

A high-resolution satellite image of the Beijing area, showing a complex network of roads, rivers, and urban areas. The image is rendered in a false-color palette, with dark brown and black representing urban areas and roads, and lighter brown and tan representing agricultural and natural land. A prominent river system is visible, winding through the landscape. The overall texture is highly detailed, showing individual buildings and road networks.

The Dragon Programme

– ESA and China Cooperate in
Earth Observation

High-resolution satellite image of the Beijing area taken with Envisat's MERIS instrument

Yves-Louis Desnos

Science and Applications Department, ESA Directorate of Earth Observation, ESRIIN, Frascati, Italy

Karl Bergquist

International Affairs, ESA, Paris

Li Zengyuan

National Remote Sensing Centre of China (NRSCC),
Ministry of Science and Technology, Beijing

ESA has been cooperating with China's National Remote Sensing Centre (NRSCC) in the development of Earth Observation (EO) applications for the last 10 years. Following recent high-level meetings between Chinese and ESA officials, it was decided to reinforce this cooperation, which has now been given new momentum with the creation of a dedicated three-year EO exploitation programme called 'Dragon'. This programme focuses on the development of EO science and applications in China using data primarily from ESA's ERS and Envisat missions.

Introduction

As China has a land surface of more than 9.6 million square kilometres, satellite-based Earth observation is clearly an ideal tool for the monitoring and overall management of the country's resources. Another important factor is that today China accounts for one-fifth of the World's population, with 1.45 billion inhabitants, and is also currently the World's fastest growing economy. With this rapid growth and the stress that it implies on the country's natural resources and its environment, remote sensing can provide precise data to help decision-makers at all levels.

Satellite data can be used in land-resource mapping applications such as forest inventory and management, rice-production monitoring, and water-resource assessment and management. A new element in the Dragon programme is the extension of techniques and methods for monitoring oceans and atmosphere as well



Prof. Jose Achache (left), ESA's Director of Earth Observation Programmes, and Prof. Zhang Guocheng (right), Deputy Director of China's NRSCC, giving their opening addresses at the Dragon Symposium in Xiamen, People's Republic of China, on 27 April 2004

as land using the full complement of Envisat's instruments.

Satellite data can also contribute to the mitigation of the effects of natural disasters by providing timely information to local and national authorities. The natural disasters that affect China are often on a gigantic scale and include flooding of the Yangtze River, earthquakes on the Tibetan plateau, and droughts, which are particularly acute in China. When such calamities occur, Earth Observation can be the key to understanding and managing the ensuing crises. Hopefully, in the near future it will also help us to predict such events through the use of assimilation models and long time series of historical data to establish trends and alert the appropriate authorities when changes in those trends are first observed.

Early Cooperation

ESA's first contacts with China in the Earth Observation domain were established when the Chinese authorities expressed an interest in cooperating on ERS data applications. China's remote-sensing ground station in Beijing was subsequently upgraded to receive ERS data in 1994 and the two sides signed an Agreement to that effect.

In May 1997, China and ESA decided to begin a cooperation project for the increased operational use of ERS data. In order to stimulate exploitation of the

Synthetic-Aperture Radar (SAR) data from ERS-1 and 2, five pilot projects were created, addressing:

- Rice Mapping in Southern China
- Land-use Mapping for the Beijing Area
- Flood Monitoring
- an Oceanographic Study, and
- Mapping China's Forests.

The following year, when China experienced its worst floods of the Century, ERS radar imagery was used for operational mapping of the flood events. The Beijing ground station was able to process and deliver ERS images to end users just 24 hours after their acquisition.

This first cooperation was considered so successful by ESA and NRSCC that it led to discussions on how to consolidate and increase it in the future. In a meeting with ESA's Director General, China's Minister of Science and Technology, Mr Xu Guanhua, commented that space applications were recognised in his country as a key tool for the development of the Chinese economy and improved living conditions for its people.

In the light of the above progress, ESA's Earth Observation Directorate and their Chinese counterparts at NRSCC began a consultation process on how to reinforce and improve the cooperation to also include joint research. The result is 'The Dragon Programme', which was officially launched in Xiamen, China in April 2004.

The Dragon Programme

Objectives

The Dragon Programme's main objective is to establish joint Sino-European teams for the exploitation of data from ESA's ERS and Envisat satellites for science and applications development. The teams, with lead scientific investigators from Europe and China, will be addressing the following identified priority themes: 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, Deriving Forest Information from POLInSAR Data, Drought Monitoring, Water Resources and Hydrology, and Climate and Ocean Systems

First achievements

Programme preparation began with special briefings for European scientists in September 2003 in Rome, and for Chinese scientists in October 2003 in Beijing. The response from both the European and Chinese scientists who attended was very positive. The Dragon Call for Proposals was then jointly prepared by ESA and NRSCC and issued in November 2003. Some 25 responses were received and



The ESA–NRSCC Dragon web site <http://earth.esa.int/dragon>



The Dragon brochure

peer-reviewed from the scientific and technical feasibility viewpoints, resulting in the final selection of 15 integrated projects covering the priority themes defined by ESA and NRSCC.

In order to facilitate the preparations, an ESA–NRSCC Dragon web site was officially launched in March 2004 (<http://earth.esa.int/dragon>). It carries technical documentation on the Programme and serves both as an information and reporting portal. A programme brochure was also prepared and widely distributed in both Europe and China.

As part of the Dragon Programme, training courses will be organised and exchanges of trainees working within the projects are also anticipated. This will strengthen both the cooperation and the technical exchanges. The first trainees

from the Chinese Academy of Forestry have already spent three months at ESRIN in preparation for the two projects related to forest monitoring using spaceborne Synthetic Aperture Radars (SARs). In October this year, a week-long training course entitled 'ESA MOST Dragon Programme Advanced Training in Ocean Remote Sensing' will be organised in Qingdao, where the three major Chinese oceanographic institutes are located.

The recent Dragon Symposium (27-29 April 2004) was organised by ESA and NRSCC and hosted by the local authorities of Xiamen. It was attended by 130 scientists representing more than 60 institutes in Europe and China, and was effectively the formal kick-off for all 15 joint projects. The joint teams have now started their work, their data requests have been refined, and detailed work plans have been established.

Research Areas within the Dragon Programme

The Dragon Programme includes projects focusing on monitoring natural land resources, on supporting natural-disaster management, and on studying the atmosphere and ocean in China. The following are just a small selection:

Rice production monitoring

The United Nations has declared 2004 the 'International Year of Rice'. China is the World's largest rice producer, accounting for 35% of global output. At the same time, harvest areas are declining and demand is forecast to increase by 70% over the next 30 years.

The rice-monitoring project will use Envisat's Advanced SAR (ASAR) capability to observe rice-growing areas day and night, regardless of cloud cover. This is particularly important because persistent cloud cover in China's rice-growing regions is currently limiting the amount of information that can be gathered using optical satellite sensors. The anticipated outcome of the project is to improve rice-monitoring techniques through better yield modelling and regular



Participants in the Dragon Symposium



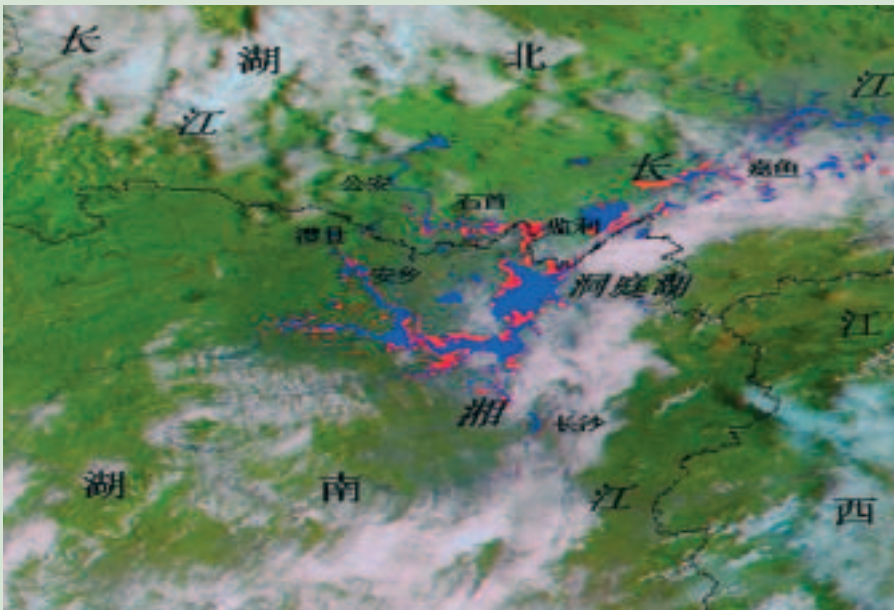
Rice fields in China imaged with Envisat's ASAR instrument using alternating polarisations

and accurate rice-field mapping at provincial level.

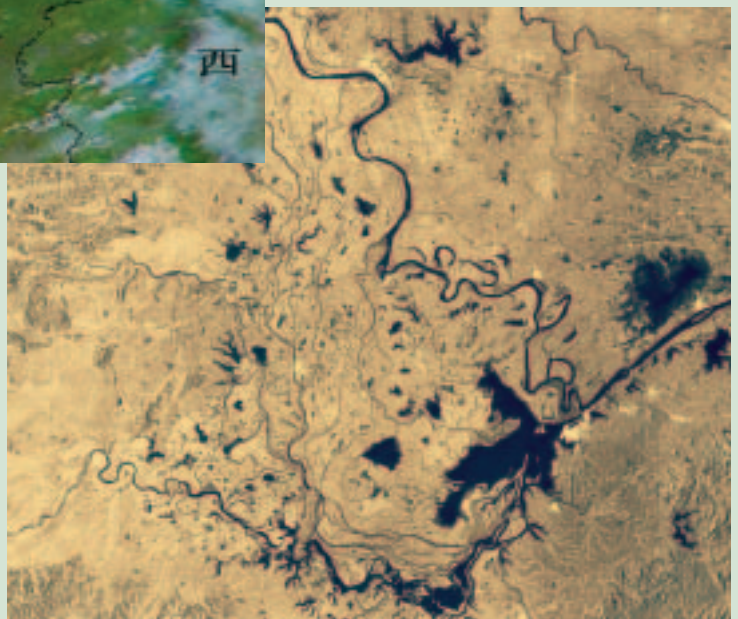
At the same time, rice fields produce methane, which is a major greenhouse gas, and both methane distribution and seasonal concentrations can be monitored and better understood using the SCIAMACHY instrument carried by Envisat. Improved water management can help to reduce methane emissions during the crop's growth cycle. Some areas have two to three crop cycles per year and so changing the water-management regime could significantly reduce methane emissions in the rice-growing regions.

Flood mapping and monitoring

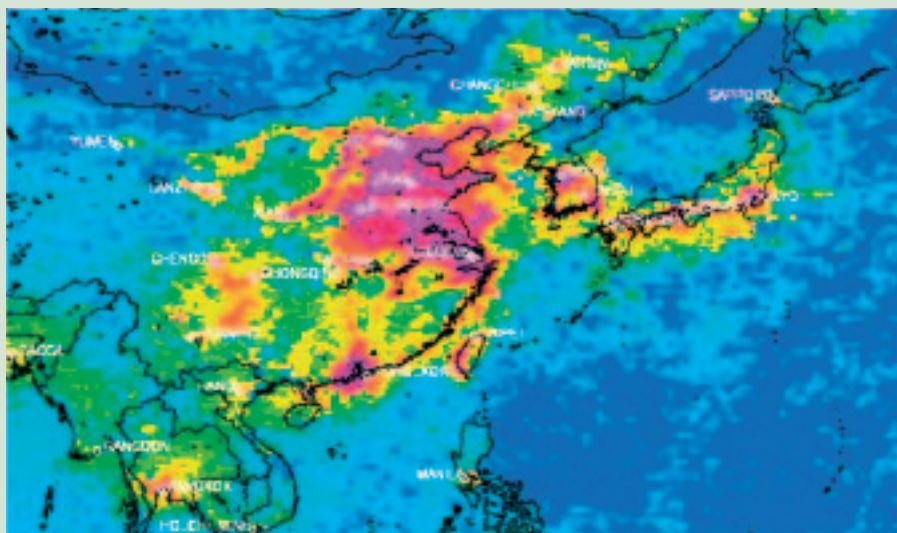
Severe floods are estimated to have cost China 32 billion US\$ in 1998 and 20 billion US\$ in 2003. Improved flood forecasting and monitoring is therefore very important for the country. In the Dragon project titled 'Flood Plain Disaster Rapid Mapping and Monitoring', Envisat's ASAR will be used to great advantage, thanks to its all-weather, day-and-night imaging capability. The project will also have a flood-prevention element, by exploiting existing ERS SAR (since 1991) and optical data archives to assess the vulnerability of particular geographical areas to inundation and reassessing particular flooding events that have occurred over the years.



NOAA AVHRR image of Dongting Lake taken on 7 July 1999. Flooded areas are displayed in red



Envisat ASAR image of Dongting Lake and the surrounding area taken in 2003



Tropospheric nitrogen-dioxide concentrations over the People's Republic of China

from Envisat's SCIAMACHY instrument (2003 to date). Maps showing the mean annual concentrations and distributions of nitrogen dioxide in China have already been made using SCIAMACHY data. When they are compared with population-density maps, it is possible to see the correlation between areas with high population densities and those with high concentrations of atmospheric pollutants. It is due to the burning of fossil fuels and the byproducts of industrial processes.

Such maps produced from temporal series of satellite observations are important tools for governments, and policy makers in assessing trends in atmospheric pollutant concentrations and implementing the necessary controls. The effectiveness of the pollution controls introduced can also be evaluated using long-time-series data sets.

Red-tide monitoring

The 'Ocean, Environment and Climate' project is a multi-disciplinary effort aimed at studying ocean waves, currents and colours, and ocean-bottom topography using a combination of SAR and optical remote sensing.

One element is the monitoring using MERIS data on 'red tides' in the China Seas. These tides occur mainly in coastal areas around the World and can have a devastating impact on the local fishing and shellfish industries. Red tides, which are caused by dense growths of bacteria and algae, can even be toxic for humans. They are becoming increasingly common in China (see accompanying table) due to the heavy sewage and industrial pollution along the country's densely populated east coast and from the Yangtze River. One of the project's goals, therefore, is to develop techniques and data sets using MERIS data to map the extents and durations of such tides so that fisheries can be provided with accurate and up-to-date information.

A so-called 'red tide' photographed from a ship off Fu Ding City, in China's Fujian Province, on 6 May 2002. This particular red tide covered an area of more than 500 km²

For disaster evaluation and recovery actions, airborne and spaceborne SAR data will provide such vital information as estimates of flooded areas per region, population numbers affected, arable land inundated, oil wells inundated, extent of railway lines submerged, and the locations and extent of breaches in embankments and flood dykes.

The project will benefit from the impressive rapid-alert system that has been put in place in China. The response time from the taking of the satellite imagery to the arrival of the relevant information on the desk of the responsible authority has been improved from a few days to just 5

hours. The model developed in China will also be tested in Europe with a view to further improving response times here too.

For forecasting purposes, EO data will be used in combination with meteorological data in the modeling chain. The goal is to be able to provide flood forecasting maps on an hourly basis.

Air-quality monitoring

The 'Air-Quality Monitoring and Forecasting' project will include the compilation of historical time series of atmospheric gas concentrations using GOME observations (from 1995 to 2003 from ERS-2), and the more recent data






Occurrences of red tides in the China Seas in 2002 and 2003

Site	Times		Area (km ²)	
	2002	2003	2002	2003
Yellow Sea	3	5	310	410
Bohai Sea	14	12	300	460
East China Sea	51	86	9 000	12 990
South China Sea	11	16	540	690
Total	79	119	10 150	14 550

Future Outlook

The Dragon Symposium in Xiamen brought together top scientists from Europe and China who are teaming up together with clear objectives and work plans to address serious environmental issues. The excellence of the joint teams, the quality in-situ data available for validation, and the timely availability of Envisat multi-sensor data sets provides confidence that the Dragon Programme will result in innovative developments in the Earth Observation science and applications domains. Having been demonstrated and validated in the China context, they can also be put to excellent use in Europe and elsewhere in the World.

The second Dragon Symposium will take place in Europe in Spring 2005 and will be the opportunity to review and assess the achievements after the first year of this joint cooperative programme with the People's Republic of China. 

MERIS image showing river-discharge and sediment loading in the East China Sea