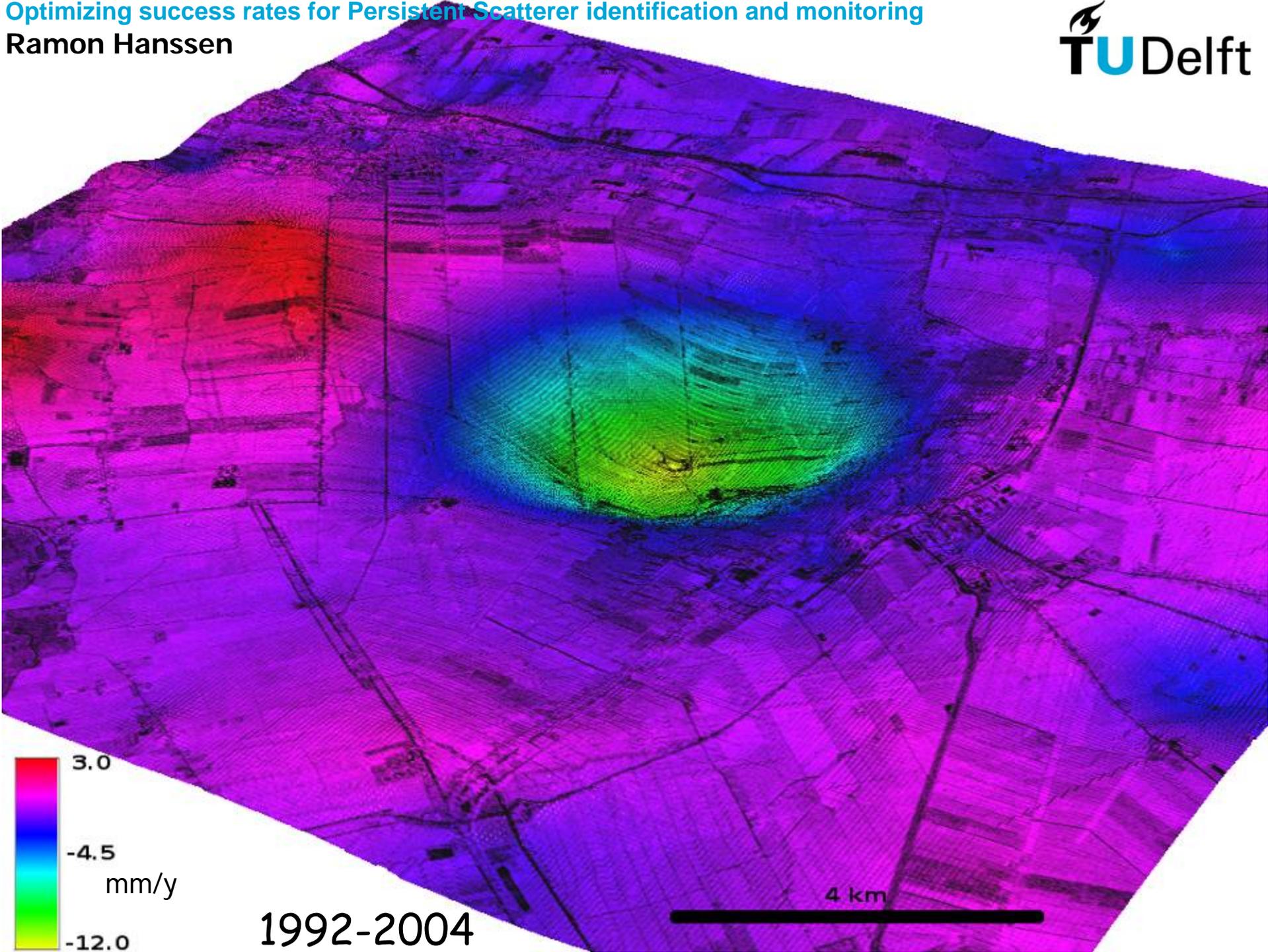


ASAR classification result



Veendam Salt Mining

Optimizing success rates for Persistent Scatterer identification and monitoring
Ramon Hanssen

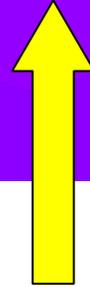
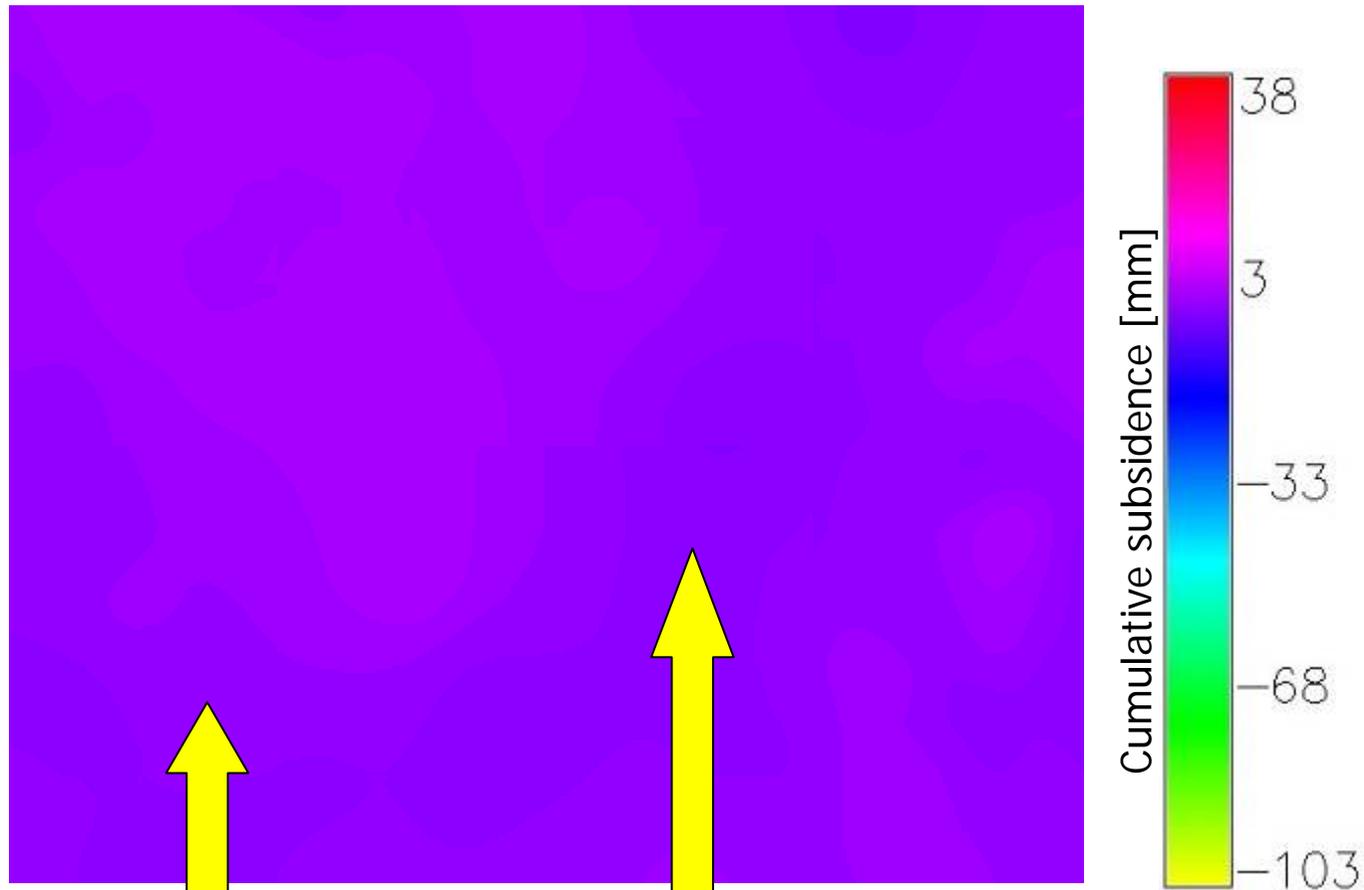




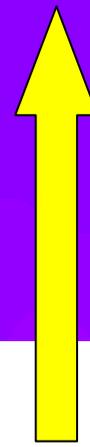
First (rough) animation deformation May 1992- Dec 2003

Optimizing success rates for Persistent Scatterer identification and monitoring

Ramon Hanssen and Astrid Humme



Uplift



Subsidence

Envisat Symposium, 23-27 April 2007, Montreux, Switzerland



ENVISAT Mission

ENVISAT mission

- ❑ **Largest European satellite & largest worldwide EO satellite:**
 - unique combination of 10 instruments addressing land, ocean, ice and atmosphere studies,
 - instruments working nominally, except MIPAS instrument
- ❑ **Satellite OK with long-term operations capabilities:**
 - 65 % of fuel available (about 5 years)
- ❑ **78 different types of data products**
 - but many more geophysical parameters
- ❑ **250 Gigabytes of data products generated per day**
- ❑ **Nominal lifetime (5 years) ends in March 2007**
 - but operations funding until end 2010





ENVISAT satellite and payload status

Mission elements	Expected evolution	Comments
Service Module	Excellent	
Propulsion and Hydrazine	Fair	Main limiting factor of the mission
Payload Equipment Bay	Excellent	
ASAR	Fair	Sub-system on redundant side
MERIS	Excellent	
AATSR	Excellent	
RA-2	Fair	Recent anomaly with altimetric range measurement On ground correction tables
MWR	Good	
DORIS	Fair	Instrument on redundant side
SCIAMACHY	Excellent	
MIPAS	Bad	Progressive mechanical degradation in non redundant part. Used on campaign basis.
GOMOS	Fair	Instrument on redundant side. New operations scenario is satisfactory.

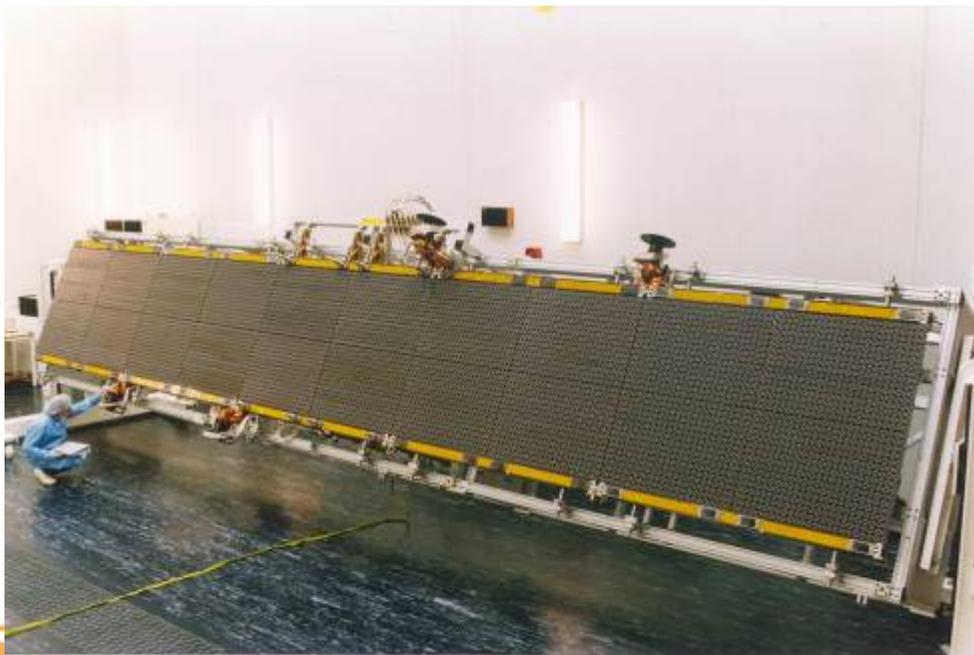


ENVISAT ASAR ***instrument*** ***performance***



The instrument ASAR

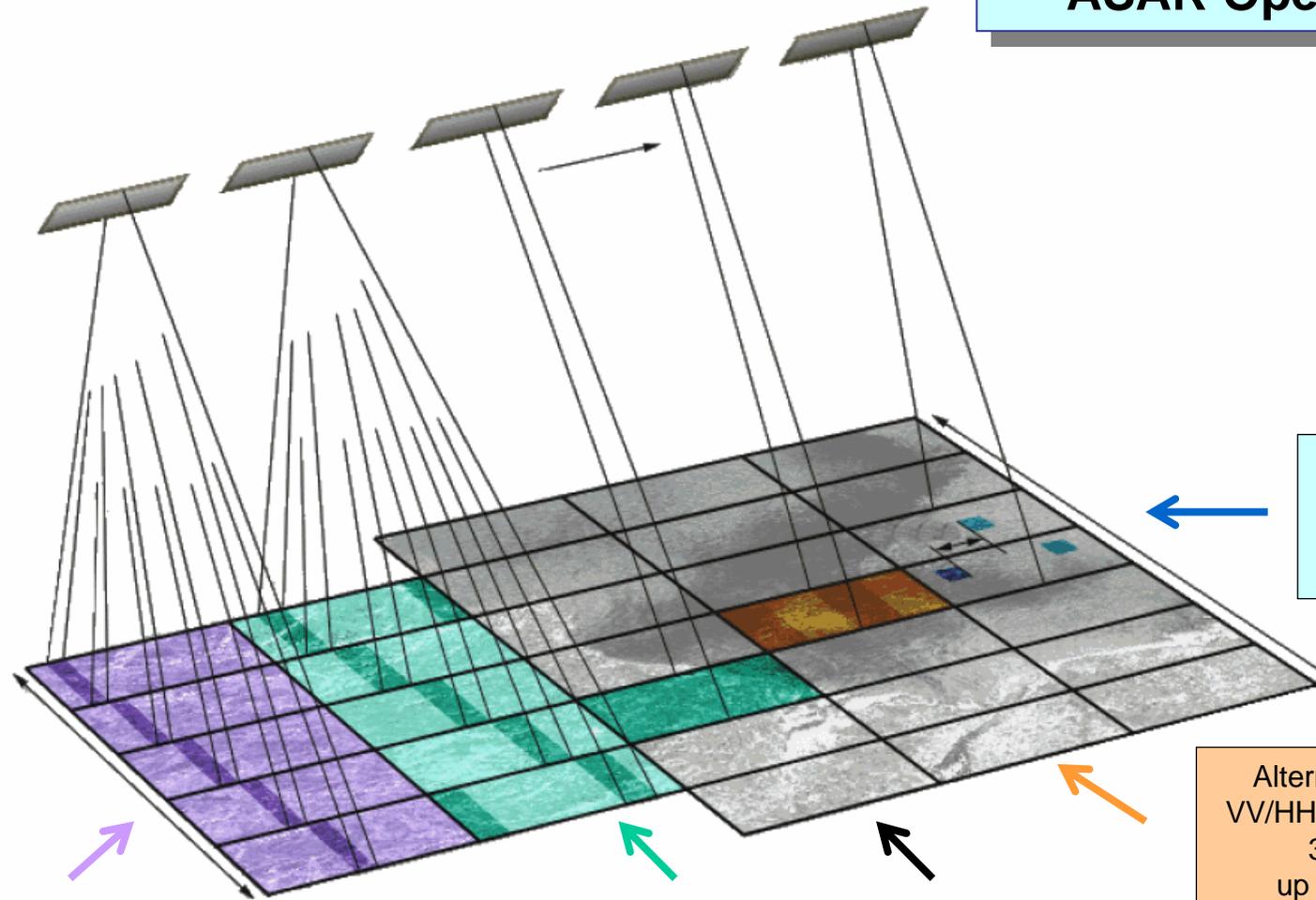
ASAR: Advanced Synthetic Aperture Radar



- Selectable incidence
- Selectable polarisation
- Wide Swath 400km (3 day repeat coverage)
- Global mode at 1km resolution



ASAR Operation Modes



Global Monitoring
VV or HH
1000m resolution
405 km swath width

Wide Swath
VV or HH
150m resolution
405 km swath width

Image VV or HH
< 30m resolution
up to 100 km swath

Alternating Polarisation
VV/HH or VV/VH or HH/HV
30m resolution
up to 100 km swath

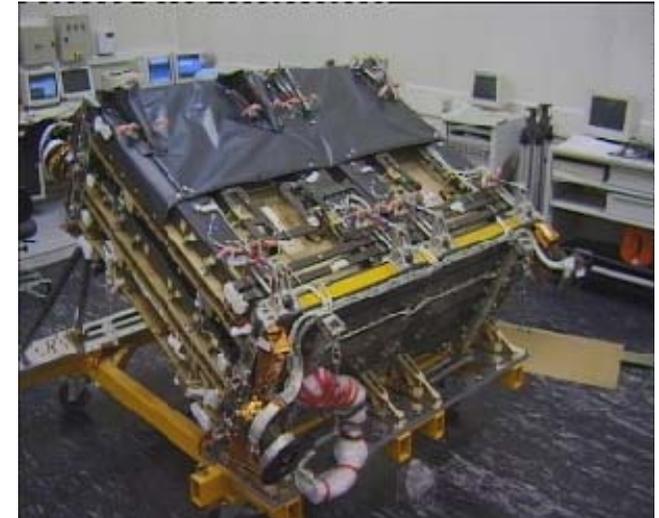
Wave VV or HH
< 10m resolution (SLC)
5 x 5 km to 10 x 5 km
vignettes



ASAR INSTRUMENT MAIN FEATURES

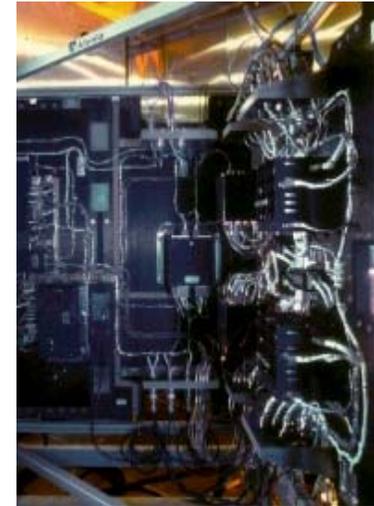
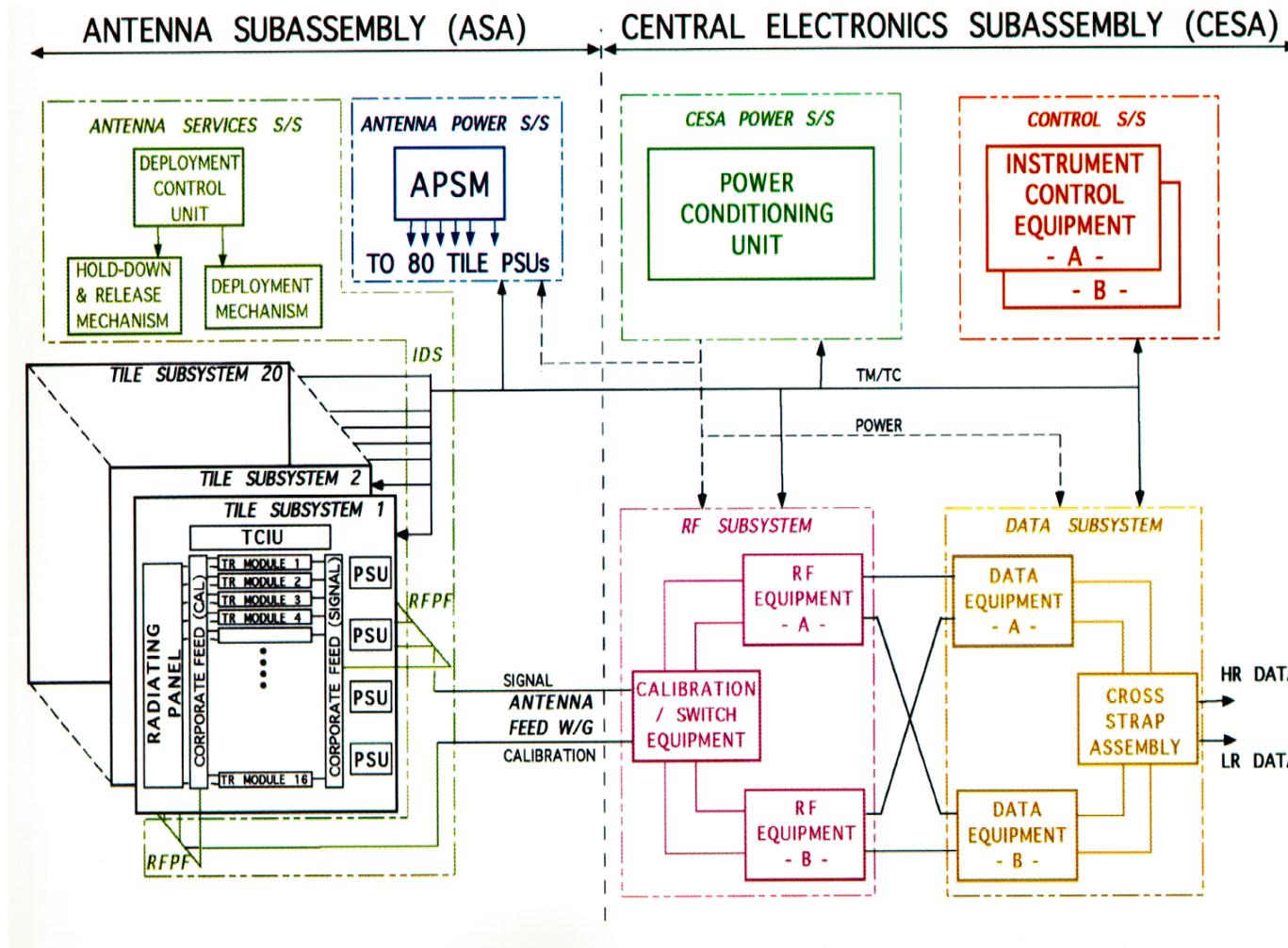
- ASAR can be operated in **HH** or **VV** in all modes but
 - Alternating Polarisation Mode where it operates in **HH/VV** or **HH/HV** or **VV/VH**
 - ASAR can select the swath position in IM, AP and WV (**7 swaths** available)
 - ASAR has a **SCANSAR 5 beams** modes of operation: WS and GM
 - **Frequency stability and datation have been improved**
 - to support interferometric applications @ 5.331 GHz
 - **ASAR includes an active array antenna**
 - **composed of 320 T/R**
 - modules with a dedicated
 - calibration path to each T/R
 - module
- 

ASAR T/R MODULE
- **ASAR includes a Digital Chirp Generator**
 - **ASAR includes a Flexible Block Adaptive Quantizer:**
 - large dynamic range of inputs signal (8 bit ADC) and compression 8/4, 8/3, 8/2
 - **ASAR includes a Temperature compensation scheme**





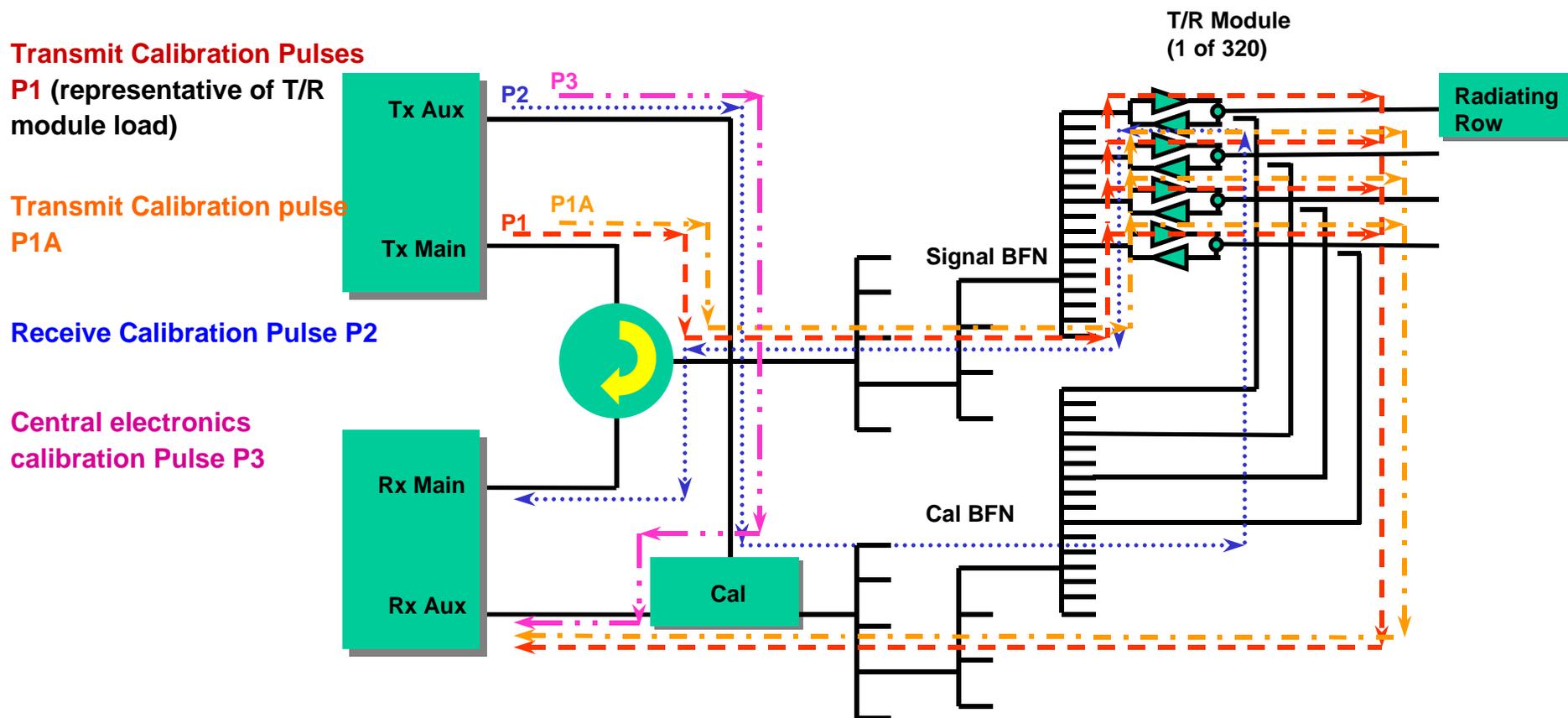
ASAR INSTRUMENT OVERVIEW





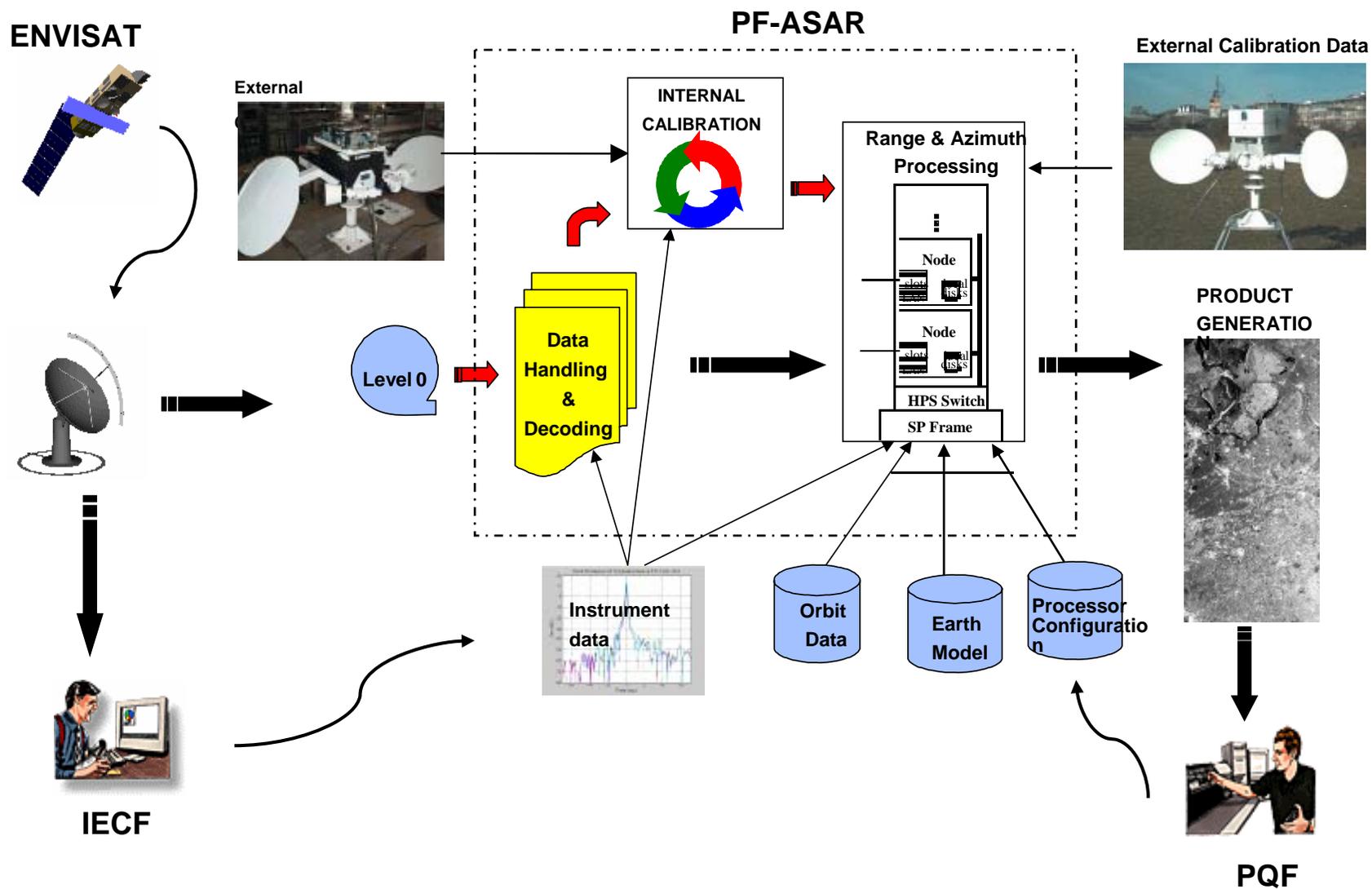
ASAR INSTRUMENT Internal Calibration

Calibration Pulses Diagram





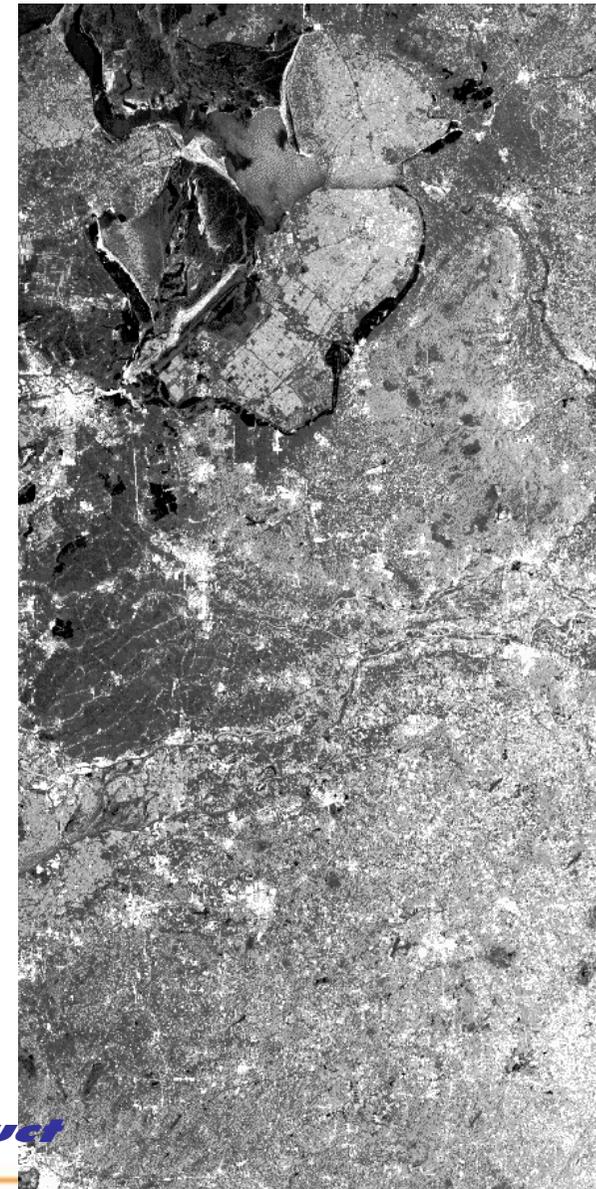
ASAR PROCESSOR Functional Bloc Diagram





3- ASAR PROCESSOR IMAGE QUALITY

	<i>Parameter</i>	<i>Specification</i>
ALL PRODUCTS	Range and Azimuth broadening	< 10% of theoretical value IRF
	PSLR degradation	< 2 dB
	ISLR degradation	< 2 dB
	Radiometric Error	< 0.1 dB (single beam) < 0.2 dB (scanSAR)
	Absolute location accuracy	<2 pixel
	Geometric distortion	<0.5 pixel
SLC	Phase Preserving Test	
	• Standard deviation	<5 degrees
	• Phase mean	<0.1 degrees
	• No discontinuity	
	Point Target Phase Error	< 0.1 degrees



Example IMM Product



2- ASAR Processor algorithms

PRODUCTS	Az. Coverage (Km)	Algorithm
IM SLC	100	Range Doppler
AP SLC	100	Modified Range Doppler
AP PRI	100	Specan
IM PRI	100	Range Doppler
IM Medium Res.	100	Specan
AP Medium Res.	100	Specan
WS Medium Res.	400	Specan
GM Image	40.000	Specan
WVI (imagette)	5 x 5	Range Doppler
WVS	5 x 5	Cross Spectra
WWV	5 x 5	Wave Spectra inversion



Product quality & calibration performance

“Review of ASAR Instrument Performance and Product Quality”, Envisat symposium Montreux April 2007

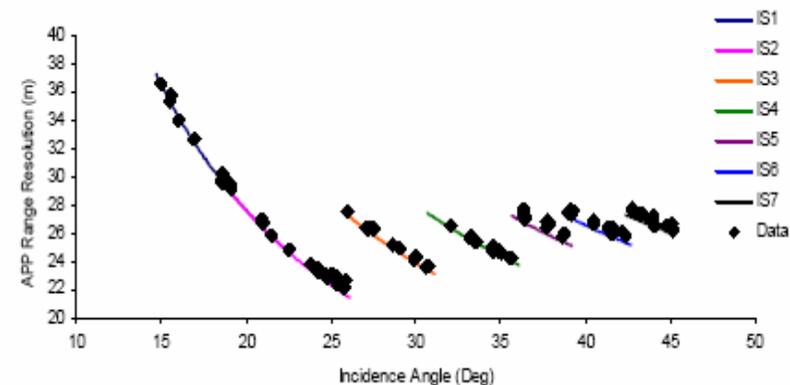
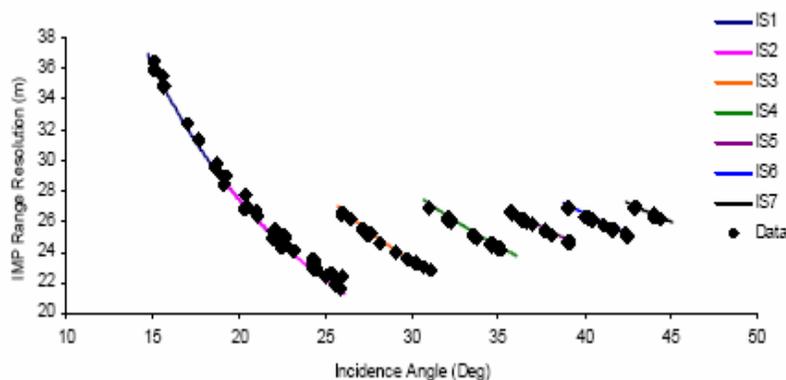
By B. Rosich, ESA-ESRIN et al



Product Quality – IRF Parameters

- Product quality is routinely monitored, mainly using data over the calibration sites (transponders, ground stations, Amazon rain forest).
- Results are stored and used for calibration and long term performance monitoring.

Product type	Az. Resolution [m]	Range resolution [m]	ISLR [dB]	PSLR [dB]	SSLR [dB]
IMP	22.13±0.49	rg-variant	-13.43±0.57	-16.67±0.98	-22.74±1.76
IMG	22.35±0.45	21.8-35.4	-13.52±0.56	-16.83±1.00	-23.32±1.55
IMS	4.76±0.04	9.44±0.05	-14.47±0.28	-19.19±0.52	-28.47±0.62
IMM	146.87±3.34	rg-variant	-7.01±4.5	-15.52±3.42	-14.65±4.82
APP	27.62±0.82	rg-variant	-12.85±0.47	-19.13±1.02	-26.99±1.64
APG	27.72±0.86	23-35.4	-12.87±0.49	-19.20±1.00	-27.65±1.34
APS	4.38±1.88	8.40±0.07	4.04±2.53	-1.87±1.41	-16.67±4.23
APM	145.03±2.86	rg-variant	-8.29±5.13	-15.39±3.43	-16.57±5.94
WSM	107.24±2.26	rg-variant	-9.06±3.92	-18.83±1.27	-17.35±5.69





Product calibration

In order to acquire sufficient data for calibration purposes while minimising conflicts with user requests, three of the four ASAR transponders have been successfully redeployed from The Netherlands to Kalimantan (Indonesia), Resolute (Canada) and Ottawa (Canada) since mid 2006.

See details about the re-deployment activity in a later presentation by C. Goetz.

- The increase of the number of calibration measurements has made possible to refine the absolute product calibration constants, particularly for AP cross-pol products.

Product Type	Relative Radar Cross Section (ReIRCS) [dB]							
	All swaths (bias±stdev)	IS1	IS2	IS3	IS4	IS5	IS6	IS7
IMP	-0.05±0.42	-0.01	-0.08	-0.02	-0.04	-0.01	-0.05	-0.1
IMG	-0.01±0.43	-0.04	-0.11	-0.04	-0.05	0.24	0.04	0.1
IMS	0.00±0.42	-0.02	-0.02	-0.09	0	0.02	0.03	0.1
IMM	0.04±0.95							
APP	-0.06±0.39	-0.28	-0.22	-0.07	0.03	-0.01	0.01	-0.03
APG	-0.04±0.47	-0.3	-0.31	-0.03	-0.06	-0.02	0.22	0.09
APS	-0.06±0.53	-0.1	-0.4	-0.01	-0.25	-0.06	0.17	0.16
APM	-0.06±0.98							
WSM	0.45±1.26							

Product Type	Mean Relative RCS [dB]			
	VV	HH	VH	HV
IMP	-0.03	-0.1		
APP	0.08	-0.04	-0.1	-0.07

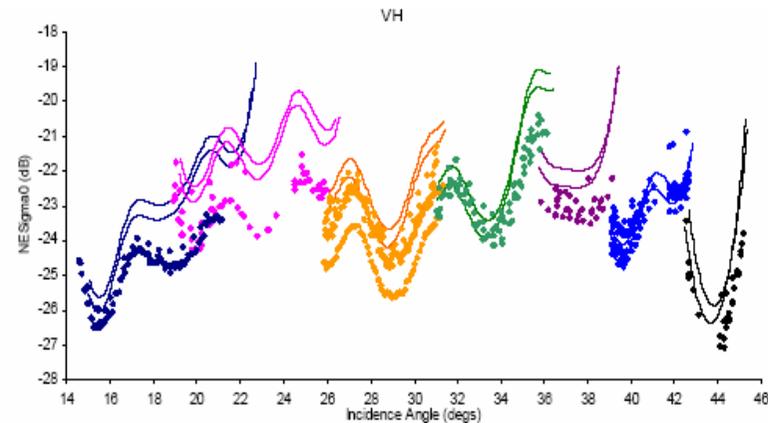
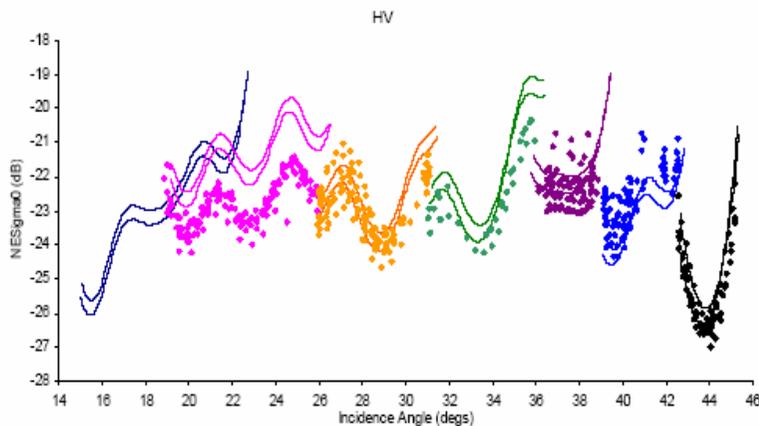


Product Quality – ENL & NESO

- As part of the routine product quality, some key parameters are monitored, particularly the radiometric resolution and NESO.

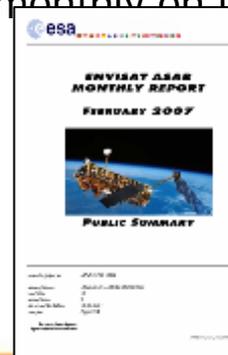
	ENL	Rad. Res [[dB]
IMP/IMG Products	3.95	1.77
IMS Products	0.96	3.05
APS Products	0.93	3.09

	APP/APG Products						
	IS1	IS2	IS3	IS4	IS5	IS6	IS7
ENL	1.76	1.73	2.25	2.66	3.3	3.78	3.73
Rad. Res [[dB]	2.44	2.45	2.22	2.08	1.91	1.8	1.81



- Routine ASAR product quality results are published monthly on line at:

http://earth.esa.int/pcs/envisat/asar/public_reports/





ENVISAT ASAR SAR exploitation



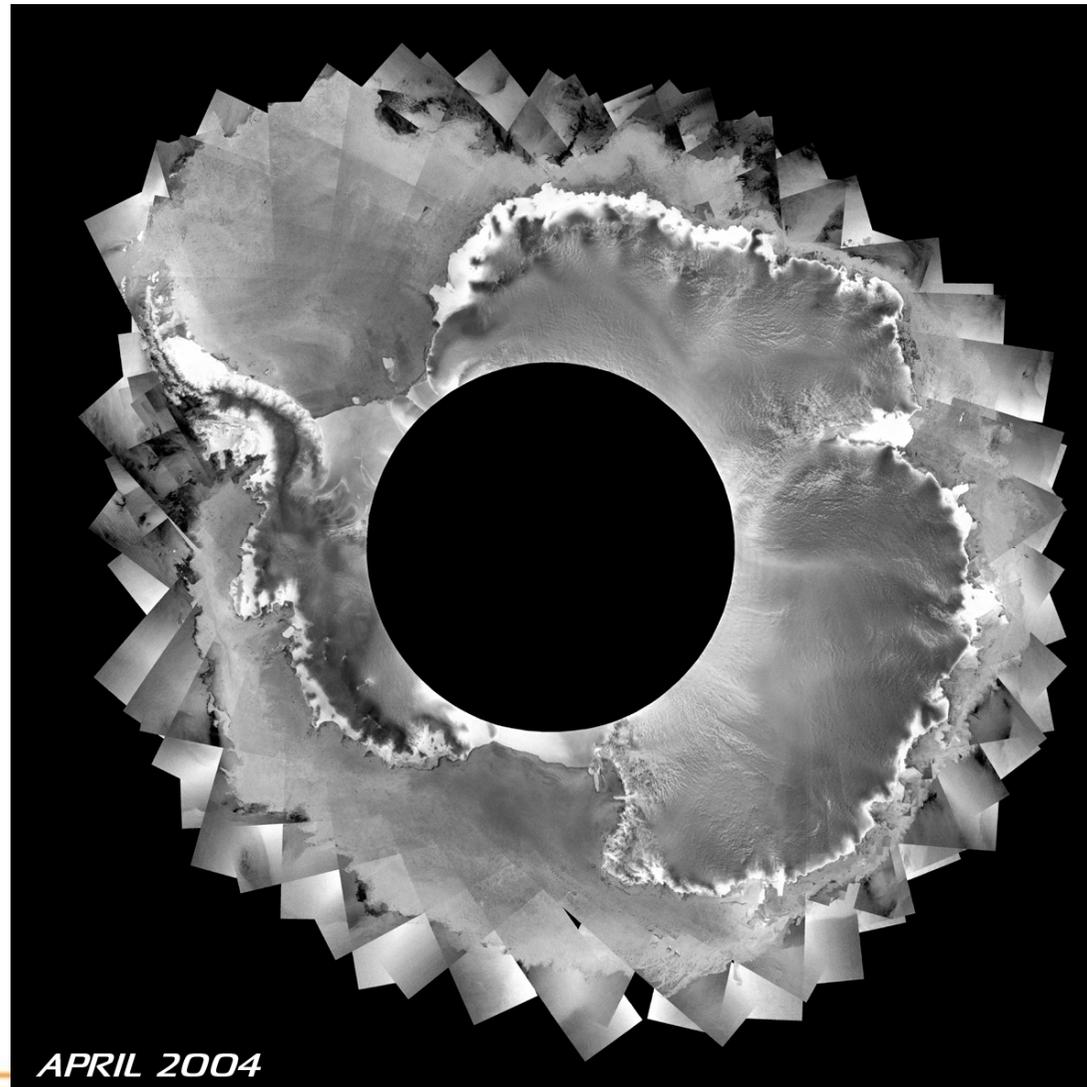
Envisat monitors Ice-Sea Ice in Antarctica

LARSEN B collapse observed
in 2002 by ERS /Envisat



Courtesy of H.Rott, Univ Innsbruck, AU

Envisat Radar monitoring Antarctica Ice
and Sea-Ice extent (April-to June 2004)



(A)SAR instrument series

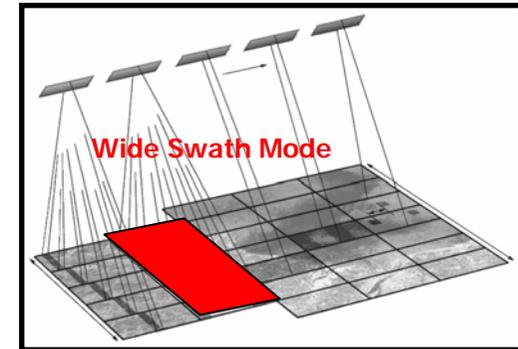
Yves-Louis Desnos



ENVISAT Imaging Radar

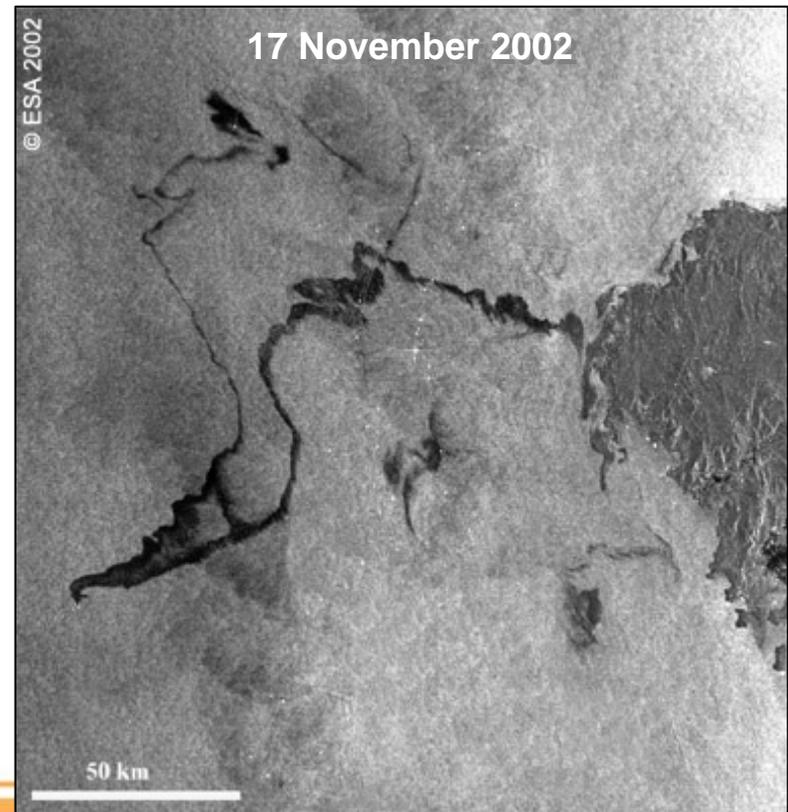


Prestige tanker oil spill - Galicia



4 September 2007

D2L2



17 November 2002

50 km

(A)SAR instrument series

Yves-Louis Desnos

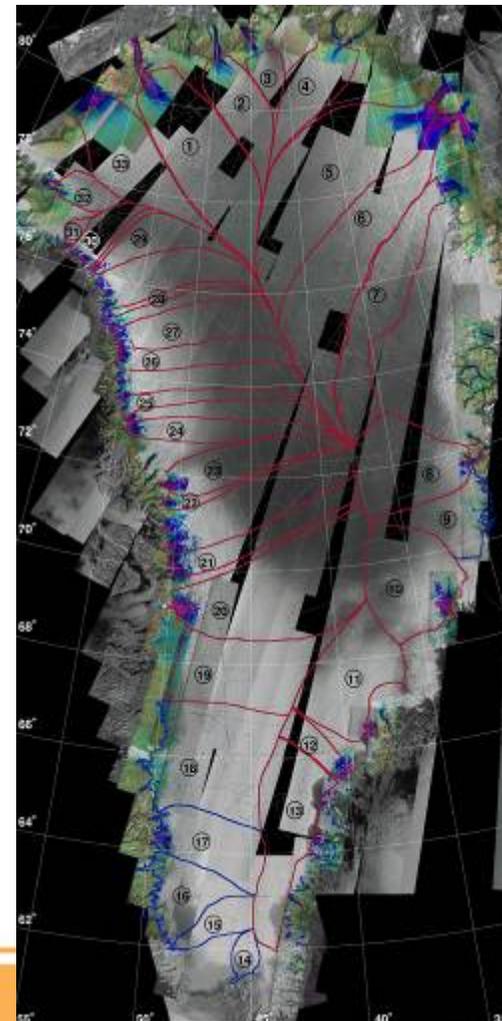
FRINGE 2005

Greenland Ice Sheet velocity structure

- “Study of glacier velocity over the Greenland ice sheet has shown significant acceleration of outlet glaciers during the last few years, doubling Greenland’s contribution to sea level rise between 1995 and 2005” – Eric Rignot, JPL
- Contribution to sea level rise is 0.65 mm/yr in 2005.



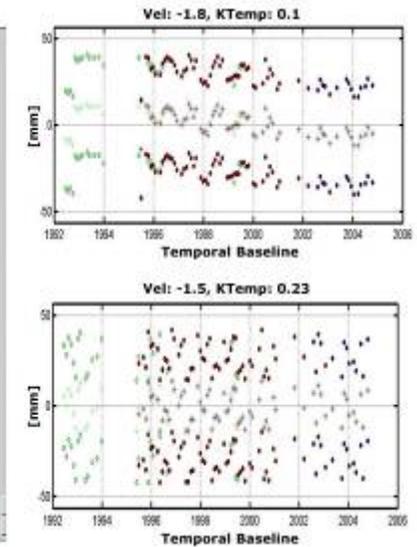
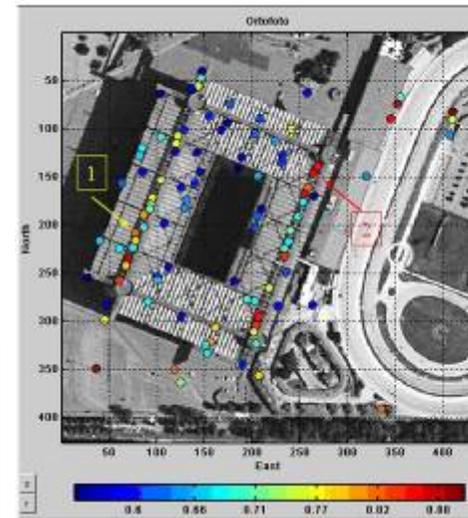
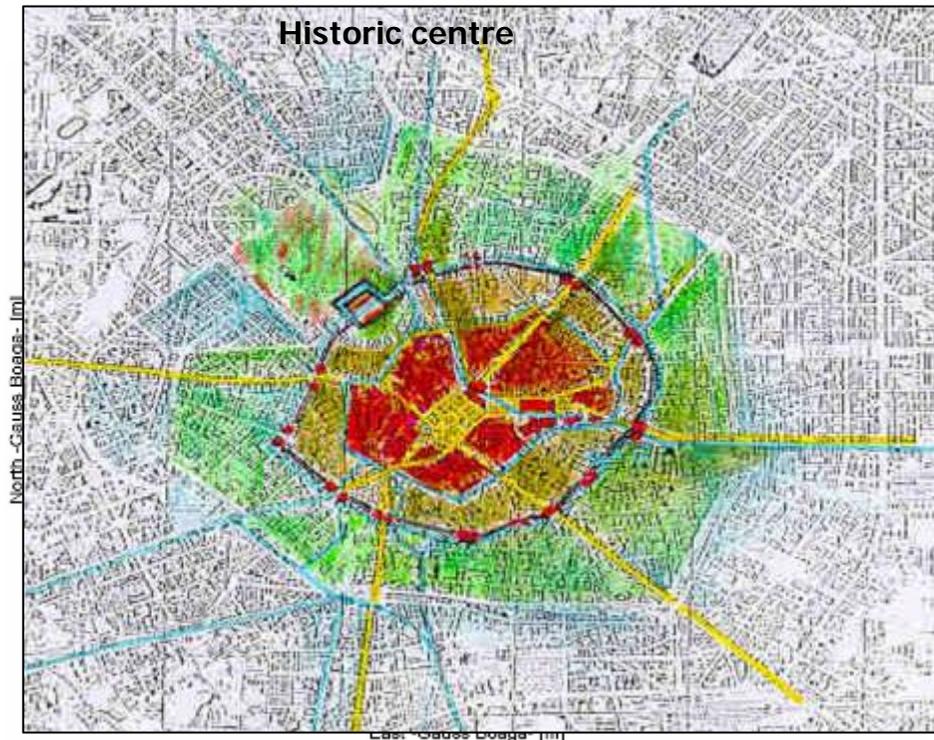
Rignot, E and Kanagaratnam, P (2006)
Changes in the Velocity Structure of the Greenland Ice Sheet, *Science* vol. 311 no. 5763, pp. 986-990



FRINGE 2005

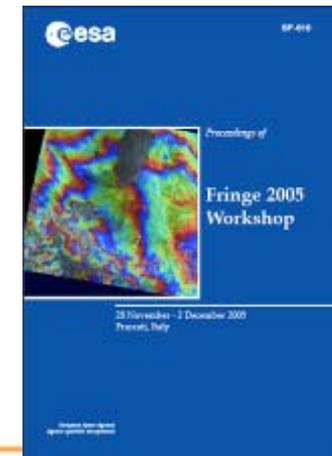
PS analysis of Milan

- “PSI extends a collection of 2D SAR images to 4 dimensions, allowing accurate 3D positioning of individual scatterers and assessing their motion, e.g. subsidence.”
- Fabio Rocca/Daniel Perissin

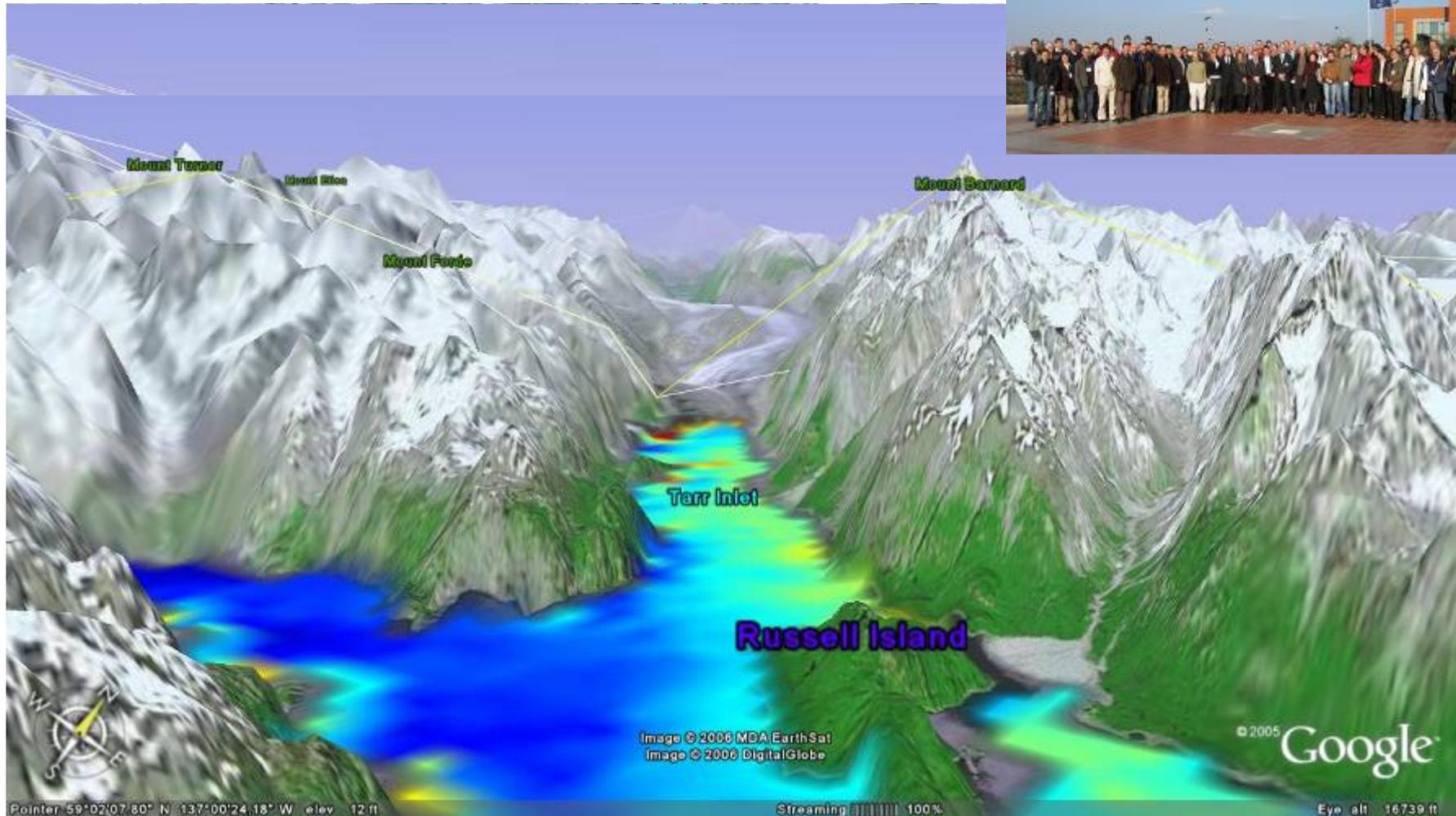


PS on the San Siro stadium
show variable thermal dilation

DTM of Milan derived
from PS measured
only at ground-level



Alaska SAR Demonstration



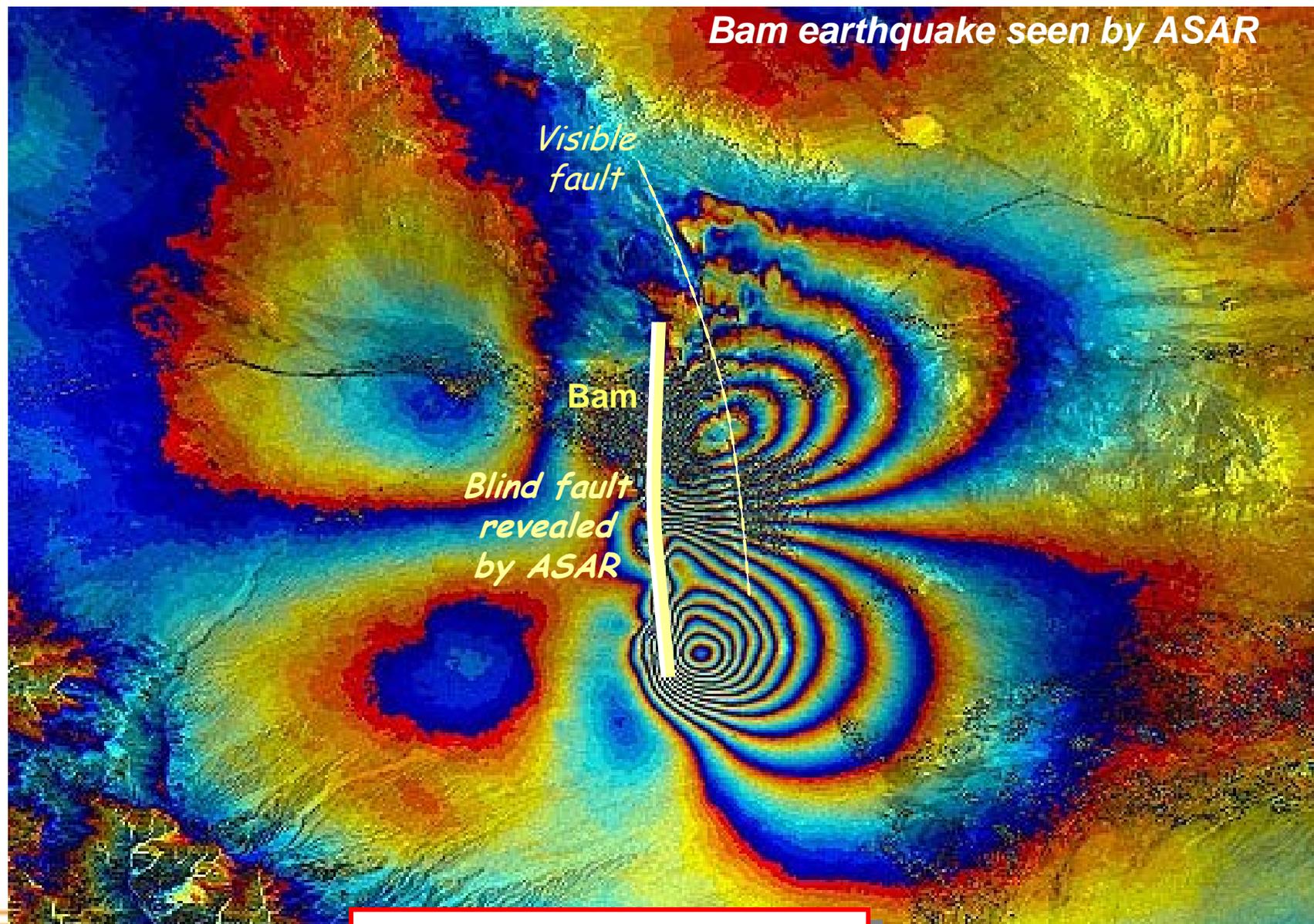
ENVISAT ASAR Wide Swath Mode, 02 Dec 2005 06:43 UT
William PICHEL et al. (ENVISAT-AO Project 431)



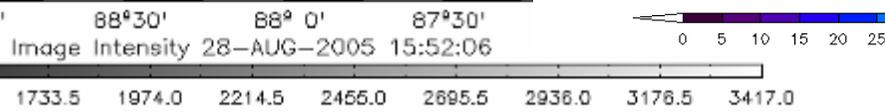
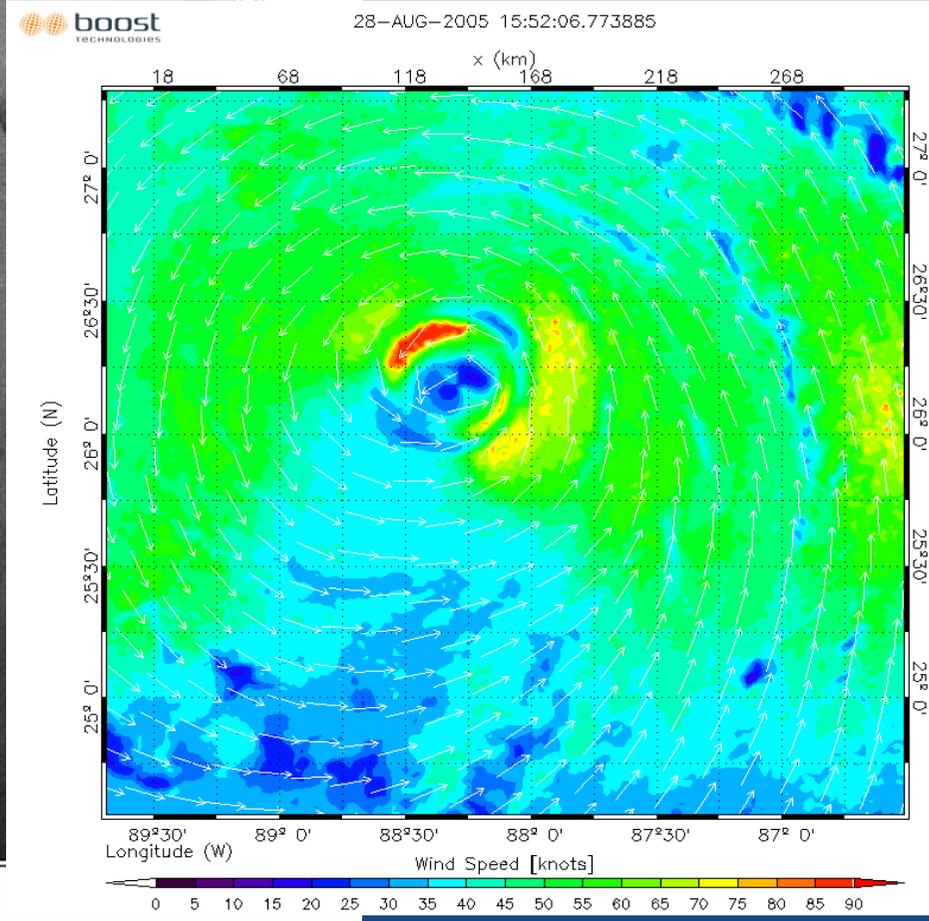
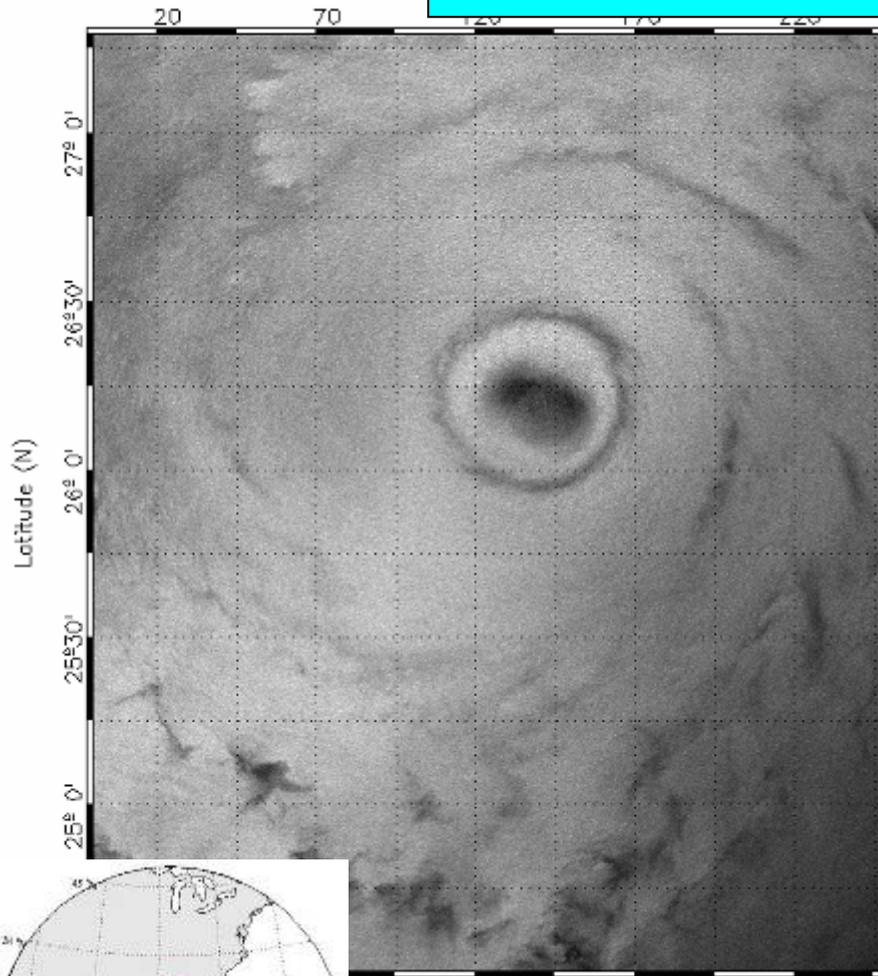


Envisat identifies blind Tectonic Faults

Bam earthquake seen by ASAR

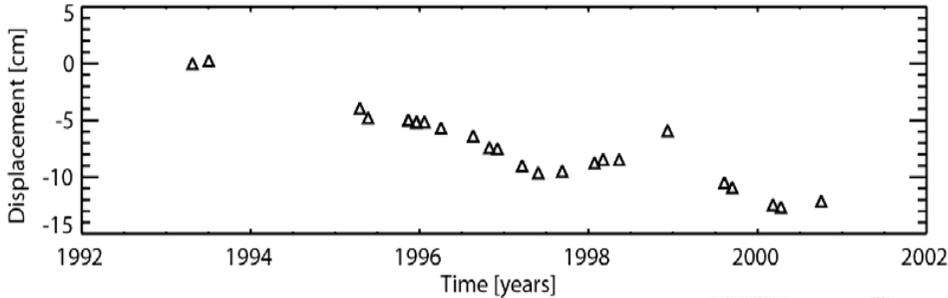
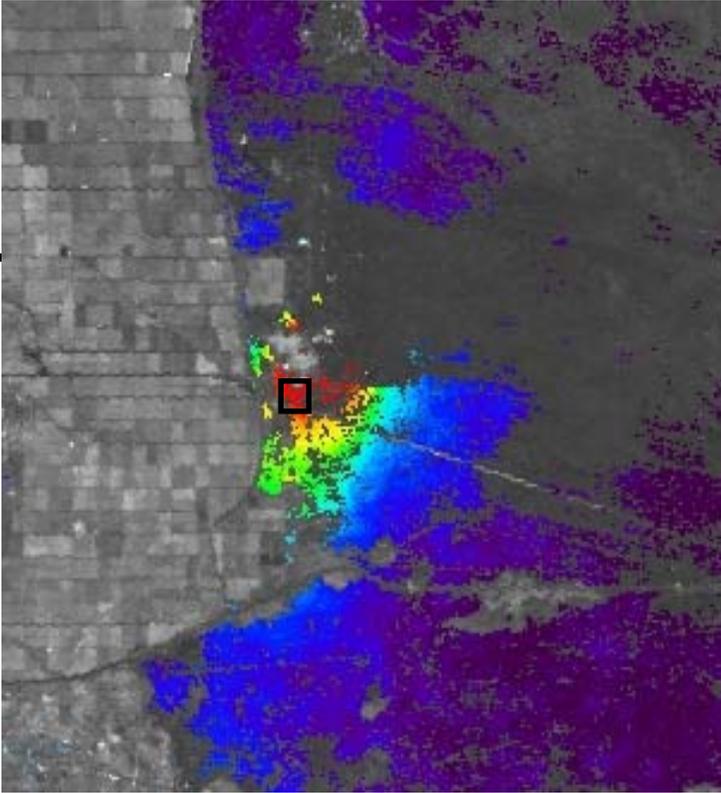
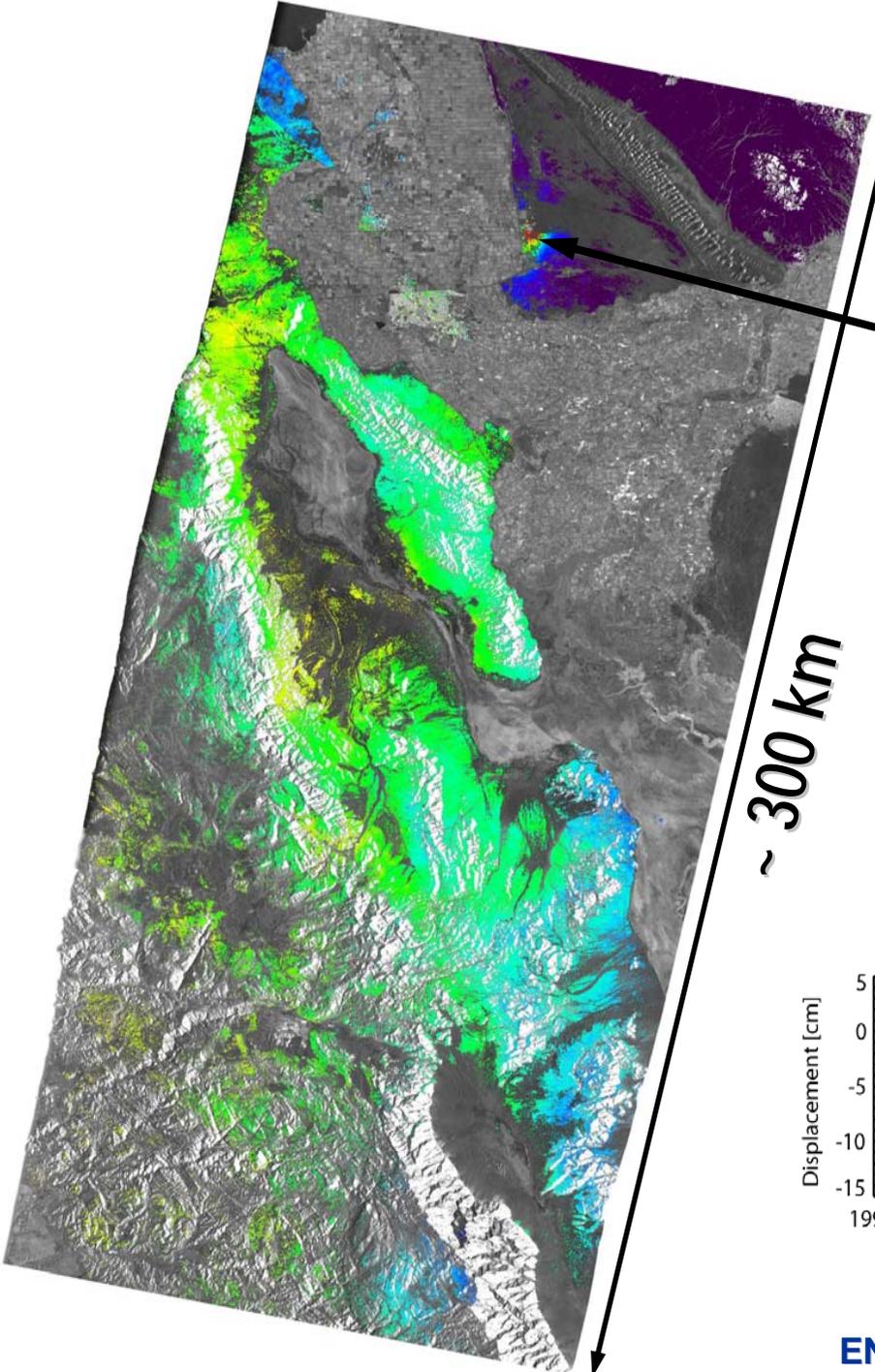


EYE OF KATRINA - ASAR 28.08.05



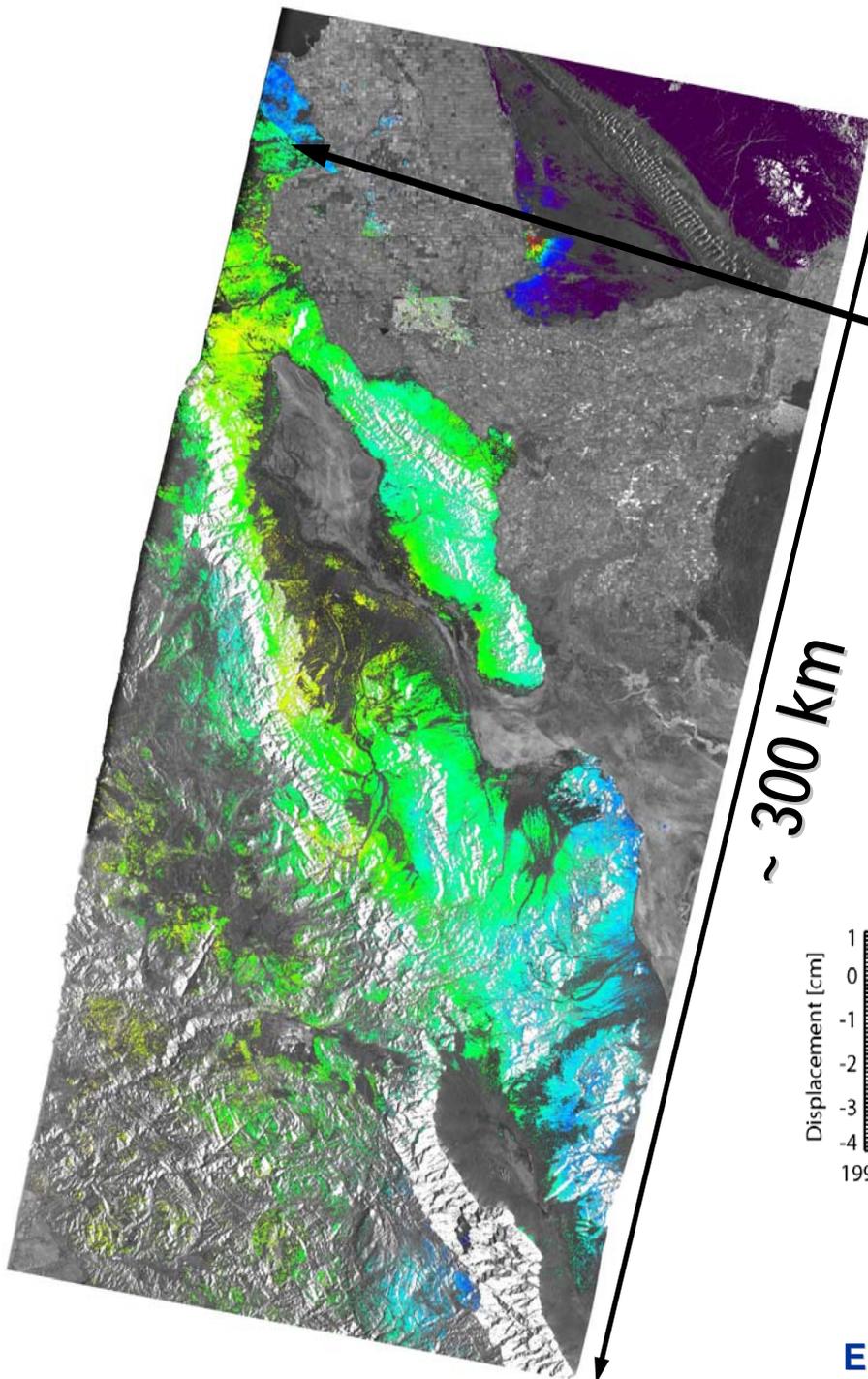
COURTESY BOOST

Baja California area (Mexico)

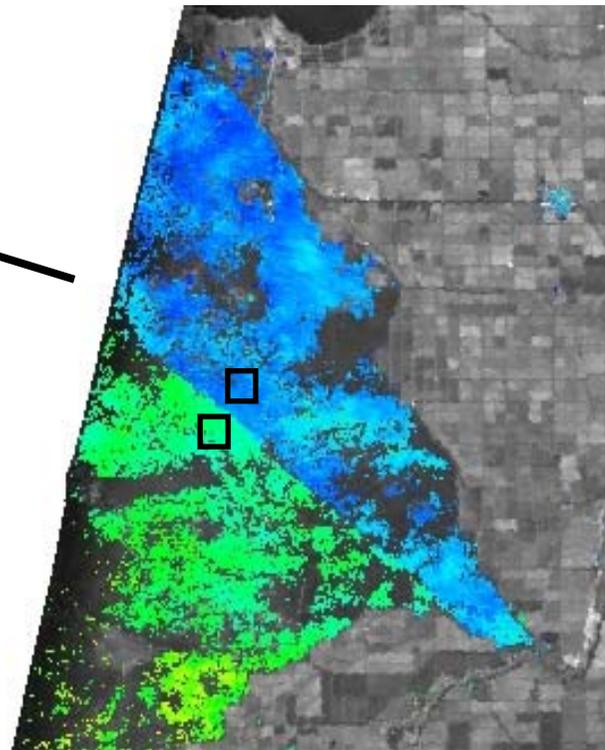


Baja California area (Mexico)

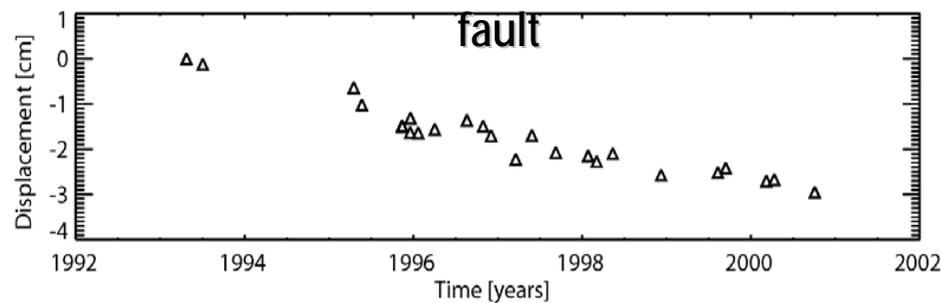
Mean velocity (mm/yr)
> 10
< -10



~ 300 km

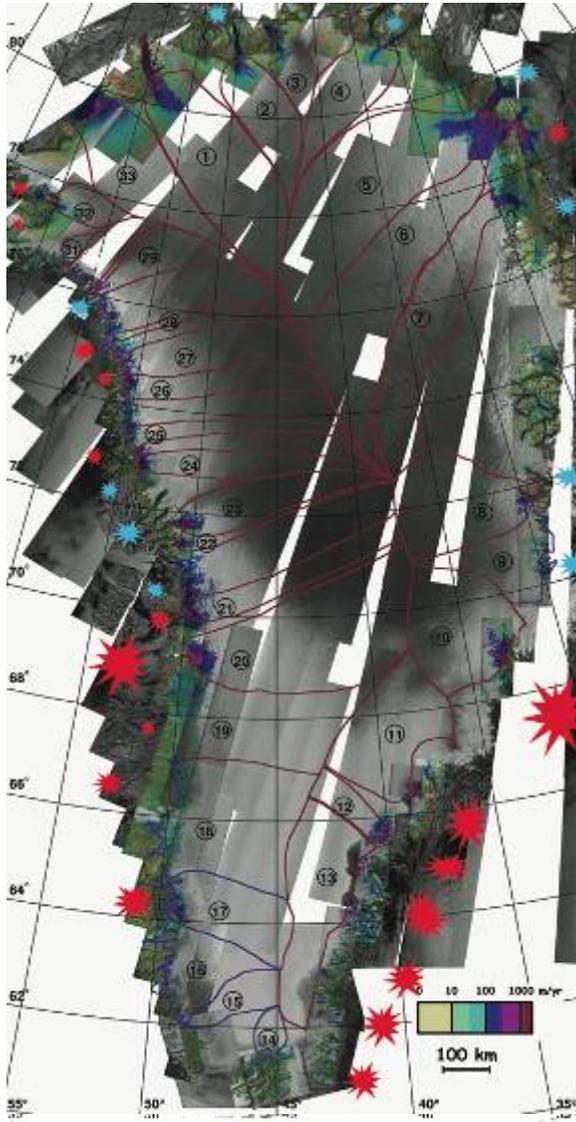


Relative motion across the Cerro Prieto

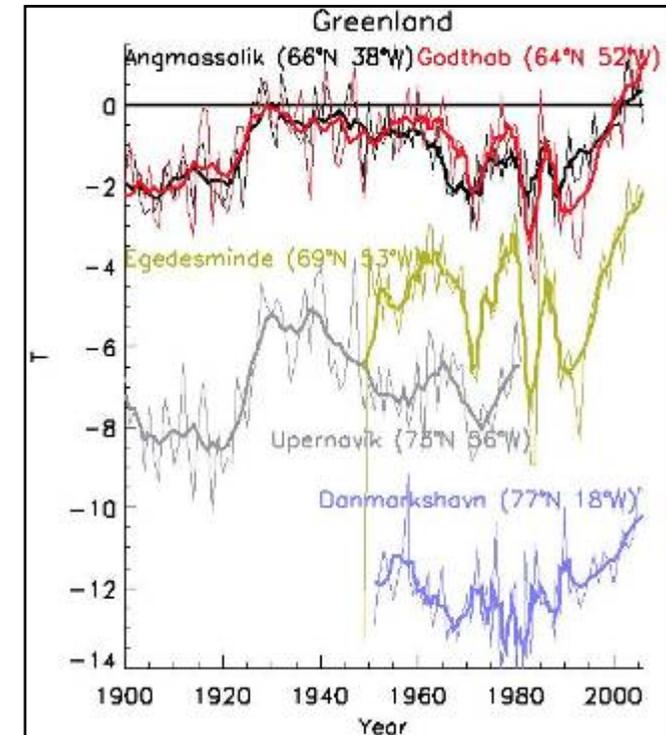




Greenland mass balance 1996-2005



- Mass deficit:
- 83 ± 30 Gt/yr in 1996
- 205 ± 37 Gt/yr in 2005
- 2/3rd of loss due to dynamic thinning.

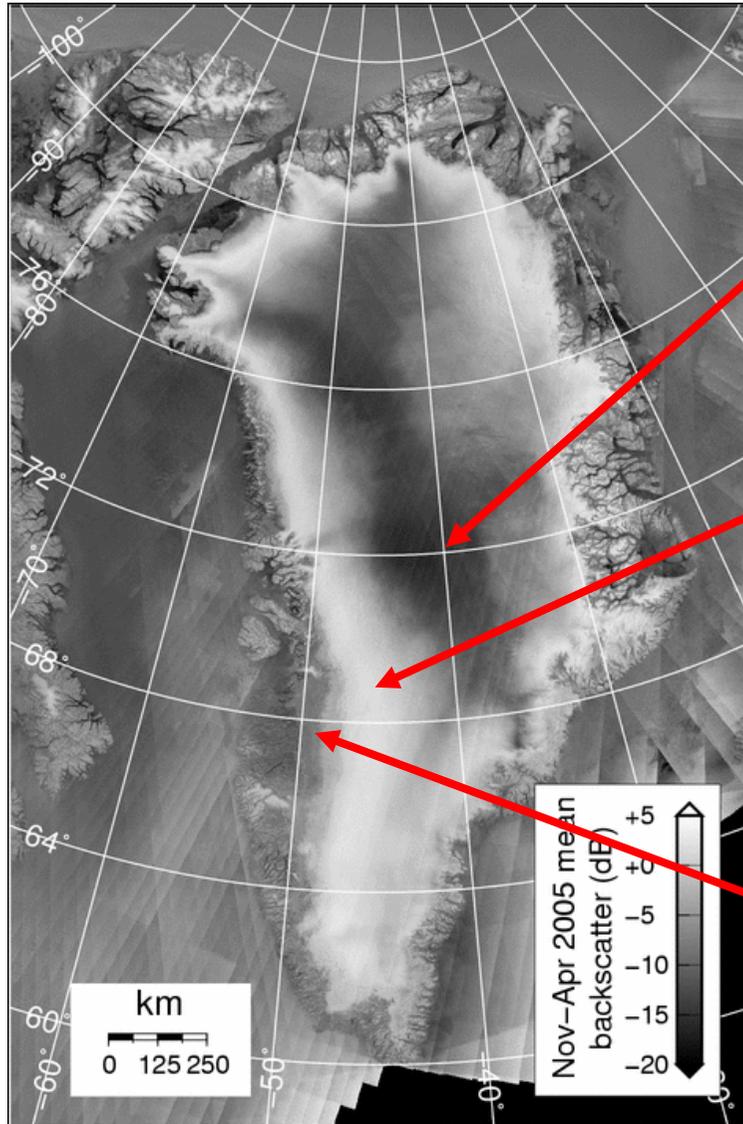


“Greenland’s contribution to sea level rise has been doubling between 1995 and 2005” – Eric Rignot, JPL

Changes in the Velocity Structure of the Greenland Ice Sheet, Science vol. 311 no. 5763, pp. 986-990
Courtesy of Rignot & Kanagaratnam,



Greenland with ASAR GM mode



Dry snow zone

Deep penetration and few scatterers

- *Consistently low backscatter*

Percolation zone

Ice lenses within snow-pack

- *High backscatter when frozen*
- Water absorbs microwave energy
- *Step reduction when melting*

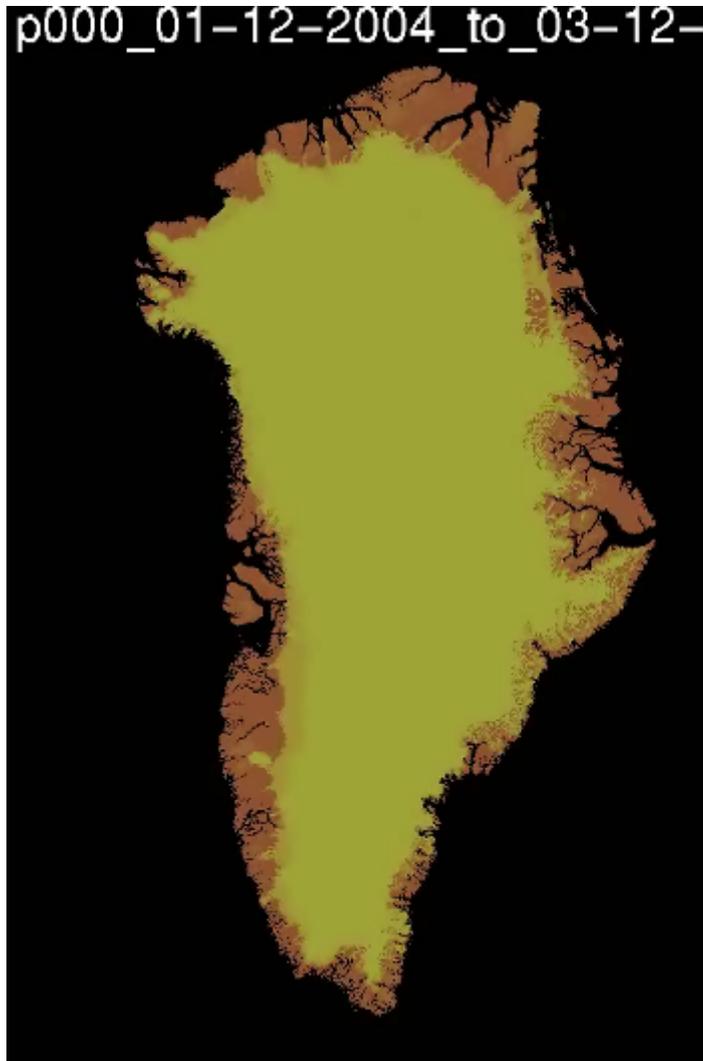
Bare ice (variable extent)

High texture and surface scatter

- *Consistent medium backscatter*



Melt extent in Greenland



no melt
melt
bare ice
no ice

- Freeze/Melt transition is dramatic
- validation with Greenland climate network
- Envisat ASAR GMM unique tool to monitor ice-sheet/ice-shelf melt extent
 - 1 km spatial resolution
 - Adequate temporal resolution (subject to BRM)
- Improved observations:
 - Melt pattern (ice shelves)
 - Small ice caps
 - Individual Greenland catchments



ENVISAT for monitoring dikes in the Netherlands

History: Zeeland, 31 Jan 1953

- Evacuation of 72000 people
- Thousands of buildings destroyed



On the potential of PS-InSAR for monitoring dikes in the Netherlands
Courtesy of Ramon Hansen Delft Institute of Earth Observation and Space Systems



Can we monitor this from space?



17000 km of water barriers:

- 3565 km primary water barriers (big rivers, sea, IJsselmeer, Markermeer),
- >14000 km regional water barriers



Overflowing



Sliding inner slope



Overtopping



Plastic horizontal sliding



Piping

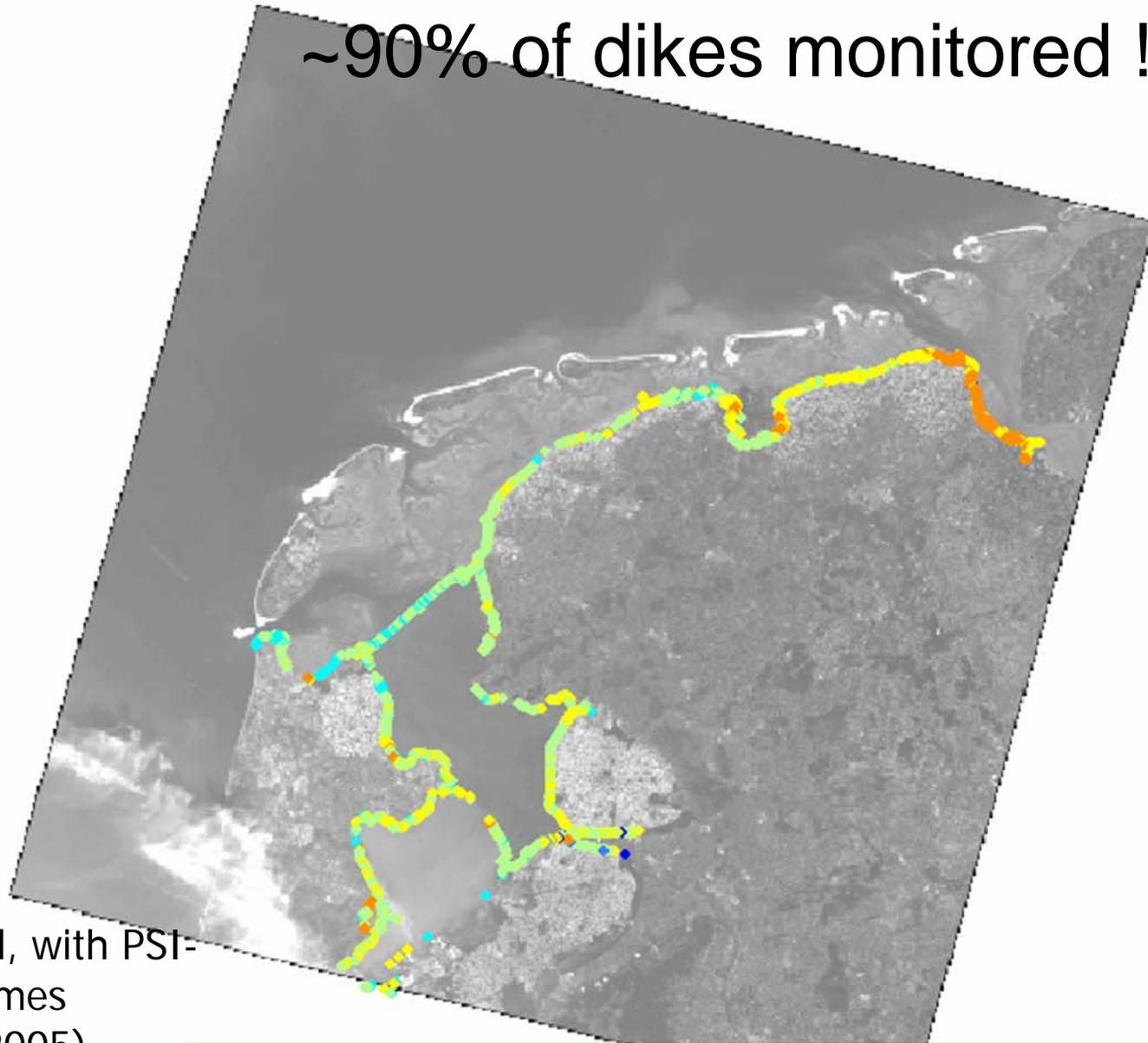
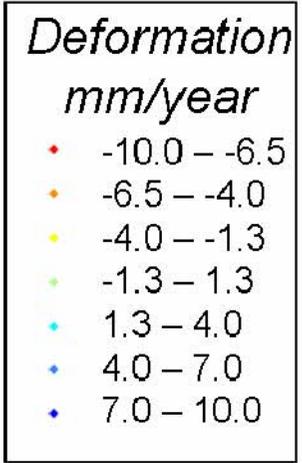


Nipping ice

On the potential of PS-InSAR for monitoring dikes in the Netherlands
Courtesy R. Hansen Delft Institute of Earth Observation and Space Systems



~90% of dikes monitored !!

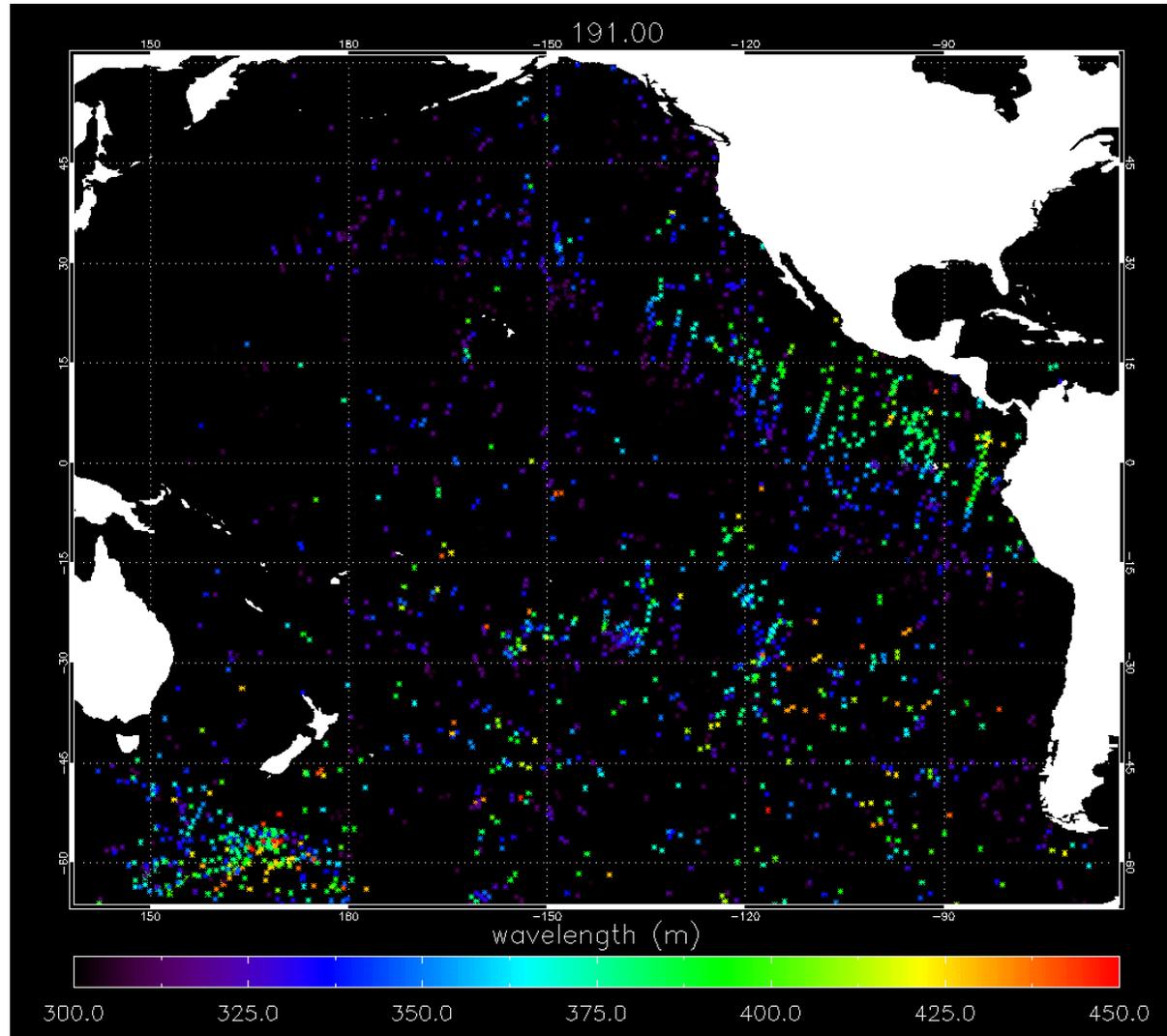


Landsat background, with PSI-dike results of 9 frames superposed (1992-2005)

On the potential of PS-InSAR for monitoring dikes in the Netherlands
Courtesy of Ramon Hansen Delft Institute of Earth Observation and Space Systems



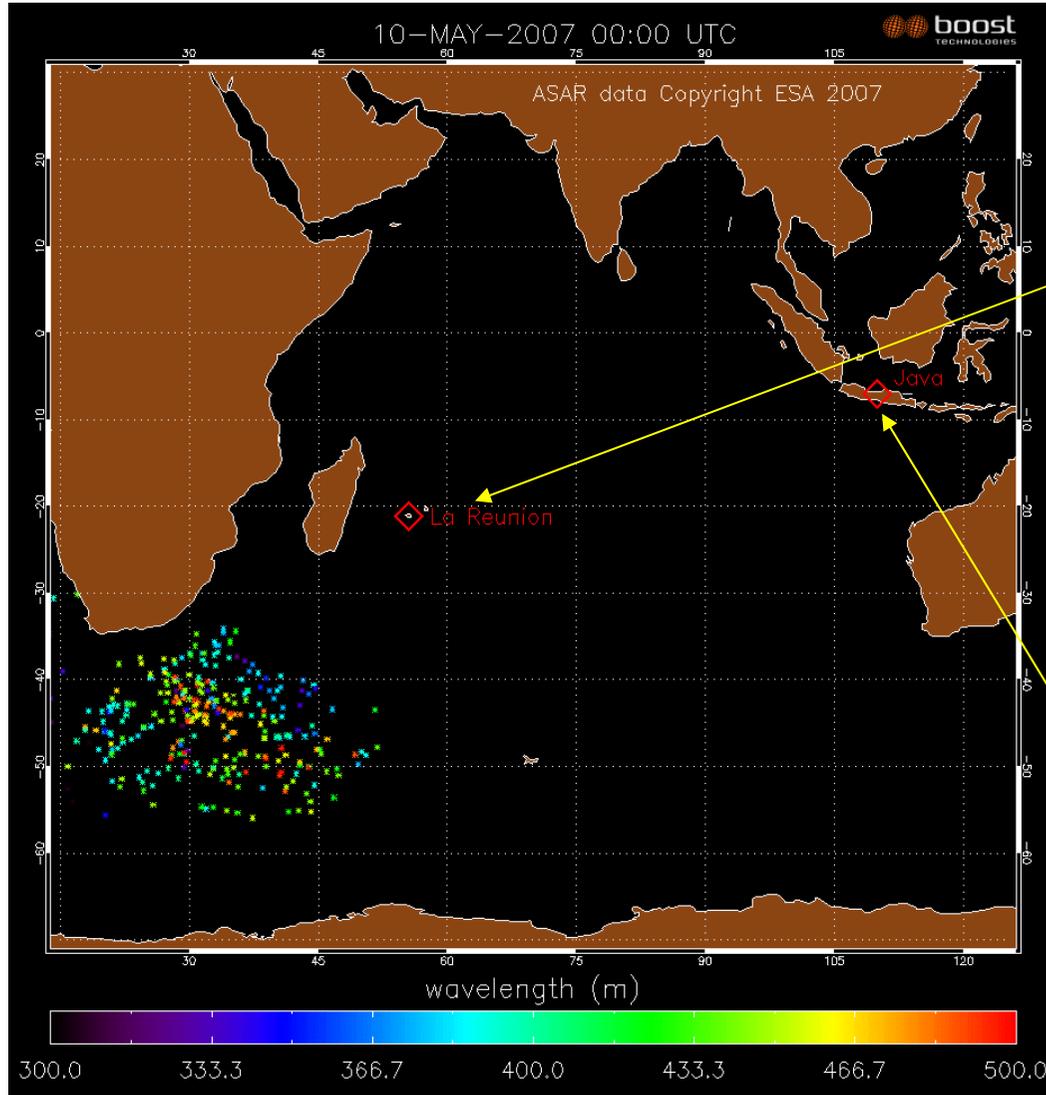
ASAR Wave Mode tracks long swell propagating across the pacific during 12 days



- 6 hour time step
- Wavelength from 300 to 450m
- Wave period from 13 to 17 seconds
- Time period from 8 to 20 July 2004



Headline news: ASAR Wave Mode tracking the long swell that hit La Reunion and Indonesia



A first giant wave of 11meter hit La Reunion island on 12th May



•A subsequent Giant wave of 7 meter hit Indonesia on 17th and 18th May

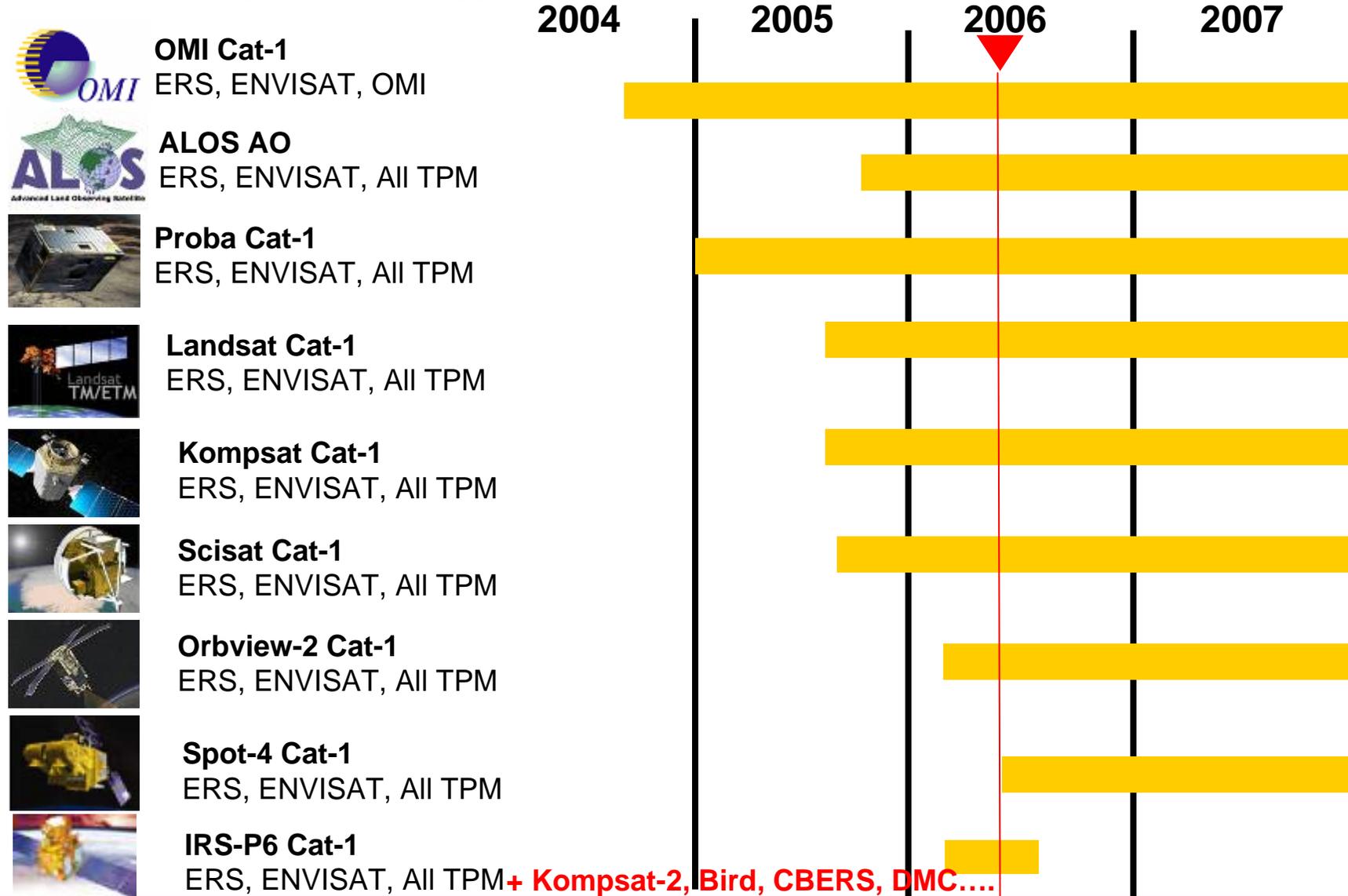


Third Party Missions



Research and Applications Opportunities

ESA selected Third Party Missions





The ALOS Mission

Mission Objectives

- Develop digital elevation models (DEMs)
- Perform regional observation for *sustainable development*
- Conduct disaster monitoring around the world
- Survey natural resources
- Develop sensor and satellite technology



Launch

- ALOS launch 24th Jan 2006 successfully by an H-IIA rocket
- **First data:** 14th Feb (PRISM), 15th (PALSAR), 17th (AVNIR-2)
- **First complete downlink with data at Kiruna 28th April**

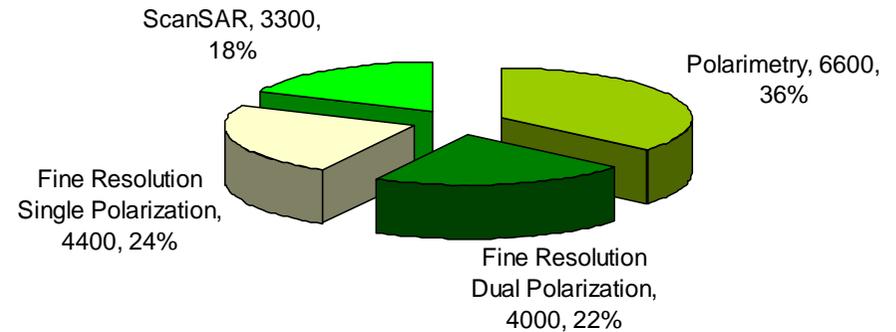
PALSAR

Phased Array type L-band Synthetic Aperture Radar. an active microwave sensor which enables all-weather, 24-hours observations. The sensor has a steerable beam in elevation and the ScanSAR mode. PALSAR has also fully polarimetric capabilities

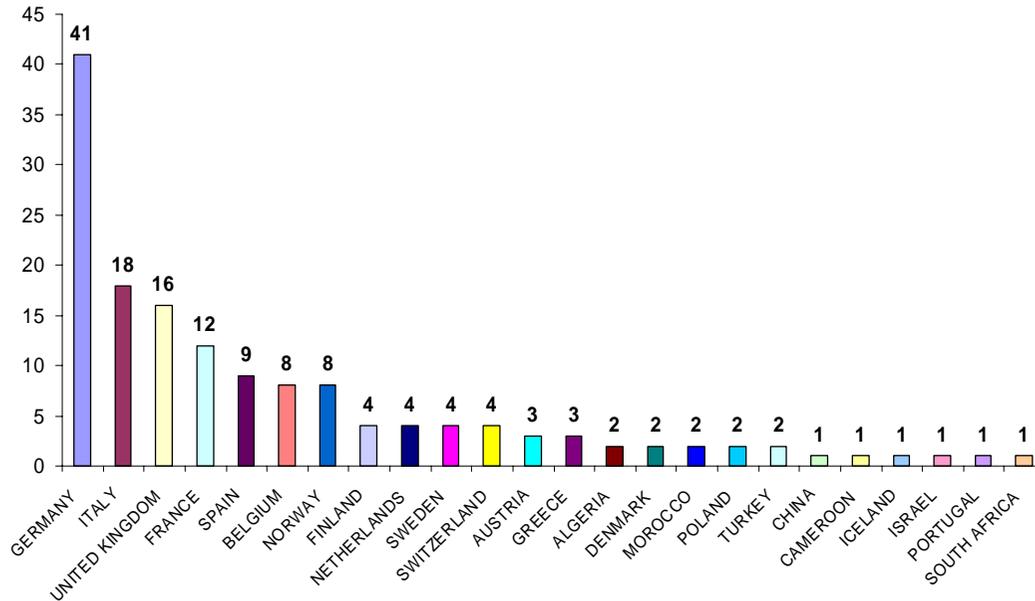
The ALOS AO

Schedule

- Opened on September 20, 2005
- Closed January 2006
- PB-EO approval May 2006
- Notification of evaluation results to the PIs: June 2006
- Start of ALOS data delivery: January 2007



Requested PALSAR Products



... 139 proposals by scientists from ESA Member States

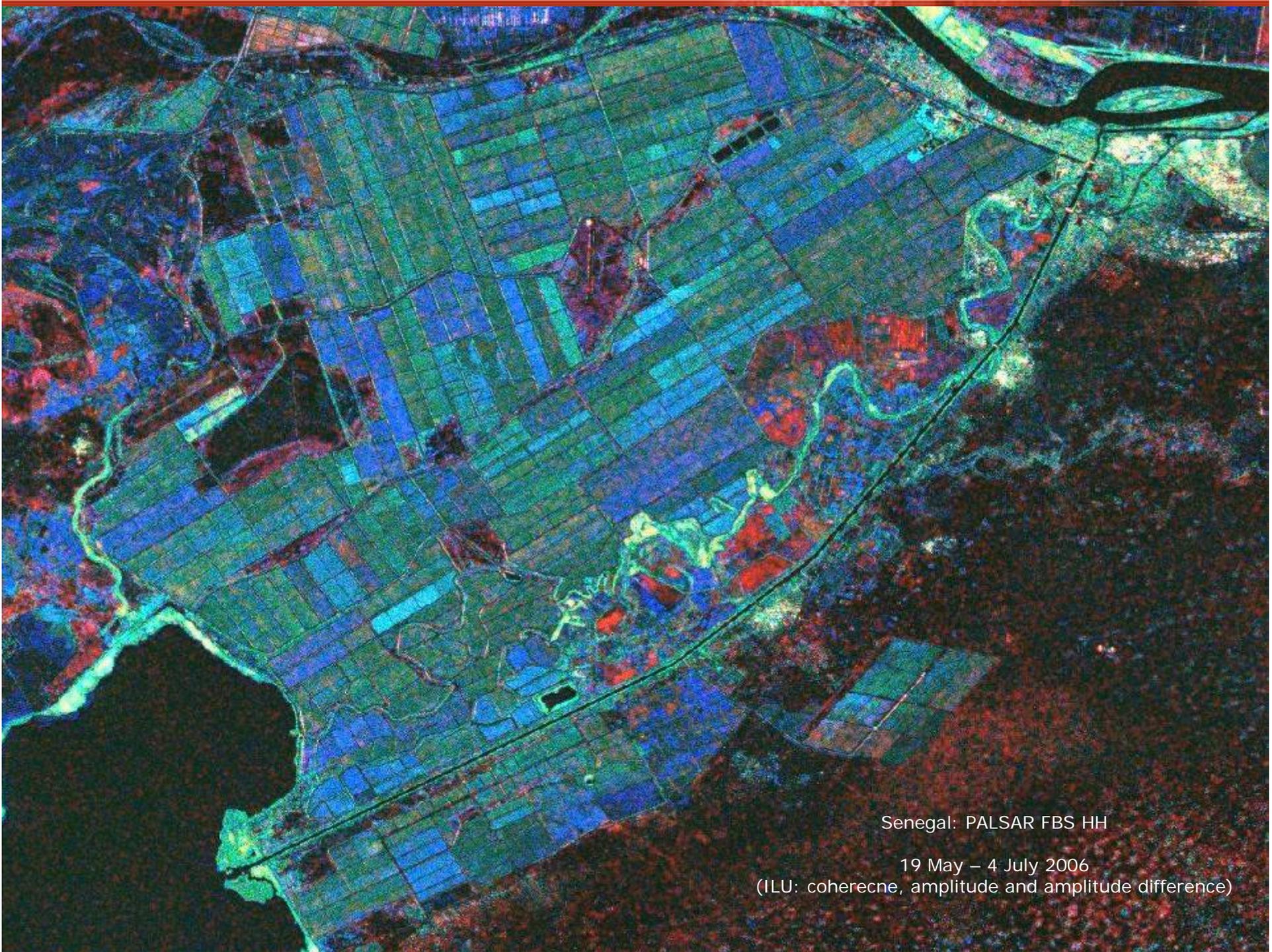


<http://eopi.esa.int/ADEN>



Celebrating the first anniversary of ALOS in orbit

PALSAR Polarimetric Image of Hamburg, GERMANY - Produced on 24th January 2007 - Red: VV, Green: VH, Blue: HH

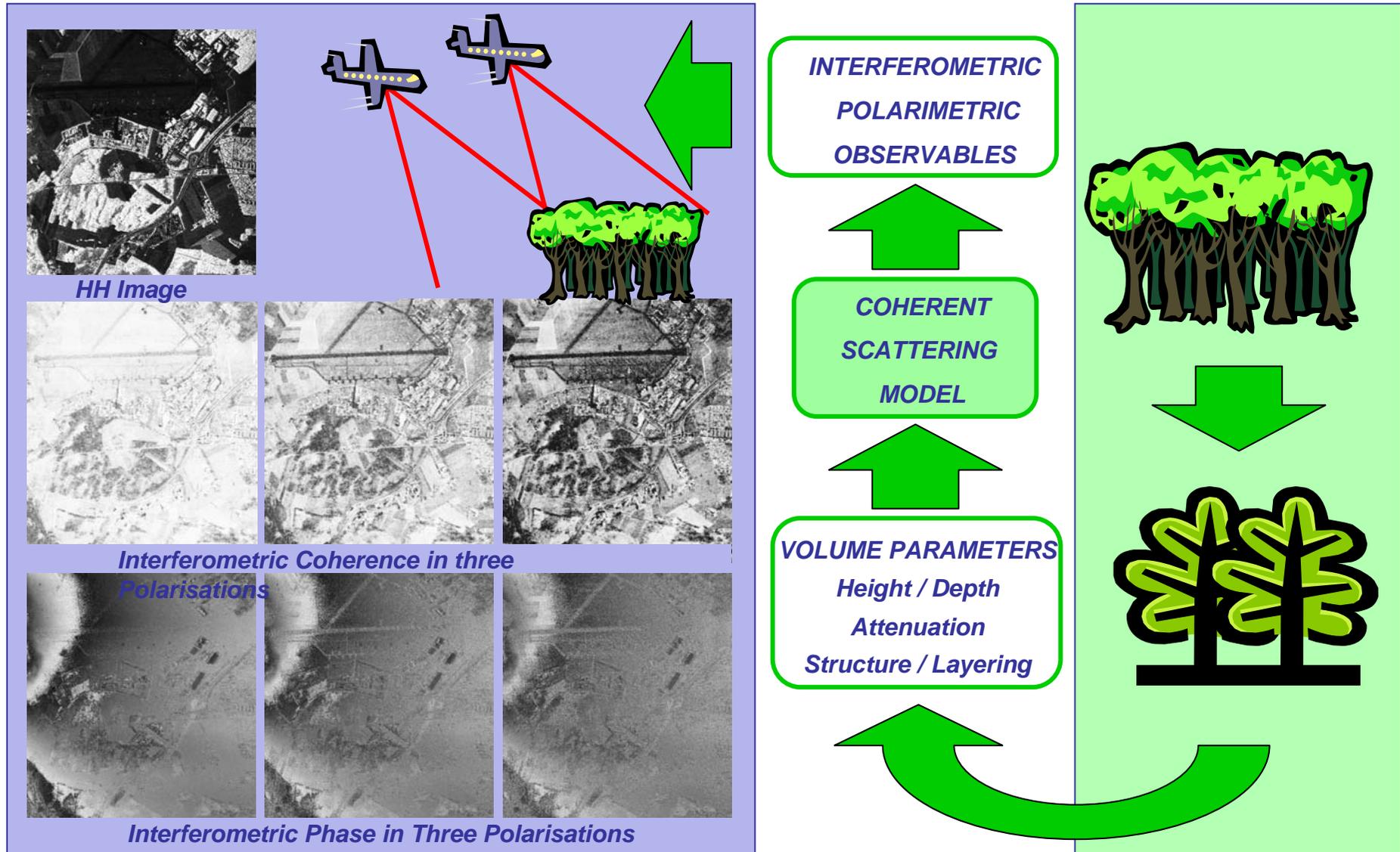


Senegal: PALSAR FBS HH

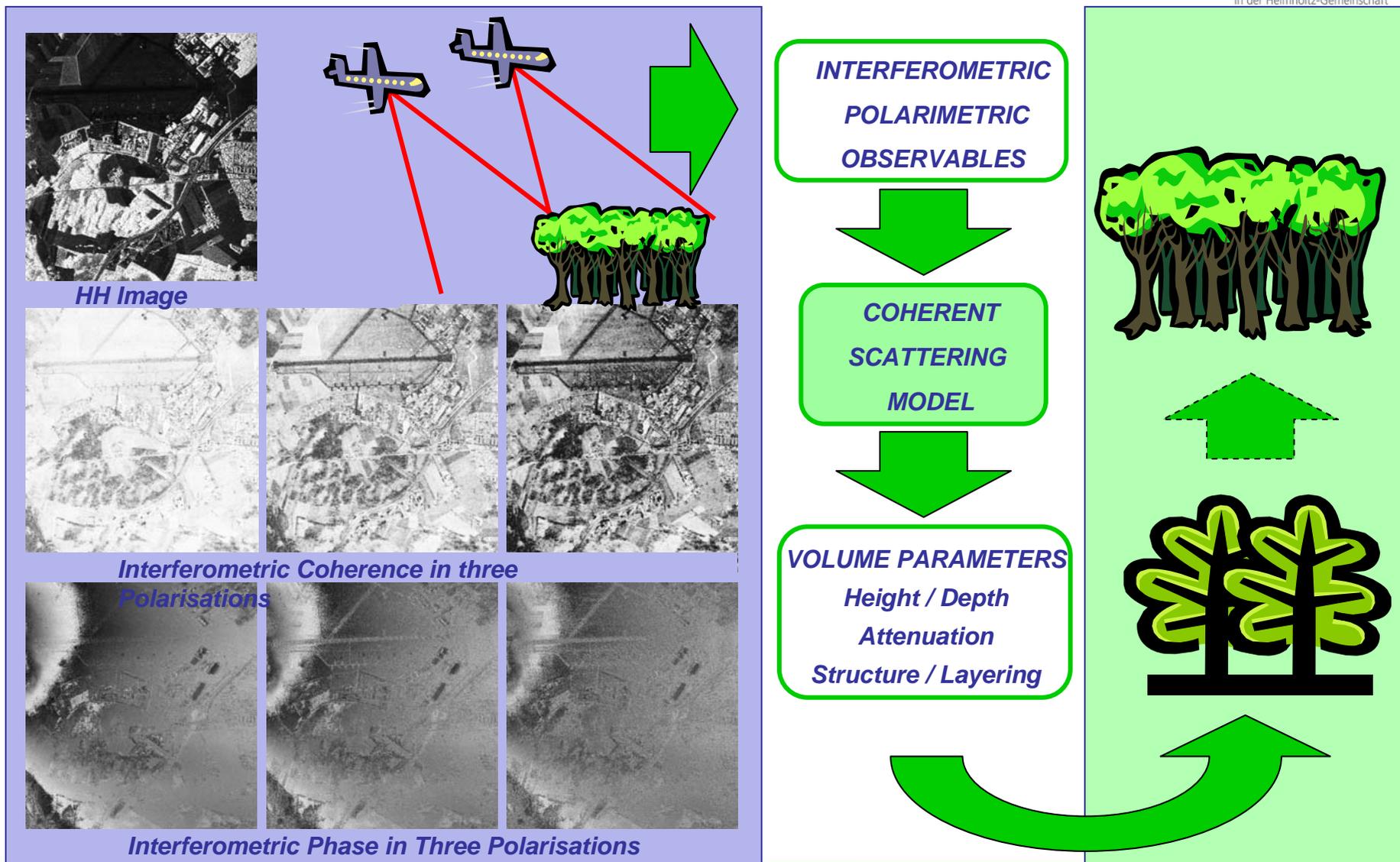
19 May – 4 July 2006
(ILU: coherence, amplitude and amplitude difference)

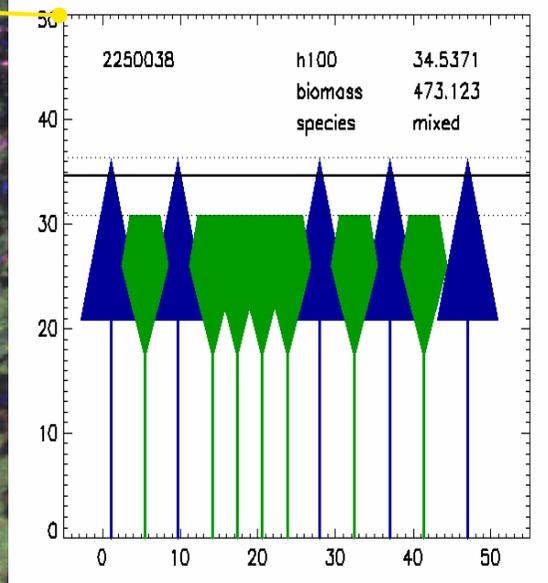
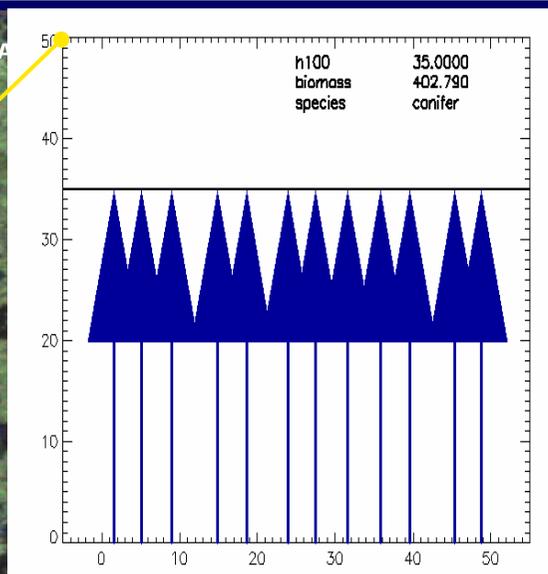
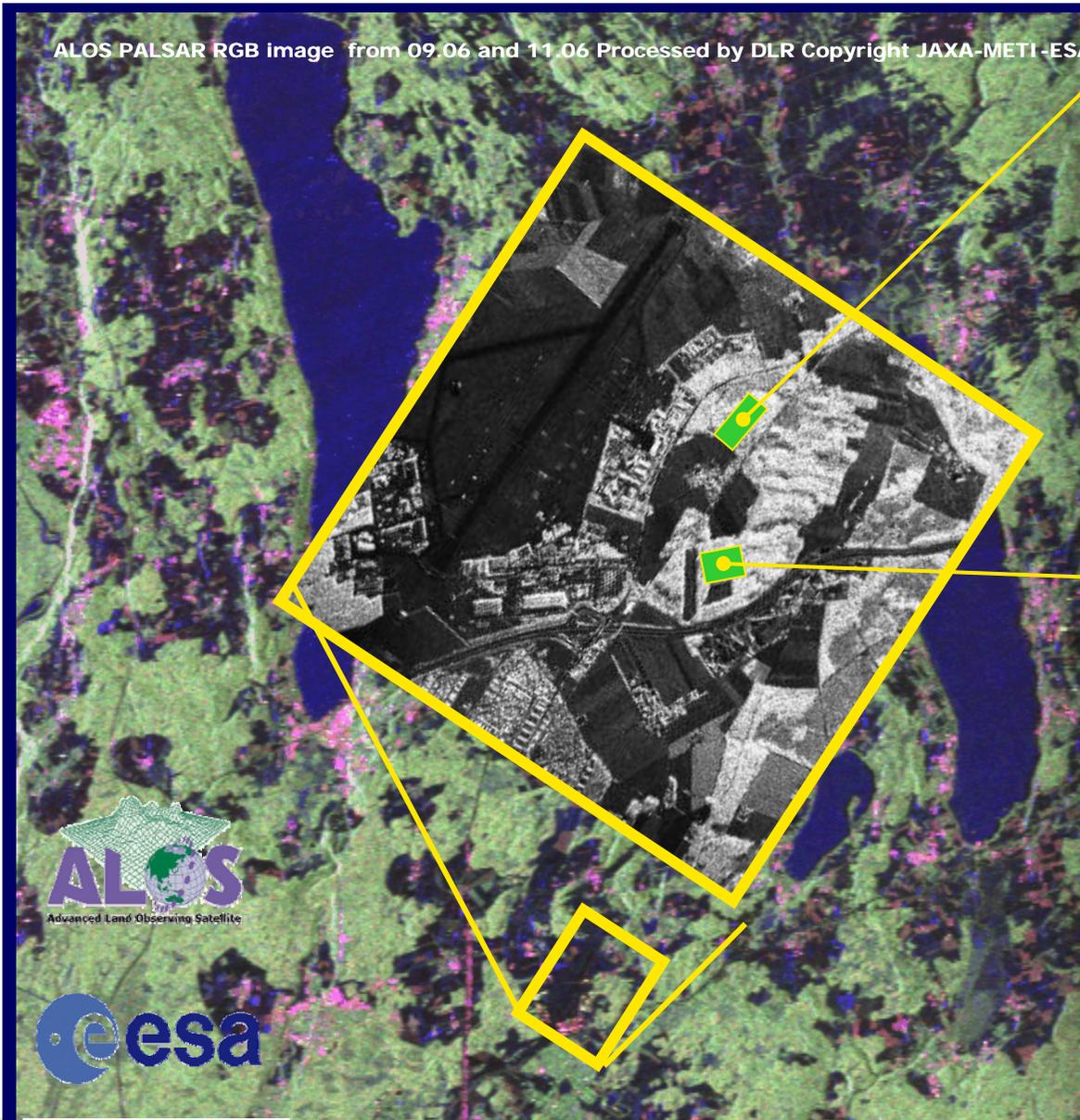


Parameter Estimation by means of Pol-InSAR: Step 1 - Modeling



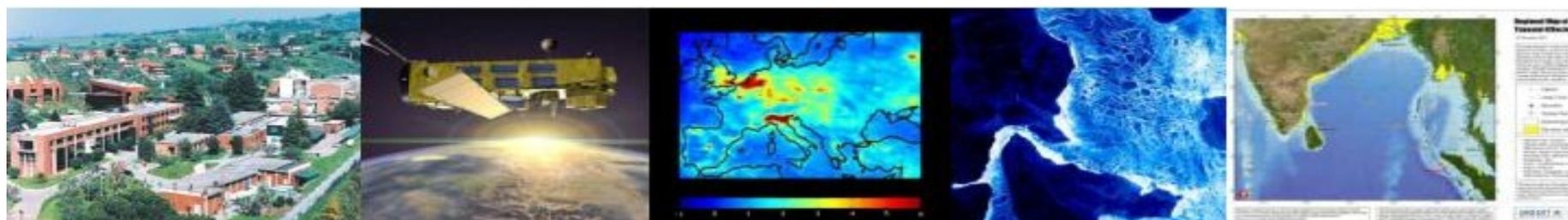
Parameter Estimation by means of Pol-InSAR: Step 2 - Inversion





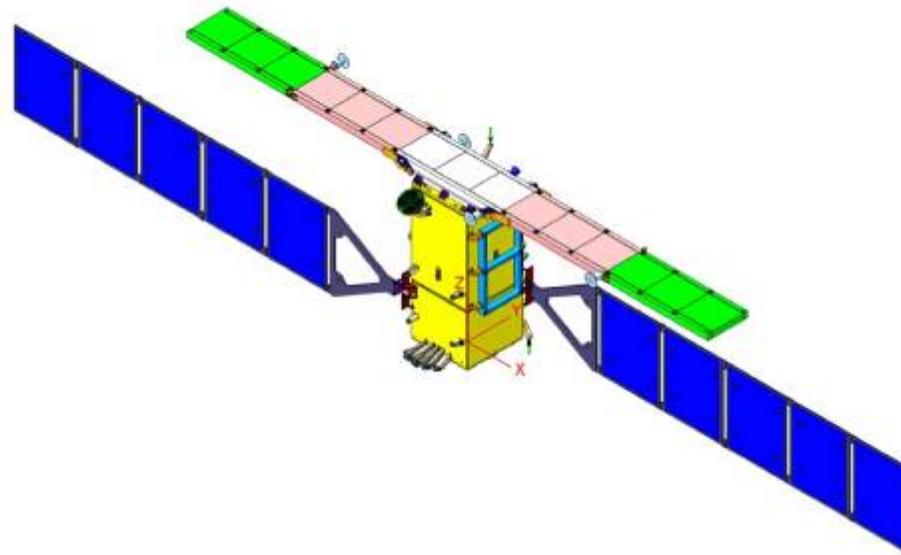


Sentinel-1





Sentinel-1



- European Radar Observatory: C-band Synthetic Aperture Radar
- Main operational mode: SAR imaging (Interferometric Wide Swath)
- Prime task: Continuity of operational SAR applications including interferometry



Sentinel-1 Services (1)

GMES Consolidated Service	Sentinel-1 Contribution
Polar Environment Services	<ul style="list-style-type: none"> •Glacier and Snow Monitoring •Iceberg Monitoring •Sea Ice Monitoring •Oil Discharge Monitoring •Near Shore Ice Complex •Land Monitoring •Lake Ice Monitoring •River Ice Monitoring
Marine & Coastal Environment	<ul style="list-style-type: none"> •Sea surface winds, currents & waves •Oil spill information services (surveillance, drift forecasting) •Ship detection services for fisheries and security
Land Information Services	<ul style="list-style-type: none"> •Basic Land Cover •Soil Sealing Map
Forest Monitoring Services	<ul style="list-style-type: none"> •Green house gas reporting •Sub-National Forest Information Updates •Mapping and Monitoring of Disturbances (Clearing, Fires) •Land Cover & Forest Indicators

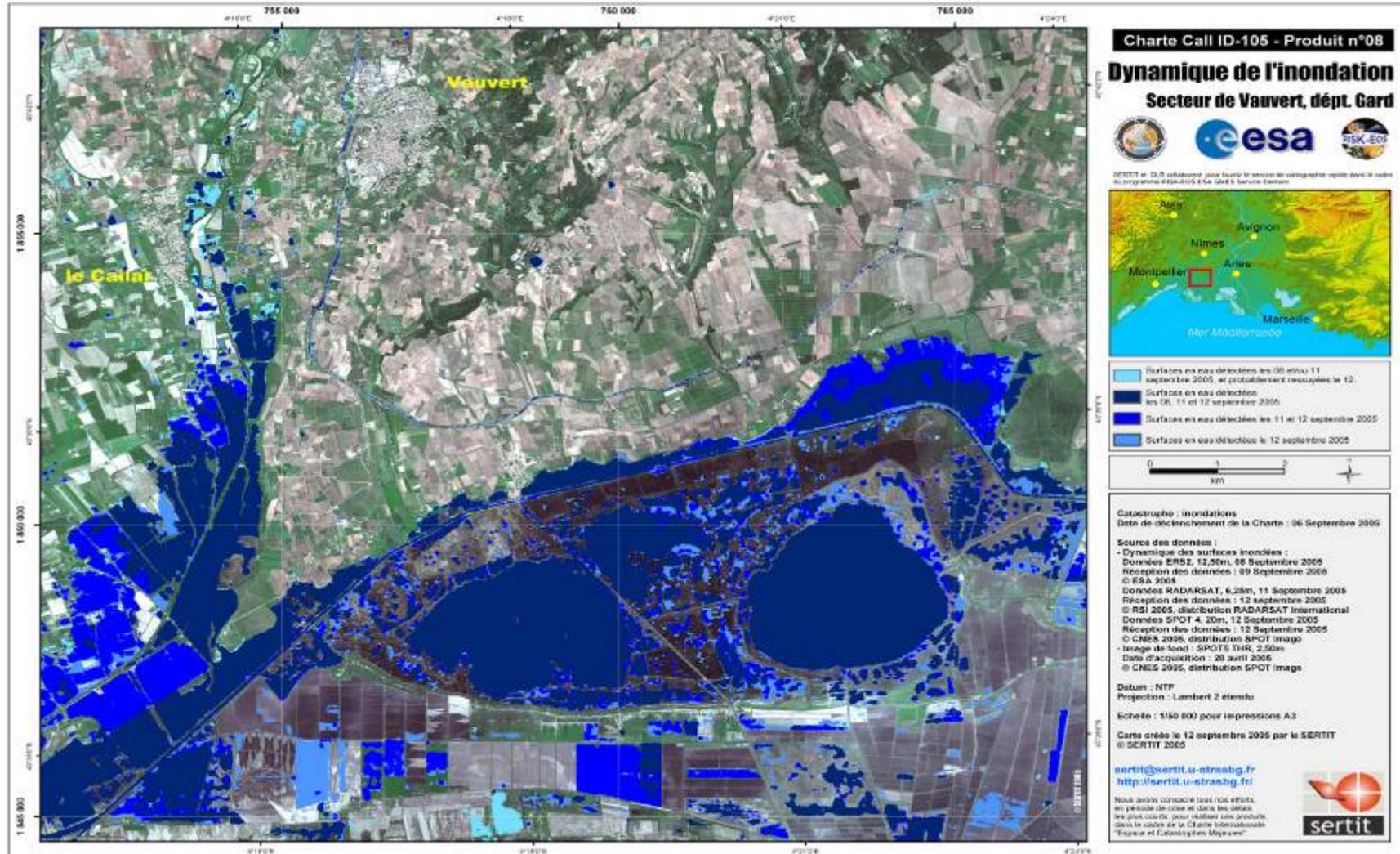


Sentinel-1 Services (2)

GMES Consolidated Service	Sentinel-1 Contribution
Geo-hazard Risk Management	<ul style="list-style-type: none"> •Historical measurements of ground motion: subsidence risk •Subsidence and landslide monitoring (tunnelling project, water table change) •Geological engineering
Flood and Fire Risk Operational Information Services	<ul style="list-style-type: none"> •Flash flood early warning •Floods rapid mapping •Flood risk analysis
Food Security Information	<ul style="list-style-type: none"> •Mapping ploughing time and acreage •Mapping planting time and acreage •Mapping cultivated area at harvest/during growing period
Humanitarian Aid	<ul style="list-style-type: none"> •Rapid mapping for out-of-area crises operation •Cartography for development and reconstruction planning



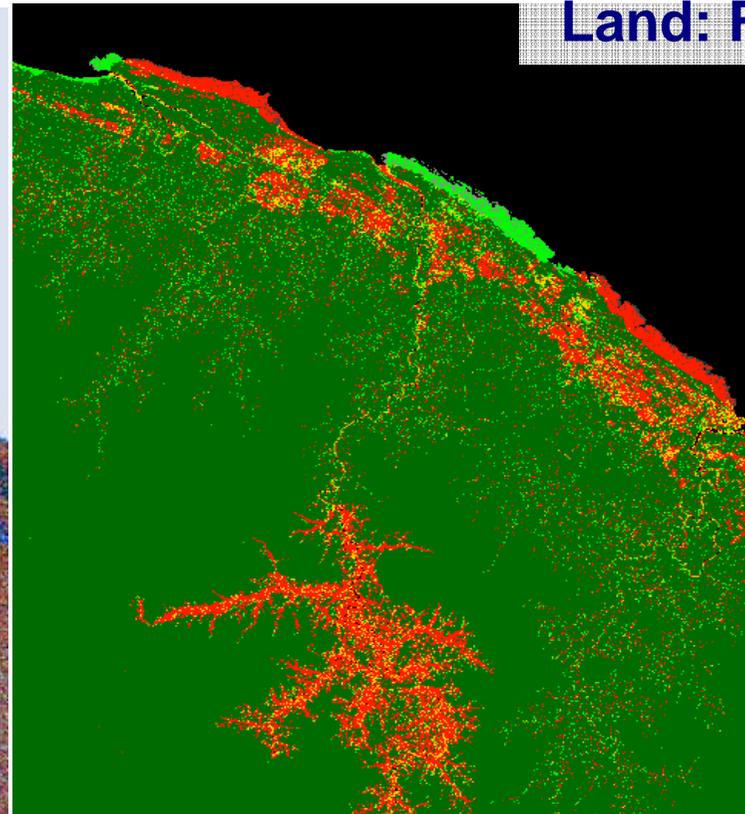
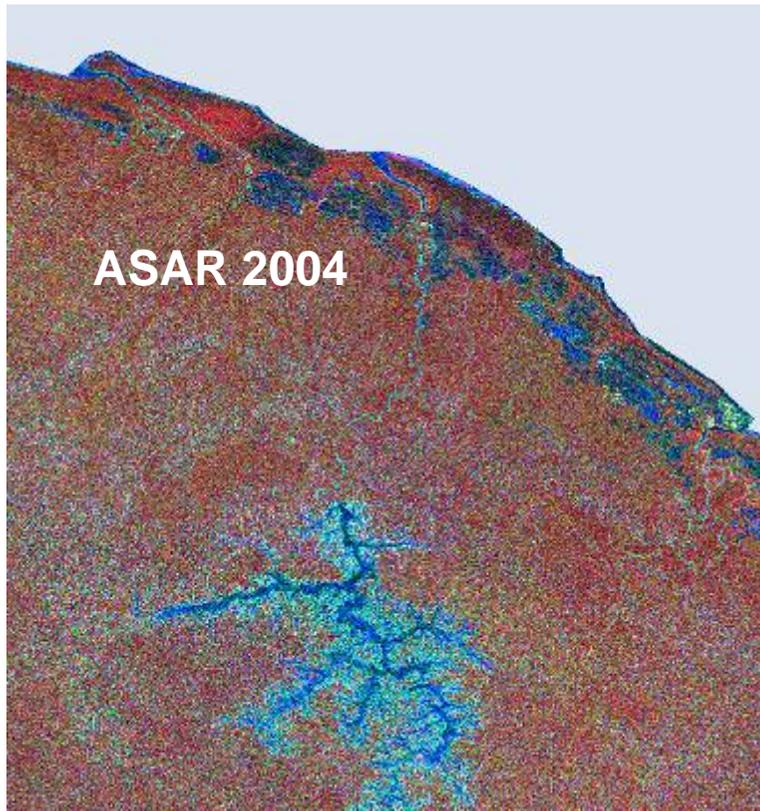
Emergency: Flood service France 2005



Flood Dynamics: 06-12 Sept



Land: Forest service



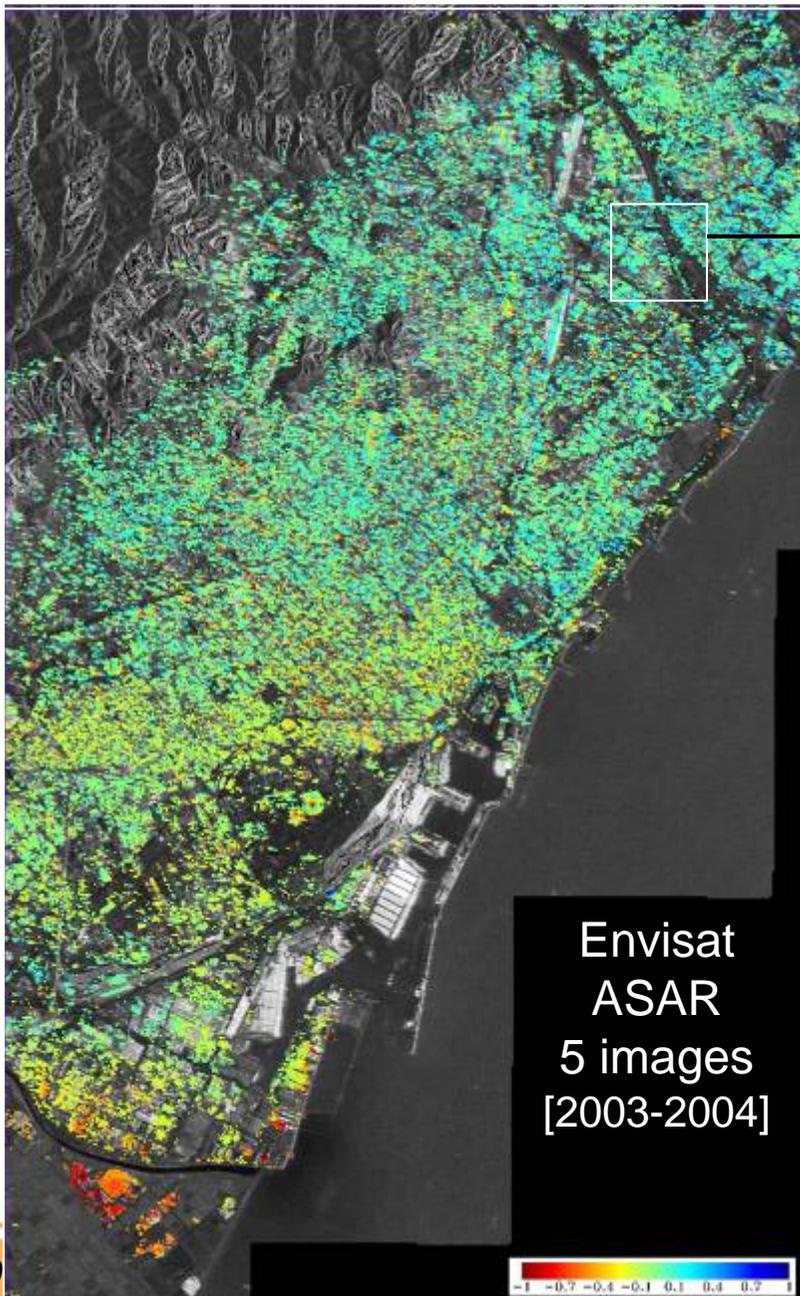
Entire French Guiana (9 million ha) mapped for Ministry of Agriculture (F)

Support to national greenhouse gas reporting under the Kyoto Protocol



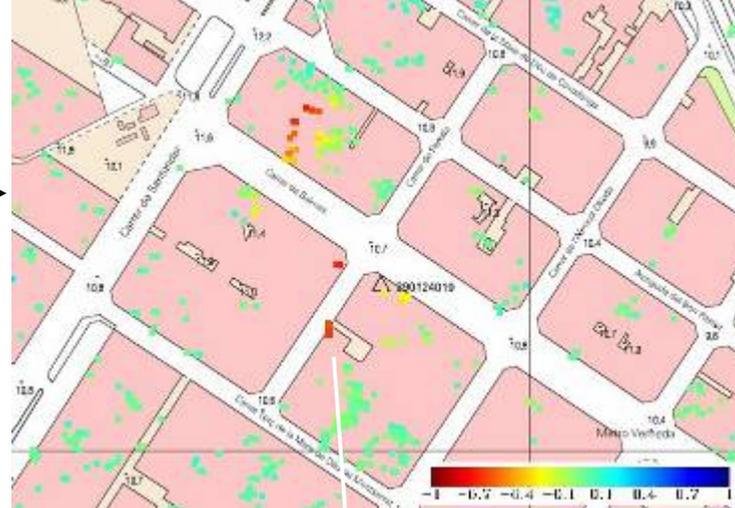
Subsidence
in
Barcelona
(Spain)

Stable
points
network
technique



Envisat
ASAR
5 images
[2003-2004]

Geo Hazard Information service





Marine: Sea Ice service

Meteorologisk institutt
met.no
Polar View

May 8th 2006

Sea Ice Service
Forecasting Division for Northern Norway

N-4283 Tromsø, Norway Tel: +47 77625482 Fax: +47 77621401 email: iktjens@met.no

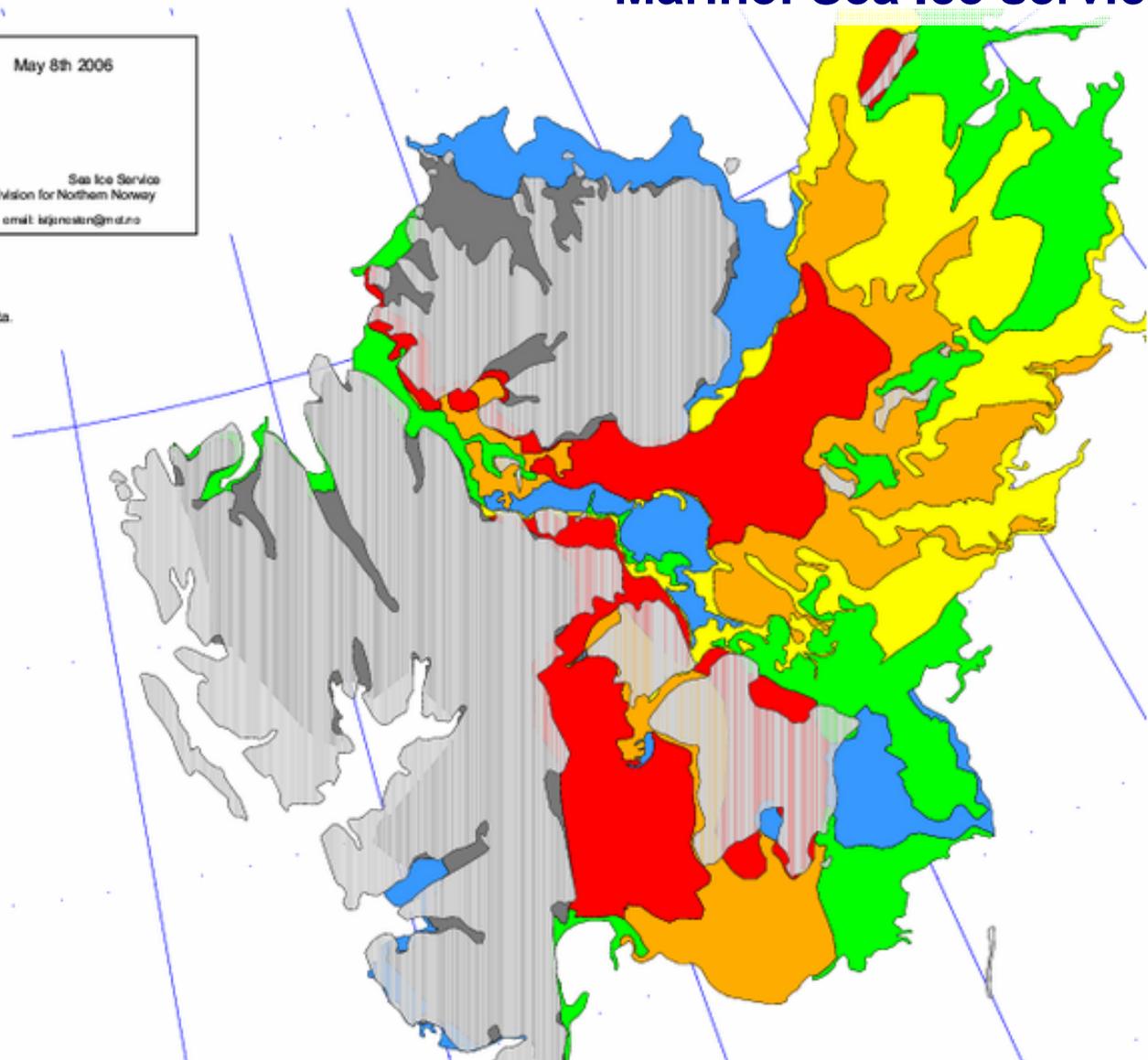
Map Projection: Stereographic Conformal

Data Source:

- 150 m resolution Radarsat/Envisat SAR satellite data.
- 500 m resolution Aqua/Terra MODIS satellite data.
- 1.5 km resolution NOAA/AVHRR satellite data.

Ice Categories:

- Fast ice
- Very Close Drift ice: 9/10 - 10/10
- Close Drift ice: 7/10 - 9/10
- Open Drift ice: 4/10 - 7/10
- Very Open Drift ice: 1/10 - 4/10
- Open Water: 0/10 - 1/10





Sentinel 1 MRD : Service Network Feedback

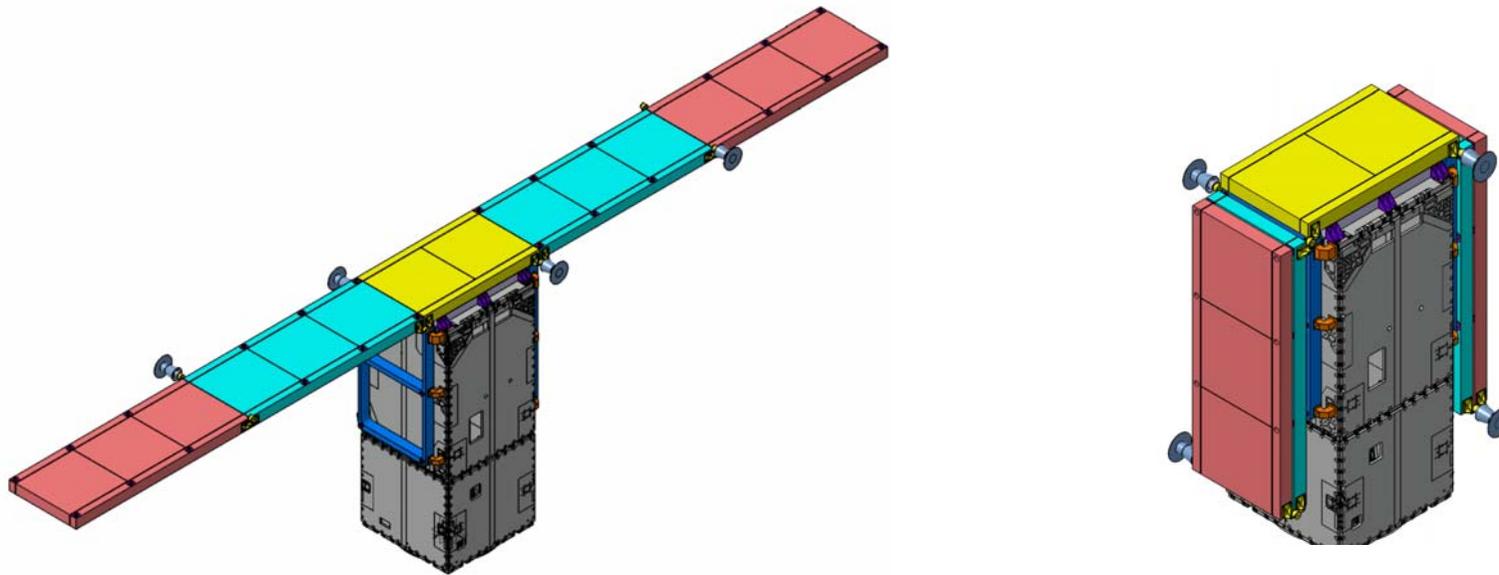
GSE Services	Sensors						Operations		
	SAR Band	Polarisation	Radiometry	Resolution	Swath Width	Revisit Cycle	Geo Accuracy	Data Delivery T	Data Order T
Iceberg Monitoring Service	Compliant	Compliant	Partially Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
River Ice Monitoring	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
Floe Edge Service	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
Glacier Monitoring	Compliant	Compliant	Compliant	Compliant	Compliant	Partially Compliant	Compliant	Compliant	Compliant
Snow Monitoring	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Partially Compliant	Partially Compliant
High resolution ice charts	Compliant	Partially Compliant	Compliant	Partially Compliant	Non-Compliant	Compliant	Compliant	Non-Compliant	Non-Compliant
Ice Forecasting (Baltic Sea)	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Non-Compliant	Partially Compliant
High-Resolution Ice Thickness Charts (Baltic Sea)	Compliant	Partially Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Non-Compliant	Partially Compliant
Oil Pollution Alert	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Non-Compliant	Compliant
Geo-hazard Land Motion Monitoring	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Partially Compliant	Compliant	Partially Compliant
Flood Monitoring	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Missing in MRD	Compliant	Compliant
Flood Risk Analysis	Compliant	Partially Compliant	Compliant	Partially Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
Rapid Mapping	Compliant	Compliant	Compliant	Non-Compliant	Compliant	Compliant	Non-Compliant	Partially Compliant	Partially Compliant
Food Security Crop Mapping	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
National UNFCCC & LULUCF Kyoto Protocol Rep	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
Environmental Monitoring	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
Forest Disturbances Detection and Monitoring	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant

Compliant Non-Compliant
 Partially Compliant Missing in MRD



Sentinel-1 Antenna Configuration

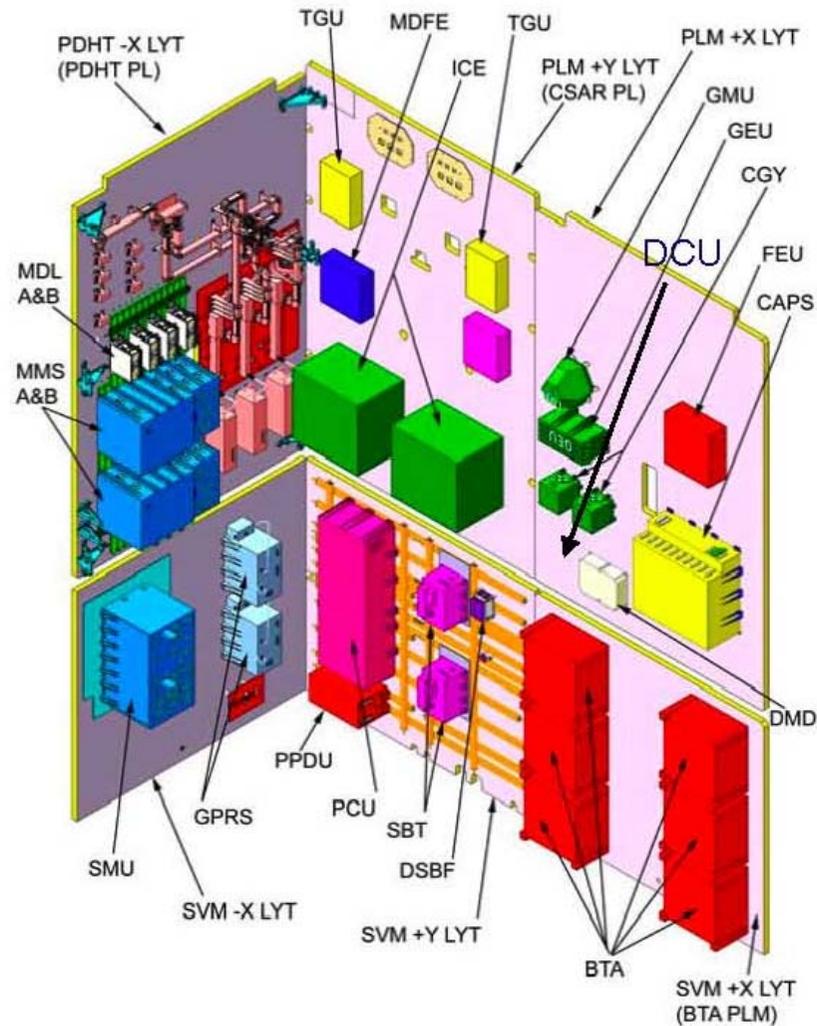
SAR antenna and Solar Array in flight configuration and stowed



***Present Status: start
Phase B2***



SAR Internal Units Accommodation



**Present
Status:
start
Phase B2**



Spacecraft Budgets

- **Mass** 2.1 ton
- **Power** 6 kW
- **Antenna size** 10 x 1.4 m
- **Fuel** > 10 years
- **Downlink rate** ~ 500 Mbps (X band)
- **Center frequency** same as Radarsat 2
- **S-1 revisit period:** 12 days
- **Phase A/B1 activities** completed
- **System Requirement Review** completed
- **Launch date** June 2011

S1 Payload

Orbit: 12 d (06:00 LTDN)	ASAR : 35 d (10:00 LTDN)
<u>Stripmap Mode (SM)</u>	
Swath: 80 km	comparable to ASAR
Resolution: 5x5 m (1L)	better than ASAR capability
<u>Extra-wide Swath Mode (EW)</u>	
Swath: 400 km	same as ASAR
Resolution: 25x100 m (3L)	better than ASAR capability
<u>Wave (WV)</u>	
Swath: 20x20 km	better than ASAR
Resolution: 20x5 m	better than ASAR
<u>Interferometric Wideswath Mode (IW)</u>	NEW MODE (BASELINE)
Swath: 240 km	
Resolution: cell area	comparable to ERS
Sensitivity, Ambiguity, Radiometric performance	comparable to ASAR
No separate AP mode but dual-pol capability in all modes without performance reduction	

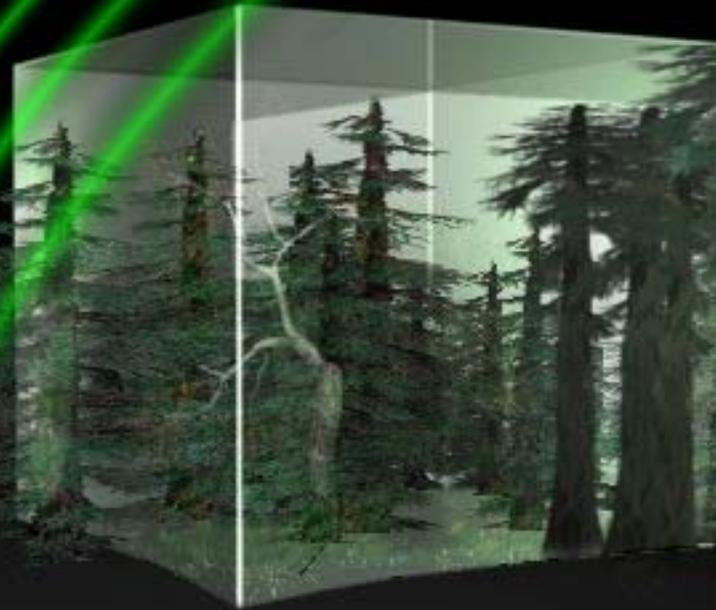


Earth Explorers Candidates

**Two “SAR missions” in the Six new Earth Explorer
Candidate missions selected for further assessment study**

“Report for Assessment” to be finalized spring 2008

BIOMASS



Malcolm Davidson BIOMASS Mission Scientist and the BIOMASS MAG(*)

(*) Thuy Le Toan, Shaun Quegan, Heiko Baltzer, Philippe Paillou, Konstantin Papathanassiou, Fabio Rocca, Lars Ulander, Stephen Plummer

Mission objectives

- Better **understanding and quantification** of **land contribution to global carbon cycle** through
 - Gridded high-resolution global estimates of **above ground biomass**
 - Monitoring and quantification of **forest disturbance** and **recovery**
 - Monitoring and quantification of **wetland areas and forest inundation**
- Additional objectives related to opportunity for spaceborne P-Band SAR images
 - Mapping subsurface structures, polar regions,
 - Mapping subsurface geomorphology in arid zones



Mission requirements



Information Product	Mission Requirements
Forest Biomass (above ground)	<ul style="list-style-type: none"> • 20% accuracy • 100-300m resolution/16 looks • 2 biomass maps/year • Polarimetric Interferometric mode • Global coverage of forests
Forest Disturbance	<ul style="list-style-type: none"> • Maps of disturbed area with 10% classification accuracy • 100m resolution/16 looks • 1-2 forest disturbance maps every 2months • Global coverage
Forest Regrowth	<ul style="list-style-type: none"> • Biomass information 20% accuracy • Biomass rate of change – 20% accuracy • 100-200m resolution/16 looks • 2 revisits/year • Global coverage with focus on tropical forests
Forest seasonal floods	<ul style="list-style-type: none"> • Inundation area information – 10% classification accuracy • 100m resolution/16 looks • 1 revisit/month during flood season • tropical forests (main target) + boreal wetlands (secondary target) for methane emission



Mission Concept

- Phase 0 Industrial activity initiated to define P-Band SAR payload and mission platform

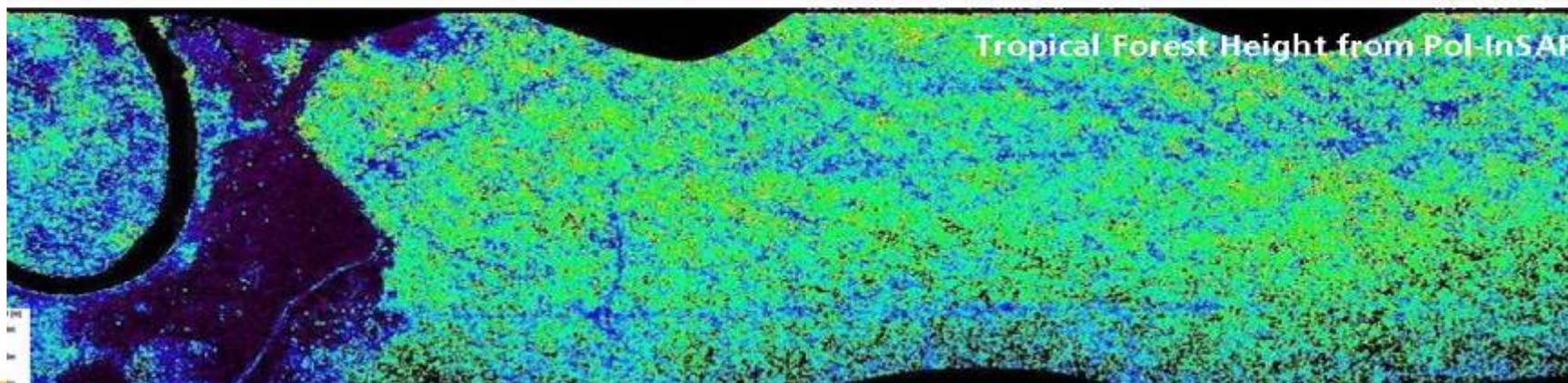
Instrument Type	P-band Synthetic Aperture Radar (SAR)
Centre Frequency	435 MHz (P-Band)
Bandwidth	≤ 6 MHz (ITU allocation)
Polarisation	Full polarimetry and/or dual polarization (HH, HV)
Data acquisition	Single pass/repeat pass polarimetric interferometry
Spatial Resolution	≤ 50 m x 50 m (≥ 4 looks)
Swath width	≥ 100 km
Noise Equivalent σ_0	≤ -25 dB (T), -30 dB(G)
Radiometric Resolution	≤ 1 dB
Radiometric Stability	≤ 0.5 dB over 1 orbit



Advanced techniques



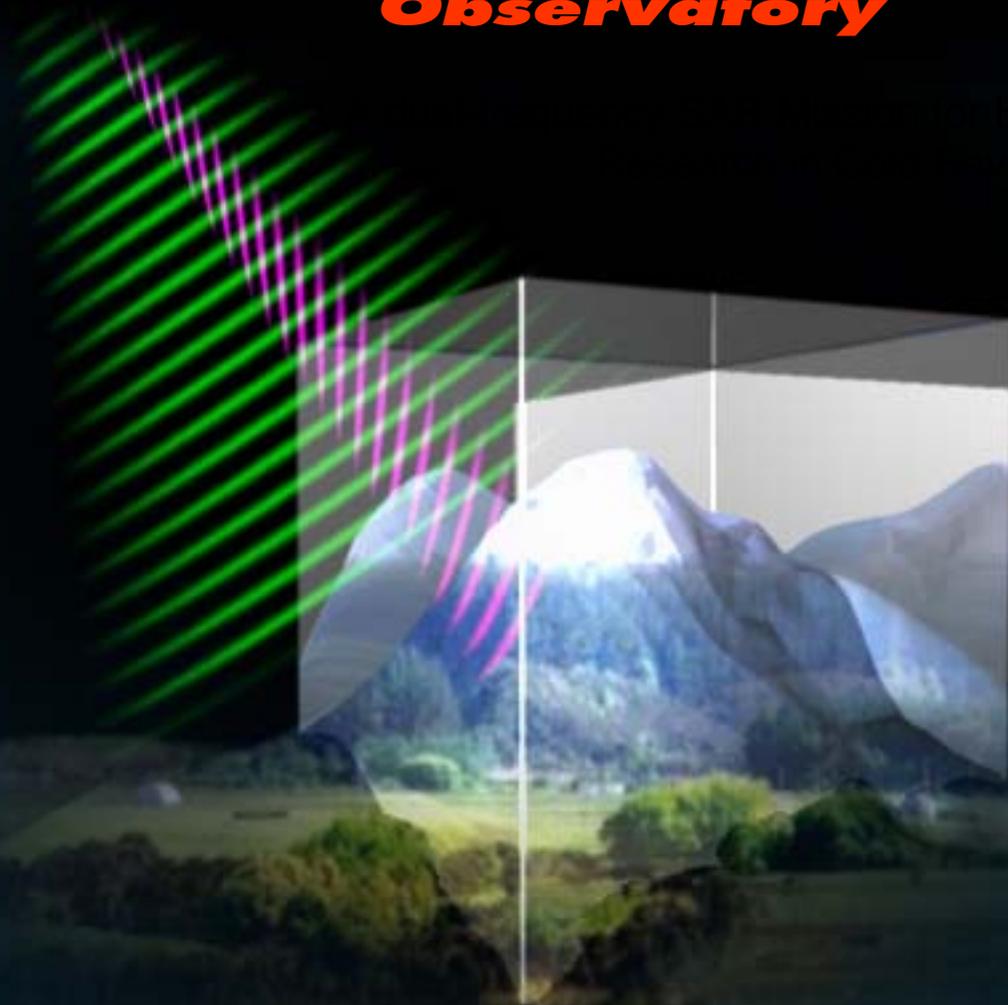
- Biomass retrieval based on advanced techniques (e.g. PolInSAR forest height, classification) expected to improve intensity-only retrievals



Cold Regions Hydrology High resolution Observatory



Centre for Hydrology and Climate
Environment



Helge Rebhan, Mission Scientist

Members of CoRe-H2O MAG Helmut Rott, Austria

Richard Essery, UK Christian Haas, Germany

Claude Duguay, Canada, Giovanni Macelloni, Italy, Eirik

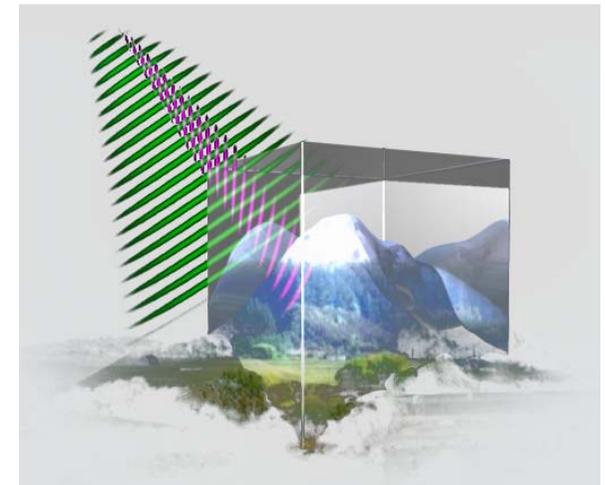
Malnes, Sweden, Jouni Pulliainen, Finland



The importance of Snow and Glaciers observations



- Global climate system
 - Improved understanding and modelling of snow cover.
- Hydrological processes
 - In high and mid latitudes snow cover is a key parameter of the water and energy cycle of land surfaces
- Glacier mass balance and runoff modelling
 - Snow extent and mass are key input parameters .
- Water management and flood control:
 - improve flood forecasting and water resources management.





Key Observation Requirements



Variable	Spatial scale [m]		Repeat interval	Accuracy (RMS)
	-Threshold -Goal	-Threshold -Goal		-Threshold -Goal
	Global	Regional		

1. Primary Parameters

Snow

Snow extent	700	200	3-15 d	4% of hydrological unit (HU)
	500	100		2% of hydrological unit (HU)
Water equivalent	500	200	15 d	20% for WE < 20 cm
	300	100		10% for WE < 20 cm

2.) Secondary Parameters

Snow

Extent of melting snow	500	100	3 d	2% of HU
Snow depth	500	200	3-15 d	10% at HU

Glaciers

Facies type	200	100	15 d	2% of glacier area
Winter snow accumulation	500	200	15 d	10% of maximum
Terminus position, lakes	N/A	50	15 d	50 m

Freshwater Ice

Ice area	N/A	50	3 d	5% of overall sea ice area
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Sea Ice

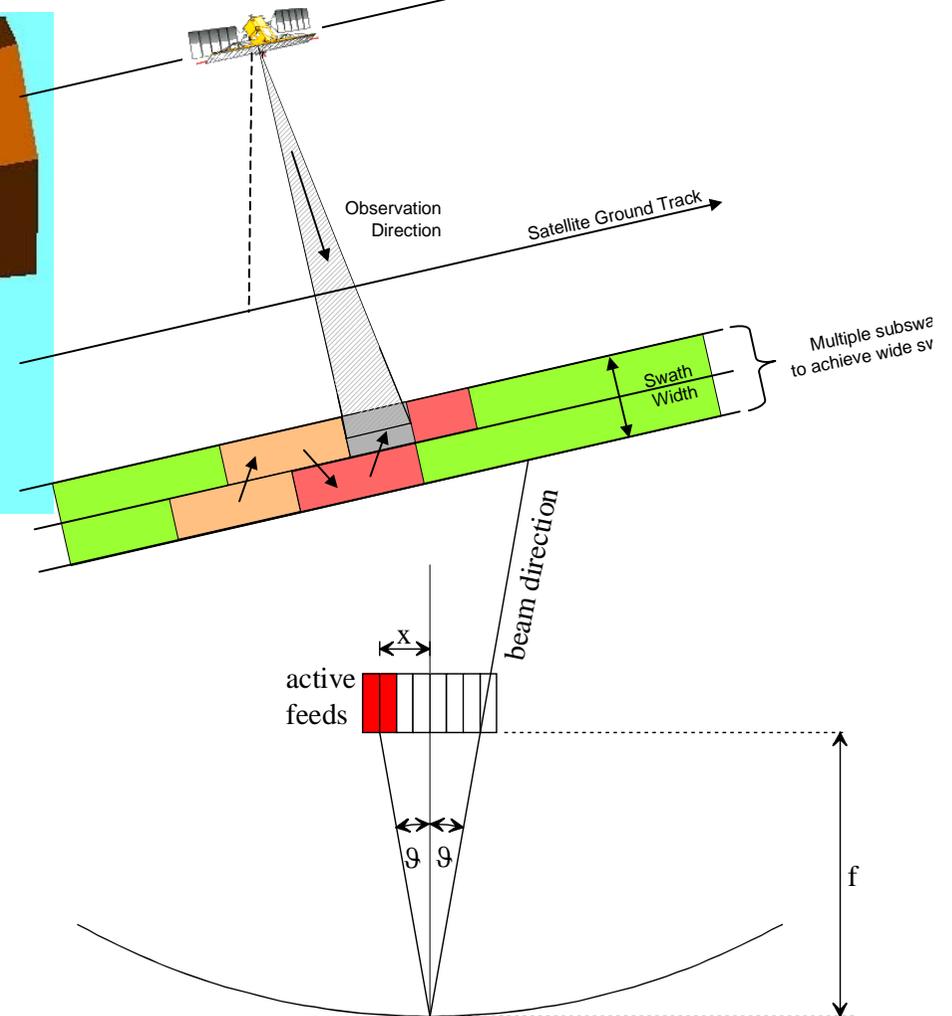
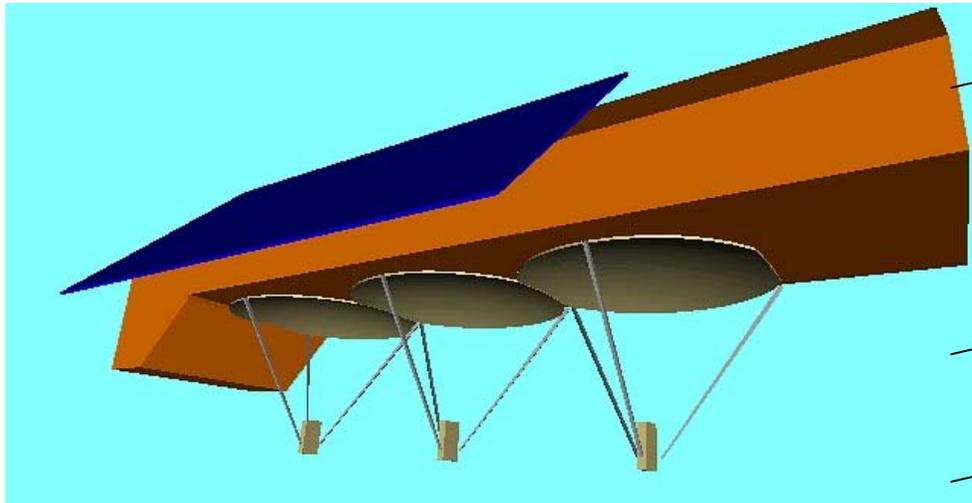
Snow Depth	N/A	200	3 -15d	ca. 10 cm
Ice Type	N/A	100	3 d	5% classification error
Ice Motion	N/A	1000	3 d	ca. 200m/day
Ice Melt	N/A	100	3 d	5% of overall sea ice area

Surface Water

Extent of open water areas	100	50	3-15 d	0.02 km ² capability
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Potential SAR Satellite Configuration



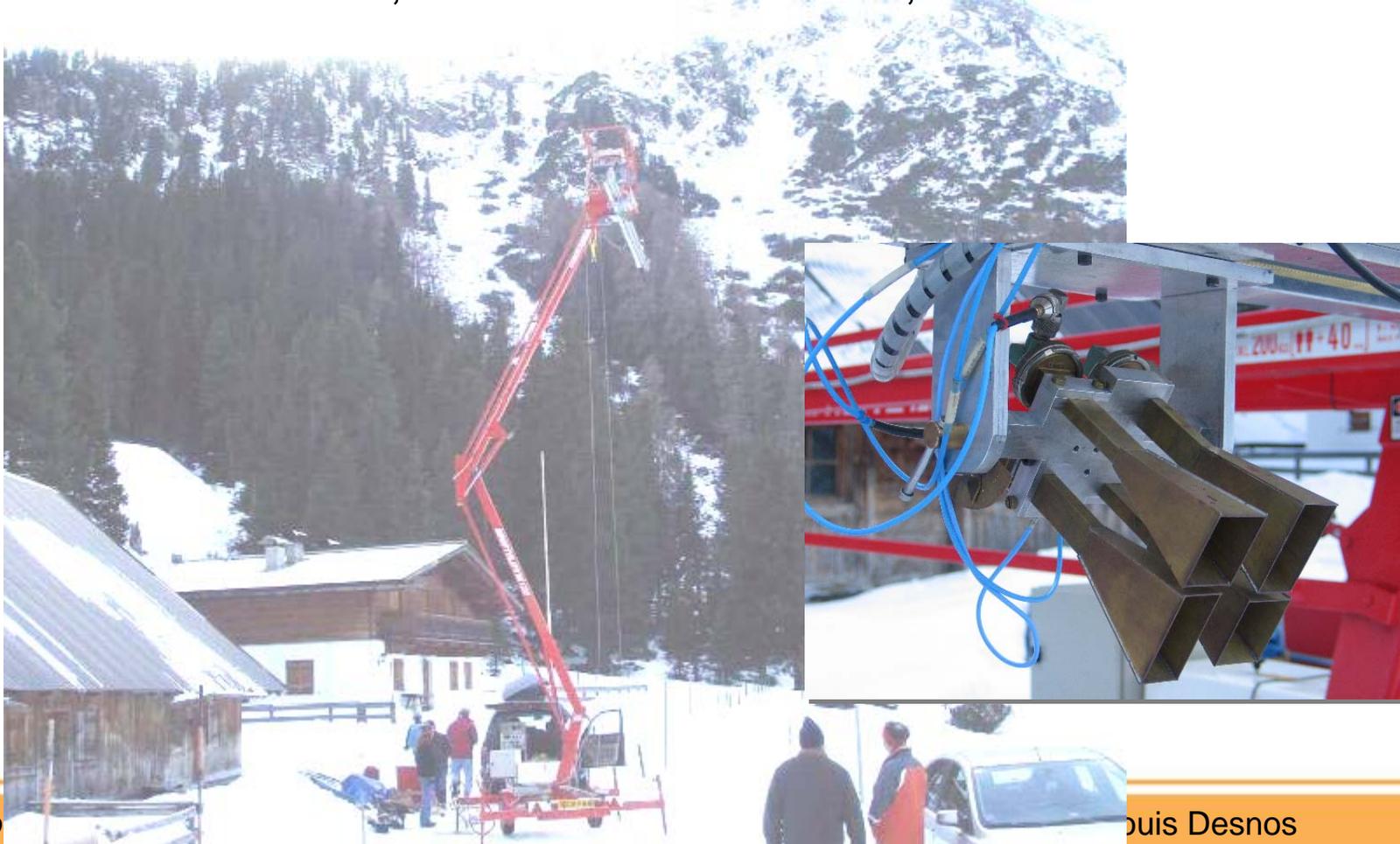
- SAR Instrument:
 - - 2 frequencies 9.6 and 17.2 GHz
 - - VV and VH Polarisation
- Scan SAR Resolution 25x10m



In-situ Campaigns ESA



- Ku-band measurement campaign in Austria Jan-Mar 07:
 - first experimental field measurements with existing Ku/X-band radar system
 - Contractor: ENVEO, Austria Univ of Cranfield, UK





THANK YOU