Abstract

The EUMETSAT Polar System (EPS) is the European part of the joint European/US operational polar satellite system (Initial Joint Polar System (IJPS)). It serves the mid-morning (AM) orbit, whereas the US part continues to serve the afternoon (PM) orbit. The Metop (MEteorological OPerational Satellite) satellites of this new polar system are jointly developed with ESA. They deliver high-resolution sounding and also high-resolution imagery in global coverage. Three Metop spacecraft are foreseen for a sun synchronous orbit in the 9:30 AM equator crossing (descending node). They provide polar data for at least 14 years from 2006 onwards, when the first Metop satellite was launched.

This paper will give an overview on the EPS mission, the products and services provided to users, and will show first results obtained from Metop-A during and after the commissioning phase.

INTRODUCTION

With the launch of Metop-A on the 19 October 2006 as first satellite of the EUMETSAT Polar System (EPS) (see also Klaes et al., 2007) the full space component of the joint US/European operational polar satellite system – the Initial Joint Polar System IJPS – was in orbit. The Metop satellites will serve the morning (AM) orbit, whereas the US NOAA satellites continue to serve the afternoon (PM) orbits.

Three Metop satellites are foreseen with a lifetime of 5 years each in order to provide at least 14 years of operational service for meteorology and climate monitoring.

PROGRAMME, PRODUCTS AND SERVICES

The EUMETSAT Polar System is composed of a space and a ground segment. The space component is composed of the Metop satellites (see Fig. 1). The ground component is has a central part and decentralised facilities, in particular the Satellite Application Facilities (SAF), which perform higher level product generation for specific meteorological application areas.

METOP PAYLOAD

Some instruments of the Metop payload are the heritage of successful pre-operational missions, namely the GOME-2 (Global Ozone Monitoring Experiment), and the ASCAT (Advanced Scatterometer). The GRAS (GNSS Receiver for Atmospheric Sounding), instrument follows on from experimental research missions and implements the radio occultation method for the first time in operational meteorology.
Other instruments are proven instruments from the US polar orbiting satellite programme, and include the AVHRR (Advanced Very High Resolution Radiometer), and the Advanced TIROS Operational Vertical Sounder (ATOVS) package. ATOVS is composed of the HIRS-4 (High Resolution Infrared Radiation Sounder), the AMSU-A (Advanced Microwave Sounding Unit - A) and the MHS (Microwave Humidity Sounder). MHS is a EUMETSAT development, and replaces the earlier AMSU-B instrument, whereas the other instruments are provided by NOAA. These instruments assure the continuity to the ATOVS suite flown on the NOAA-KLM satellites and a common instrumentation with the afternoon satellite of IJPS.

![Figure 1: Metop satellite (artist view, source ESA).](image)

The most innovative and technically advanced instrument is the IASI (Infrared Atmospheric Sounding Interferometer), which is developed by CNES and provides unprecedented high vertical temperature and humidity resolution sounding.

**GROUND SEGMENT**

The EPS Ground Segment (Figure 2) has the following components:

- Command and Data Acquisition stations at Svalbard and a backup control center in Madrid;
- A central component at EUMETSAT headquarters in Darmstadt, Germany, where mission control and planning are done, as well as global data pre-processing and selected product processing;
- Eight Satellite Application Facilities (SAF) hosted at the National Meteorological Services from the EUMETSAT Member States, which form centers of expertise along themes of meteorological applications;
The Unified Meteorological Archive and Retrieval Facility (UMARF) obtains all meteorological products from EPS and the other EUMETSAT Programmes. (UMARF is not a formal part of the EPS Programme).

The EPS system generates products at three processing levels:

- **Level 0** — the raw instrument data from the spacecraft. Data are transmitted in binary form and categorized by instrument.

- **Level 1** — the calibrated and navigated physical quantities for each instrument, such as radiances, brightness temperatures, reflectances, and bending angles. Product examples include reflectances and brightness temperatures from AVHRR, IASI, and ATOVS radiance data with cloud information, ASCAT backscatter data, and GOME radiances.

- **Level 2** — Geophysical quantities. Examples include IASI and ATOVS vertical profiles of temperature and humidity, ozone and trace gas amounts from the central facility, ocean surface wind vectors, and total precipitable water and others from the decentralised Satellite Application Facilities.

**PRODUCTS AND SERVICES**

Instrument measurements are transmitted to users in different ways. Global measurements are stored on board during one orbit on a solid state recorder and are sent to a Ground station on Svalbard (Spitzbergen). This happens about 14 times a day. The data are further sent to the central facility in Darmstadt, Germany and are processed to level 1b(c). The resulting level 1b(c) products are disseminated to Users and the decentralised ground segment components via EUMETSAT’s EUMETCast broadcast service. The users obtain the data nominally 2h15 min after sensing. The decentralised components of the ground segment, eight satellite Application Facilities (SAF) which are hosted by national weather services from EUMETSAT member states, are oriented according to meteorological themes. They process the level 1 products to level 2 and higher products. These are disseminated to the users via EUMETCast or via GTS, the global telecommunications system coordinated by the World Meteorological Organisation (WMO). All data and products are archived in the EUMETSAT Unified Meteorological Archive and Retrieval Facility (UMARF), where they can be retrieved by Users. The data are also sent to the partner NOAA in the US, and EUMETSAT obtains and processes data from the afternoon satellite from NOAA. (Figure 2 provides a summary of EPS/Metop services.)

*Figure 2: EPS Ground Segment and Services.*
Users are also able to receive the data directly. Metop sends the data to the ground continuously in the L-Band and those users who have corresponding receiving stations (AHRPT) can receive these data as long as the satellite is in view of the tracking antenna. The user must however do the data processing himself.

**FIRST RESULTS**

After the launch on the 19 October 2006, the payload switch on was performed as part of the Satellite in orbit verification phase (SIOV). The product calibration and validation was started in parallel as the SIOV activities allowed. This made it possible to start trial dissemination of the first AMSU-A products to the users less than two weeks after the launch on the 31 October 2007. This could be successfully repeated for most of the remaining instruments. EUMETSAT is now disseminating all level 1 products and level 2 products and will start to disseminate the remaining ATOVS level 2 product soon. Note that many of the processing chains have been declared operational already.

<table>
<thead>
<tr>
<th>Product</th>
<th>Current Status</th>
<th>Future Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVHRR/3 Level 1</td>
<td>Operational</td>
<td></td>
</tr>
<tr>
<td>AMSU-A Level 1</td>
<td>Operational</td>
<td></td>
</tr>
<tr>
<td>MHS Level 1</td>
<td>Operational</td>
<td></td>
</tr>
<tr>
<td>HIRS/4 Level 1</td>
<td>Operational</td>
<td></td>
</tr>
<tr>
<td>IASI Level 1</td>
<td>Operational</td>
<td></td>
</tr>
<tr>
<td>ASCAT Level 1</td>
<td>Demonstration</td>
<td>Pre-Operational 10/07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Operational End 2007</td>
</tr>
<tr>
<td>GOME Level 1</td>
<td>Pre-operational</td>
<td>Operational 10/07</td>
</tr>
<tr>
<td>GRAS Level 1</td>
<td>Demonstration</td>
<td>Operational 11/07</td>
</tr>
<tr>
<td>ATOVS Level 2</td>
<td></td>
<td>Demonstration 26/09/07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pre-operational 30/10/07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Operational 19/11/07</td>
</tr>
<tr>
<td>IASI Level 2</td>
<td>Demonstration</td>
<td>Pre-operational 26/09/07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Operational 12/10/07</td>
</tr>
</tbody>
</table>

*Table 1: Central products dissemination status.*

All instruments and products performed nominally from the beginning. EUMETSAT disseminates IASI level 1c and IASI level 2 products. IASI was switched on the 27 November 2007, with the on-board processing switched off. So interferograms were received on the ground. In the EPS Calibration and Validation Facility the first interferogram was decoded (see Figure 3) and later processed to the first IASI spectra in the IASI Technical Expertise Centre by CNES.
Subsequently the IASI on-board processing was switched on and the on-board processing processed the first pre-calibrated spectra which was transmitted to the EPS CGS and processed by the IASI Level 1 PPF. Figure 4 shows a typical IASI Level 1c spectrum, as it is now processed in routine operations. IASI processing was declared operational the 18 July 2007, and IASI level products are also disseminated via the WMO Global Telecommunication System (GTS). Level 2 products followed in trial dissemination on the 25 September 2007.

IASI and ATOVS instrument data have already shown a positive impact from the assimilation into Numerical Weather Prediction at ECMWF and the Met Office UK.

The other instrument products are as well performing nominally and serve as input to subsequent level 2 processing. Examples shown are scatterometer winds (Figure 5) processed at KNMI, which are disseminated in trial dissemination.
Figure 5: Scatterometer winds processed at KNMI.

and also total Ozone and NO2, processed in the Ozone Monitoring SAF from GOME-2 data. Figure 6 shows the NO2 product.

Figure 6: Global NO2 Columnar amount from GOME-2 on Metop, 11 Jan 2007, processed in the O3M SAF.
More detailed information can be found on the EUMETSAT web page (www.eumetsat.int).

CONCLUSION

Metop-A has been launched the 19 October 2006 and all instruments are working nominally. It assures the continuity to the current system and through the long duration of the programme and the long term archiving of the data and products a long term usage by meteorology and climate monitoring and research can be envisaged. Metop satellites also include an innovative element which provides highly improved data for weather forecasting and climate monitoring. Notably the IASI instrument is expected to be a reference standard for future operational IR sounding missions and also for climate monitoring applications.

EPS/Metop supports both operational meteorology and climate monitoring, and will provide a contribution to global earth system monitoring.

REFERENCES

1. D. Klaes et al., An Introduction to EPS/Metop, accepted by Bull. Amer. Met. Soc., 2007