geostationary meteorological satellite system (Meteosat first generation under the Meteosat Transition Programme (MTP), and the Meteosat Second Generation (MSG)). The EUMETSAT Polar System (EPS) is EUMETSAT's contribution to the low Earth orbiting, sun synchronous weather satellites system (Initial Joint Polar System (IJPS) with the Unites States). The Jason-2 programme is an optional programme and provides Ocean surface topography measurements since summer 2008. Together with these systems User and Data Services are provided.

Programmatic Aspects

Low Earth Observation Systems

EUMETSAT Polar System (EPS)

The EUMETSAT Polar System (Klaes et al., 2008) complements the US provided system and provides services in the mid-morning orbit. Together with the US it continues the NOAA polar orbiting satellite system in the frame of the Initial Joint Polar System (IJPS). The EUMETSAT satellites of EPS are the Metop (METeorological OPerational) satellites, jointly developed with ESA (Edwards et al., 2006). They provide hyper-spectral sounding and high-resolution imagery in global coverage. The Metop satellites fly in a Sun synchronous orbit with 9:30 a.m. (Local Solar Time (LST)) equator crossing (descending node). After the successful launch of Metop-A on 19th October 2006, EPS provides data and products. Metop-B and Metop-C, respectively, will follow Metop-A. Metop satellites have a nominal lifetime of 5 years; however the performance in orbit allowed extending the life time of the Metop-A satellite to six years. Consequently the launch of Metop-B is now planned for April 2012. Metop-C will follow in 2016 (TBC). Metop-B and –C are recurrent copies of Metop-A.

Figure 1: EPS Space Segment: The Metop Satellite.

No HIRS/4 will be flown on Metop-C, as IASI will have proven its value. The EPS programme will cover at least 15 years of operation. For mission objectives and expected capabilities see Klaes et al. (2007).

Optional Programmes: Jason-2

The Jason-2 programme is EUMETSAT's first optional programme. EUMETSAT contributes to the operations of the overall system and to the generation of the data stream, using a European Earth Terminal and a real time processing chain.

Within this programme EUMETSAT is part of a joint undertaking with four agencies: EUMETSAT, the French Centre National d'Etudes Spatiales (CNES), the US National Oceanic and Atmospheric Administration (NOAA) and the US National Aeronautics and Space Administration (NASA). This forms the Ocean Surface Topography Mission (OSTM). OSTM is an important element in the overall altimetry data system and brought high precision altimetry to a full operational status. Jason-2 was launched in June 2008 from Vandenberg AFB, Ca., U.S.A. EUMETSAT and NOAA process and disseminate the Near Real Time products, whereas CNES processes and delivers off-line high precision products.

Geostationary Systems

Meteosat-7 provided since 1997 the European meteorological geostationary satellite data coverage under the Meteosat Transition Programme (MTP). Meteosat-7 has the same capabilities as its predecessors. Together with the first MSG satellite Meteosat-8, Meteosat-7 was operated as part of a redundant two-satellite system until June 2006. Today the operational geostationary service is provided by the Meteosat Second Generation satellites. MSG-1 was successfully launched in August 2002 and started its operational service in January 2004. It has significant improvements in the observation capability and a nominal lifetime of seven years. In addition to the main observation mission it embarks a climatology experimental mission (the Geostationary Earth Radiation Budget (GERB) Instrument), a Search and Rescue mission and a mission communication payload. The second satellite of this series, MSG-2, was launched on 21st December 2005. It is currently providing the nominal operational satellite service at 0° W as Meteosat-9. Meteosat-8 was relocated to 9.5 ° E in March 2008 and is currently providing rapid scan services over Europe. MSG-3 and MSG-4 are foreseen to be launched in 2011 and 2014.

The Indian Ocean Coverage is provided by Meteosat-7 at 57.5° E. Meteosat-6 provides coverage for the Data Collection Platform and back up to imagery mission as well as rapid scan service over the Indian Ocean at 67.5 °E.

SPACECRAFT AND INSTRUMENTS

EUMETSAT Polar System (EPS/Metop)

The Metop satellites of EPS are flying in a Sun synchronous, near polar orbit with an equator crossing time of 09:30 AM LST (descending node), i.e. the so called (mid-) morning orbit. The mission objectives for operational meteorology and climate monitoring are reflected by an appropriate payload. Novel technology and hyperspectral infrared sounding capability is provided by the IASI (Infrared Atmospheric Sounding Interferometer) instrument, improving soundings both in unprecedented accuracy and also vertical and horizontal resolution. The HIRS/4 (High Resolution Infrared Radiation Sounder) instrument, the AMSU-A (Advanced Microwave Sounding Unit - A) and the MHS

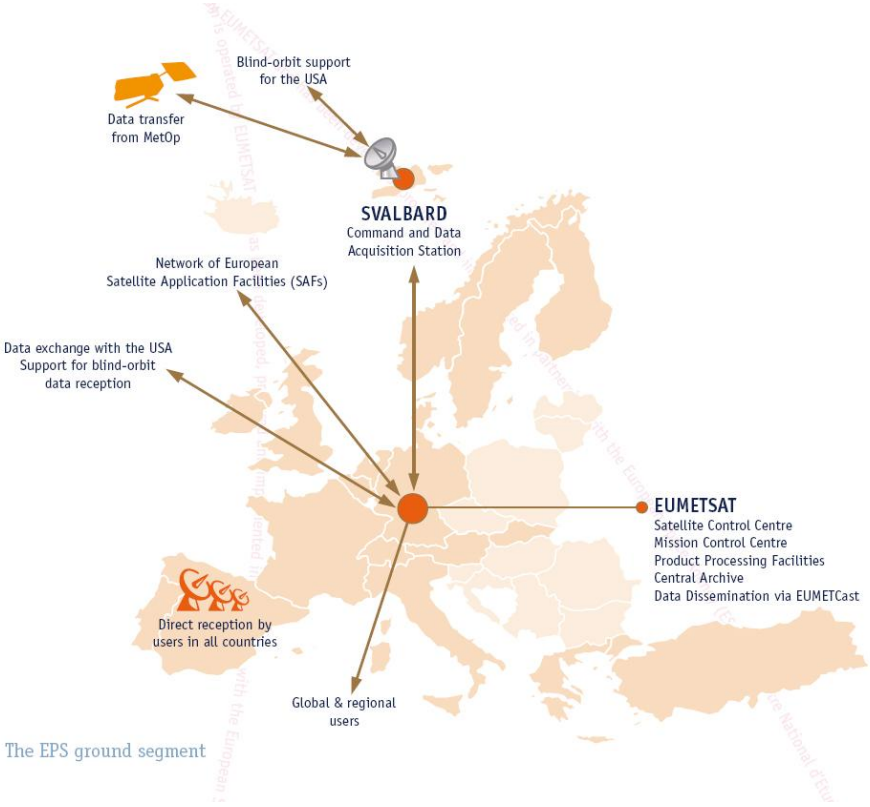

Figure 2. EPS Ground Segment.

(Microwave Humidity Sounder) instrument as successor of AMSU-B (MHS was developed by EUMETSAT), provide the continuity to the polar sounding capabilities onboard the NOAA-15, NOAA-16 and NOAA-17 spacecraft and complement the payload of the two NOAA-IJPS spacecraft, NOAA-18, in orbit since May 2005, and NOAA-19, in orbit since 6 February 2009. The proven AVHRR/3 (Advanced Very High-Resolution Radiometer) multi-spectral imager provides visible and infrared imagery at high horizontal global resolution and complements the sounders. EPS products processed centrally are level 1 products from all instruments and level 2 sounding products from ATOVS and IASI (from the EPS Core Ground Segment (CGS)). The distributed Satellite Application Facilities, which provide a large number of level 2 and higher level products (see Figure 2 for EPS services.) are centres of excellence hosted by EUMETSAT member states. All products are operational. Addionally so called Day-2 products have been made operational in the Central facility, namely soil moisture from ASCAT (since December 2008), Vegetation Index (NDVI) from AVHRR (since summer 2009) and Polar Cap Winds from AVHRR (being implemented into operations currently); see also Klaes (2009).

Instruments, successfully flown as research missions on ESA ERS satellites, are now flown in longer term operational service. The Global Ozone Monitoring Experiment (GOME-2) for ozone profiling and trace gas retrieval provides products to support global change monitoring, climate monitoring and atmospheric chemistry. An Advanced Scatterometer (ASCAT) provides improved retrieval capabilities to derive wind vectors at the ocean surface, and continues the successful SCAT instrument on ESA's ERS-1 and ERS-2 satellites. ASCAT also provides soil moisture over land, to support NWP.

GRAS (GNSS Radio-Occultation Atmospheric Sounder) provides further sounding capabilities, and makes use of the information on the atmosphere and ionosphere contained in the GPS navigation satellite signals through the radio-occultation technique. It is the first operational radio-occultation mission for meteorology and climate monitoring. A GRAS Ground Support Network (GSN) supports the clock error corrections required for the GPS and Metop clocks as well as a precise orbit determination.

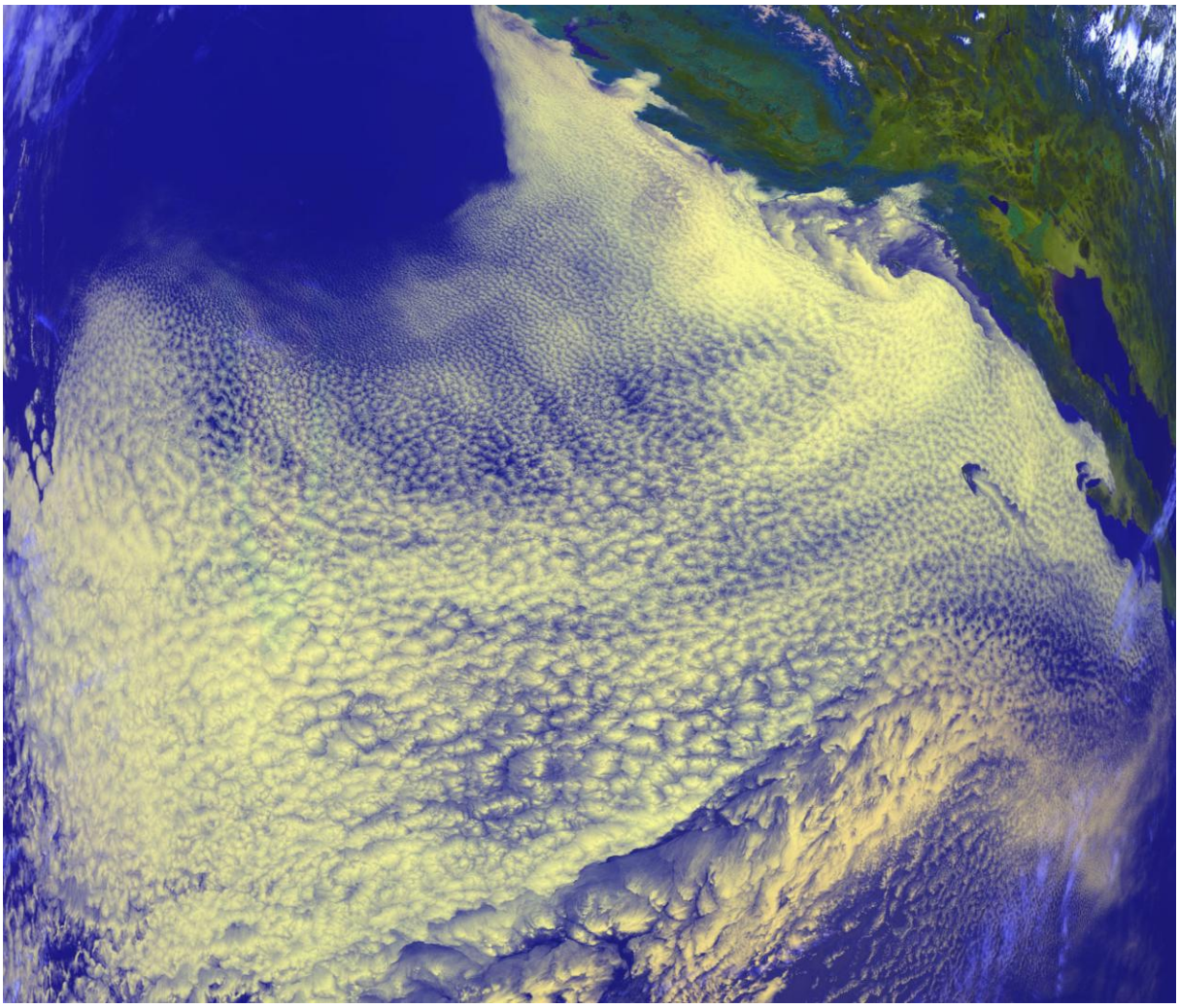

Figure 3: Full Resolution AVHRR on Metop-A (RGB324i) 25052009 1755 UTC.

Metop-A was successfully launched in October 2006 and declared operational (Spoto et al., 2006) in March 2007. All products are now operational (see Figure 3 for an example), have already in 2007 demonstrated their positive impact on applications, namely Numerical Weather Prediction, and continue to do so. Preparations for Metop-B are well under way.

After successful investigation of the root cause of an anomaly with the HRPT service, which caused its switch off in July 2007, a re-switch on with periodical operations over areas, where the risk of heavy ion impact has low probability, was done.

Improvements of the product timeliness are planned through an Antarctic Data Acquisition (ADA) service being investigated in co-operation with NOAA.

Geostationary Satellites

Meteosat Transition Programme

The first generation Meteosat and the equivalent Meteosat Transition Programme Satellites (Meteosat-7) have as payload a three-channel imager with broad-band channels in the visible, infrared, and water-vapour regions of the spectrum. The spacecraft is spin stabilised with 100 rotations per minute. The imager yields a full disk image every 30 minutes. The sampling distance at the sub satellite point is 2.5 km for the visible, 5 km for the infrared and water vapour channels. There are 5000 x 5000 pixels of visible and 2500 x 2500 pixels of infrared and water vapour channel data per full disk image. The products include satellite-tracked winds, cloud products, upper level tropospheric humidity, and others. Meteosat-7 was transferred towards a position at 57.5 ° over the Indian Ocean to provide the IODC, after Meteosat-9 became operational.

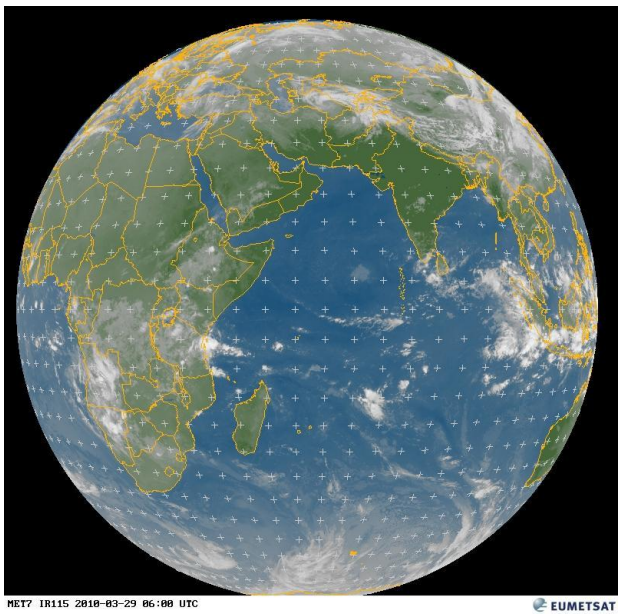

Figure 4. IODC service with Meteosat-7, 29 March 2010 0600UTC..

Meteosat Second Generation

The Meteosat Second Generation spacecraft is also a spin-stabilised satellite. Its payload comprises the Spinning Enhanced Visible and Infrared Imager - SEVIRI) with 12 different spectral channels (see Figure 5) in the visible and infrared region of the spectrum (see example image in Figure 6) and the GERB (Geostationary Earth Radiation Budget) instrument intended to provide measurements of the Earth Radiation Budget from geostationary orbit. As new products stability parameters are derived from pseudo-sounding (e.g. lifted index). Humidity fields are derived in the upper and mid-troposphere and total ozone fields are estimated. The sampling of the image data at the sub-satellite point is 3 km with exception of the High Resolution Visible channel (HRV), where the resolution is planned to be 1 km. The full disk image is composed of 3750 x 3750 pixels (except for HRV). One full disk image is provided every 15 minutes, but alternative repeat cycles up to 3 minutes are also possible. In HRV mode the scan area can be selected among predetermined rectangular blocks. Products are generated in the ground segment facilities at EUMETSAT's HQ and in the distributed part of the EUMETSAT application ground segment, the Satellite Application Facilities (SAF's). Meteosat-9 is providing the operational service over 0° W, whereas Meteosat-8 provides rapid scan service for Europe over 9.5 °E.

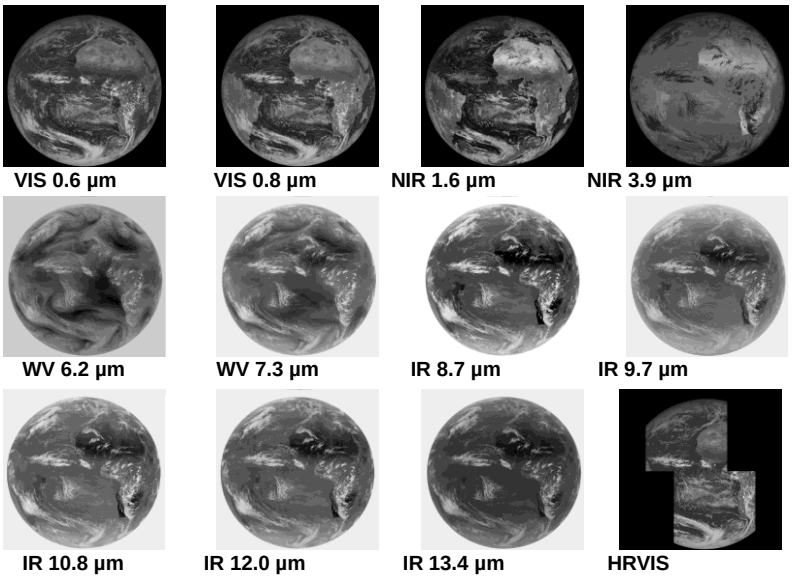

Figure 5: MSG capabilities: Example images from 12 SEVIRI Channels.

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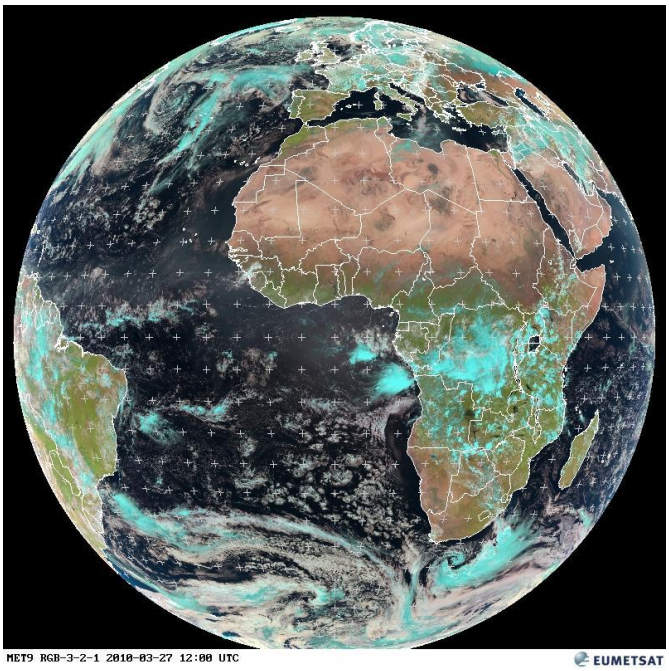

Figure 6: Meteosat-9 TGB 27 March 2010 1200 UTC.

EUMETSAT ADVANCED RETRANSMISSION SERVICE

EUMETSAT provides a fast delivery service of Advanced TOVS data, based on HRPT stations for the North Atlantic and European Area. The service was installed based on an initiative of the members of the HIRLAM Group (Denmark, Finland, Ireland, The Netherlands, Norway, Spain, Sweden and Iceland) in November 2000. The service provides ATOVS level 1a and level 1c data with a timeliness of 30 minutes to cover the needs of EUMETSAT Member States regional and local numerical weather prediction requirements for sounder data. Today the data of ten HRPT stations are distributed. The operational phase will be continued and extended for use with NOAA-N and Metop. ASCAT level 1b dissemination and AVHRR will be part of the service. It is planned to add IASI as well in 2010. More details can be found on EUMETSAT's web site (see http://www.eumetsat.int, on the EARS (EUMETSAT Advanced Retransmission Service) home page.)

Outlook

EUMETSAT and ESA have in 2001 jointly started the process to define the follow on service for the geostationary satellite service, the Meteosat Third Generation (MTG), aimed at having the first satellite in orbit around 2016. Several user and expert workshops have been conducted, and baseline concepts are being explored. Missions foreseen with a two satellite system are a) Multispectral imaging (FCI (Flexible combined Imager), providing SEVIRI continuity, but enhanced capability), b) IRS (Infrared Sounder) Infrared hyper spectral resolution sounding, c) Lightning imager (LI),

d)UV/VIS/NIR sounding. IRS and UV/VIS will be hosted on a sounding satellite (MTG-S), the imagers FCI and LI on MTG-I, the imaging satellite. Both are planned to be three-axis stabilized platforms. Phase B has started and an MTG programme proposal is being presented to EUMETSAT delegations for approval. The detailed design and production of the Satellites and of the Ground Segment is planned to start after the approval by EUMETSAT Council of the programme proposal for the Development and Operations Phase in 2010.

The requirements analyses, and the Phase 0 activities for the Post-EPS era have also been completed and Phase A activities are under preparation. They aim for a need date in 2018 (core-mission) / 2020 (full mission) for an EPS follow-on service.

The Ocean surface topography mission (Jason-2) will be continued with a follow on Jason-3 for which an optional programme was agreed. Launch of Jason-3 is planned for 2013.

EUMETSAT is working with ESA to implement the operations of the marine part of the Sentinel-3 satellite of the Global Monitoring for Environment and Security (GMES) initiative of the EU and ESA. A third party programme has been agreed and is under development. The launch of the first Sentinel-3 is planned in 2013.

Conclusions

EUMETSAT's contribution to the global system of satellite observation within the WMO Space Programme comprises considerably improved sounding capabilities which provide a major contribution towards the improvement of operational meteorological services, in particular numerical weather prediction. Impact studies for various instruments on Metop have shown that the forecast skill does improve. The MSG satellites are currently the most advanced geostationary meteorological satellites. An important contribution to climate monitoring arises from EPS and the coming programmes and satellites. Further contributions from EUMETSAT include optional programmes like the Jason-2 data processing and distribution. The continuity of EUMETSAT mandatory programmes and of the other services is reflected by new core, optional and third party programmes.

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