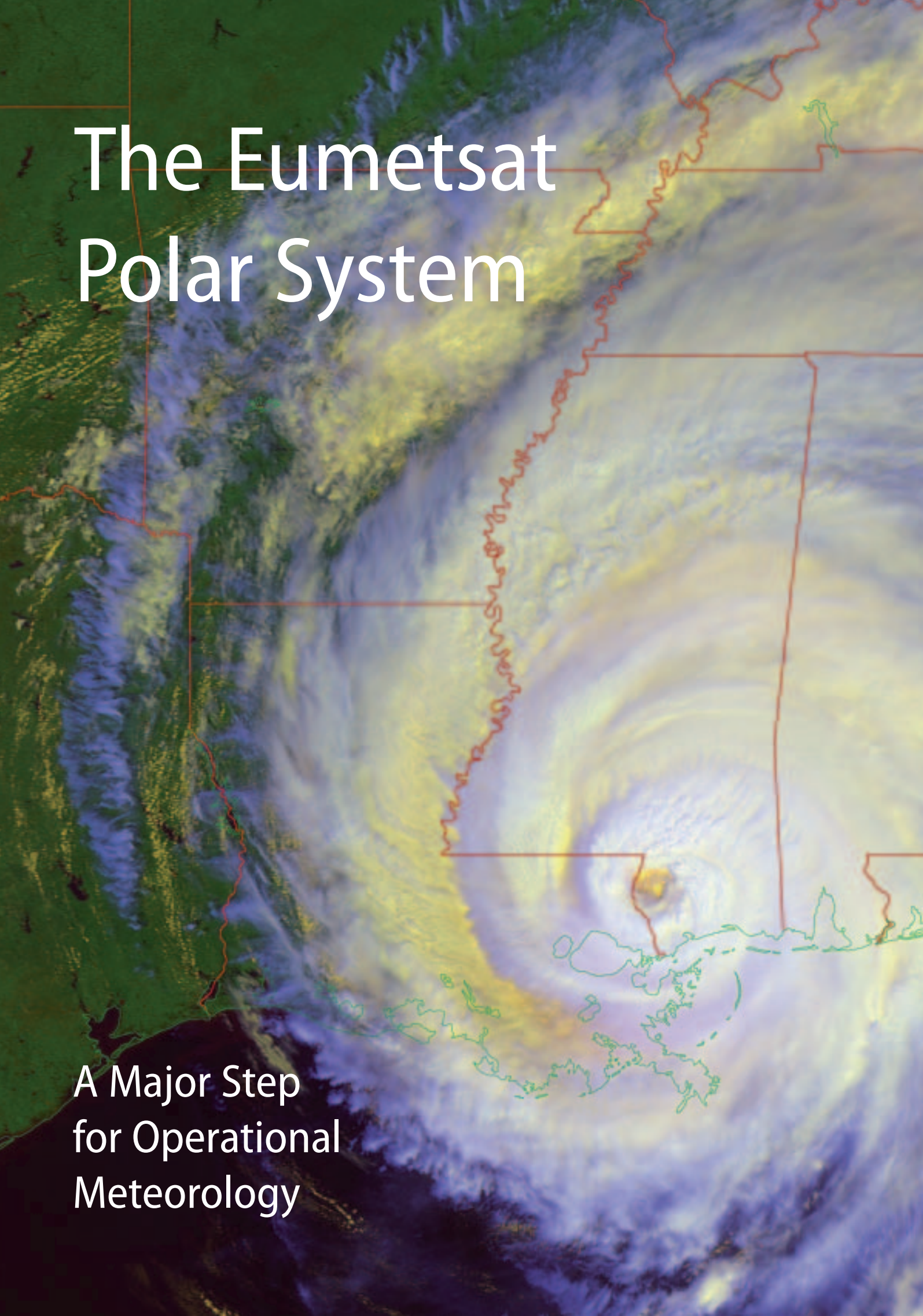

The Eumetsat Polar System

A Major Step for Operational Meteorology

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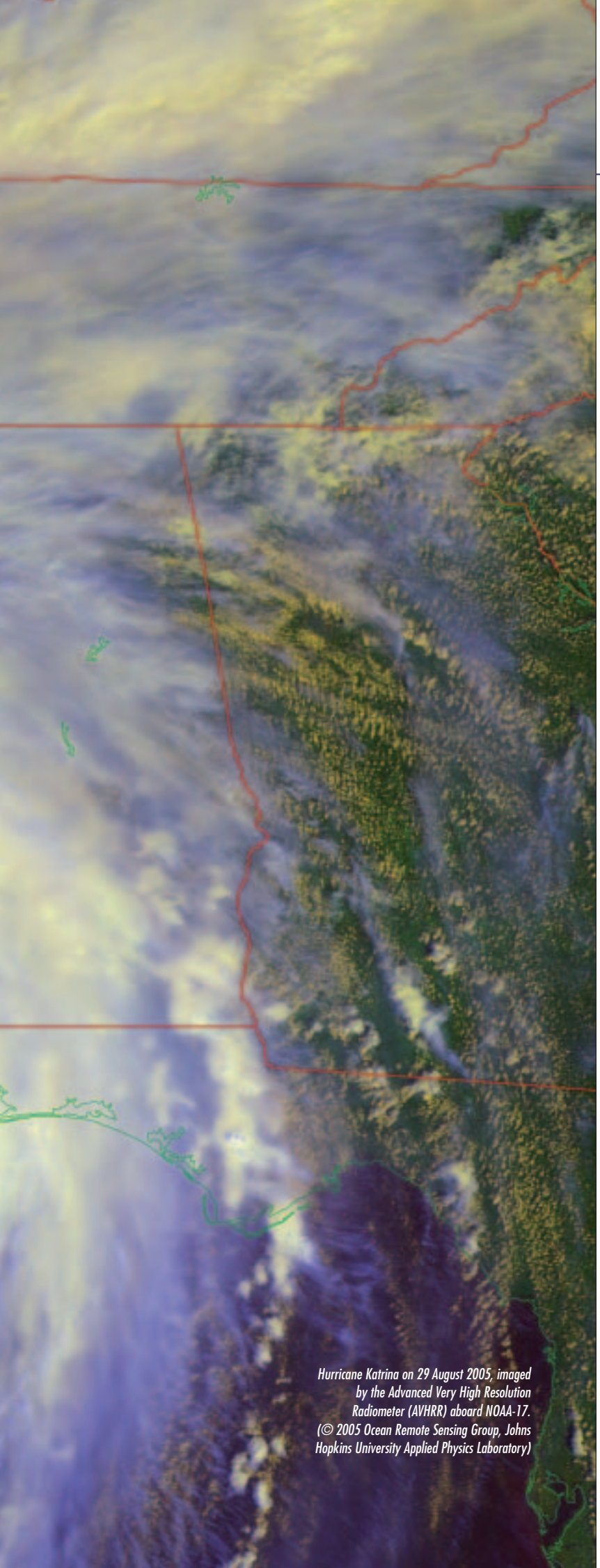


Hurricane Katrina on 29 August 2005, imaged by the Advanced Very High Resolution Radiometer (AVHRR) aboard NOAA-17. (© 2005 Ocean Remote Sensing Group, Johns Hopkins University Applied Physics Laboratory)

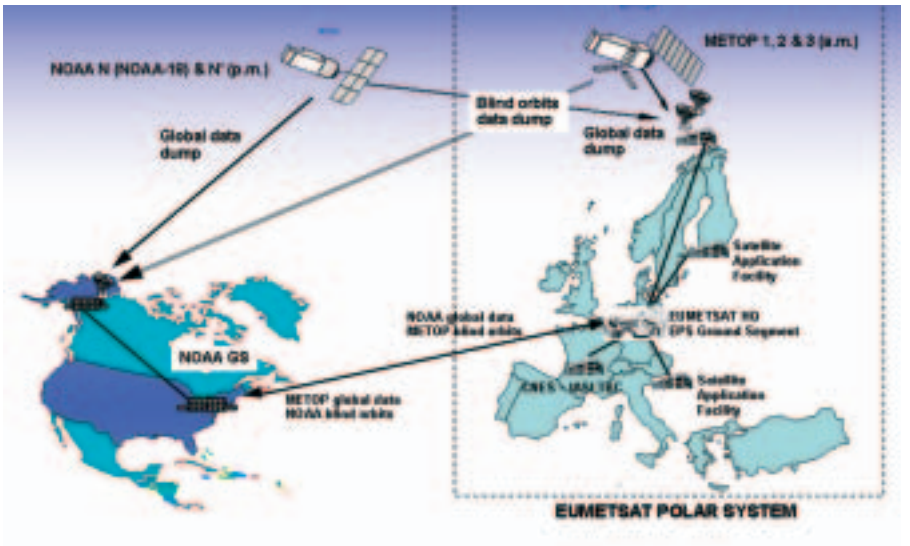
The Eumetsat Polar System (EPS) covers the MetOp satellites and Eumetsat's ground infrastructure and services. It is the European contribution to the Initial Joint Polar System, established jointly with the US National Oceanic & Atmospheric Administration (NOAA). EPS will patrol the 'morning orbit' while NOAA continues with the 'afternoon orbit'. In addition to its prime objective of operational meteorology and climate monitoring, EPS also addresses a wide range of other environmental issues such as the atmosphere's minor constituents, cloud distribution and ocean-surface wind effects. EPS is planned for 14 years of operations, starting in 2007, following completion of in-orbit commissioning.

Introduction

For more than 30 years, the operational meteorological satellite data from low orbit have been provided by a series of satellites operated by the US National Oceanic & Atmospheric Administration (NOAA). At any one time, the system has two operational polar-orbiting satellites in 'morning' and 'afternoon' orbits (referring to the local time as the satellite crosses the Equator).

Many years of discussions and planning on Europe assuming the responsibility for the morning service culminated in the ESA Meteorological Operational (MetOp) and the coordinated Eumetsat Polar System (EPS) Programmes being approved in 1998 and 1999, respectively.

The ESA MetOp-1 Programme covers development of the first satellite, while the EPS Programme includes the manufacture of two further satellites (MetOp-2 and MetOp-3), the launch of all three and a new ground segment to operate these satellites and process, archive and distribute their data. EPS is designed for a total operational life of 14 years. The EPS Programme also provides a financial and material contribution to the ESA MetOp-1 Programme.



The Initial Joint Polar System. An orbit is 'blind' when the satellite does not come within range of its usual ground stations. GS: Ground Segment.

EPS and International Cooperation

EPS is the European element of the Initial Joint Polar System (IJPS), established through a Cooperation Agreement between Eumetsat and NOAA to contribute to the global meteorological polar-orbiting observing system.

The objective of the IJPS is to ensure the continuity and timely availability of meteorological data through a series of polar satellites with a mid-morning equator-crossing time of 09:30 (Europe) and an afternoon equator-crossing time of 14:00 (USA).

EPS is built around a Space Segment (the MetOp satellites and their payloads) and a dedicated Ground Segment, described below. MetOp's instruments result from a number of international cooperations: AVHRR, HIRS, AMSU-A and SEM are provided by NOAA as part of IJPS; MHS is directly procured by Eumetsat; IASI is a joint development by Eumetsat and CNES; GOME-2 and GRAS are jointly funded by Eumetsat and ESA; ASCAT is provided by ESA; A-DCS is provided by CNES; the Search & Rescue package is provided by CNES and the Canadian Department of National Defence. (The instrument acronyms are explained in the companion article 'The MetOp Satellite'.)

The EPS Missions

Operational meteorology

Operational meteorology covers a wide spectrum of activities for predicting how the atmosphere, and especially associated weather conditions, will evolve. These activities are supported by observations coordinated through the World Weather Watch (WWW) of the World Meteorological Organisation (WMO). Standard observations are routinely made every 3–6 hours (the 'synoptic hours') and distributed to the operational meteorological community over the Global Telecommunications System (GTS) of the WMO.

Observations provided by operational meteorological polar satellites are essential components of this observing system. Existing satellites have many well-established operational capabilities, while MetOp will add to them based on heritage from pre-operational missions or will allow promising operational evolution.

Climate monitoring

Earth-observation satellites have an important contribution to make in understanding our climate; operational satellites are pre-eminent in providing the necessary long-term monitoring required for detecting real climate change.

It is necessary to observe many different climate parameters and study them simultaneously in a multi-disciplinary approach. Even quite small trends in the climate, if continued over the long term, can lead to immense environmental problems and enormous expenditure to counter the adverse effects.

Many climate-monitoring requirements coincide with, or overlap, the requirements for operational meteorology. The objectives for monitoring climate change that are additional to those already established for operational meteorology are listed in the table on the facing page.

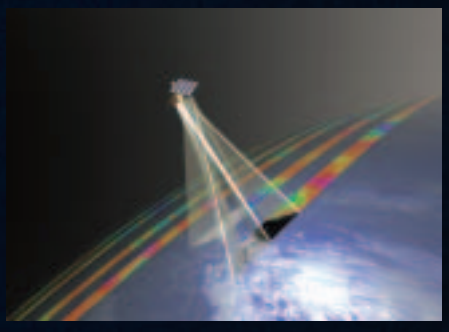
Further mission capabilities

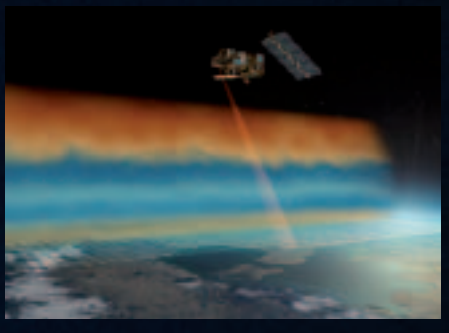
Although driven by the need to return operational meteorology and climate-monitoring data, the EPS mission is also a source of data on a wide range of other environmental issues, including:

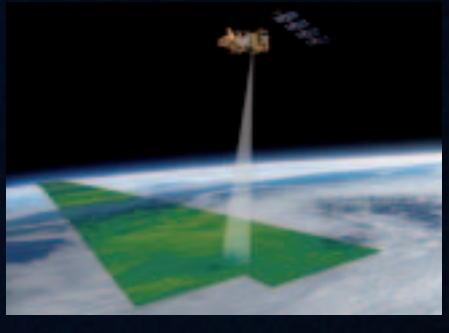
– Earth sciences;
– atmospheric minor constituents and trace gases;
– cloud distribution;
– wind forces at the ocean surface.

Additional services

The satellite is further designed to







EPS/MetOp Missions

Mission	*Function*
Global operational sounding	Provides information on the 3-D temperature and humidity of the atmosphere, to support Numerical Weather Prediction (NWP)
Global imagery	Provides cloud imagery for forecasting applications, sea-surface temperatures and global radiation budget parameters. Supports the global sounding mission by identifying cloud-free areas
Global ocean surface wind vectors	Provides wind speed and direction over the global ocean surface and supports NWP systems by providing these data in otherwise data-sparse regions
Data collection and location	Collection of observations from ocean buoys and similar *in situ* Data Collection Platforms (DCPs). Includes determination of the DCP location. Supports the WWW
Global data access	Delivery of global data to the meteorological services within 2.25 hours of observation; primarily supporting global-scale forecasts
Local data access (HRPT and LRPT)	Broadcast of data to local receiving stations while a satellite is visible, supporting regional forecasting. Two services are required: High-Resolution Picture Transmission (HRPT) and Low-Resolution Picture Transmission (LRPT)

Climate-Monitoring Missions

Mission	*Function*
Sea-ice monitoring over the oceans	Provides information on the coverage of ice and snow (in addition to ship routing in operational meteorology)
Ice and snow monitoring over land	Provides information on the coverage of land surfaces by ice and snow (in addition to operational meteorology)
Global precipitable water mapping	Provides information on the global distribution of water (also supports NWP)
Global ozone mapping	Provides information on the distribution of ozone in the upper atmosphere

monitor its space environment, for routine analysis of the charged particles in low orbit. EPS will also become part of the international search and rescue service that is already operating via today's NOAA satellites.

The MetOp Satellites

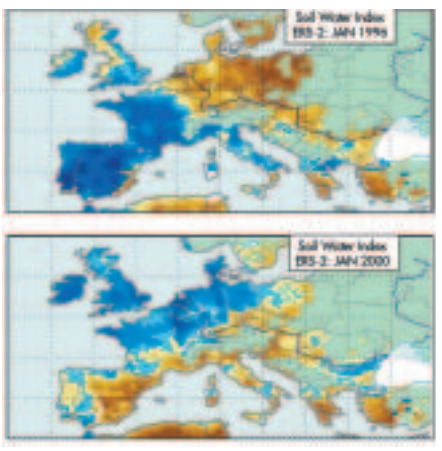
MetOp and its payload ensure continuity with the current observing system and adds new capabilities inherited from pre-operational missions such as Envisat.

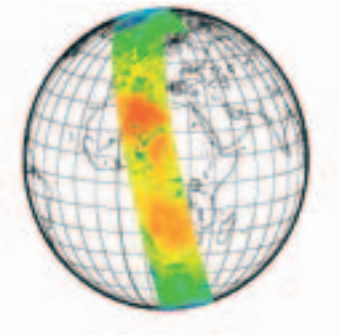
The HIRS, AMSU-A and MHS instruments constitute the Advanced TIROS Operational Vertical Sounder (ATOVS) suite. With AVHRR, they match the instruments carried by the NOAA satellites.

In addition to these currently operational sounding and imaging instruments, MetOp is carrying new-generation instruments: the Infrared Atmospheric Sounding Interferometer (IASI), the Global Ozone Monitoring Experiment (GOME-2), the Advanced SCATterometer (ASCAT) and the Global navigation satellite system Receiver for Atmospheric Sounding (GRAS).

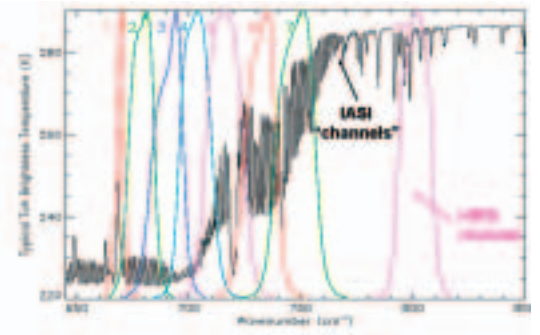
Other payload items include the Space Environment Monitor (SEM), the Advanced Data Collection System (A-DCS), and the Search & Rescue (S&R) package.

ASCAT will provide the data for emerging land applications such as monitoring global soil moisture. This will also contribute to Numerical Weather Prediction. The example here uses information from ESA's ERS-2 satellite; blue indicates higher moisture levels

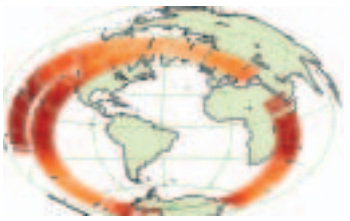




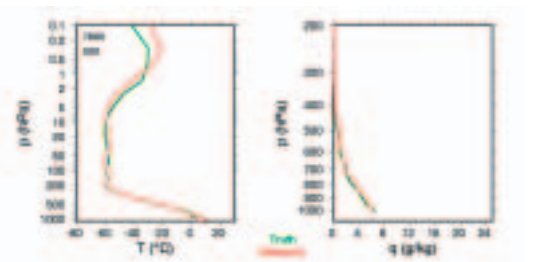
The temperatures processed by Eumetsat from the MHS instrument on NOAA-18



A typical IASI 8461-channel spectrum compared with the 19 channels of the previous-generation High Resolution Infrared Radiation Sounder (HIRS)



The atmosphere's temperature extracted from simulated IASI data



Simulated IASI data showing how accurately temperature (T), pressure (p) and humidity (q) can be calculated. The red curves show IASI's result against the green true values

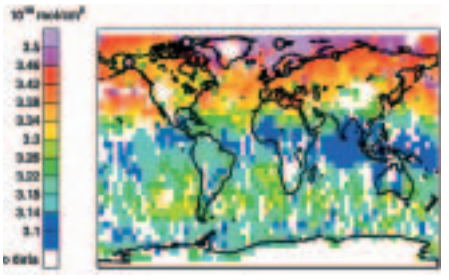
The IASI Instrument

IASI is a major element of the EPS/MetOp mission. It represents the next generation of atmospheric sounders and should allow a significant step forward in providing temperature and humidity profiles of much higher accuracy and resolution than hitherto available.

IASI is introducing new and advanced technology. As a Michelson interferometer working in 8461 spectral channels, its main task is to measure the atmosphere's temperature, water vapour and trace gases globally.

Part of the instrument is an Integrated Imaging System, consisting of a broadband radiometer working at 10–12 micron at high spatial resolution. The field of view covers 64 x 64 pixels and provides information in the focal plane of the sounder, allowing coregistration with AVHRR for precise knowledge of position and detailed analysis of cloud properties inside the IASI sounder pixels.

IASI will be important for measuring key trace gases in the atmosphere, such as the methane shown here



The IASI data will be used in synergy with the microwave sounding instruments, to which the scanning is synchronised. It is expected that IASI will considerably improve the quality of weather forecasting through the direct ingestion of its measurements into the forecast models. It will also improve climate monitoring by measuring key trace gases such as ozone, carbon dioxide, methane and nitrous oxide, all important for atmospheric chemistry.

The EPS Ground Segment

The EPS Ground Segment includes all the ground facilities required to support the orbiting MetOp satellites and the EPS mission, including both normal and degraded mission modes. Its objectives are:

– to ensure that the satellites perform their mission nominally.
– to perform the ground operations to fulfil the global mission, acquiring and processing the global data received from the NOAA and MetOp satellites and disseminating the processed data to the Eumetsat member states. This includes product quality control, data archiving, and provision of user services.
– to perform all the ground operations to support the local data-access mission (HRTP/LRPT).
– to support NOAA for global data acquisition and telemetry, tracking and control during blind orbits of the NOAA ground segment (and on request for specific operations).
– to support the space environment monitoring and data-collection missions.

The core ground segment provides the following functions at the different sites:

– the Central Site, at Eumetsat headquarters in Darmstadt (D), includes all the functions for monitoring and controlling the satellite and the ground segment. Included are the generation of the centrally extracted products and their dissemination.
– the Polar Site, at Svalbard (latitude 78°N), hosts the Control & Data Acquisition (CDA) station that will receive the MetOp recorder dump every orbit and command the satellite. The CDA will also receive NOAA satellite data dumps when they are beyond their own stations.
– the Back-Up Control Centre (BUCC) Site, close to Madrid (E), was created in case of major problems with the central site.

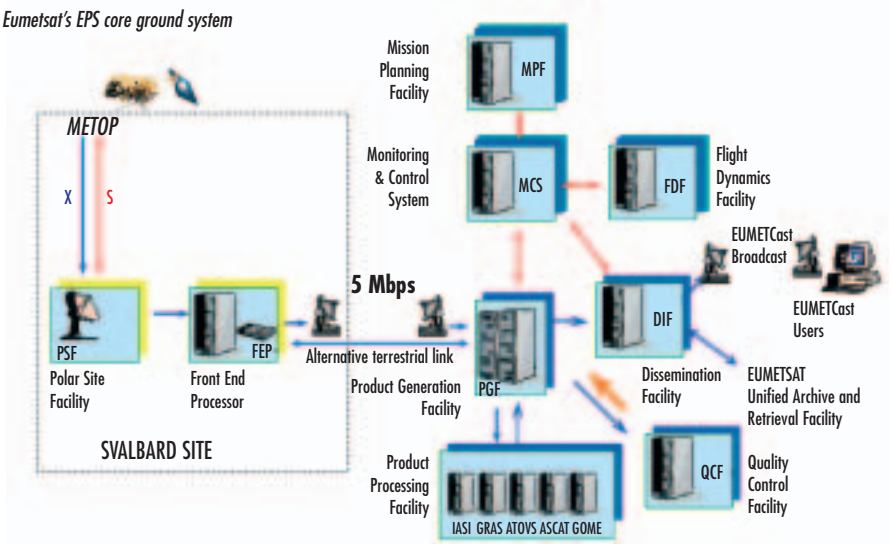
The core ground segment was developed by a European consortium led by Alcatel Alenia Space (F). The Polar Site and BUCC infrastructure services are contracted out to KSAT (N) and INTA (E), respectively.

The EPS ground segment includes the Eumetsat multi-mission dissemination system (EUMETCast) for near-realtime delivery to users of the global data and products derived from the MetOp data for the morning orbit and NOAA data for the afternoon orbit.

Conclusion

The EPS Programme is a major investment by Europe's meteorological and research and development communities in the global meteorological observing system. It will provide products and services of unprecedented quality to the European and international operational users, as well as to the larger community of Earth scientists.

Eumetsat's EPS core ground system



Research Announcement of Opportunity

The instruments on the MetOp satellites provide continuity for the operational sensors that have long been flying on the NOAA satellites. Such series of long-term data are valuable sources of information for research into, for example, climate change. MetOp also carries the advanced European ASCAT, GOME-2, GRAS, IASI and MHS instruments, which not only largely fulfil the requirements for operational meteorology and climate monitoring, but also offer a unique opportunity for innovative research in all aspects of Earth sciences.

This is why ESA and Eumetsat jointly offer free access for the worldwide scientific community to the EPS data and products for the projects selected through the joint Research Announcement of Opportunity (RAO) that was opened in July 2004. Such free data access is also granted to those proposals exploiting synergy with Meteosat Second Generation and Meteosat, as well as the ERS and Envisat data and products.

The peer review selected 50 proposals, mainly from European scientists but also some from Argentina, Australia, Brazil, Canada, Kyrgyzstan and the US. More than 250 researchers are involved.

About half of the projects request ERS and Envisat data, demonstrating the synergy of MetOp with such missions. In particular, this is the case for the GOME and SCHIAMACHY instruments in atmospheric chemistry.

The first Workshop of selected Principal Investigators took place at ESRIN on 15–17 May 2006, before the first MetOp launch. More than 40 scientific projects were presented to a restricted audience by the Principal Investigators, explaining their plans in atmospheric research, land, oceanography, hydrology, climate, methods, calibration and validation. In return, the scientists were briefed on the status of MetOp and the EPS ground segment, including information on how and when to get the data.

The interest in MetOp raised among the research community was highlighted by the success of the call for innovative projects. The first results will be presented at the second Workshop about a year after MetOp's launch.