Atmospheric Composition Measurements from the EUMETSAT Polar System (EPS) and plans for Post-EPS

EUMETSAT

R. Munro, P. Schlüssel, D. Klaes, P. Phillips & C. Accadia
Summary

1. MetOp
2. GOME-2 on MetOp
3. IASI on MetOp
4. Plans for post-EPS
### MetOp payload

**ESA / EUMETSAT / CNES**
- **GOME-2** UV/VIS scanning spectrometer  
  - O3 & trace gases...
- **ASCAT** C-band radar scatterometer  
  - wind over oceans
- **GRAS** GPS satellite receiver (occultation)  
  - T & H2O profiles
- **MHS** Microwave radiometer 89/190 GHz  
  - H2O profiles
- **IASI** FTIR spectrometer (nadir)  
  - T, H2O, O3, CO2...
- **DCS/Argos** Data collection from remote stations
- **S&R** Data collection from emergency transmitters

**NOAA / NASA**
- **AVHRR** high-spatial resolution VIS/IR imager  
  - clouds, sea ice,…
- **HIRS** VIS/IR filter-wheel radiometer  
  - T/p profiles, O3
- **AMSU-A** Microwave radiometer for 50 GHz O2 line  
  - T/p profiles
- **SEM** Particle radiation monitor
MetOp: Satellite and Met-Instruments

- AVHRR-3
- IASI
- HIRS-4
- Metop A,B only
- AMSU-A1
- AMSU-A2
- MHS
- GOME-2
- GRAS
- ASCAT
Metop - fully integrated
GOME-2 on MetOp

⇒ European Operational Global Ozone Monitoring on-board MetOp 1-3 satellites in 2006 to 2020

⇒ GOME-1 launched on-board ERS-2 in April 1995, still operational, provides
  - trace gas total columns (ozone, NO2, SO2, BrO, OCIO, HCHO,...)
  - ozone profiles; aerosol, cloud, polarisation information

⇒ Improvements for GOME-2
  - polarisation measurement of s- and p-polarised light in 15 bands
  - white light source
  - improved calibration approach
  - numerous small improvements
  - furthermore, adaptations to different satellite environment were needed.
GOME-2 Measurement Principle

Mission orbit:
- near-polar sun synchronous
- 5 days repeat cycle
- descending node: 09:30
- mean altitude 825 km
- Inclination 98.7°
GOME-2 Scan Pattern

- Forward scan 1920 km
- Duration 4.5 s
- Integration time 187 ms
- 24 ground pixels
- Size 40 * 80 km²
- PMU pixel size
- 192 ground pixels
- Size 40 * 10 km²
GOME-2 In-flight calibration

⇒ daily sun calibration
⇒ daily spectral calibration
⇒ daily dark signal characterisation
⇒ daily white light source characterisation
⇒ monthly calibration
  - spectral calibration
  - diffuser monitoring
  - engineering parameters
⇒ moon calibration
GOME-2 Spectral Bands

Example of a sun spectrum

Example of an earthshine spectrum

PMD bands

Earth radiance [photons/s.cm².nm.sr]

Solar irradiance [photons/s.cm².nm]

Wavelength [nm]

200 300 400 500 600 700 800

10^8 10^9 10^10 10^11 10^12 10^13 10^14 10^15

Earth radiance [photons/s.cm².nm.sr]

0 10 20 30 40 50 60 70 80

200 300 400 500 600 700 800

10^8 10^9 10^10 10^11 10^12 10^13 10^14 10^15

Solar irradiance [photons/s.cm².nm]

aerosols

BrO

OClO

NO

H₂O

O₃

O₂
Global Tropospheric O3 from GOME-1 - R. Siddans, RAL, private comm

16-18 July 1998

Map showing O3 levels during the specified period.
GOME-2 Data Processing

(slots courtesy of SRON)

- Data acquisition
- Raw data
- NRT level 0-1 processing
- Level 1b data
- NRT level 1-2 processing
- NRT products
  (ozone, UV, aerosols...)
- Offline processing
- Other products
- Ozone Monitoring SAF
- Ozone Monitoring SAF
  & Scientific data user

- MetOp
- EPS CGS
- EUMETSAT

- 0
- 135 min
- 180 min
- time
# IASI Mission and Measurement Principles

<table>
<thead>
<tr>
<th>Mission</th>
<th>Primary mission objective → temperature and humidity profiles with improved accuracy and vertical resolution (1K and 10% @ 1 km vertical resolution, respectively)</th>
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<tbody>
<tr>
<td></td>
<td>Further mission objectives are related to the measurement of trace gases (ozone, methane, carbon monoxide, ...) as well as surface and cloud properties</td>
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<tr>
<td>Technique</td>
<td>IASI is based on a Michelson interferometer. Spectral range 3.6 to 15.5 μm (645 to 2760 cm⁻¹) Spectral sampling: 0.25 cm⁻¹ giving 8461 spectral samples Spectral resolution after apodisation: 0.5 cm⁻¹</td>
</tr>
<tr>
<td></td>
<td>IASI is nadir-viewing and across track scanning. 30 fields-of-view along the scan line are sampled in 2×2 matrices of circular fields of view with a diameter of 12 km</td>
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</table>
IASI Field of View
Comparison of IASI and HIRS Spectra

HIRS 19 channels versus IASI 8461 spectral samples
IASI Data Transmission and Processing

⇒ Satellite to ground transmission:
  - On-board storage and direct broadcast to local users
  - Down-link of global data to Svalbard receiving station after each completed orbit
  - Transmission of data to EUMETSAT Headquarters at Darmstadt

⇒ Data processing at EPS Core Ground Segment:
  - Generation of Level 1 products (decommutation, calibration, apodisation, geo-location, and mapping of imagery)
  - Generation of Level 2 products (geophysical parameters)

⇒ Distribution to users:
  - Near-real time transmission of products to users (Level 1: 2.15 h, Level 2: 3 h) via satellite broadcast (EUMETCast)
  - Distribution of sub-sampled data via GTS to WMO users
  - Storage in Unified Archival and Retrieval Facility (UMARF) for later access by users
The state vector to be retrieved consists of the following parameters:
- Temperature profile at a minimum of 40 levels
- Water vapour profile at a minimum of 20 levels
- Ozone columns in deep layers (0-6 km, 0-12 km, 0-16 km, total column)
- Land or sea surface temperature
- Surface emissivity at 12 spectral positions
- Columnar amounts of N2O, CO, CH4, CO2
- Cloud amount (up to three cloud formations)
- Cloud top temperature (up to three cloud formations)
- Cloud phase

In case of clouds and elevated surface the state vector has to be modified.

Additionally off-line scientific products are anticipated.
Ozone Profile Retrieval from Nadir-uv & -ir Combination

Provided courtesy of RAL

Prior error = ECMWF forecast error covariance
Post-EPS Overall Planning - the follow on to MetOp beyond 2020
Post-EPS Phase Planning

Mission Requirements

Architecture Concepts

User Consultation

2004

Initial Scope of Tentative Missions

Introduction of Tentative Missions at MTG 2nd UC Workshop

Atmospheric Sounding & Wind Profiling AEG

Ocean Topography & Imaging AEG

Cloud, Precipitation & Land Surface Imaging AEG

Atmospheric Chemistry AEG

Introduction to SAF Network

Analysis and Input/Feedback by SAF Network

Analysis by Climate Experts

Consolidation of Application Requirements

UC Consolidation Workshop

Observation Mission Req.

Support Mission Req.

Assess METOP Commissioning Results

Programmatic Requirements

RSE Support to AEGs

Obs. Techniques Consolidation

Sensor Concepts & System Architecture

Sensor Concepts & System Architecture MTR

Pre-Developments TRL-2

2005

2006

2007

2004

2005

2006

2007

Post-EPS Phase Planning

Mission Requirements

Architecture Concepts

User Consultation
Application Experts Groups

⇒ Support of EUMETSAT user consultation towards Post-EPS

⇒ Analysing the needs of EUMETSAT users in the 2020+ timeframe
   - Starting with MTG Position Papers
     • Global numerical weather prediction
     • Regional numerical weather prediction
     • Now-casting
   - Analysing the evolution of those applications
   - Taking account of further applications:
     • Operational oceanography
     • Atmospheric chemistry and carbon cycle (protocol monitoring and air quality)
     • Land surface analysis at large scale
     • Climate monitoring

⇒ Formulation of EUMETSAT user needs: Position Papers
Atmospheric Chemistry Mission: Approach to Generating Requirements

⇒ Generated by a dedicated Application Expert Group (AEG)

⇒ Heritage
  - Integrated Global Atmospheric Chemistry Observations (IGACO) Report from the IGOS Atmospheric Chemistry Theme Partners
  - ESA commissioned CAPACITY study to define the Geophysical Data Requirements for an Operational Atmospheric Chemistry Monitoring Mission

⇒ Requirements specified for satellite observations only

⇒ Prioritisation per application remaining aware of observing feasibility
Atmospheric Chemistry Mission: User Data Requirements Tables

⇒ **Ozone & Surface UV**
- Priority 1 (protocol/forecast): O3 stratosphere/UT profile & column
- Priority 2 (assessment): stratospheric ClO, BrO, HNO3 & aerosol (heterogeneous chemistry)

⇒ **Composition - Climate**
- Priority 1: O3 & H2O profiles; trop CH4 (emissions)
- Priority 2: CO2 (emissions); trop CO & NO2 (chemistry);
  - stratospheric N2O/CH4 (circulation); AOD & cirrus

⇒ **Pollution & Air Quality**
- Priority 1 (regulation/AQ index) O3, NO2, CO, SO2, AOD
- Priority 2 (forecast): H2O, H2CO, aerosol type
Points on Mission Concept

⇒ Considering data reqs for the three applications and drawing on the extensive assessment of observing techniques for CAPACITY, two points noted re mission concept:

⇒ Nadir-viewing uv-swir and ir spectrometers complementary in (a) near-surface sensitivity and (b) detectable constituents
  - Requirements for near-surface observations of trace gases and aerosol addressed by this combination

⇒ Limb-viewing mm-wave and ir spectrometers complementary in (a) cirrus sensitivity and (b) detectable constituents
  - Requirements for vertical profiling addressed optimally by combination of limb- and nadir-sounding