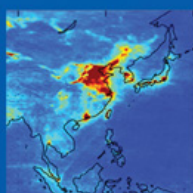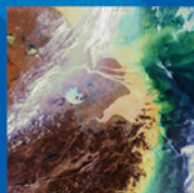esa

NRSCC

DRAGON PROGRAMME

2005 BROCHURE

DRAGON

2005

THE 2005 DRAGON BROCHURE

This 2005 Dragon Programme brochure presents the activities undertaken since the project kick off in Xiamen, April 2004. Over the last 15 months in Europe a briefing was made to Greek scientists in October 2004 about the Dragon Programme and as a result Greek scientists have joined several of the projects as co-investigators. In China ESA and NRSCC have organised two progress meetings in Beijing, in November 2004 and April 2005 respectively.

At these meetings, Chinese scientists provided details about their project progress and further defined their EO data requirements. As one key component of the programme, an advanced training course in Ocean remote sensing was successfully held at the Ocean University of China, Qingdao, P.R.China during 6 days in October 2004 and was attended by 78 scientists. Since the formal start of the programme, a large quantity of ENVISAT/ERS EO data has been made available to all of the projects and detailed coordination of all requested acquisitions over China has been performed.

Joint publications and articles have been prepared by ESA/NRSCC and are available via the Dragon web site at http://earth.esa.int/dragon/.

 The second Dragon annual symposium is to be held in Greece in June 2005 at which results will be presented for the 15 projects.

In addition young scientists have been appointed on the Dragon projects in Europe and China and will report in the annual symposium.

The next steps during 2005 are the preparation for an advanced training course in land remote sensing that will be held at the Beijing Capital University in Beijing in October 2005. In addition, 2005 will also see the preparation of a Dragon Programme mid term joint publication as an ESA/NRSCC special publication.

We look forward to this continuing collaboration and the exchange of new results over the lifetime of the Dragon Programme.

Best regards,

THE DRAGON PROGRAMME CO-ORDINATORS

ESA - Yves-Louis Desnos, e-mail: yves-louis.desnos@esa.int

NRSCC - Li Zengyuan, e-mail: zengyuan.li@forestry.ac.cn

ABOUT TO THE DRAGON PROGRAMME

Background

ESA, together with the National Remote Sensing Centre of China (NRSCC), an entity under the Ministry of Science and Technology of the P.R. China, have cooperated in the field of Earth Observation application development for the last ten years. The cooperation has taken on a new momentum with the creation of a dedicated three-year Earth Observation exploitation programme called Dragon (2004 to 2007). The programme formally kicked-off in April 2004, with a three day Symposium that was held in Xiamen city in P.R. China. The Dragon programme focuses on science and applications development in P.R. China using mainly data from ESA ERS and Envisat missions.

Objectives

The Dragon Programme is targeted to land, ocean and atmospheric investigations in the P.R. China that are outlined by NRSCC in the ESA-MOST Dragon proposal, available at http://earth.esa.int/Dragon

- To promote the use of ESA data from the ERS and Envisat satellites

- To stimulate scientific exchange in EO science and technology by the formation of joint Sino-European teams

- To publish co-authored results of the research and applications development

- To provide training in processing, algorithm and product development from ESA EO data in land, ocean and atmospheric applications

Project Themes

The thematic areas under investigation are as follows:

- Agricultural Monitoring
- Flood Monitoring
- Forest Mapping
- Rice Monitoring
- Forest Fire Monitoring
- Oceanography
- Terrain Measurement
- Seismic Activity
- Landslide Monitoring
- Air Quality Monitoring and Forecasting
- Chemistry/Climate Change in the Atmosphere
- Forest Information from POLInSAR
- Drought Monitoring
- Water Resources Assessment
- Climate and Ocean Systems

The Dragon programme web site

http://earth.esa.int/dragon

INDEX

2004 XIAMEN SYMPOSIUM, P.R. CHINA

- Date: April 27th - 30th 2004
- Gu Lang Yu Island - Xiamen, Fujian Province, P.R. of China
- Hosts: ESA/NRSCC and local authorities
- 130 participants (from 60 institutes in Europe and China)
- 50 presentations available on-line at:

http://earth.esa.int/dragon/Dragon_symposium.htm

Symposium participants at the Marine Garden Hotel Conference Centre on Gu Lang Yu Island, Xiamen

The 2004 Dragon Symposium was the formal kick off for all the 15 projects at which time the joint teams started their work, refined their Earth Observation and other data requests and produced their detailed work plans.

At the Xiamen Symposium, the joint Sino-European teams made presentations on their projects over 3 days. The programme included presentations on the monitoring of land natural resources, on supporting natural disasters management, on studying the atmosphere and oceanography in China.

:: Xiamen Symposium organising committee

:: Chinese and European participants to the Dragon Symposium Xiamen April 27-30 2004

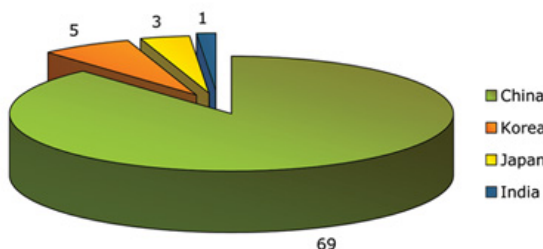# ADVANCED TRAINING COURSE IN OCEAN REMOTE SENSING

- Date: October 25th - 30th 2004
- Hosts: ESA, NRSCC, MOST and Ocean University of China
- Lecturers:

Dr. Roland Doerffer GKSS Research Centre, **Germany**
Prof. David Llewellyn-Jones Univ. of Leicester, **UK**
Dr. Pierre-Yves Le Traon CLS, **France**
Prof. Johnny Johannessen NERSC, **Norway**
Prof. Werner Alpers Univ. of Hamburg, **Germany**
Prof. Ming Xia-He Ocean University of China, **China**

ESA-MOST Dragon Programme

ADVANCED TRAINING COURSE IN OCEAN REMOTE SENSING

25 - 30 October 2004
Ocean University of China, Qingdao, China

MERIS Reduced Resolution image (1.2 km) 15th February 2004 of China East coast

:: The lecturers

- China
- Korea
- Japan
- India

Ph.D. students, postdoctoral and research scientists interested in ocean remote sensing from China and other Asian countries were invited to a one-week training course organised jointly by ESA and MOST in the framework of the Dragon Programme. The advanced training course was hosted by the Ocean University of China (OUC) in Qingdao.

LECTURES ON:

- Current and future European and Chinese EO satellite missions
- Principles of SAR, MERIS, (A)ATSR, and RA measurements
- Products and applications in operational oceanography
- Practical exercises with BEAM and Bilko software tools

78 PARTICIPANTS
(selected from 125 applications)
- Associate or Assistant Professors
- Senior scientists
- Engineers
- Ph.D. students

:: The participants to the Training Course

• POLInSAR techniques to extract forest parameters
• POLSAR based forest classification
• ERS and ASAR interferometric data processing for forest mapping application
• ERS SAR and ASAR APS absolute calibration
• Pre-processing and combination of ERS and JERS scenes
• Processing of ASAR AP data for rice mapping

From 17 February to 16 May 2004, Chen Erxue (left) and Pang Yong (right) from the Chinese Academy of Forestry, Beijing were hosted as trainees by ESA

Chen Erxue learned about and performed processing using experimental airborne data sets for forest parameter retrieval. Simulated and real airborne POLInSAR datasets were used to study and evaluate the three-stages-inversion algorithms with non-optimisation coherence data as inputs. The coherence optimisation algorithm was also incorporated and a much better tree height inversion result was produced when compared to ground data.

POLSAR data processing and classification methodologies were studied and validated with full-polarization airborne data. Since this time, the trainees have performed POLSAR decomposition and classification using SIRC/X data over a Chinese test site (shown right). Partial polarization data was extracted from the airborne data to simulate the Envisat APS HH-VH data. An investigation was performed to see the potential of this kind of data for land cover classification.

Pang Yong studied ERS SAR Tandem data and Envisat ASAR AP IMS data processing and ILU generation with a view to mapping forest areas in China. Also the additional information content of combining ILU with JERS SAR data was performed with a view to improving forest stand parameter estimation similar to methods applied in the SIBERIA I and II projects. The potential of ASAP APS mode data for forest and rice mapping was investigated particularly the use of absolutely calibrated ASAR AP imagery.
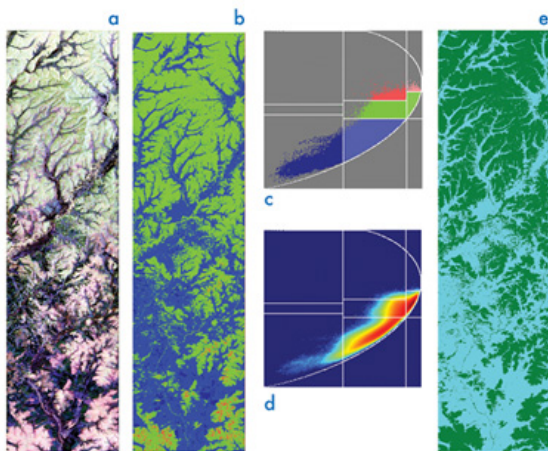
(a) L band Quad-polarization SIR-C/X SAR data, April 16, 1994, in NE of P.R. China, (b) H-Alpha unsupervised classification result, colours stand for terrain types defined in H-Alpha plane shown in (c). (d) 2-D representation of terrain types frequency occurrence in H-Alpha plane for different terrain types defined in (c). (e) A forest and none-forest map generated directly from (b) with some none-forest terrain types combined as one class. 80.0% total classification accuracy was achieved according to validation using ground true data.

:: Land use classification map using multi-temporal ASAR AP data acquired on 22 June 04, 12 Aug 04, and 5 Oct 04. Rice fields are shown in green, dark blue areas are water bodies.

DRAGON PROGRAMME MANAGEMENT

- 22 November 2004 Progress Meeting n.6 at Chinese Academy of Forestry, Beijing
- 25 April 2005 Progress Meeting n.7 at Chinese Academy of Forestry, Beijing
- 28 and 29 April 2005 Dragon Project Meeting at Ocean University of China and First Institute of Oceanography, Qingdao

Progress meeting on 28 April 2005 at Ocean University of China and First Institute of Oceanography, Qingdao

:: ESA and NRSCC officials meeting with Chinese investigators, 22 November 2004, Chinese Academy of Forestry, Beijing
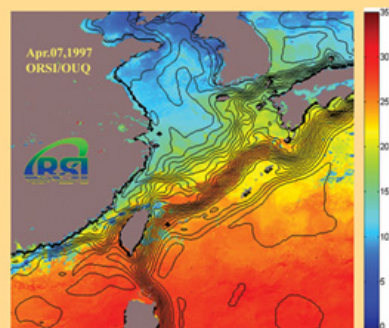

:: ESA and NRSCC officials with Chinese investigators, 25 April 2005, Chinese Academy of Forestry, Beijing

On 22 November 2004, ESA and NRSCC had a joint progress meeting with Chinese Dragon investigators in Beijing. The progress and status of ESA EO data delivery to the projects was reviewed and further planning for EO data acquisitions was made.

On 25 April 2005, ESA and NRSCC had a joint progress meeting with Chinese Dragon investigators for 11 of the projects. ESA/NRSCC jointly prepared the programme for the 2005 Santorini Symposium in Greece. The advanced training course for Land Remote Sensing was defined and initiated.

Visits were also made to the Ocean University of China and the First Institute of Oceanography by ESA on 27 and 28 April 2005. ESA informed on the preparation and programme for the 2005 Santorini Symposium in Greece.

:: Model Output Sea Surface Height over Satellite Sea Surface Temperature (Courtesy of OUC)

DRAGON DATA DELIVERY

- A total of some 2500 ASAR and SAR scenes delivered to PIs
- A total of some 1500 MERIS FR scenes delivered to PIs
- Low Rate data accessed through the Internet
- Some 2500 orbits of Atmospheric Chemistry data delivered on DVD to Chinese partners
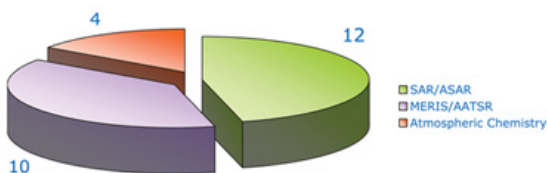
ENVISAT is the largest Earth Observation spacecraft ever built. It was launched from French Guiana by Ariane 5 the 1st March 2002

ERS and ENVISAT data (by instrument type) requested and accessed by the 15 projects (Fig.1)

ASAR/SAR

- ASAR and SAR data newly planned and from the archive are available on CD/DVD (Amount of data distributed so far as per Fig.2)
- ASAR planning requests are analyzed up-front in order to minimize the cancellations due to mode conflicts
- ASAR data in Near Real Time are available to the Flood Monitoring project in case of flooding, via Internet through the Rolling Archive

MERIS/AATSR

- MERIS FR data newly planned and from the archive are available on CD/DVD
- MERIS FR planning requests are analyzed up-front in order to minimize the cancellations due to on-board recorder conflicts
- MERIS RR and AATSR data are systematically available to 5 projects (Forest Fire, Flood Monitoring, Oceanography, Forest, Oceanography and Climate) via Internet through the Envisat Web File Server (Fig. 3)

ATMOSPHERIC CHEMISTRY

- GOMOS, MIPAS, SCIAMACHY and GOME data (already available to European Partners through FTP) were provided to Chinese Teams on DVD

Legend:
- SAR/ASAR
- MERIS/AATSR
- Atmospheric Chemistry

Values shown: 4, 12, 10

:: Fig. 1

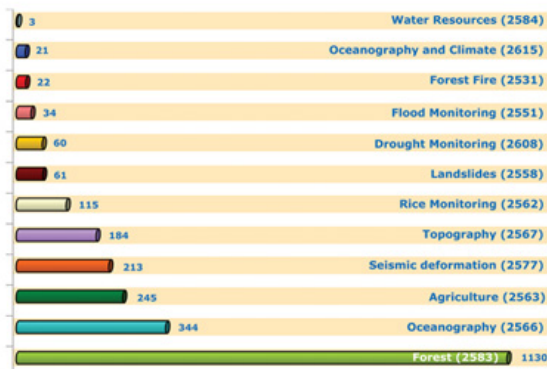| Value	Category
3	Water Resources (2584)
21	Oceanography and Climate (2615)
22	Forest Fire (2531)
34	Flood Monitoring (2551)
60	Drought Monitoring (2608)
61	Landslides (2558)
115	Rice Monitoring (2562)
184	Topography (2567)
213	Seismic deformation (2577)
245	Agriculture (2563)
344	Oceanography (2566)
1130	Forest (2583)

:: Fig. 2

:: Fig. 3

DRAGON STUDY AREAS

- Instrument's planning conflicts are checked up-front following the "Dragon conflict free" scheme
- Out of the 2300 ASAR and MERIS FR planning requests, 90% were successfully planned
- The 10% unplanned were due to conflicts with Commercial requests or due to the fact that Eastern part of China is not in Artemis visibility (i.e. no simultaneous ASAR HR/MERIS FR acquisitions)

ERS-2: European Remote Sensing satellite was launched from French Guiana by Ariane 4 the 21st April 1995.

The study areas for 12 Dragon projects requesting ASAR HR and/or MERIS FR planning are shown on the map. A conflict free scheme was set up in close coordination between ESA and the Lead Investigators in order to minimize the planning cancellations due to conflicts among the Dragon Projects.

The most critical situation is currently in the southeast part of the country, where 9 areas and the relevant requests are concentrated: several different modes of ASAR as well as some MERIS FR acquisitions are needed by the projects.

- Forest (2583)
- Oceanography (2566)
- Agriculture (2563)
- Seismic Deformation (2577)
- Topography (2567)
- Rice Monitoring (2562)
- Landslides (2558)
- Drought Monitoring (2608)
- Flood Monitoring (2551)
- Forest Fire (2531)
- SAMOS (2615)
- Hydrology (2584)

MID TERM CALL FOR PAPERS AND PUBLICATION

NRSCC and ESA propose that mid-term results are published as an ESA Special Publication (SP-1286)

Objectives

- To provide results of the project teams' work at half way through the Dragon Programme
- Co-authorship of papers by European and Chinese scientists
- Make available the Special Publication as a CD-ROM and paper printed volume to all Dragon investigators

Schedule

- The call is open from 1th July 2005
- Papers must be submitted by 30 September 2005
- The CD-ROM and printed volume shall be available in early 2006

Guidelines for submission are available at: http://earth.esa.int/dragon/mtc_guidelines.pdf

ADVANCED TRAINING COURSE IN LAND REMOTE SENSING

Venue
The course will be hosted by the Capital Normal University in Beijing

Dates
From 10 to 15 October 2005

Registration
Registration is free of charge. The course is open to Chinese and SE Asian countries students

Sponsors
The course is being sponsored by MOST/NRSCC, Beijing Capital Normal University and ESA

Course Content
The lectures and practical sessions shall cover theory and processing of data from ESA ERS1/2 and Envisat satellites as well Chinese satellite EO data for science and application development over land

The course programme and registration forms will be made available from the Dragon website:

http://earth.esa.int/dragon

Beijing Capital Normal University

# Agriculture and Land Use: ENVISAT Applications in Fujian Province

Prof. Shaun Quegan, e-mail: S.Quegan@shef.ac.uk
Prof. Wang Qinmin, e-mail: Qmwang@fzu.edu.cn

Dr. Guoijin He, Dr. Thuy Le Toan, Dr. Mike Wooding, Prof. Li Zengyuan, Dr. Wang Xiaoqin, Prof. Lan Zhangren, Dr. Chen Chongcheng, Mrs. Zhu Qingdong
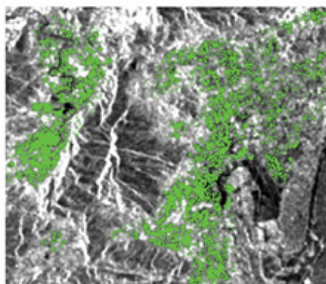
Agricultural production in Fujian Province includes tropical fruit, rice and flowers
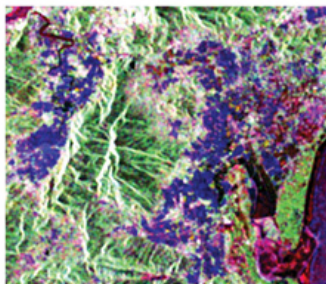
:: In this multi-temporal ASAR AP mode composite, rice fields have blue signatures, Fujian Province, P.R. China (ASAR C-VV 7 May 04, C-VH 7 May 04, C-VV 11 June 04)
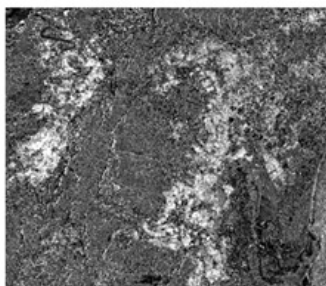
:: Using Principal Component Analysis, rice fields are much brighter in the second component compared to other classes

:: Using this signature, rice fields can be easily classified (shown green)

OBJECTIVES OF THE PROJECT:

To develop and validate methodology using ENVISAT data for three main issues:
• Land use, land cover classification, with emphasis on agriculture and forestry, in interaction with the related Dragon application projects.
• Agricultural monitoring by retrieving crop and soil biophysical parameters.
• Land use, land cover changes using historical and/or archived ERS data.

RESEARCH CONTENT
Methodology research
Land use, land cover and crop classification using ENVISAT ASAR
• To investigate novel methods exploiting the new features of ENVISAT ASAR in land use, land cover and crop classification: multitemporal dual-polarisation, multi-incidence capability
• To investigate scaling approach for regional mapping from high resolution (ASAR Narrow Swath) to medium resolution data (ASAR Wide Swath)

VEGETATION MONITORING
- To investigate retrieval of surface parameters from ENVISAT data (soil moisture from ASAR WS, crop biomass from ASAR NS , LAI and fPAR from MERIS data),
Application projects at Fujian
- Land use change monitoring
- Forest monitoring
- Productivity estimation
Estimation of Net Primary Productivity of the region.
Contributing to the Dragon rice project by using crop growth models for rice yield prediction.

Joint project meeting in China between European and Chinese scientists working on the rice monitoring project – January 2005

Rice Monitoring in China

Dr. Thuy Le Toan, e-mail: Thuy.Letoan@cesbio.cnes.frDr .
Tan Bingxiang, e-mail: Tan@forestry.ac.cn

Dr. Alberte Bondeau, Mr. Alexandre Bouvet, Prof. John Burrows, Dr. Leonidas Toulios, Prof Li Bingbai, Prof. Li Zengyuan, Prof. Shaun Quegan, Mr. He Wei, Mr. Mike Wooding

OBJECTIVES

To develop and validate methodology using ENVISAT data for two main issues :
• Food security
• Global climate change

CONTENTS

• Rice harvest area: Application of the multitemporal analysis method developed using ERS SAR data and exploration of new techniques using ASAR dual polarisation data and ASAR wide swath data.
The methods will be developed in the test area (Jiangsu), and will be applied to Fujian Province for validation.
• Rice yield prediction: Use of biophysical parameters retrieved from ENVISAT data in rice yield models.
• Methane emission from rice fields: It has been indicated that changing water management in rice paddies can contribute significantly to the decline in the rate of increase of atmospheric methane concentration. In China, mid season drainage, which reduces the flux of CH4, gradually replaces continuous flooding. The objective is to estimate methane emission using a biochemical model to extend field measurements of trace gas to regional scale, based on rice acreage and duration of flooding detected using ASAR data.
• 1st Year Results:
New techniques of mapping of rice growing areas using (a) single date dual polarisation and (b) multidate wide swath ASAR data, have been developed and tested in the Jiangsu province.
The results show promising applications at province and regional scales using ASAR data.
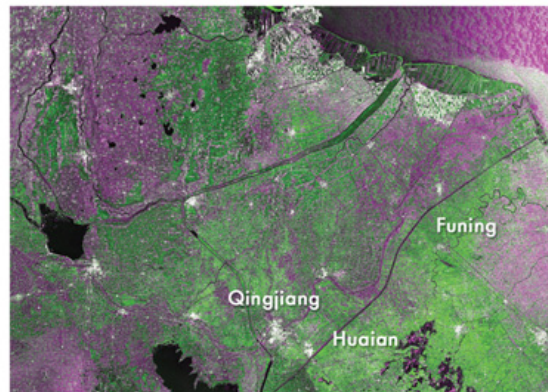
:: ASAR Wide Swath image of the region North of Huaian (210 Km x 127.5 Km), Jiangsu province (WSM 18-08-2004, WSM 27-10-2005)


:: Classification of rice growing areas (shown green) using backscatter temporal change of ASAR WSM imagery shown top

The Forest DRAGON – Forest Related Development of Radar Applications for Geomatic Operational Networks

Prof. Li Zengyuan, e-mail: Zengyuan.Li@forestry.ac.cn
Prof. Christiane Schmullius, e-mail: c.schmullius@uni-jena.de

Mr. Oliver Cartus, Dr. Chen Erxue, Dr. Stefan Erasmi, Dr. Thuy Le Toan, Prof. Yuanchang Lu, Dr. Jens Nieschulze, Dr. Pang Yong, Dr. Achim Roth, Dr. Maurizio Santoro, Dr. Urs Wegmüller, Dr. Andreas Wiesmann
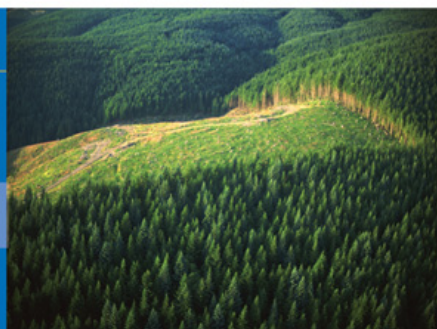
The present forest covers an area of around 130 million hectares, the three most important forest regions are the North East, the South East and central China
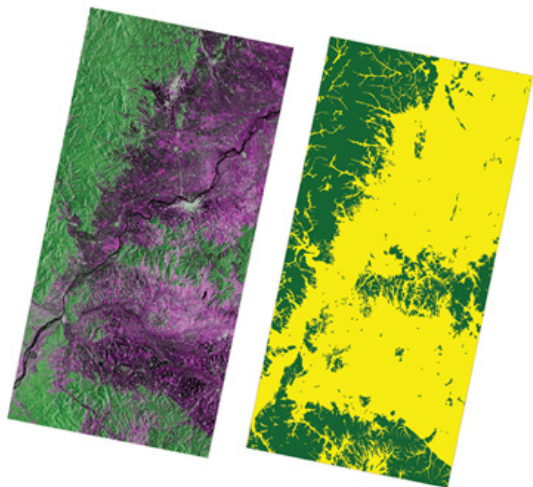
:: Forest maps 1996 ERS SAR Tandem ILU (right), ASAR A.P. intensity images March 2005 (left)
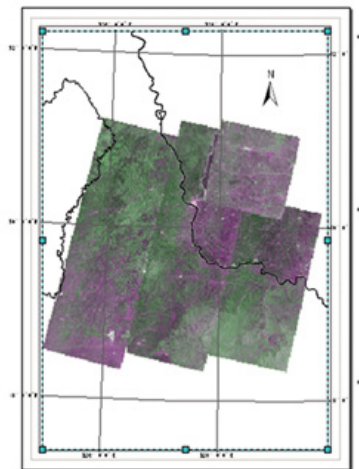
:: Mosaic ASAR A.P. data March 2005

The scope of the "FOREST DRAGON" project is to generate on a regional basis forest base maps from the ERS-1/2 tandem and JERS-1 missions, and updated versions from Envisat ASAR data for the three most important forest regions of China.

•North-East: The synergy between ERS coherence and JERS backscatter will be exploited for the generation of a classified biomass map covering all forests. The methodology applied will follow the well-established classification approach developed by the SIBERIA project. The forest base map will be provided at 50 m pixel size. Envisat ASAR Alternating Polarisation data will be used for the production of a forest/non-forest map in order to provide an update to the forest base map.

•South-East: Due to the relevant forest diversity and the mostly wet weather conditions, biomass mapping using ERS and JERS data seems to be less feasible. Nonetheless, a study for biomass classification using the SIBERIA algorithm will be carried out. Envisat ASAR Alternating Polarisation data will be used for forest/non-forest mapping.

•Center: A possible third phase of the project will consider the generation of a forest/non-forest map for the Central region of China. Wide Swath Envisat ASAR data at 100 m pixel size will be used.

The final products together with local in situ information will be integrated into GIS. This will provide a unique reference for forest resources information systems and new information for climate change issues (carbon budget and Kyoto protocol) in one of the most changing regions of the Earth.

Forest Fire Monitoring Demonstration by Satellite Remote Sensing in China

Prof. José-Luis Casanova, e-mail: Jois@latuv.uva.es
Dr. Xianlin Qin, e-mail: Noaags@forestry.ac.cn

Dr. Johann G. Goldammer, Dr. Federico Gonzalez-Alonso,
Dr. Charalabos Kontoes, Prof. Li Zengyuan, Ms. Cristina
Moclán

In the P.R. China, the main fire regions are in Inner Mongolia, the montane-boreal forest in Northeast and tropical South of the country.

OBJECTIVES

1. To select a forested pilot area in China, which was historically affected by forest fires. This area will be selected by the Chinese partners.

2. To develop a suitable technique to obtain a risk forest fire index by means of AATSR and MERIS images. This risk index will merge several indicators: an indicator of vegetation evolution, an indicator of vegetation humidity, and indicator of meteorological conditions, mainly wind speed, and others. The parameters of this risk index will be adapted to the pilot area taking into account the historical fires and if necessary other factors such as fuel land cover, topographical conditions and so on.

3. To adapt a hot spot detection technique to the fires on the pilot area by means of AATSR images. This technique will include fire temperature detection, burning area, fire thermal power and reaction intensity. The Dozier method, including atmospheric effects will be applied to determine fire temperature and burning area. From these two values, the thermal power of the fire will be obtained. This thermal power is directly related to the destructive effects of fire and other characteristics such as high flame.

4. To set up a suitable methodology for burnt area cartography by means of MERIS and ASAR images.

The deliverables will be operational techniques for risk mapping, hot spot detection and analysis and burnt area cartography, by means of MERIS, AATSR and ASAR images, all of them tailored to the Chinese pilot area.
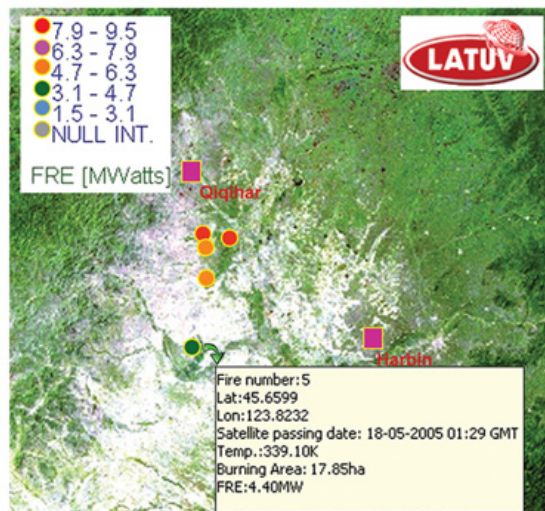
:: Envisat AATSR detected fires on 18 May 2005 displayed using a prototype on-line system for NE China developed by LATUV, Courtesy of Prof. José-Luis Casanova
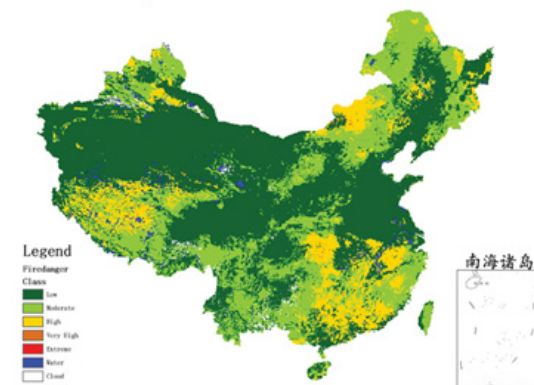
:: Fire Danger Rating map, P.R.China, Courtesy of Dr. Qin Xianlin, Chinese Academy of Forestry, Beijing

:: DRAGON PROJECT ID 2556

Techniques for Deriving Forest Information from Polarimetric Sar Interferometry

Prof. Shane Cloude, e-mail: Scloude@eleceng.adelaide.edu.au
Prof. Li Zengyuan, e-mail: Zengyuan.Li@forestry.ac.cn

Dr. Irean Hajnsek, Dr. Konstantines P. Papathanassiou,
Prof. Eric Pottier, Dr. Laurent Ferro-Famil, Dr. Erxue Chen,
Dr. Hong Zhang

Ground photo of German test site used to retrieve forest height (page bottom). The pine forest has been damaged by acid rain

This project aims to bring together, for the first time, experts in POLarimetric Interferometric Synthetic Aperture Radar (POLInSAR) and quantitative forest sciences from Europe and China.

OBJECTIVES

1. To study the potential impact of this new radar technology on forestry applications in China,
2. To review the current status of POLInSAR research in China and Europe and enable technology transfer where required,
3. To establish possibilities for future collaborative research aimed at development and validation of quantitative forestry remote sensing applications using POLInSAR techniques.
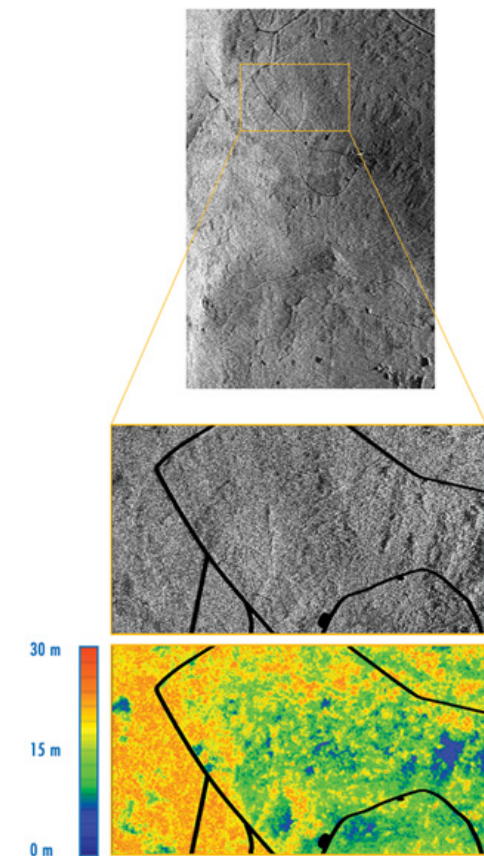
:: POLarimetric Interferometric SAR (POLInSAR) data can be used to retrieve forest stand parameters. The top image shows an airborne HH polarisation image of a forest stand. The bottom image shows a classification of the forest stand into tree height based on the polarimetric, interferometric signatures at L-band. (Courtesy of DLR)

esa

POLSARPRO

Includes teaching material!

The Polarimetric SAR Data Processing and Educational Tool v2.0

http://earth.esa.int/polsarpro

POLSARPRO is a toolbox for the scientific exploitation of polarimetric SAR data and a tool for high-level education in radar polarimetry

With a recent acquisition POLIMI successfully completed the test of the Corner Cubes shown. Chinese partners will install and test the Corner Cubes in the Tanshan/Tian Test Site.

Topographic Measurement

Prof. Li Deren, e-mail: drli@whu.edu.cn
Prof. Fabio Rocca, e-mail: Rocca@elet.polimi.it

Dr. Alessandro Ferretti, Prof. Mingsheng Liao, Prof. Yang Minghui, Dr. Alessandro Parizzi, Prof. Wang Chao, Prof. A-Gen Zhang

OBJECTIVES
• Urban subsidence
• Landslide analysis & monitoring
• Three Gorges Dam site stability
• Identification of flooded plain based on coherence

The scientific investigations will focus on the application on topographic mapping and earth deformation monitoring by Envisat/ASAR data. ASAR data offer an evident potential in this field because there is large area covered with cloud and mist through the year in many areas of China. Interferometry using Synthetic Aperture Radar (SAR) data gives researchers a new set of tools to measure topography, tiny shifts and deformations in the Earth's surface, valuable in the study of landslides urban subsidence, earthquakes, floods and other natural cataclysms in China.
This proposal will respond to the ESA mission objectives on the following aspects
• Evaluation of potential applications of ASAR data in generating DEM and monitoring the earth deformation;
• Investigation of the method for synthetical application of ERS-1/2 data and ASAR data;
• Development of relevant algorithms and data processing procedures;
• Cost-benefit analysis for Technology Transfer from European partner to Chinese partner to speed up the technical diffusing in China and explore the applications of ESA data in topographic measurement, such as the permanent scatterer in long-term deformation monitoring.
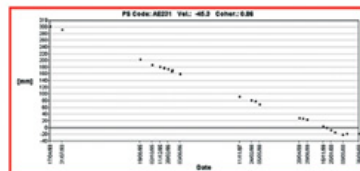
:: P.S. measurements data refer to the time interval 1993 to 2000. (Courtesy of POLIMI)
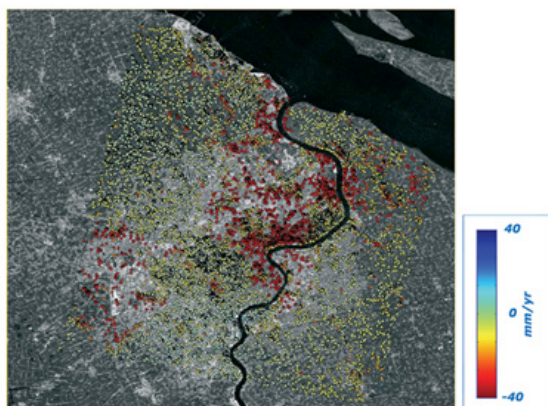
:: Average displacement rate of the radar benchmarks (PS) identified from a time series of ERS SAR images in Shanghai city, P.R. China. (Courtesy of Politecnico di Milano)
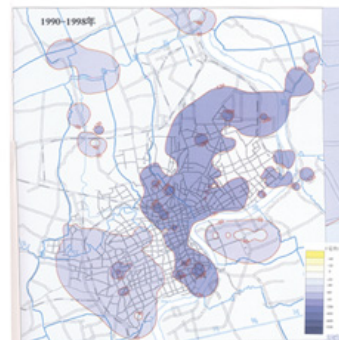
:: Ground surveyed subsidence map of Shanghai city. (Courtesy of Shanghai Institute of Geological Survey)

Seismic and Inter-seismic Deformation Across Two Main Strike-slip Faults of Tibet (The Kunlun and the Haiyuan Faults) from conventional and Permanent Scatters INSAR

Dr. Sun Jianbao, e-mail: suninsar@yahoo.com
Dr. Cécile Lasserre, e-mail: Lasserre@geologie.ens.fr

Prof. Xu Xiwei, Prof. Evangelos Lagios, Prof. Shen Zhengkang, Ms. Liang Fang

Surface rupture zone of Kokoxili earthquake crossing Gelmod-Lhasa Road in N80W direction at the 2894 km road-marker. (Photo towards the west), Courtesy of Prof. Xu Xiwei
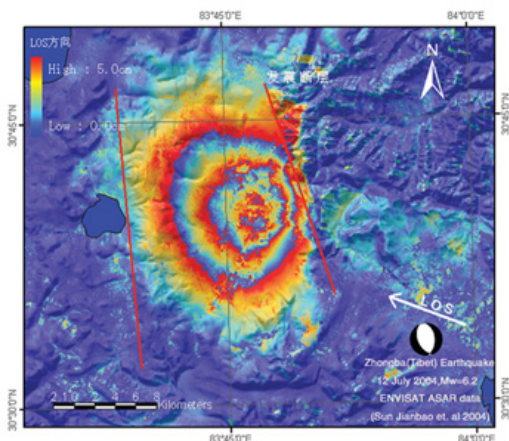
:: Co-seismic deformation map of the Zhongba earthquake in Southern Tibet measured using pre and post seismic motion D-InSAR ASAR data (top). The estimated Line of Sight (LOS) deformation is shown bottom.
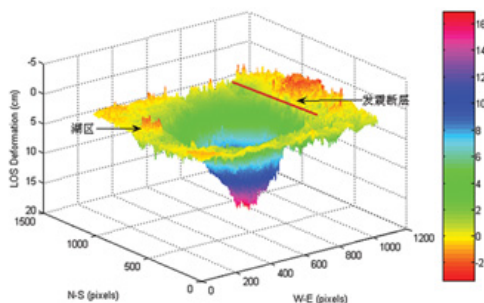
:: Because of the remoteness and altitude of this area, measurements using conventional methods (including GPS) are impossible. But using ESA EO data, it has proved feasible to produce these products.

Seismic and Interseismic deformation along the Kunlun fault (PI: Sun Jianbao)

Long time series ERS and Envisat ASAR InSAR and PS InSAR will be used to investigate potential slip rate along the Dongdatan-Xidatan segment, the possible triggering effects of the Manyi earthquake on the Kokoxili earthquake, as well as the effects of the Kokoxili earthquake on the seismic hazard potential of other segments of the Kunlun fault.

Interseismic deformation across the Haiyuan fault (PI: C. Lasserre)

The interseismic strain across the Haiyuan fault system using the Permanent Scatterers technique will be mapped. Standard DInSAR processing methods revealed poor phase coherence on test interferograms, due to the loess cover. GPS data across the fault will provide control points on the InSAR measurements.

Northwest end of Xianshuihe Fault (PIs: E. Lagios and Shen Zhengkang)

The fault is seismically active at present with around 9-10 mm/yr left-slip across the Xianshuihe fault. A rate measurable by INSAR with a 4-5 year time scale if the coherence is high enough between SAR acquisitions. The InSAR results will be compared with GPS data collected from the Crustal Motion Observation Network of China between 1998 and 2001.

Yadong-Gulu Rift (PIs: E. Lagios and Shen Zhengkang)

This rift system is the most important in southern Tibet. It has a high West –East extention rate (about 5-7mm/yr) according to the recent GPS studies.

Corner reflectors being positioned in the field, Three Gorges Dam area.
Courtesy of Prof. Jan-Peter Muller

:: DRAGON PROJECT   ID 2558

Monitoring the Landslides in Three Gorges Area by Using Corner Reflector Differential SAR Interferometry

Prof. Jan-Peter Muller, e-mail: jpmuller@ge.ucl.ac.uk
Prof. Qiming Zeng, e-mail: Qmzeng@pku.edu.cn

Dr. Xiaoguang Hao, Dr. Zhenhong Li, Dr. Jian Guo Liu, Dr. Ye Xia, Prof. Jingfa Zhang, Prof. Zhuxi Ouyang

OBJECTIVES

1. Measuring and monitoring landslides
2. Investigating Corner Reflector and Persistent Scatterer Interferometry (PS) techniques and their application in China
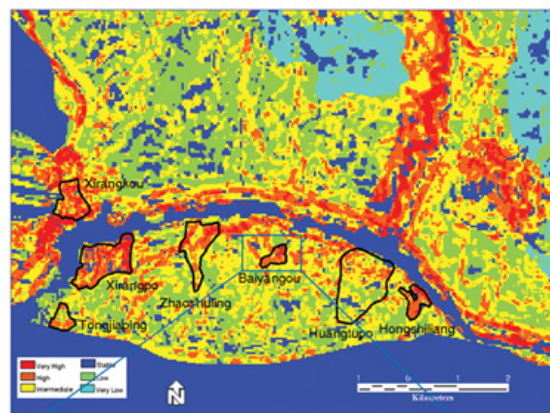3. Studying atmospheric correction techniques for InSAR
4. Investigating the relationship between the rising water levels and landslide frequency

METHODS

1. Identification of corner reflectors from co-registered SAR-SLC data
2. Identification of natural PS targets
3. Interferogram generation and removal of topographic and differential signatures
4. Correction of atmospheric phase corruption using GPS and MERIS WV
5. Association of differential phase with stable corner reflector targets
6. Validation of InSAR results with GPS bencmarks
7. Interpretation of results in the context of rising water levels

MILESTONES

1. Install 40 corner reflectors around the areas affected
2. Acquire ERS and programme ASAR datasets
3. Produce the best possible topography
4. Perform repetitive GPS site inspections
5. Process narrow swath interferograms
6. Develop wide-swath interferometry system for wide area monitoring
7. Assess the potential of using GPS and MERIS for atmospheric correction
8. Assess flood monitoring potential
9. Assess erosion of upstream areas and their contribution to sediment load
10. Validation, analysis and interpretation

Baiyangou landslide

A very recent reactivation of an older, deeper landslide which now threatens this new bridge

:: Landslide hazard map of the Badong area, derived from geo-spatial analysis of thematic layers including slope derived from EO data. (Courtesy of Dr. Jian Guo Liu)

:: DRAGON PROJECT   ID 2551

Assessment of the Synergistic Exploitation of Envisat ASAR and MERIS Data for Plain Flood Rapid Mapping and for Flood Support Risk Management

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V. Anastassopoulos, R. Andreoli, Dr. N. Baghdadi, Dr. O. Cerdan, Dr. JF. Desprats, Dr. Fan Yida, Dr. P. Faucher, Dr. P.de Fraipont, Dr. Huang Shifeng, Dr. Ch. King, Pr. M. Gay, Dr. M. Lafaye, Pr. Li Jing, Pr. Liu Dingsheng, Pr. Li Xiufen, Dr. C. Puech, Dr. V. Tsagaris, Dr. Wang Xingling, Pr. Wang Yuguang, Dr. Xin Jingfeng

Flood water inundating urban areas, P.R. China
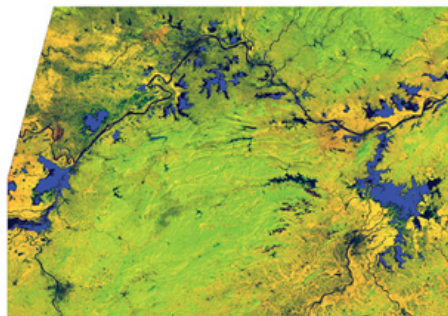
:: MERIS image of the Poyang-Dongting Lakes, based on MERIS full resolution geophysical products exploitation, photosyn_rad, toa veg, tot_susp, ie channels 20, 21, 19, in RGB
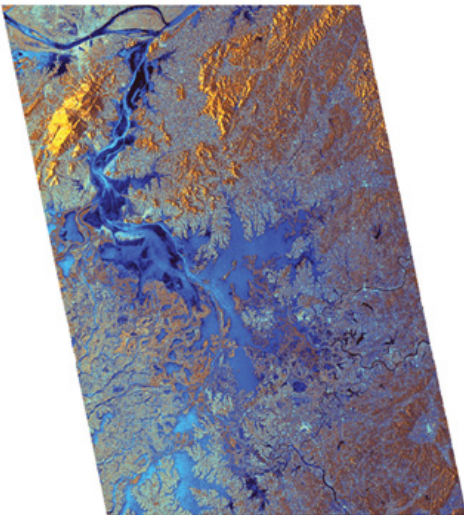
:: ASAR HH/HV AP image of Poyang Lake acquired during the NRT test in February 2005. During the winter, the water level of the Poyang Lake is at its lowest. The blue variations within water bodies are mostly related to water surface roughness characteristics. Brown areas on the lake borders correspond to flat wet lowlands which are flooded on an annual basis between June to September.

Envisat MERIS and ASAR data will be used to map and monitor both the wide floods affecting China and Mediterranean watershed representative of the flash flood, "CEVENOL" phenomenon.

• Assessment of the Envisat data will be carried out to define the optimum ASAR configuration and synergistic exploitation with MERIS data to insure thematic accuracy and maximize coverage of the sites well representative of Asian major flood plains and French fast flood

• Robust and semi automatic flood procedure (based on morpho-mathematic approach combined with object/target oriented methods, within a time series exploitation context) have to be defined and tested in order to provide a ASAR fast processing tool for further NRT flood mappings actions

• Studies will link meteorological and hydrological simulation models and damage assessment on off-line mode (to generate RISK MAPS associated to impacts of flood corresponding to various return periods).

The project will deliver the major steps, in term of data assimilation, data processing, information merging for further operational exploitation of Earth observation data for floods mapping and monitoring.

Over these wide areas yearly affected by flooding, it is essential to elaborate and to test an assimilation procedure taking in account all the major acquisition parameters influencing/disturbing the SAR signal.

Hydrological observation stations in study catchments provide daily meteorological data that can be used to calibrate and run surface run-off models, Courtesy of Xin Jingfeng

Satellite Tools for Water Resources Assessment and Management at River Basin Scales

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Prof. Li Jiren, e-mail: Lijiren@iwhr.com

Mr. Charles Baubion, Prof. Benoit Deffontaines, Prof. Paolo Gamba, Prof. Gong Huili, Prof. Emmanuel Ledoux, Prof. Li Jing, Dr. Marianthi Stefouli, Dr. Xin Jingfeng

Studies of water resources in China will be conducted via the use of Coupled Hydrological surface water and groundwater models, at the basin scale and with water quality. In-situ measurements will include river discharge, rainfall, temperature, aquifer head data, aquifer and/or river water quality data, and aquifer properties. As a complementary aspect, the possibility of using SAR data to assess sea ice freshwater resources in North China will also be evaluated.

RESULTS OF THE PROJECT

• A calibrated coupled surface water/groundwater quality model developed for one year representing a large basin in the Beijing area of China, and a comparison of different modelling approaches of the same basin.

• A new methodology for processing satellite images for providing the necessary input for such models

• A detailed analysis of the data requirement of the model, and of the pertinence of the satellite images for providing the necessary data

• A description of the data that are necessarily based on ground measurements or historical records to calibrate the models

• A GIS system common to all data, both ground based or resulting from image processing, and designed to directly provide the input data for the models

• An assessment of the SAR images to estimate sea ice freshwater resources in North China

• A new methodology/algorithm for land surface information extraction and for water resource assessment
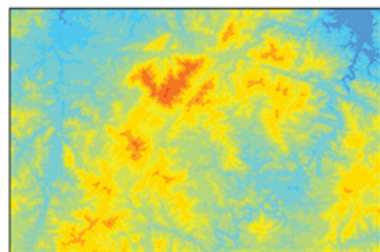
:: 125m DEM colour shaded, Shiguanhe test site, P.R. China

:: River network and basin extent extracted from DEM, Shiguanhe test site, P.R. China

red: measured discharge
blue: modelled discharge
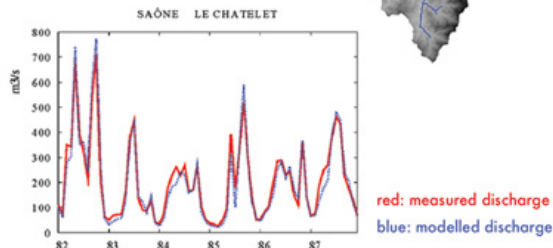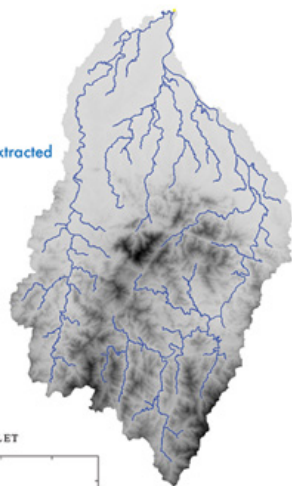
:: Example calibration of Surface Models made with daily meteorological data, and discharge measured in several stations along the Saône river (France).

:: DRAGON PROJECT ID 2608
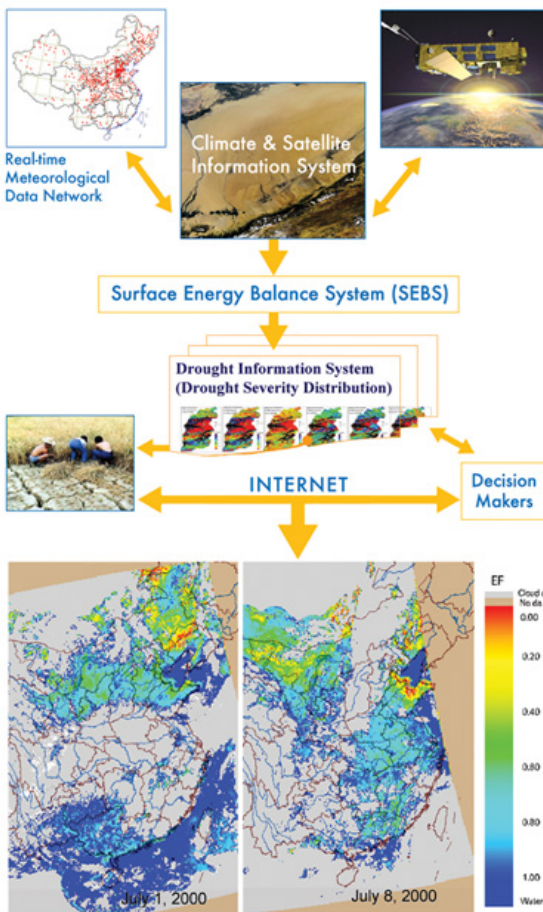
Drought Monitoring and Prediction over China

Prof. Youqi Chen, e-mail: Chenyqi@mail.caas.net.cn
Prof. Bob Su, e-mail: B_su@itc.nl

Dr. Cristos Gainnakopoulos, Dr. Yanbo He, Mrs. Caixing Li, Prof. Li Jiren, Prof. Li Wan, Prof. Zhao-Liang Li, Prof. Qinhuo Liu, Prof. Yaoming Ma, Prof. Massimo Menenti, Dr. Michael Petrakis, Dr. Tom Rientjes, Prof. Jose Sobrino, Prof. Peter Troch, Mr. Rogier Van de Velde, ir. Kees van Diepen, Dr. Wout Verhoef, Dr. Liming Wang, Prof. Jun Wen

In P.R. China, the North West is drier and more arid than the South and East and this affects the distribution of agricultural production.

Real-time Meteorological Data Network

Climate & Satellite Information System

Surface Energy Balance System (SEBS)

Drought Information System (Drought Severity Distribution)

INTERNET

Decision Makers

EF
Cloud or No data
0.00
0.20
0.40
0.80
0.80
1.00
Water

July 1, 2000

July 8, 2000

:: SEBS will combine meteorogical and satellite data to provide an on-line drought monitoring system. Already early results show the potential to generate products over China using optical imagery (bottom) (B. Su et al, 2003)

OBJECTIVES

To develop an operational system for nation wide drought monitoring and drought impact assessment for application in agriculture and hydrology.

CONTENTS

• The project will combine the satellite data (from 1981 to present) with ground survey and experimental data to carry out a climatology of the most fragile areas to drought and the evolution of the ecotones by analysis of maps of critical physical parameters at regional scale, such as albedo, emissivity, vegetation coverage, land surface temperature, evapotranspiration, and soil moisture

• Construction of physically based drought indices that can be used to quantify the extent, severity and duration of droughts

• Field measurements and experiments in Northern China areas chosen in critical zones. In these areas the algorithms proposed will be validated and/or improved

• An Internet based operational drought monitoring and prediction system will be developed applying GIS

• Transfer of knowledge and methodologies, and establishment of long-term co-operation between the participant groups by workshops and scholar exchanges. This will take the form of dedicated training and exchanges of scientific and technical personnel involved in the development of the methodologies and the operational implementation of these methodologies. To ensure the sustainability of the project, these activities will be given high priority.
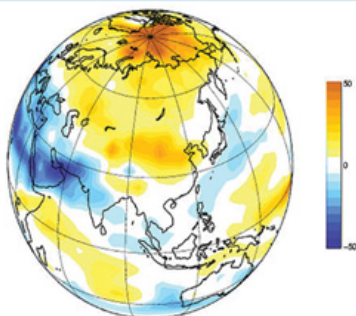
Annual change in precipitation at CO_2 doubling. Seaonal, inter-annual to decadal predictability; low-and-high latitude teleconnections, Courtesy of Prof. Helge Drange

Coupling and Variability of the Southeast Asian Monsoon and Ocean Systems (SAMOS)

Prof. Johnny A. Johannessen, e-mail: Johnny.johannessen@nersc.no
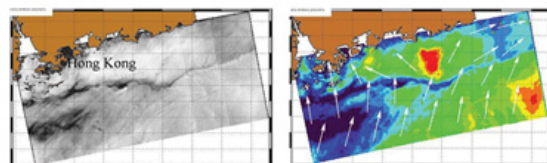Prof. Prof. Hui-Jun Wang, e-mail: wanghj@mail.iap.ac.cn

Prof. Helge Drange, Prof. Ming-Xia He, Dr. Bertrand Chapron, Prof. Zifa Wang, Dr. Laurent Bertino, Dr. Knut Frode Dagestad, Lasse Pettersson, Prof. Jinhuan Qiu, Prof. Pucai Wang, Prof. Liu Yi

BACKGROUND

The coupled Southeast Asian Monsoon and ocean system is a regular seasonal climate feature that has coupled connection with and impact on the near surface wind field, sea surface temperature, evaporation and precipitation signals. This in turn leads to changes both in the atmospheric and ocean circulations. By the systematic use of coupled atmosphere-ocean models and inter-comparison and validation with satellite observations the aim is to advance the ability to understand and predict the dominant interactive coupling processes. The satellite data will primarily focus on microwave and optical sensors on board the ERS and Envisat satellites. In addition passive microwave satellite data will be used. The key study quantities are ocean currents, fronts, eddies, waves, near surface wind, SST, precipitation water quality and atmospheric and ocean pollution. It will also examine the impact of the seasonal variability of the freshwater runoff to the coastal circulation system.
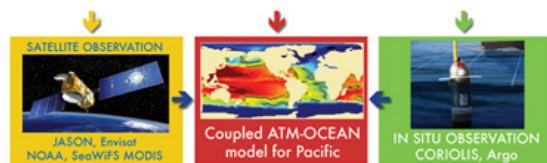
OVERVIEW OF METHODOLOGY

The Southeast China Sea has been studied using primarily 50 Envisat ASAR images and MERIS spectrometer data in combination with a numerical ocean model. The two set of inserts show ASAR wide swath radar backscatter changes and corresponding wind speed derived from combination of QuickScat wind direction and ASAR backscatter. SAR images will also be compared with output from an oceanographic model (HYCOM) and an atmospheric model to test the correspondence and agreement with output from numerical models.

:: ASAR image of distinct narrow front and derived wind products

SAMOS System Components

SATELLITE OBSERVATION — JASON, Envisat NOAA, SeaWiFS MODIS

Coupled ATM-OCEAN model for Pacific

IN SITU OBSERVATION CORIOLIS, Argo

Hind cast, Now cast and Forecast of ocean events in the Southeast China sea, China sea, Yellow sea, Etc...

:: DRAGON PROJECT ID 2579

Dragon-Star - Exploitation of GOMOS and MIPAS Measurements for Studying the Change in the Middle Atmosphere
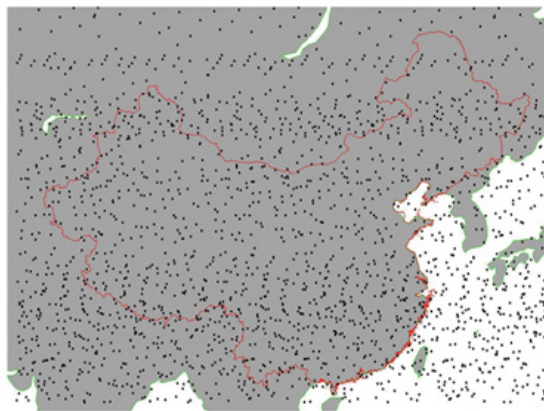
Dr. Erkki Kyrola, e-mail: Erkki.Kyrola@fmi.fi
Dr. Qiu Hong, e-mail: Qiuh@nsmc.cma.gov.cn

Dr. Dimitrios Balis, Prof. Bruno Carli, Dr. Seppo Hassinen, Dr. Hu Liqin, Dr. Kostas Kourtidis, Dr. Esko Kyro, Ms. Li Xiaojing, Dr. Johanna Tamminen, Prof. Christos Zerefos
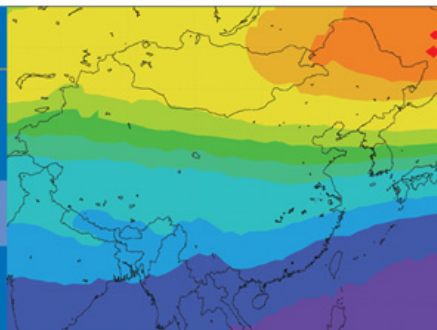
Total Ozone over China from TOMS in Jan. 1998

In this project we will seek opportunities to enhance the exploitation of Envisat, especially GOMOS and MIPAS, data for atmospheric research.

A joint project between the GOMOS Expert Support Laboratory FMI and the MIPAS laboratory IFAC and the Chinese Team at National Satellite Meteorological Center (NSMC) provides experience on how expert instrument teams and a normal data user team can work together in using rather complicated data from GOMOS and MIPAS. The data access for GOMOS will first be provided by FMI but eventually it should be possible to access data by the public domain tools developed by ESA and FMI and by the cooperative tool development effort by the teams.

GOMOS and MIPAS data will be used for middle atmosphere studies on local and global scale problems. In the beginning validation comparisons between GOMOS, MIPAS and the Chinese ground stations are carried out. After gaining experience larger data sets and assimilation tools will be used to study the middle atmosphere processes and change.

Common research projects for Chinese and ESA earth observation satellites will be investigated.

:: During 2003 GOMOS measured more than 100 000 night time and daytime occultations. The map shows the distribution of night time occultations over China
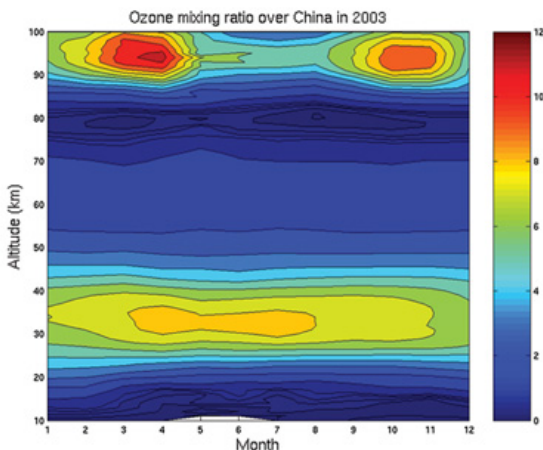
:: Time-evolution of the ozone profiles in the altitude region of 10-100 km in the area shown by the map above. The analysis is based on 2500 night time occultations measured by GOMOS in 2003

Training in the use of sun photometers by staff of the National Satellite Meteorological Centre, Beijing

:: DRAGON PROJECT ID 2580

Air Quality Monitoring and Forecasting in China

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Dr. Zhang Peng, e-mail: zhangp@nsmc.cma.gov.cn

Prof. John Burrows, Prof. Gerrit de Leeuw, Dr. Zhao Fengsheng, Dr. JianZhong Ma, Dr. Zhang Peng, Dr. Qiu Hong, Dr. Paul Simon, Dr. Ronald van der A, Dr. Roeland van Oss

Air pollution has become a problem with increasing importance. Much of the anthropogenic air pollution travels long distances into areas far from the emission source and affects human health and damages flora and fauna. Large-scale fossil fuel combustion and fossil fuel related activities, in particular in China with an increasing energy demand and inherent fuel consumption, but also biomass burning, wind-blown dust and volcanic eruptions are important emission sources. The quantification of the concentrations near the sources and the subsequent transport of pollutants is essential to monitor air pollution conventions. Forecasting of air pollution is important to warn and inform the general public.

This project will focus on the monitoring and forecasting of air quality of China and its environment. The trace gases ozone, nitrogen dioxide, sulphur dioxide, carbon monoxide, methane and aerosols will be retrieved from satellite observations of ERS-2, ENVISAT and AURA. For monitoring these trace gases existing retrieval methods will be combined with data assimilation techniques to determine the tropospheric component of the quantified trace gas concentrations.

Using data assimilation in combination with meteorological forecast fields from ECMWF allows to make forecasts of the air pollution levels. The retrieval methods will be validated by intercomparison of different retrieval algorithms and by comparison to ground based measurements in China. The combination of model results and satellite retrievals will improve our understanding of the air quality over China.
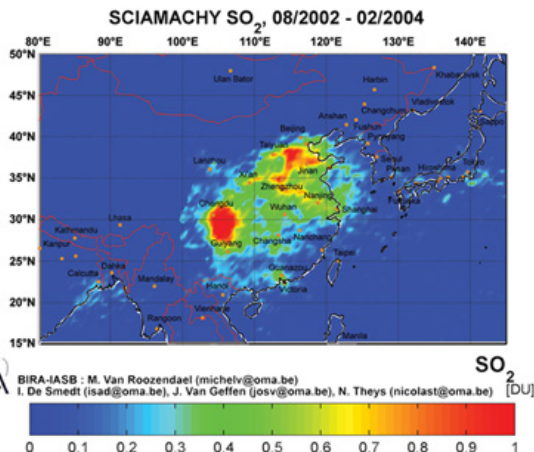
:: The figure shows SO_2 concentrations in the troposphere. In this image, high concentrations can be seen South of Beijing and in Sichuan Province.
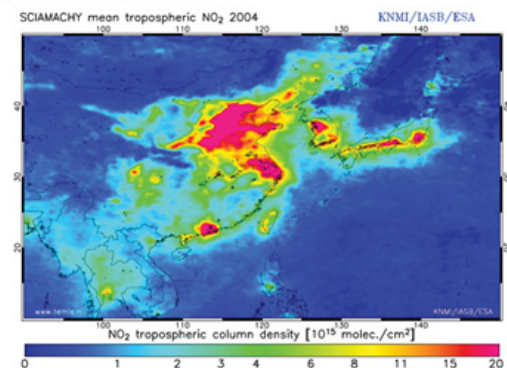
:: Temporal series of satellite observations can be used to monitor the distribution and concentration of atmopsheric pollutants, in this case NO_2. Notice high concentration in densely populated regions East of China and Hong Kong.

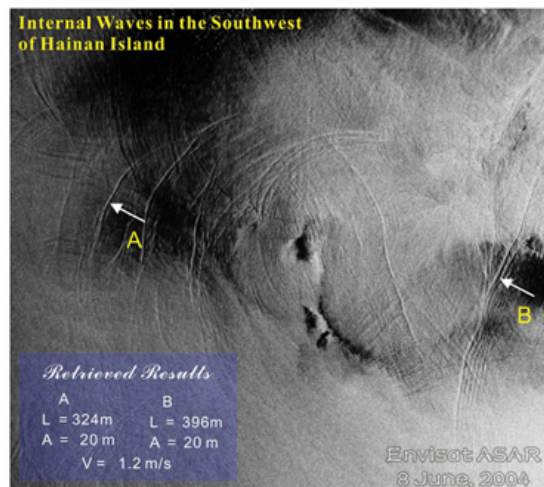## Oceanography from Space - Internal Wave, Ocean Wave, Shallow Water Topography, Ocean Color, Kuroshio Current

Prof. Werner Alpers, e-mail: alpers@ifm.uni-hamburg.de
Prof. Ming-Xia He, e-mail: mxhe@orsi.ouc.edu.cn

Dr. Bertrand Chapron, Dr. Wenzhong Chen, Mr.Tingwei Cui, Dr. Roland Doerffer, Dr. Keping Du, Prof. Tao Du, Dr. Mingqiang Fang, Prof. Jurgen Fischer, Dr. Lei Guan, Prof. Ruilong He, Mr. Lianbo Hu

Dragon Oceanography from Space European and Chinese team members in Xiamen 2004

Internal Waves in the Southwest of Hainan Island

Retrieved Results

A	B
L = 324m	L = 396m
A = 20 m	A = 20 m
V = 1.2 m/s	

Envisat ASAR
8 June, 2004

:: The number, length, distribution and propagation direction of internal waves can be determined from ASAR intensity images as shown above
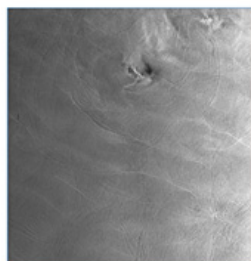
:: ERS-2 SAR image
8th July 1998
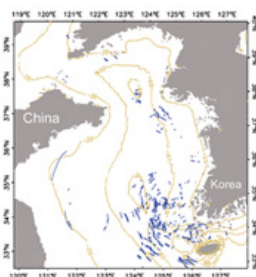
:: The distribution of internal waves in the yellow sea

The objectives of the proposal are to study the following topics using ENVISAT multi-sensor data:

• Distribution and characteristics of internal waves in the China Seas;

• Spatial and temporal characteristics of ocean wave directional spectrum in the China Seas;

• Detecting method for shallow underwater bottom topography;

• Retrieval methods for ocean colour in the China Seas;

• Impact of the variation of the Kuroshio on oceanic processes in the China Seas and Global climate change.

INTERNAL WAVE

Retrieval of the parameters of internal waves by ASAR. Assimilation of the parameters of internal waves by satellite observations to a numerical model of the propagation of internal waves in the Northern part of South China Sea. The method for the retrieval of internal wave parameters developed by Chinese partners and the numerical model for internal wave in the Northern part of South China Sea will be used.

HyperTSRB being prepared for deployment in Qingdao coastal waters, P.R. China

Oceanography from Space - Internal Wave, Ocean Wave, Shallow Water Topography, Ocean Color, Kuroshio Current

Prof. Werner Alpers, e-mail: alpers@ifm.uni-hamburg.de
Prof. Ming-Xia He, e-mail: mxhe@orsi.ouc.edu.cn

Prof. Zhang Jie, Prof. Johnny Johannessen, Dr. Pierre-Yves Le Traon, Prof. Hongping Li, Dr. Liping Li, Mr. Xiaoming Li, Prof. Zhishen Liu, Prof. David Llewellyn-Jones, Dr. Yi Ma, Dr. Junmin Meng, Prof. André Morel

OCEAN WAVE

Comparison of several methods for retrieving ocean wave directional spectrum in the China Seas. Software running in the Windows system for ocean wave directional spectrum retrieval by SAR data using Hasselmann's method has been developed.
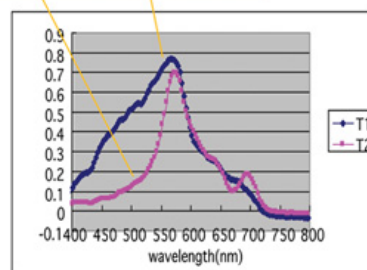
SHALLOW WATER TOPOGRAPHY

Developing shallow water topography detection technology using SAR data. Analytical and numerical models will be developed to extract information about underwater bottom topography from ASAR data based on SAR imaging mechanisms and a dynamical model.

RED TIDES

Red tides develop mainly in coastal areas and they affect directly fishing and shell fish industries. Red tides can even be toxic to humans and are caused by the dense growths of bacteria and algae. They are increasingly common due to heavy pollution from sewage and industries along the densely populated east coast of China and the Yangtze River. An objective is to develop techniques and data sets using optical satellite sensors to map the duration and extents of such tides. Results from spectrometer measurements show that Red tides have quite characteristic spectral response.
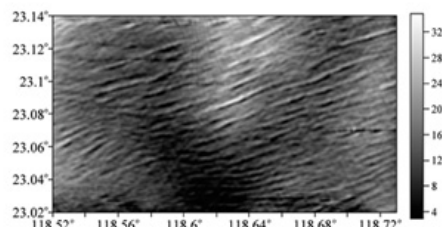
:: Gray level map (above) of water depth inverted by SAR image of 2004 (depth in metres), Taiwan Shoals

:: The spectral response of red tide affected (photo in foreground) and non-affected (photo in background) sea water measured using HyperTSRB
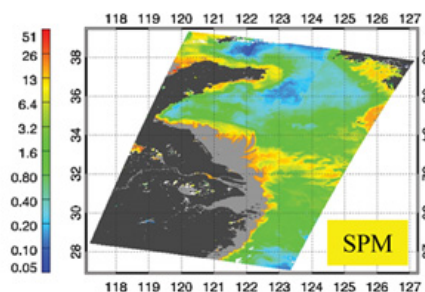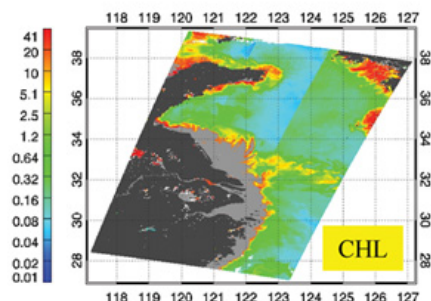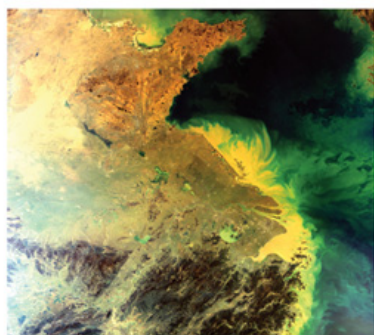
Oceanography from Space - Internal Wave, Ocean Wave, Shallow Water Topography, Ocean Color, Kuroshio Current

Prof. Werner Alpers, e-mail: alpers@ifm.uni-hamburg.de
Prof. Ming-Xia He, e-mail: mxhe@orsi.ouc.edu.cn

Dr. Roland Romeiser, Ms. Wei Song, Ms. Ling Sun, Prof. Junwu Tang, Dr. Haili Wang, Prof. Manqing Wu, Mr. Jungang Yang, Dr. Kan Zeng, Dr. Tinglu Zhang, Prof. Chaofang Zhao, Prof. Minghui Zhu

Oceanography from Space, team members from the Ocean University of China, Qingdao

OCEAN COLOUR

The study will investigate retrieval, validation and application of MERIS data in the China seas. A database of the IOPs of oceanic and atmospheric constituents in the China Seas will be developed.

An ANN-based bio-optical algorithm for MERIS data in the China Seas will be developed and compared with the semi-analytical algorithm. A methodology for monitoring red tide events in China coastal seas using MERIS and other satellite data will also be developed.

KUROSHIO CURRENT

In this study, decadal-scale satellite SST, SSH and SSW will be assimilated in a numerical model that has already been developed.

:: MERIS low resolution image (1.2km) of East coast of China (top) and derived products (middle – chlorophill concentration, bottom - suspended matter)

List of Institutions Cooperating in the Dragon Programme

* Aristotle University of Thessaloniki, Greece

  Beijing Capital Normal University, China

  BIRA, Belgisch Instituut voor Ruimte-Aëronomie, Belgium

  BRGM, Bureau de Recherches Géologiques et Minières, France

  Cemagref, Institut de Recherche pour l'Ingénierie de l'Agriculture et de l'Environnement, France

  CESBIO, Centre d'Etudes Spatiales de la Biosphère, France

  China Seismological Bureau, China

  Chinese Academy of Forestry, China

  Chinese Academy of Meteorological Sciences, China

  Chinese Academy of Sciences, China

  Chinese Academy of Survey and Mapping, China

  Chinese National Center for Disaster Reduction, China

* CLS Space Oceanography Division, France

  CNES, Centre National d'Etudes Spatiales, France

  CNR, Consiglio Nazionale delle Ricerche, Italy

* Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, China

* Demokritus University of Thrace, Greece

  DLR, Deutschen Zentrum für Luft- und Raumfahrt, Germany

  Ecole des Mines de Paris, France

  Ecole Pratique des Hautes Etudes, France

  ENS, Ecole Normale Supérieure, France

  First Institute of Oceanography, China

  FMI, Finnish Meteorological Institute, Finland

  Freie Universität Berlin, Germany

  Friedrich-Schiller-Universität Jena, Germany

  Fundación General Universidad de Valladolid, Spain

  Fuzhou University, China

  Gamma Remote Sensing Research and Consulting AG, Switzerland

  Georg-August-Universität Göttingen, Germany

  GFZ, GeoForschungsZentrum, Germany

  GKSS Forschungszentrum, Institute for Coastal Research, Germany

* ICL, Imperial College London, United Kingdom

  IFREMER, Institut français de recherche pour l'exploitation de la mer, France

  INIA, Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Spain

  INPT/ENSEEIHT, Institut National Polytechnique de Toulouse/Ecole Nationale Supérieure d'Electrotechnique, d'Electronique, d'Informatique, d'Hydraulique et des Télécommunications, France

* Institute of Atmospheric Physics, Chinese Academy of Sciences

* Institute for Geology and Mineral Exploration, Greece

  Institute of Meteorological Sciences, China

  Institute of Natural Resources and Regional Planning, China

* ITC, International Institute for Geo-Information Science and Earth Observation, The Netherlands

  Jiangsu Academy of Agriculture Sciences, China

List of Institutions Cooperating in the Dragon Programme

KNMI, Koninklijk Nederlands Meteorologisch Instituut, The Netherlands

* LIAMA, Sino-French Laboratory for Computer Sciences, Automation and Applied Mathematics, China

METEO France, France

Ministry of Water Resources, China

* NAGREF, National Agricultural Research Foundation, Greece

* National and Kapodistrian University of Athens, Greece

* NOA, National Observatory of Athens, Greece

NERSC, Nansen Environmental and Remote Sensing Centre, Norway

NRSCC, National Remote Sensing Centre of China

NSMC, National Satellite Meteorological Center, China

Ocean University of China, China

* PIK, Potsdam Institute for Climate Research, Germany

POLIMI, Politecnico di Milano, Italy

RSAC, Remote Sensing Applications Consultants Ltd, United Kingdom

SERTIT, Service Régional de Traitement d'Image et de Télédétection, France

* Shanghai Institute of Geological Survey

SOGREAH, Société Grenobloise d'Etudes et d'Applications Hydrauliques, France

State Key Lab. for Information Engineering in Surveying, Mapping and Remote Sensing, China

State Oceanic Administration, China

T.R.E. s.r.l., Tele Rilevamento Europa, Italy

TNO/FEL, Toegepast Natuurwetenschappelijk Onderzoek/Fysisch en Electronisch Laboratorium, The Netherlands

UN/ISDR, International Strategy for Disaster Reduction, Germany

Università degli Studi di Pavia, Italy

Universität Bremen, Germany

Universität Hamburg, Germany

* Université de Marne-la-Vallée, France

Université de Rennes 1, France

Université du Littoral Côte d'Opale, France

Université Pierre et Marie Curie, Paris VI, France

University College London, United Kingdom

* University of Adelaide, Australia

* University of Leicester, United Kingdom

* University of Patras, Greece

University of Sheffield, United Kingdom

Wageningen Universiteit, The Netherlands

* New partner institution joining the Dragon Programme since April 2004