



Earth Observation

Missions in Operation

Envisat and ERS-2

2004 will remain the year of the tsunami tragedy that hit Southern Asia on 26 December. Around 200 images were provided through the Charter mechanism from the Envisat, IRS P6, Spot, Radarsat and CHRIS/Proba satellites. Once more, the International Charter on Space and Major Disasters earned itself worldwide recognition as an efficient mechanism for providing satellite imagery during emergencies.

The Charter was started in 2000 by the European, French and Canadian space agencies joined later by the USA, India, Argentina and Japan. With an average of one call every two weeks, the Charter consolidated its level of activity in 2004.

Seventy-nine activation requests have been honoured since the beginning of Charter activities. The calls originated from civil-protection agencies in countries that are signatories of the Charter, the European Commission's Monitoring and Information Centre, and the specialised UN agencies.

All types of disasters were addressed on all Continents during 2004, including five earthquakes, three hurricanes, floods, landslides, volcanic eruptions or tremors, forest fires in South America, and the humanitarian emergency in Darfur.

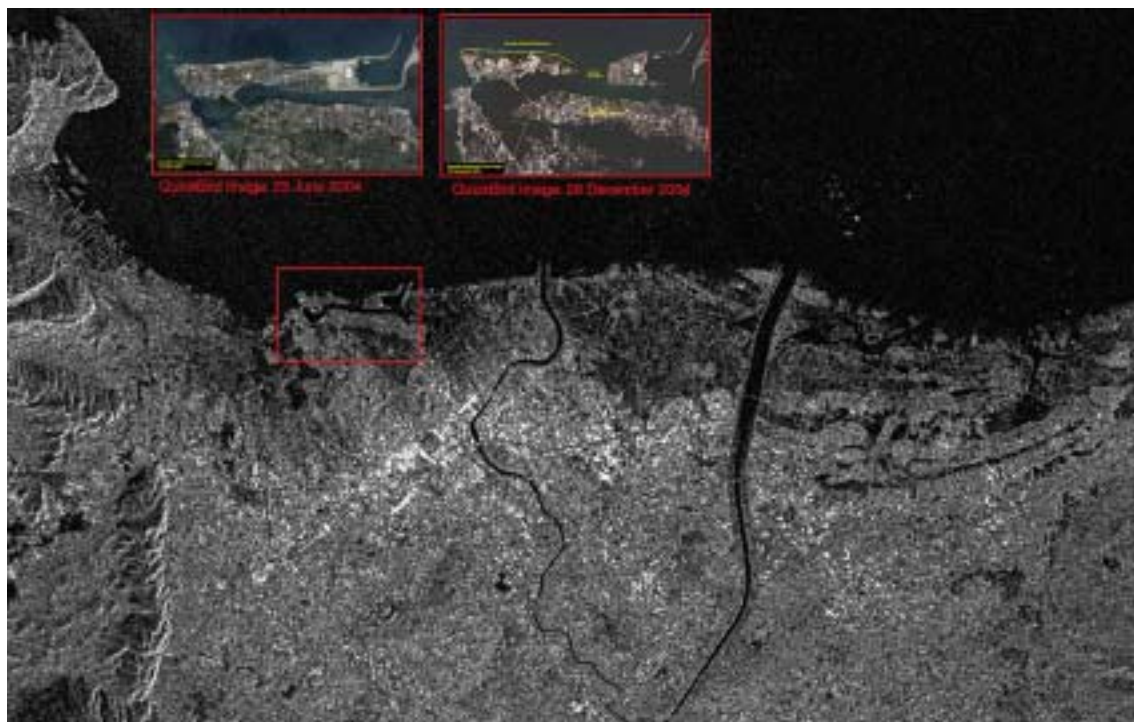
After more than nine years, the ERS-2 mission is still fully operational, providing high-quality data to more than 7000 scientific users, meteorological offices and commercial users. The demand for ERS High-Resolution data has steadily increased over the years, accounting for 14 000 of the products shipped in 2004.

In its third year of operations, the Envisat mission is serving an ever-growing user community. By the end of the year, more than 700 scientific projects were regularly accessing Envisat data, while the commercial users (served through the EMMA and SARCOM distributing entities) are increasingly receiving their data via direct downlinks to non-ESA stations. The number of

Metosat-8 composite visible
image acquired on
18 February 2004

Post-Tsunami image of the Banda Aceh area (Sumatra) produced by ESA using Envisat ASAR data. The two small inserts are QuickBird optical images taken before and after the disaster, showing damage to the island along the shoreline similar to the ASAR imagery. Because it is all-weather and has an extended swath, ASAR has the capacity to detect damage at any time of the day or night throughout the area observed

(Copyrights: Envisat data - ESA, QuickBird data - DigitalGlobe)

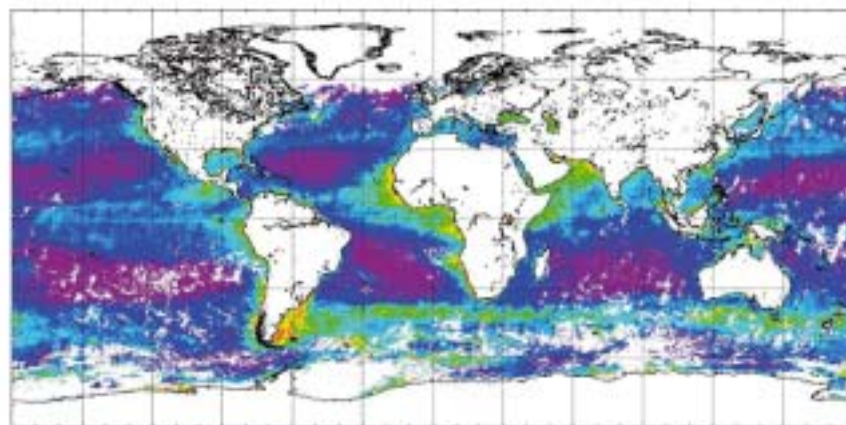


ASAR scenes acquired at the specific request of users has quadrupled in one year.

The Envisat Symposium in Salzburg (A) in September was by far the largest EO event organised by ESA. Attended by almost 1000 participants, it established the Envisat mission as one of the major tools available to the Earth Science community.

Major achievements from the exploitation of 14 years of ERS and Envisat data include:

- confirmation of global climate change
- impact of anthropogenic activities measurable from space
- European global-monitoring capability for atmosphere, ice, oceans and land change.

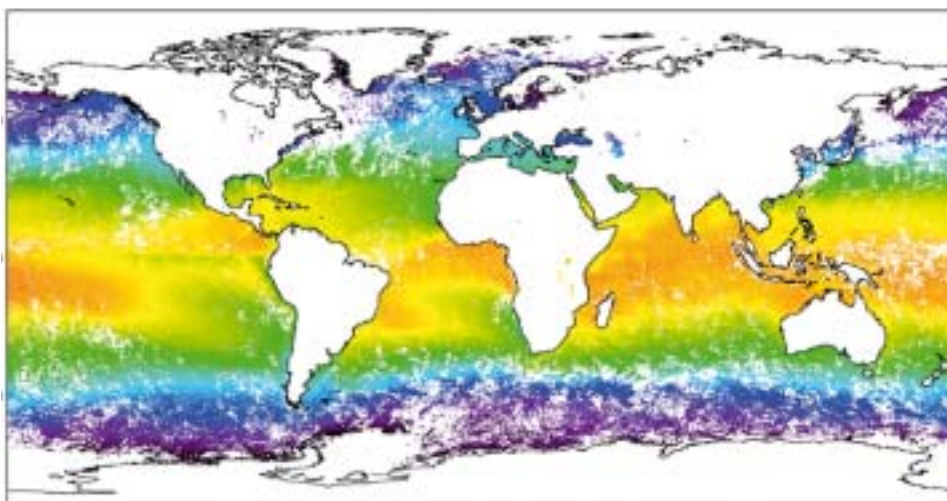


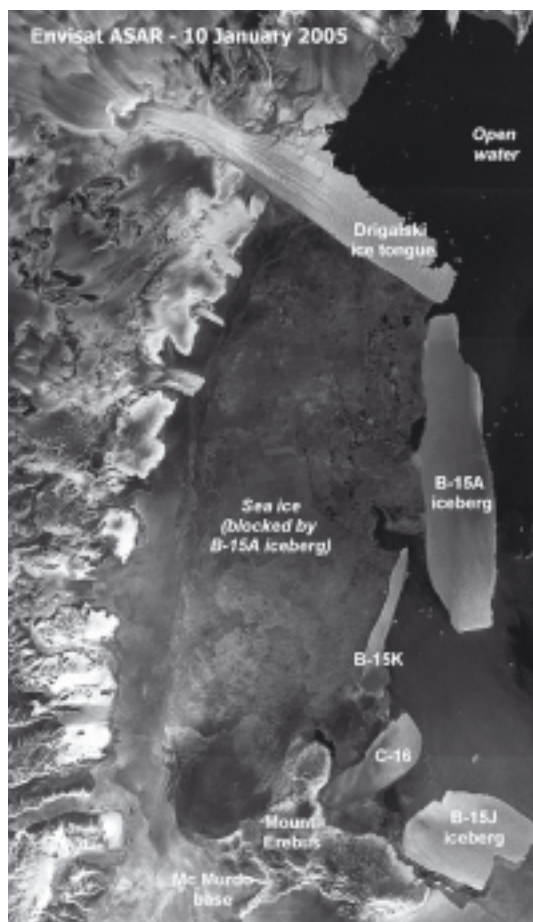
Global chlorophyll coverage from Envisat's MERIS instrument

Some of the most spectacular results presented at the Symposium were on:

- **Climate change:** Global sea-level rise of about 3 mm/year and a seasurface temperature increase of about 0.13°C over 10 years. The AATSR series provides 14 years of consistent data with an accuracy of 0.1 K on a global scale.
- **Atmosphere:** Worldwide monitoring of air pollution, with evidence of fast growing air pollution in China since 1995. Emissions from vessels on the main shipping routes have been observed from space for the first time.

ATSR/AATSR measurements show an upward trend in sea-surface temperature of $0.13 \pm 0.03^\circ\text{C}/\text{decade}$ (Courtesy of David Llewellyn Jones, Univ. Leicester (UK))

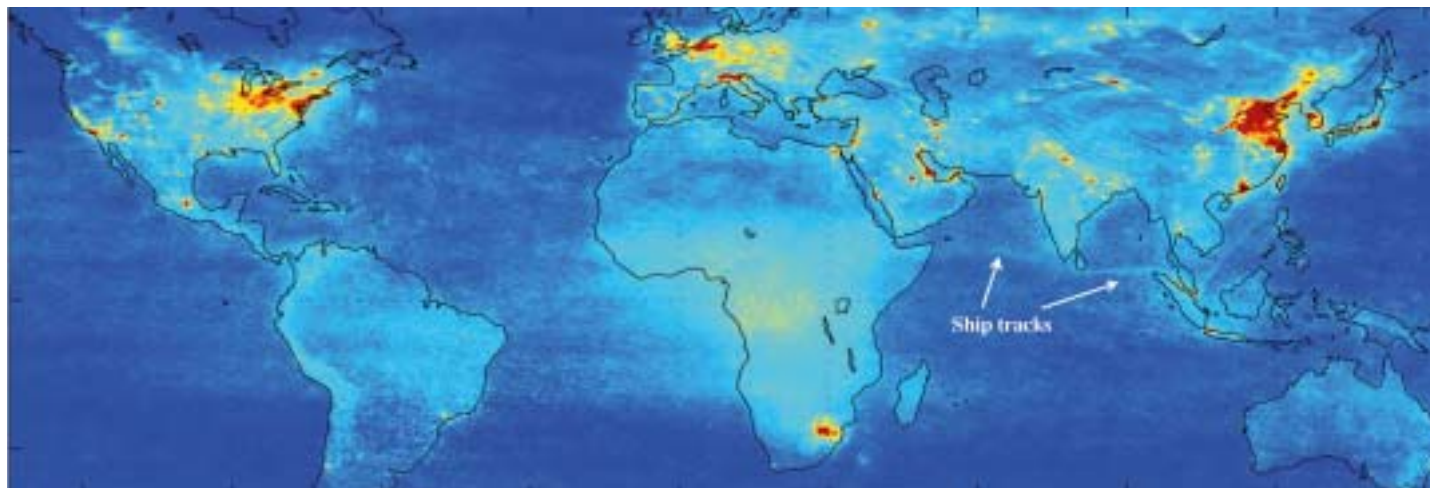




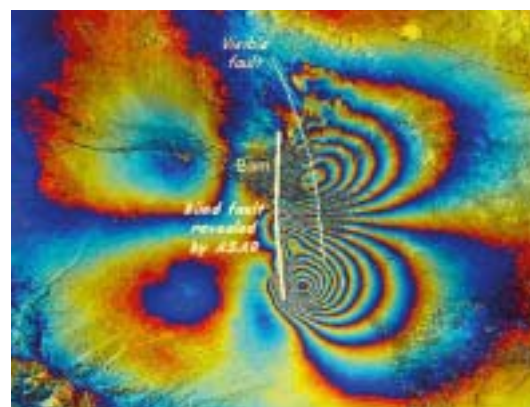
The motion of the B-15 iceberg

- **Polar areas:** Daily monitoring of sea-ice motion and observation of ice-shelf collapse in Antarctica.
- **Oceanography:** Quantification of global chlorophyll concentration. The latter is a measure of phytoplankton biomass, which plays an important role in fixing CO₂ through photosynthesis.

Global NO₂ measurements from Sciamachy for the period January 2003 to June 2004 (Courtesy of Steffen Beirle, Univ. Heidelberg (D))



The origins of the Bam earthquake analysed using ASAR data
(Courtesy of A. Monti-Guarnieri, POLIMI (I))



- **Tectonics:** Identification of the blind tectonic fault at the origin of the Bam earthquake (Iran) in December 2003 using ASAR interferometry. The results were surprising, establishing that while Bam lies in a seismic belt, this particular quake had originated from a point no one had expected. The fault revealed by ASAR showed up as a distinct band of discontinuity in the interferogram, with motion on either side of it ranging from as little as 5 cm to as much as 30 cm.

The Earthnet Programme

The Earthnet Programme ensures access to EO data from other space agencies and mission operators – the so-called ‘Third Party Missions’ – both in Member States and worldwide. Such missions currently include Landsat, Spot, NOAA, Terra/Aqua, OrbView/Seawifs, QSCAT and Proba. The list will be further extended in 2005 to include Bird, Scisat, Coriolis, DMC, IRS-P6, KOMPSAT, SAC-C, CBERS and Rocsat-2, making a total of more than twenty Third-Party missions covered by Earthnet. It also makes available historical archives of the JERS-1, Nimbus-7, IRS-P3 and Landsat missions, built up over the last 25 years.

New EO missions will be regularly scrutinised and added to the list if they satisfy a number of criteria, such as the value to Europe of the mission’s data for both scientific and operational purposes, its accessibility and cost in terms of ground-segment facilities, and finally its relevance to ESA’s EO strategy and objectives.

International cooperation projects were set up during 2004 with Russia, China and African countries, through the Bear, Dragon and Tiger programmes, respectively. A contingency-operation agreement with the Canadian Space Agency and Radarsat is being negotiated to increase user confidence in EO data access.

Ground-Segment Harmonisation

A European harmonisation effort was further pursued in 2004, under the supervision of a Ground Segment Coordination Body. Today, unlike a few years ago, users and projects are requesting coherent access to a multitude of EO data. User services continue to increase and handle a growing number of missions, as do the ground-segment facilities through a multi-mission design concept, in cooperation with national facilities and industry. The degree of cooperation with other mission operators has progressively increased, and is particularly successful for activities in the context of the International Charter on Space and Major Disasters.

Ground-segment harmonisation has become even more important with the preparation of the GMES programme and the need for coherent access to EO data.

The ESA EO sites have been complemented by an EO Portal, providing well-structured access to information about many ESA and non-ESA missions.

Missions under Development

Earth Explorer Missions

CryoSat

CryoSat has been designed to measure variations in the thickness of the polar ice sheets and the thickness of floating sea ice. Its data are intended to be used to study the mass balances of the Antarctic and Greenland ice sheets, to investigate the influence of the cryosphere on global sea-level rise, and to provide important observations of sea-ice thickness for use in Arctic and global climate studies.

The project is now well-advanced: integration of the proto-flight model was completed by EADS Astrium (D) and the spacecraft transported at the end of July to IABG (D) for environmental testing. These tests also confirmed the compatibility of CryoSat with its Rockot launcher. Development of the

Flight model of CryoSat at IABG (D) for environmental testing



Artist's impression of the
ADM-Aeolus mission

ground segment is complete, including the processing facility for the SIRAL radar-altimeter data. Launch is due to take place from Plesetsk at the end of September 2005.

GOCE

The Gravity Field and Steady-State Ocean Circulation Explorer (GOCE) core mission is designed to provide unique models of the Earth's gravity field and the geoid, on a global scale and with unprecedented accuracy and spatial resolution.

Following detailed consolidation of the design the year before, 2004 was devoted mainly to manufacturing and testing the various development models. Ground-segment development progressed according to plan, with the Design Review being successfully completed in November. The predicted launch date remains August 2006.

SMOS

The Soil Moisture and Ocean Salinity (SMOS) mission will demonstrate the observation of two key Earth-system variables from space: namely the soil moisture content over land surfaces, and the amount of salt dissolved in the oceans. Both parameters are key to understanding our climate and its changes, but have not so far been measured.

The SMOS payload, consisting of the Microwave Interferometric Radiometer with Aperture Synthesis (MIRAS) instrument plus supporting elements, moved into its full development phase (Phase-C/D) during the year. The satellite's Proteus platform, contributed by CNES, is currently in the design phase (Phase-B).

The procurement process for the Eurokot (Bremen, D) vehicle for SMOS's launch, currently planned in 2007, was initiated at the end of the year.



ADM-Aeolus

The Atmospheric Dynamics Earth Explorer (ADM-Aeolus) core mission, to be launched in 2008, will provide the first ever measurements of wind profiles from space. As the only such mission under development in the World, it will provide measurements far into the stratosphere where there have historically been almost none, and is therefore expected to enable significant advances in numerical weather prediction, especially in terms of predicting extreme weather events.

The main development phase (Phase-C/D) of the satellite procurement contract is well underway, and the ground segment also made good progress.

The payload data segment will consist of X-band reception from Svalbard (N), processing for engineering correction at Tromsø (N), and the derivation of wind products at the European Centre for Medium Range Weather Forecasts (ECMWF) in Reading (UK). Command and control will be conducted from ESOC in Darmstadt (D) using the Kiruna (S) ground station.



MSG-2 in flight configuration and MSG-3 in pre-integrated form in Alcatel Space's clean room in Cannes (F)
(Courtesy of Alcatel Space)

Earth Watch Missions

Meteosat Second Generation

MSG-1, renamed Meteosat-8 once in orbit, has completed its first year of routine operations, to the full satisfaction of the user community, with the optical performance of the Spinning Enhanced Visible and Infrared Imager (SEVIRI) and the Geostationary Earth Radiation Budget (GERB) instrument being of excellent quality.

The MSG-2 spacecraft has completed environmental testing and is now ready for shipment to Kourou in French Guiana, where it will be prepared for an Ariane-5 launch in November 2005.

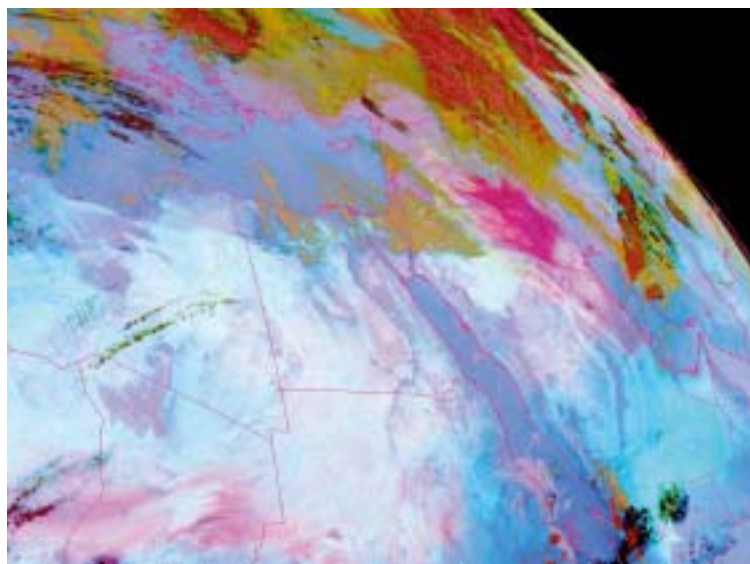
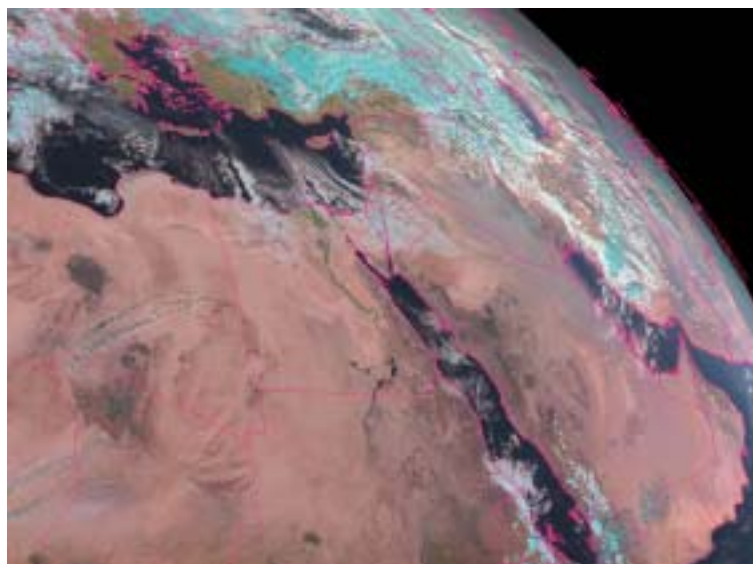
Environmental testing on the MSG-3 spacecraft has also been completed and, after the MSG-2 launch campaign, it will be put into long-term storage until its own launch, currently foreseen in 2009.

MSG-4 procurement activities progressed according to plan, with most subsystems having already been delivered and some pre-integration activities at system level already started. Full integration will start after the MSG-2 launch.

MetOp

Some very important milestones were achieved within the MetOp programme in 2004:

During the night of 23-24 November 2004, a dust storm (and cold air) moved into Saudi Arabia. The Meteosat-8 high-resolution visible image (left) shows the dust cloud as a bright, featureless area when compared with the well-structured desert surface. The dust storm can also be seen in the infrared image (right) where it appears as a relatively cold area compared to the hot desert surface
(Courtesy of Eumetsat)

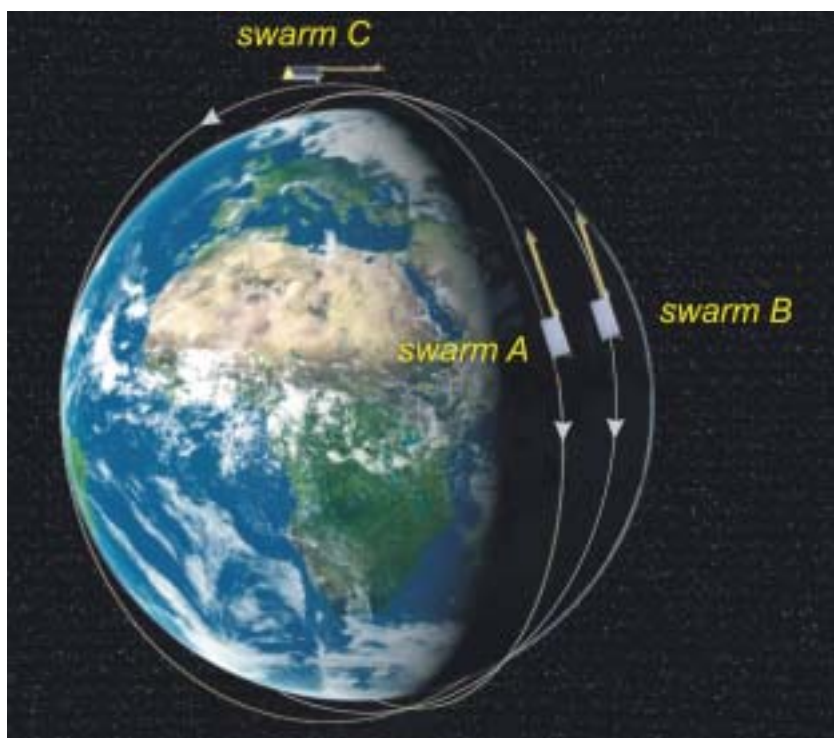


- The MetOp-1 spacecraft was successfully completed and the first part of the Flight Acceptance Review held with positive results. The spacecraft is now in storage, where it will remain until its reactivation for launch in the 2010 time frame.
- Integration of the first MetOp spacecraft to be launched, MetOp-2, is now well underway, with the major electromagnetic-compatibility and mechanical-environment test campaigns being successfully completed by the end of the year. Launch is planned for April 2006.
- Links with the wider meteorological community were strengthened through a variety of activities.

InfoTerra/TerraSAR

The main objective of the TerraSAR mission is to provide geo-information services to commercial users exploiting joint data products from TerraSAR-L and TerraSAR-X (being developed concurrently as a German national programme). The TerraSAR-L system will provide ESA with its most powerful radar-imaging programme to date, key mission characteristics being a 5-year mission lifetime, global coverage from a 14-day repeat, 640-km altitude orbit, and 20 minutes of data acquisition per orbit.

Most of the Earth's magnetic field originates from a 'dynamo' operating in its outer core. There are, however, other contributions that the accurate observations of the Swarm fleet will help to disentangle



The principal payload is an L-band SAR instrument based on an 11 m x 2.9 m, active-phase-array antenna with 160 transmit/receive modules. More than 600 Gbit of data can be stored onboard and downloaded to a network of ground stations via a 300 Mbit/s link. The spacecraft platform, based on the novel 'Snapdragon' configuration, has a total launch mass of 2.4 t, to be accommodated on the Soyuz Fregat ST launcher. The solar array supplies 5 kW of power.

Fuegosat

The first step of the Fuegosat Consolidation Element has been completed. By prototyping and demonstrating services with the users



in their operational environment, the understanding of their needs and the capabilities of the space system have been consolidated. The architecture has been defined for a mission that should help to fight fire as a source of disaster that causes millions of hectares of forest to be lost every year. Such an architecture could consist of non-dedicated operational assets such as the GMES Sentinels, and dedicated sensors operating in the mid- and thermal-infrared for enhanced fire detection and monitoring.

Preparation of Future Missions

These activities address future Earth Explorer and Earth Watch missions designed to improve our knowledge of the Earth system and to deploy space-based solutions in such critical areas as climate-change detection, environmental monitoring, sustainable development,

risk management and other areas of relevance to the GMES initiative, in addition to well-established areas such as operational meteorology.

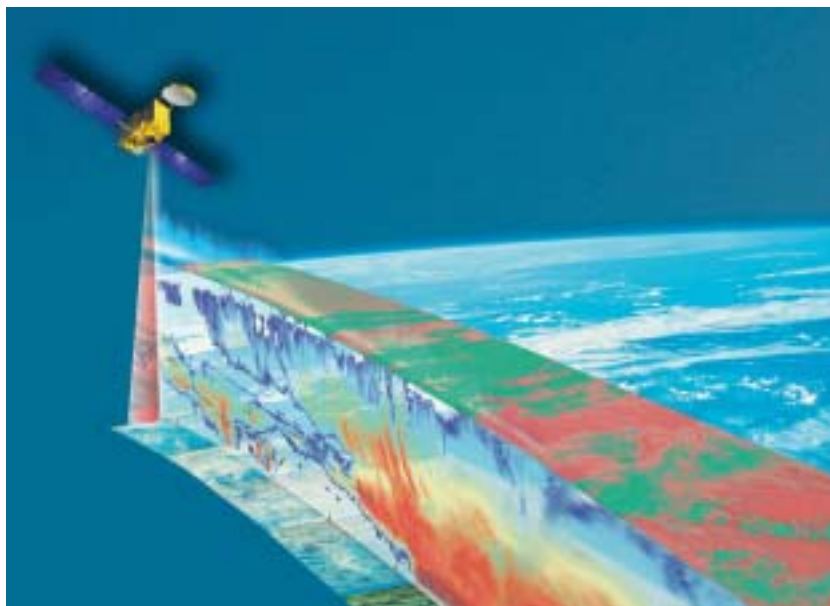
Earth Explorer Missions

The results of studies on the feasibility of six mission candidates – EarthCARE, SPECTRA, WALES, ACE+, EGPM and Swarm – were presented at a meeting at ESRIN (I) in April attended by 300 representatives from the scientific community and industry. Based on advice from the scientific community, Swarm and EarthCARE were selected for implementation, and both will fly around the end of the decade.

This brings the total number of Earth Explorer missions to six. They address a wide range of scientific issues, increasing our knowledge about how the Earth system works, how it changes, and how human activities impact upon the system.

Swarm, the fifth Earth Explorer mission, will monitor the magnetic and electric environment surrounding the Earth. By using a unique constellation of three small satellites, variations in the measured fields can be attributed to the dynamical behaviour of the solid Earth and to interactions with the incoming radiation from the Sun. Together with measurements from another Earth Explorer mission, GOCE, which will measure the Earth's gravity field, Swarm will provide new knowledge about the dynamics of the Earth's surface and improve our ability to understand the mechanisms of earthquakes, which pose an increasing threat to a growing population. Planned for launch in 2009, Swarm will be the culmination of a sustained European effort that started with the Danish Ørsted, and continued with the German CHAMP mission.

EarthCARE, which is a cooperative mission with Japan planned for launch in 2012, will be the sixth Earth Explorer mission. It will address the role of clouds and aerosols in the climate system, and will accurately measure the Earth's radiation balance. Clouds represent one of the most complex and important elements in our planet's climate system. Aerosols can have both a cooling and a heating effect, depending



on the nature of particles, and human activities are strongly affecting the atmosphere's aerosol composition. EarthCARE will improve our knowledge of the factors influencing global change and the role that human activities are playing in the global warming that is currently being observed.

In the ten years since the birth of the Earth Explorer concept in 1994, nearly 70 mission proposals have been scrutinised, and six have been selected. They are currently in different stages of development, with the first, CryoSat, due for launch in 2005, and the last so-far selected, EarthCARE, in 2012.

Earth Watch GMES Missions

Analysis of mission requirements derived from user and service needs has led to the establishment of concepts for the first dedicated Global Monitoring for Environment and Security (GMES) space missions, the so-called 'Sentinels'.

A set of preparatory activities has been defined for execution in 2005, including socioeconomic-benefit studies and studies of implementation scenarios and architectures, encompassing all components but with emphasis on the Earth Observation component. The preparatory activities also include definition studies for Sentinel-1, a C-band SAR mission providing continuity with ERS, Envisat and Radarsat SAR data, Sentinel-2, a super-spectral optical-

The EarthCARE mission will provide essential input data for numerical modelling and for global studies of the divergence of radiated energy, the aerosol-cloud-radiation interaction, the vertical distribution of water and ice and their transport by clouds, the vertical cloud-field overlap and cloud-precipitation interactions, among other major burning scientific issues



imaging mission providing enhanced continuity with Spot and Landsat, and Sentinel-3, a mission devoted to monitoring of the oceans and land/vegetation on a global scale by means of an optical imager in the visible and thermal infrared and an advanced altimeter. Initial studies have also been planned for Sentinel-4 and Sentinel-5, devoted to monitoring atmospheric composition from geostationary and low Earth orbits, respectively.

Development of Services, and Applications

DUP-DUE

Many new projects were started within the Data User Programme (DUP) and Data User Element (DUE), leading to the establishment of global datasets, such as mapping of aerosols, coastlines, sea ice, deserts, aquifers and land cover. These projects were carried out in close collaboration with the relevant user institutions such as humanitarian-aid organisations, river-basin authorities, environmental ministries and agencies, forestry and agriculture ministries, WHO, UNESCO, FAO and UNEP.

Global Monitoring for Environment and Security (GMES)

The 10 contracts consolidating GMES services were successfully completed in 2004, with a clear mandate from the user communities to expand the role of EO-based information as a response to their policy-driven requirements for information. This activity resulted in the provision of an unprecedented number of products and services, ranging from iceberg location maps to water-quality maps for European coastal waters, delivered to over 200 user organisations from all over Europe and Africa.

Two new consolidation activities were started in 2004 in the areas of atmospheric-pollution monitoring and decision-making support for humanitarian-aid operations, such as the tsunami in Southeast Asia and the humanitarian crisis in Darfur.

All GMES services activities have been coordinated with the European Commission through the GMES Programme Office. This included preparations for the Earth & Space

Week in Brussels in February 2005, and detailed planning for the scaling-up of service provision for the next three-year period of 2005 to 2007.

EOMD

Through ESA's EO Market Development (EOMD) programme, service providers continued to work closely with potential customers in the areas of civil engineering, mining, oil and gas exploration, production and transportation, aquaculture, sailing, marine transport and certification, renewable energy, and re-insurance. More than 30 specific service trials designed together with these potential customers are planned to take place throughout 2005.

Education

EO education activities focused on the enrichment of Eduspace, the ESA multilingual EO web site for secondary schools developed under the auspices of EURISY. A new module titled 'Africa from Space' and accompanying study cases were integrated into the operational version of the website. LEOWorks 2.0, the upgraded version of the Eduspace image-processing tool for teachers and students, became operational during the summer.

Teacher events and courses dedicated to trainers were supported within Europe and also beyond. Several international trainees and national fellows were hosted at ESRIN during 2004.

GRID

2004 saw the completion and transfer into operation of mature GRID-based applications, with in particular the integration of the Envisat MERIS dedicated data-processing tool (BEAM) into the so-called 'GRID on-Demand' environment to generate various Level-3 products used for promotion and mosaicking of the ASAR global mode over the Antarctic continent.

The GRID environment allows the accessing of large datasets at source, instead of delivering the data products from the acquisition/storage facilities to the user site. GRID provides the user community with quick accessibility to data, high-performance computing resources and therefore rapid results.