STATUS OF THE EUMETSAT SATELLITE PROGRAMMES
TOWARDS THE NEXT GENERATION METEOROLOGICAL SATELLITES

Kenneth Holmlund
EUMETSAT

P. Schlüssel, R. Stuhlmann, L. Schüller, J. Schmetz, M. Cohen S. Rota, D. Klaes R. Munro, F. Montagner, C. Hanson, J. Grandell
And many other contributors from EUMETSAT and its partners
EUMETSAT’S MISSION

- The primary objective is to establish, maintain and exploit European operational meteorological satellite systems, taking into account as far as possible the recommendations of the WMO.

- A further objective is to contribute to operational climate monitoring and detection of global climatic changes.

- Through fulfilling these objectives, contribute to environmental monitoring, where interactions with the ocean and the atmosphere are involved.
Current EUMETSAT satellite fleet

**METOP -A and -B**
(LOW-EARTH, SUN – SYNCHRONOUS ORBIT)

EUMETSAT POLAR SYSTEM/INITIAL JOINT POLAR SYSTEM

**JASON-2**
(LOW-EARTH, 63° INCL. NON SYNCHRONOUS ORBIT)

OCEAN SURFACE TOPOGRAPHY MISSION

**METEOSAT SECOND GENERATION -8.-9.-10, MSG-4 (-11)**
(GEOSTATIONARY ORBIT)

TWO-SATELLITE SYSTEM:
- METEOSAT-11: IN-ORBIT BACKUP
- METEOSAT-10: FULL DISK IMAGERY MISSION AT 0° (15 MN)
- METEOSAT-9: RAPID SCAN SERVICE OVER EUROPE AT 9.5°E (5 MN)
- METEOSAT-8: BACK UP AT 3.5°E

**METEOSAT – 7 (1st GENERATION)**
(GEOSTATIONARY ORBIT)

INDIAN OCEAN DATA COVERAGE MISSION AT 57°5 E (UNTIL END 2016)
Current EUMETSAT satellite fleet – Extrapolated end 2016

METOP -A and -B
(LOW-EARTH, SUN-SYNCHRONOUS ORBIT)
EUMETSAT POLAR SYSTEM/INITIAL JOINT POLAR SYSTEM

Sentinel -3a
(LOW-EARTH, SUN-SYNCHRONOUS ORBIT)
Copernicus Global Marine and Land Environment Mission Operated by EUMETSAT

JASON-2, -3
(LOW-EARTH, 63° INCL. NON SYNCHRONOUS ORBIT)
OCEAN SURFACE TOPOGRAPHY MISSION

METEOSAT SECOND GENERATION -9, -10, -11
(GEOSTATIONARY ORBIT)
TWO-SATELLITE SYSTEM:
- METEOSAT-11: IN-ORBIT BACKUP
- METEOSAT-10: FULL DISK IMAGERY MISSION AT 0° (15 MN)
- METEOSAT-9: RAPID SCAN SERVICE OVER EUROPE AT 9.5°E (5 MN)

METEOSAT -8 (2nd GENERATION)
(GEOSTATIONARY ORBIT)
INDIAN OCEAN DATA COVERAGE MISSION AT 40° E (TBD June 2016)
Meteosat-7 is the last
Located over
- Indian Ocean
- until end of 2016
From MVI RI on MTP to SEVIRI RI on MSG...
Proposing development of Multi-Mission Calibration and Monitoring System (MuMiCS)

To integrate monitoring systems for onboard, vicarious and inter-calibration

For GEO and LEO sensors in different spectral bands

Concept Engineering Change Proposal (ECP) will be submitted early 2015
Upper Layer (ice) COT scaled 0-11
Lower Layer (water) COT scaled 0-42
2011 July 25 11:30-12:30  RGB 0.6, 0.8, 8-7-11

CTP: Ice blue, water green, COT represented by vertical bar 75/150 hPa COT-1

2-Layer Winds?
Meteosat Second Generation – Development Highlights

- Use of the OCA heights to set AMV altitudes (operational readiness only after MSG-4 launch)

Traditional AMV product (CLA heights)

AMV product (OCA heights)

Improved heights over Sahara jet

Identification of multi-layer situations
Volcanic Ash 2011 June to August
Scientific development for future / enhanced products (3)
Coccolithophore blooms from the geostationary orbit?
Met-8 super-rapid scans 2.5 min experiment

2.5 minutes
Repeat Cycle

5 minutes
Repeat Cycle

15 minutes
Repeat Cycle
Meteosat Third Generation

- Continuation and enhancement of service from geostationary orbit in 2020 – 2040

- Twin satellite in-orbit configuration:
  - MTG A: optical imagery and lightning mission
  - MTG B: sounding mission
    - Flies the Copernicus Sentinel-4 instrument

- Two sets of successive satellites (4+2) for 20 years of operations

=> More today at 11:45!
EUMETSAT Polar System Programme

- Metop-A launched in 2006
- Metop-B launched in 2012
- Metop-C launch scheduled for 10/2018
- Sun Synchronous orbit
- 820 km, 9h30 LST, 100 min
- Sole source of mid-morning orbit data
- 11 Instruments
- Soyuz Launcher Service (Baikonur/Kourou)
- ESOC LEOP Service (Darmstadt)
- Central & distributed Ground Segment components
- 14+ years of operations
The EUMETSAT polar system as part of the initial joint polar system shared with the US

- Coordinated programmes
- Exchange of instruments
- Coordinated operations, data and services
- Only Metop provides mid-morning service
- And now China has committed to the early morning orbit
Current Capabilities - EUMETSAT Polar System

- **AVHRR**
  Advanced Very High Resolution Radiometer

- **HIRS/4**
  High-resolution Infrared Radiation Sounder

- **IASI**
  Infrared Atmospheric Sounding Interferometer

- **AMSU-A1**
  Advanced Microwave Sounding Unit-A1

- **MHS**
  Microwave Humidity Sounder

- **GRAS**
  GPS Receiver for Atmospheric Sounding

- **GOME-2**
  Global Ozone Monitoring Experiment

- **AMSU-A2**
  Advanced Microwave Sounding Unit-A2

- **ASCAT**
  Advanced SCATterometer
Atmospheric Profiling
Hyperspectral Infrared L2 - IASI L2 v6 Temperature vs ECMWF ANA

Results: T. August, M. Crapeau, T. Hultberg, X. Calbet
Atmospheric Profiling
Hyperspectral Infrared L2 - IASI L2 v6 Temperature vs ECMWF ANA

Results: T. August, M. Crapeau, T. Hultberg, X. Calbet
Atmospheric Profiling
Hyperspectral Infrared L2 - IASI L2 v6 TCWV vs MSG

Results: M. Koenig (EUMETSAT)
Towards a IASI CO Profile product: a premiere

The IASI L2 processor v6 implements the FORLI-CO algorithm developed at ULB/LATMOS (O3M-SAF CDOP-2)
Atmospheric Composition
Trace Gas Products – IASI SO2 from ULB / LATMOS / O3M SAF

IASI/MetOp - Sulfur dioxide

14/04 10PM

15/04 10AM

15/04 10PM

16/04 10AM

IASI/MetOp - Ice

IASI/MetOp - Ash

SO2 total column
Credits ULB/LATMOS

© L. Clarisse/D. Hurtmans/P. Coheur/C. Clerbaux
GOME-2 SO$_2$ courtesy of University of Bremen (Andreas Richter & colleagues)
Scientific development for future / enhanced products
Wave optics for retrieval of GRAS profiles

- Wave optics gives more data in the lowest 5 km...
- ...without increasing stdevs...
- Negative biases of GO removed

Under investigation; can be improved

Uncertainty in NWP reference data
Aerosol: PMAp (GOME-2 + AVHRR)
Metop A & B combined

AOD (PMAp – METOP A & B)

Ocean = Operational retrieval
Land = test retrieval in development
Global dual Metop winds

Metop winds over South Pole (QI > 80)

One Metop

Dual Metop
Metop-B is in the same orbital plane as Metop-A

Morning Orbit

Equator crossing time: 09:30 LST
Orbit phasing: 48.93 min.
AVHRR winds

Single Metop polar, 17/09/2014, 1:31-1:52

Global AVHRR, 18/09/2014, 9:04-9:46
## But Metop-A is growing old: Options (LTAN evolution)

<table>
<thead>
<tr>
<th>Last OOP</th>
<th>2015</th>
<th>2016</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTAN Drift (mins)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed GT</td>
<td>GT Hops</td>
<td>Drifting GT</td>
<td>Fixed GT</td>
</tr>
<tr>
<td>2</td>
<td>Dec 2016</td>
<td>Dec 2016</td>
<td>May 2017</td>
</tr>
<tr>
<td>60</td>
<td>Feb 2020</td>
<td>Feb 2020</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td></td>
<td></td>
<td>Jan 2021</td>
</tr>
<tr>
<td>120</td>
<td></td>
<td></td>
<td>Sep 2021</td>
</tr>
<tr>
<td>180</td>
<td></td>
<td></td>
<td>Dec 2022</td>
</tr>
</tbody>
</table>
EPS Second Generation

- Continuation and enhancement of service from mid morning polar orbit in 2021 – 2040

- Twin satellite in-orbit configuration:
  - **Metop-SG A**: optical imagery and sounding mission
    - Flies the Copernicus Sentinel-5 instrument
  - **Metop-SG B**: microwave imaging mission

- Two series of 3 successive satellites for 21 years of operations

- European contribution to the Joint Polar System (JPS) shared with the US/NOAA

=> More today at 11:45!
MONITORING THE OCEAN IN SUPPORT OF COPERNICUS
Sentinel-3 Satellite and Payload
First launch S-3a 4 February 2016

- **SLSTR**: Sea and Land Surface Temperature Radiometer
- **SRAL**: Synthetic Aperture Radar Altimeter
- **OLCI**: Ocean and Land Colour Instrument
- **MWR**: Micro-Wave Radiometer
- **LRR**: Laser Retro-Reflector
- **DORIS**: Doppler Orbitography and Radiopositioning Integrated by Satellite
- **STM**: Surface Topography Mission = SRAL + MWR
Sentinel-3 Marine product contents

**Level 1B:** SLTSR (radiance, BT at TOA) and OLCI (radiance at TOA) and SRAL(waveforms) (ESA and EUMETSAT)

**Level 2 OLCI:**
- Normalised water surface reflectance
- Algal pigment concentration for open and for coastal waters
- Total suspended matter concentration
- Diffuse attenuation coefficient
- Coloured dissolved matter absorption
- Photosynthetically active radiation
- Integrated water vapour
- Aerosol optical depth
- Aerosol Angström exponent

**Level 2 SLTSR:**
- Sea surface temperature (L2P GHRSSSST standard)

**Level 2 SRAL:**
- Sea/coastal zone surface height
- Significant wave height
- Wind speed
- Backscatter coefficient $\sigma_0$
- Sea ice height, freeboard
- Total water, liquid water (from MWR)
Global mean sea level during the altimetry era has risen at a nearly constant rate since 1993 (+/- 3 mm/year).

Relatively consistent despite large regional interannual variations and accelerations in the melting of land ice.
Combining Sentinel-3 & Jason altimetry for operational oceanography and climate change monitoring

(Courtesy CNES/CLS/ESA)
Mean sea level trends: regional differences

- Why has the western Pacific risen 3 times faster?
- Why has sea level dropped near the U.S. West Coast?
- How will regional sea level change in the future?
THANK YOU – QUESTIONS?