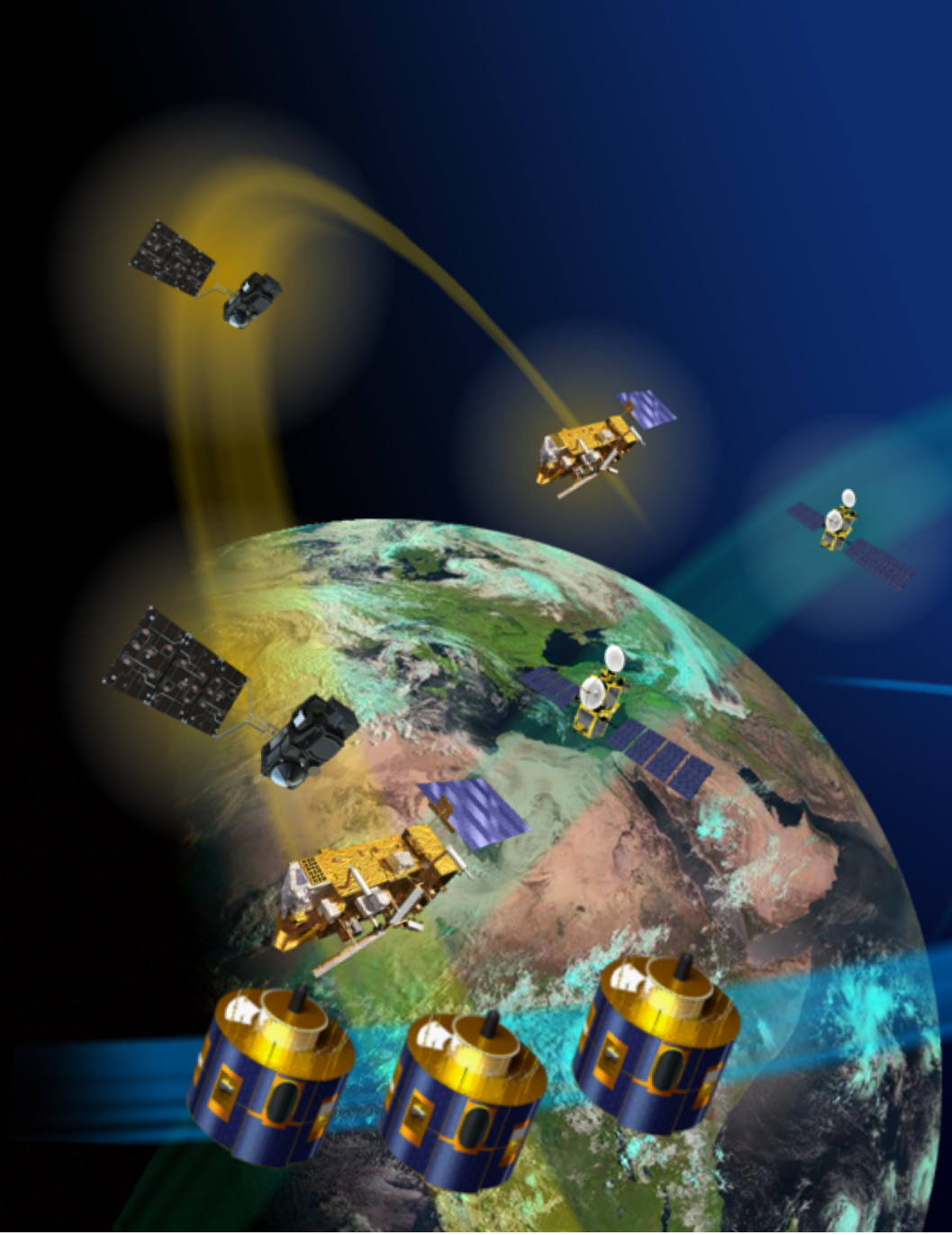


Overview of EUMETSAT

Dr. Bojan R. Bojkov

Head of Remote Sensing and Products Division

EUMETSAT

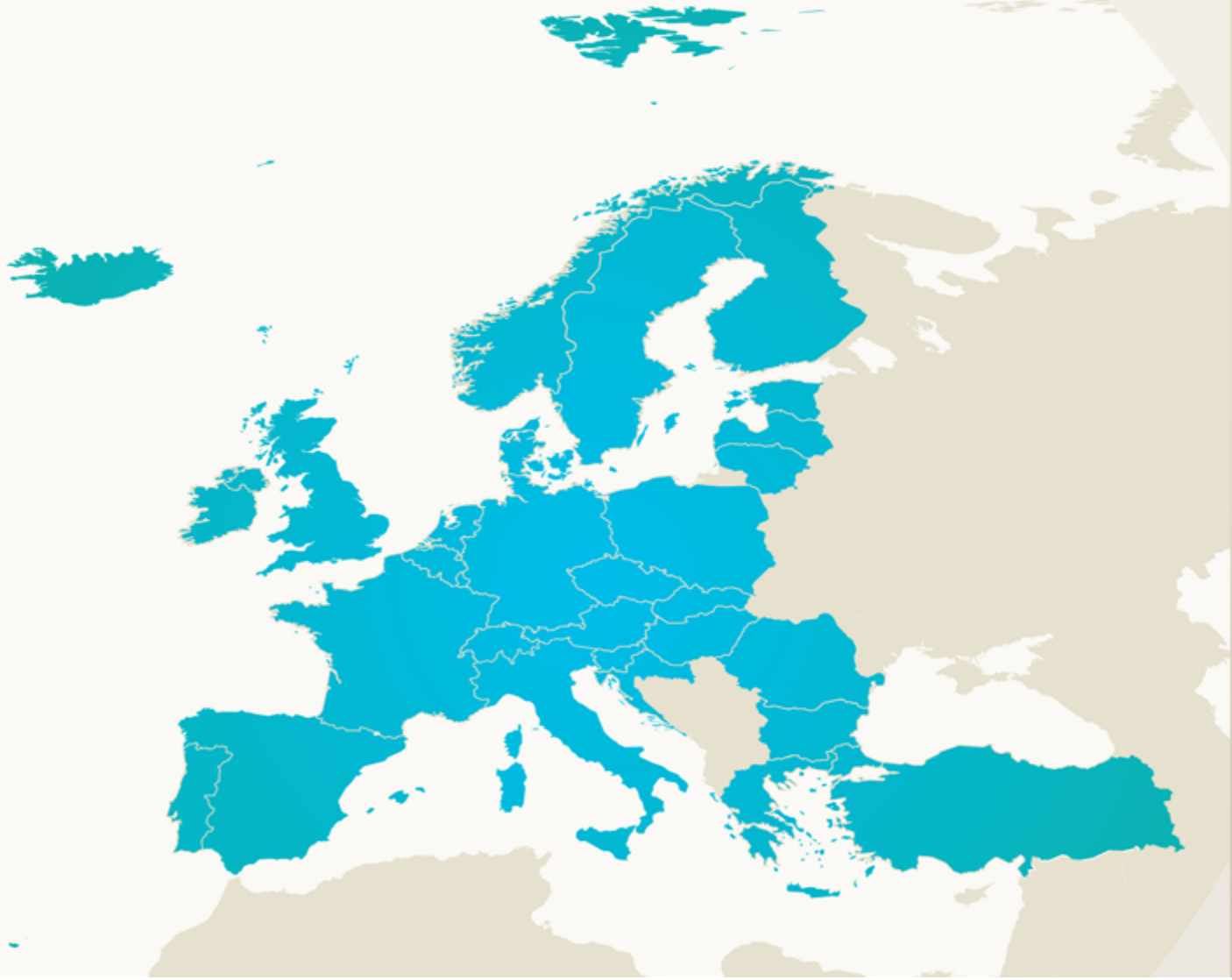
Outline

- Introduction
- EUMETSAT Programmes – *current, future, and optional*
- EUMETSAT and Copernicus
- Satellite Application Facilities (SAF) highlights
- Conclusion

EUMETSAT: Introduction

EUMETSAT – an intergovernmental organization with 30 Member States

AUSTRIA
BELGIUM
BULGARIA
CROATIA
CZECH REPUBLIC
DENMARK
ESTONIA
FINLAND
FRANCE
GERMANY
GREECE
HUNGARY
ICELAND
IRELAND
ITALY
LATVIA
LITHUANIA
LUXEMBOURG
THE NETHERLANDS
NORWAY
POLAND
PORTUGAL
ROMANIA
SLOVAK REPUBLIC
SLOVENIA
SPAIN
SWEDEN
SWITZERLAND
TURKEY
UNITED KINGDOM



EUMETSAT Mission and Vision

Primary objective:

Establish, maintain and exploit European systems of meteorological satellites.

Further objective:

Contribute to the operational monitoring of the climate and the detection of global climatic changes.

Vision:

Be the leading user-driven operational agency in Europe for Earth observation satellite programmes that fulfil the objectives of its Convention, and a trusted global partner for those outside Europe who share these objectives.

EUMETSAT Priorities

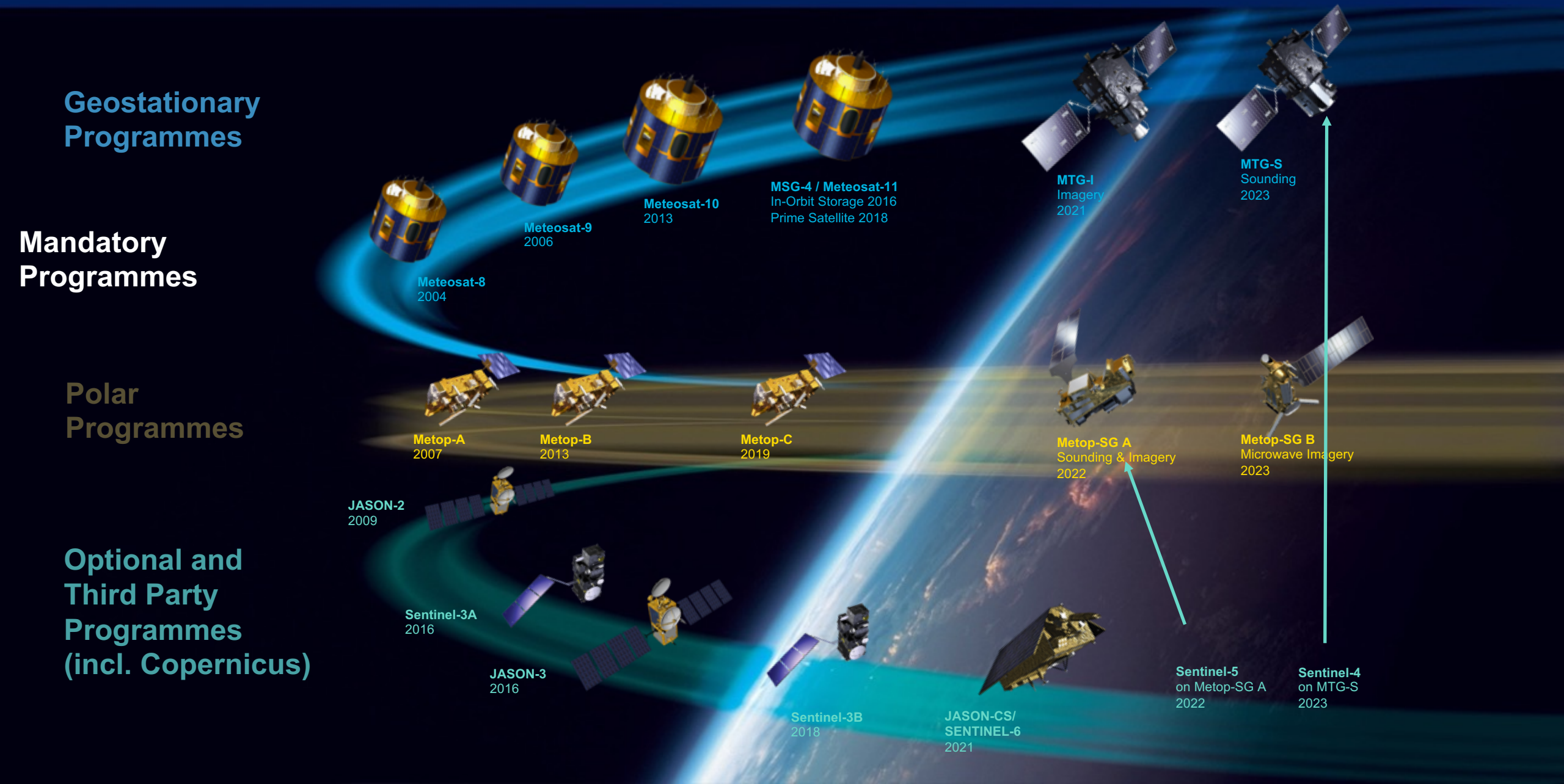
In realising its vision, the first priority shall be to fulfil in the most effective manner, through its own satellite programmes, the essential requirements of its Member States for observations and data services for operational weather and Earth system monitoring and forecasting, and for climate services.

The second priority shall be to establish additional capabilities in partnership with the European Union and other satellite operators to achieve synergy with its own satellite missions for the common benefit of its Member States and partners.

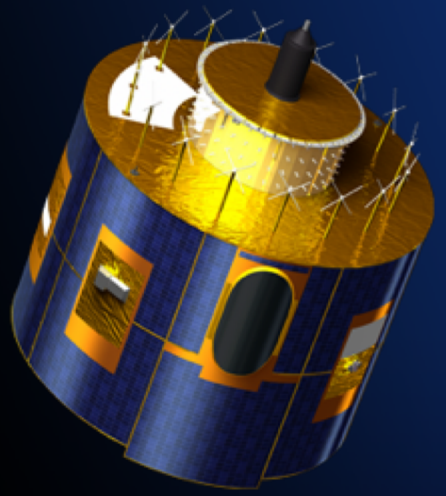
EUMETSAT Programmes

The satellite systems

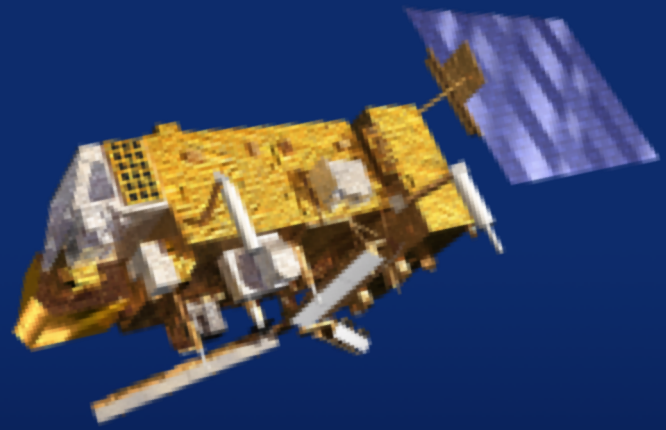
EUMETSAT Missions – current and future



The need for two types of meteorological satellites



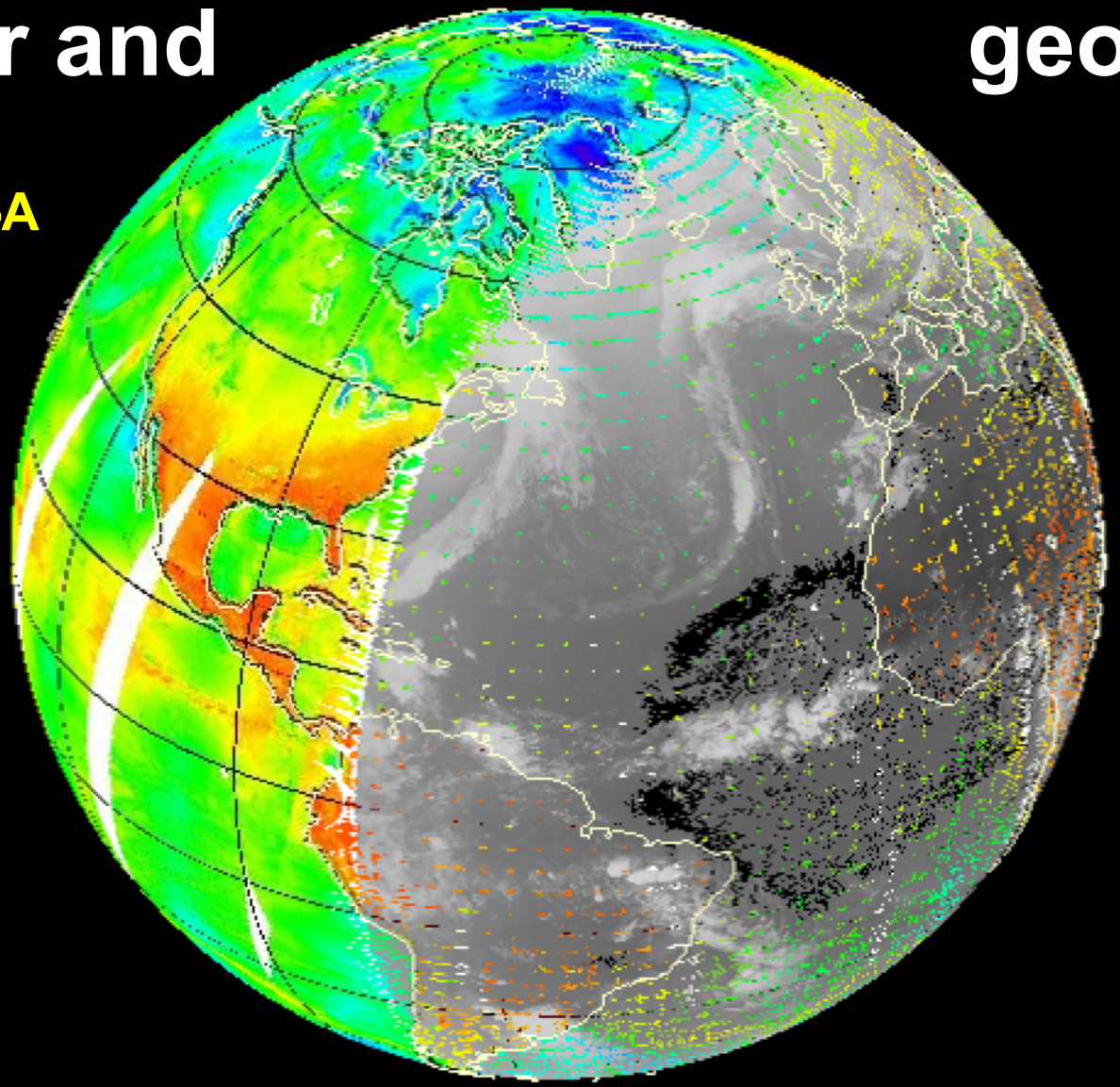
Geostationary orbit
Vital for forecasts up to a few hours



Polar orbit
Critical for forecasts up to 10 days

Global view from Polar and geostationary Orbits

MHS on Metop-A
(89 GHz)



Meteosat 8
(IR)

Roesli, 2006

data composit of Meteosat-8 and Metop-A
SEVIRI 10.8um - MHS 89GHz

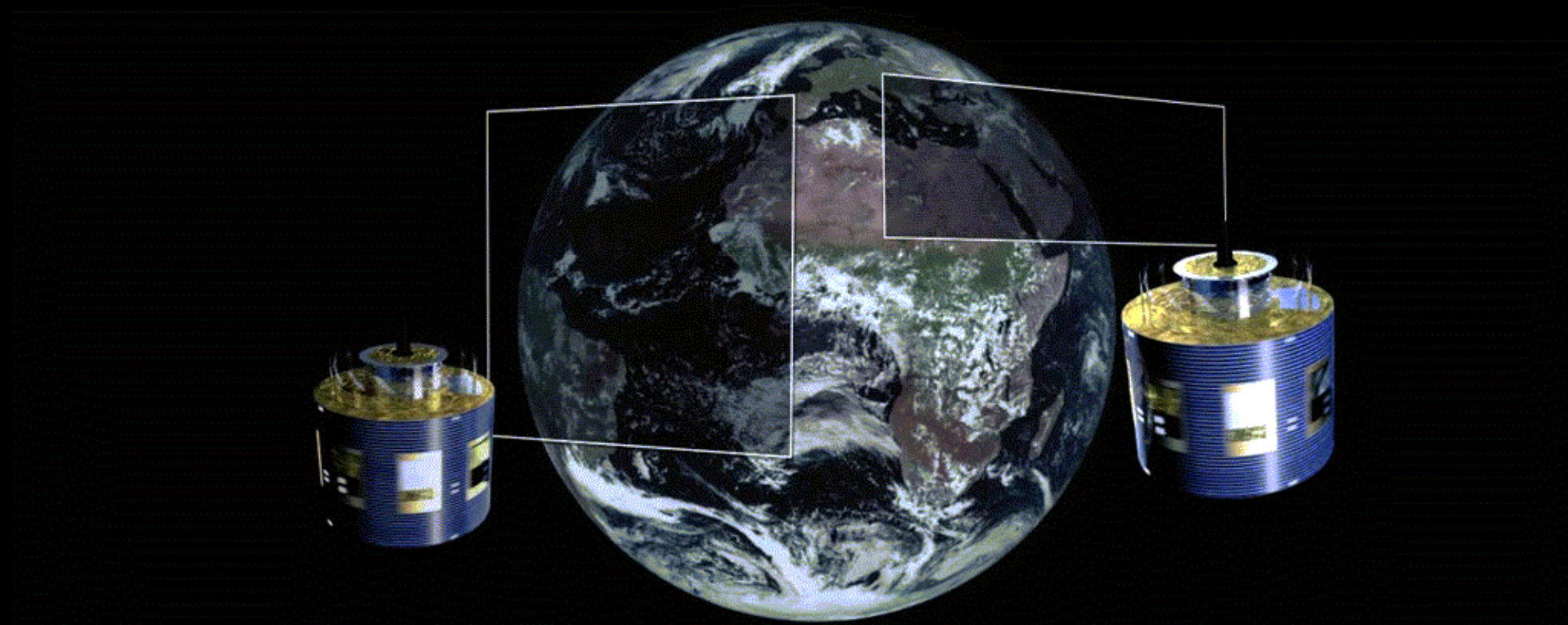
Space-based Global Observing System 2015 → 2022

- Operational GEO and LEO satellite systems supporting meteorology (following WMO data sharing)
- Meteorological satellites from EUMETSAT, CNES and EC (Europe), NOAA (USA), CMA (China), Roshydromet (Russia), JMA (Japan), IMD (India), KMA (S. Korea), Meteorological Society (Taiwan)
- Contributions from science missions such as from the A-Train (NASA/CNES)

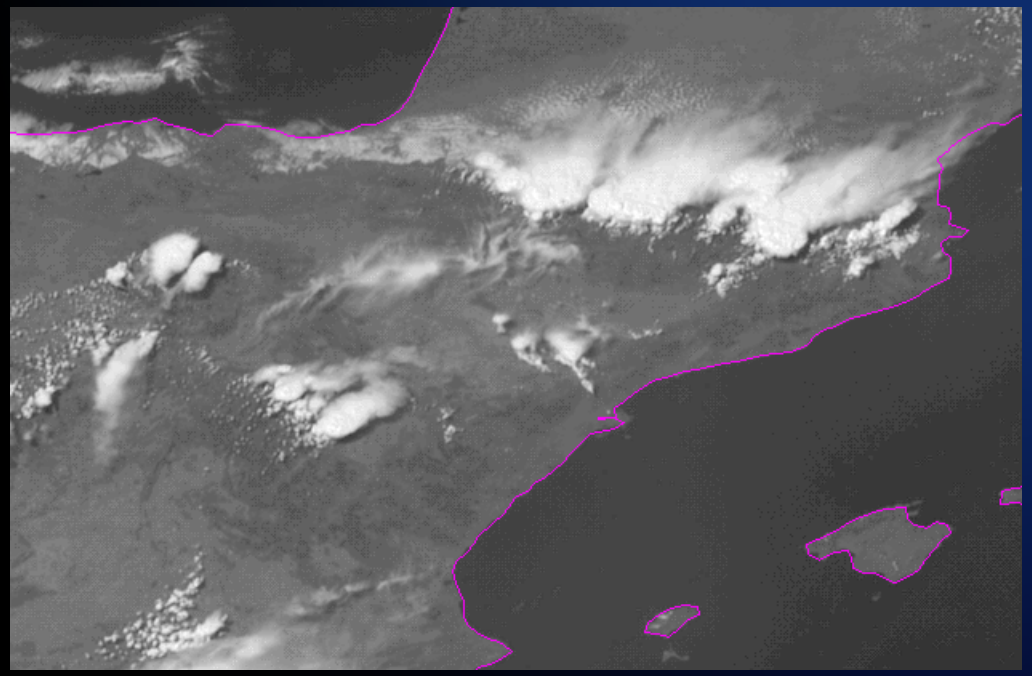
EUMETSAT satellite systems

Current mandatory programmes assure continuity until the 2020 time frame

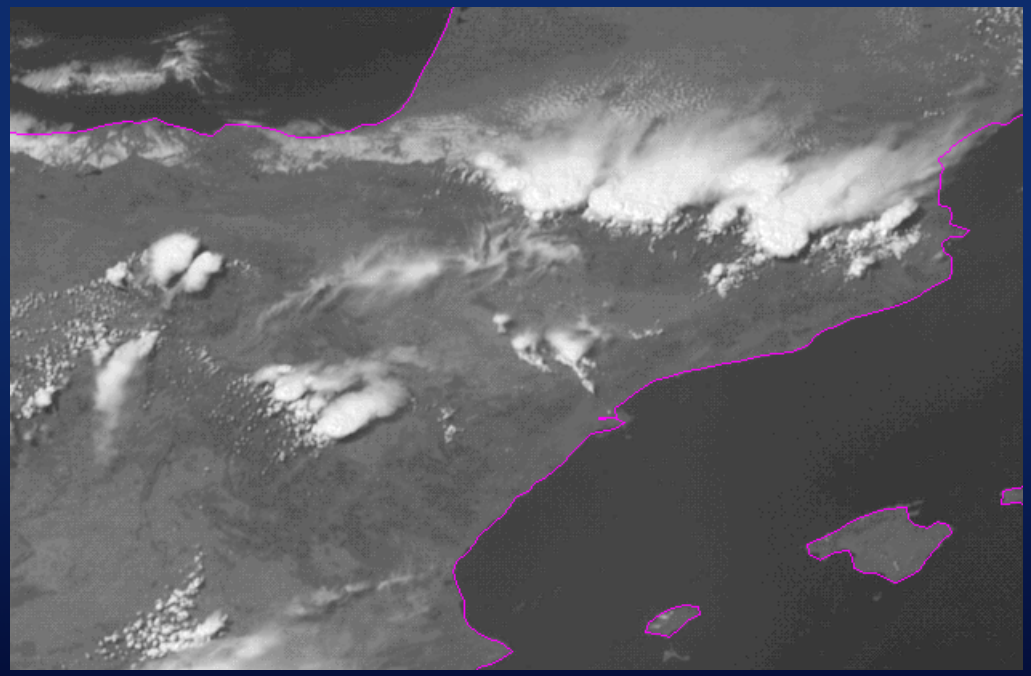
Meteosat Second Generation: a two-satellite operational system



The operational capability of a two-satellite system



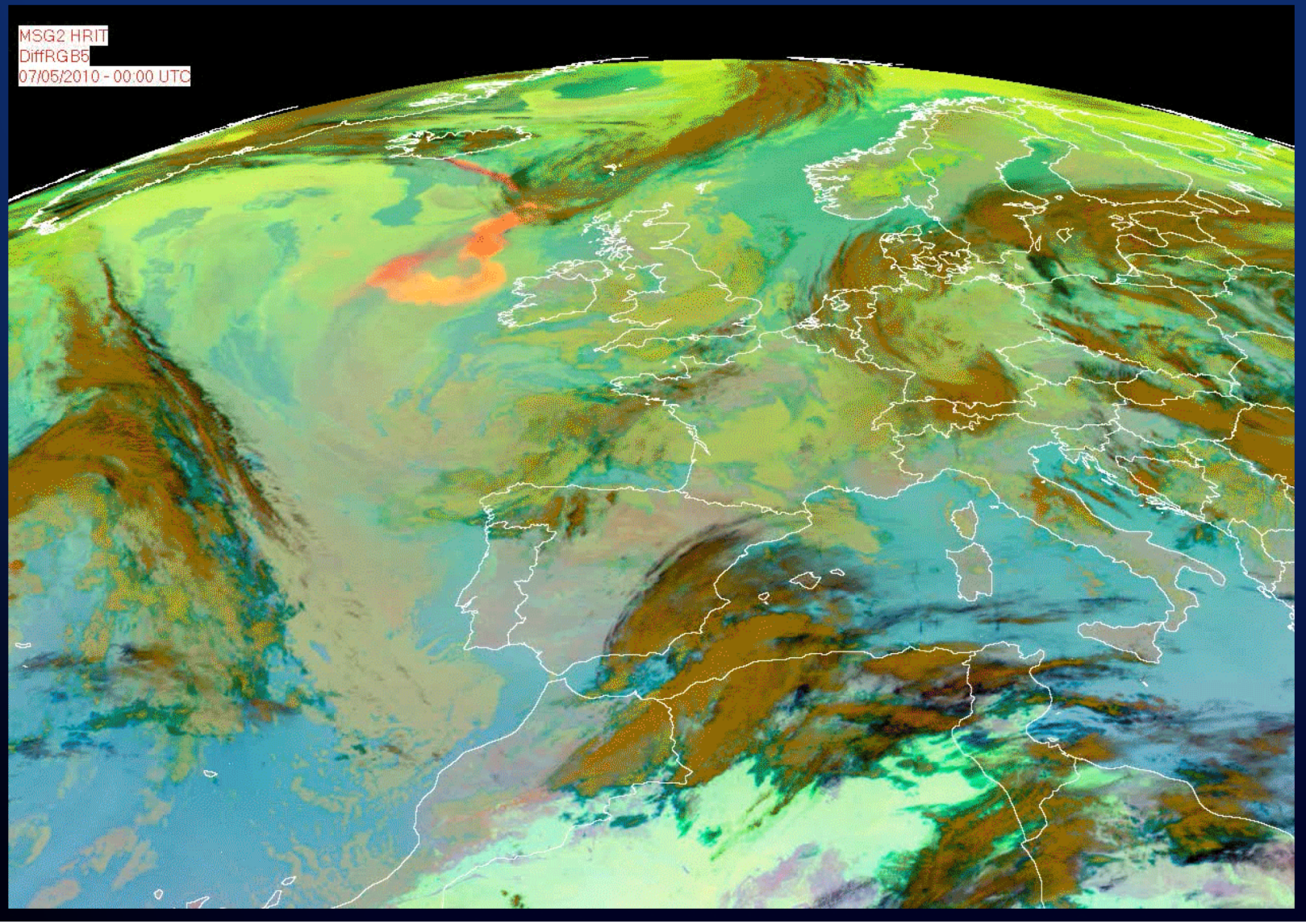
15-minute scan



5-minute scan

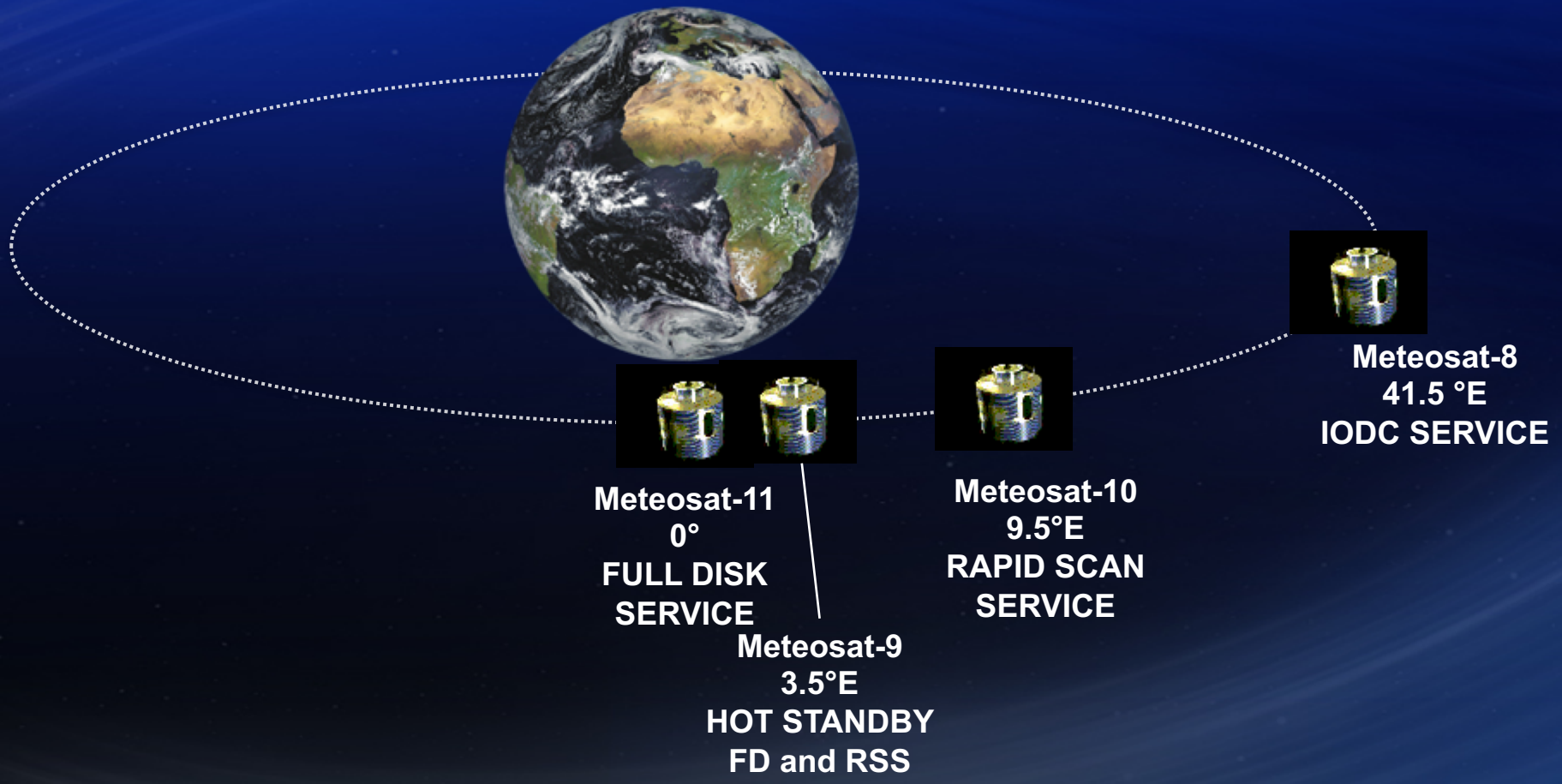
MSG for transport: aviation

Eyjafjallajökull ash cloud from 7 to 11 May 2010 (second eruption)

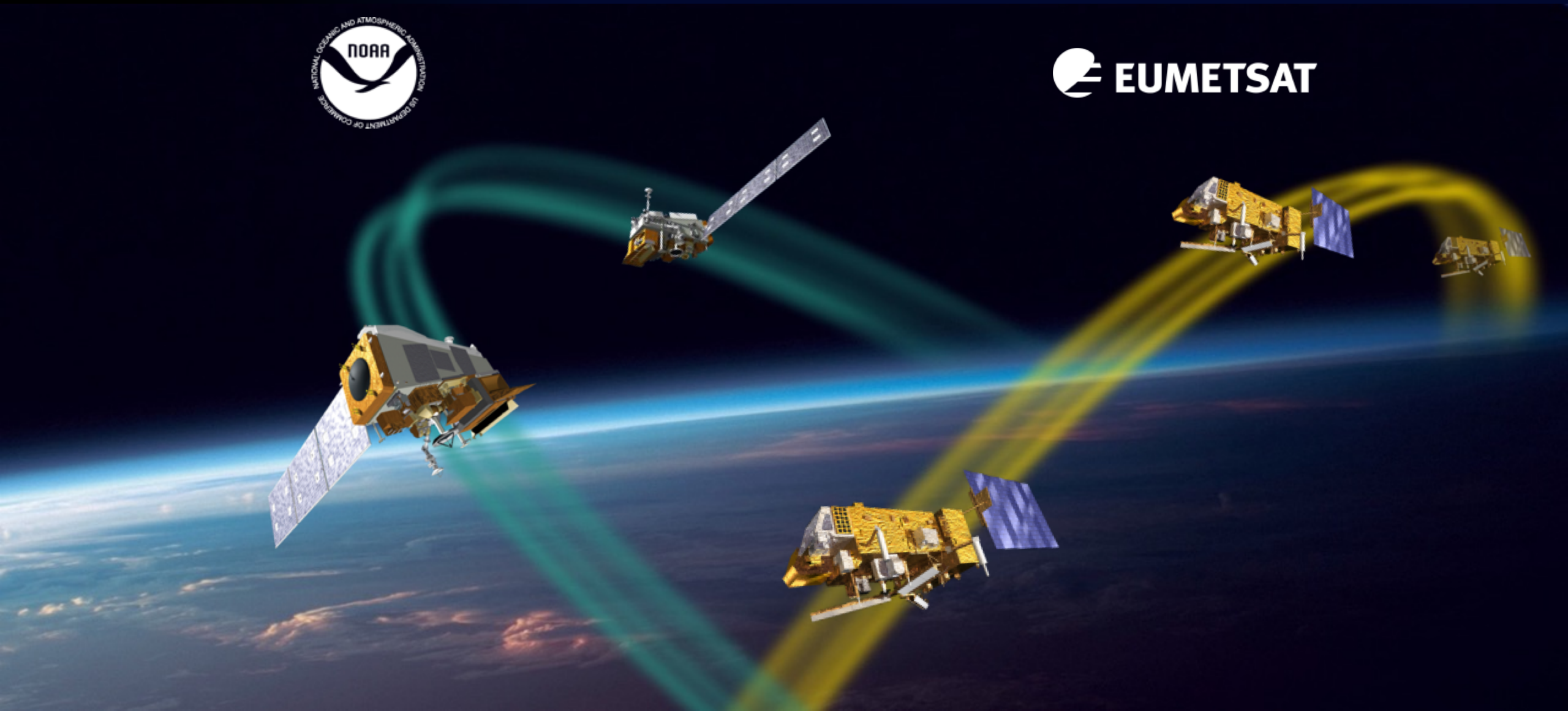


GEO CURRENT OPERATIONAL CONFIGURATION:

4 MSG Satellites assure continuous services until the 2020 timeframe



EUMETSAT Polar System:
part of the Initial Joint Polar System (IJPS) shared with the US



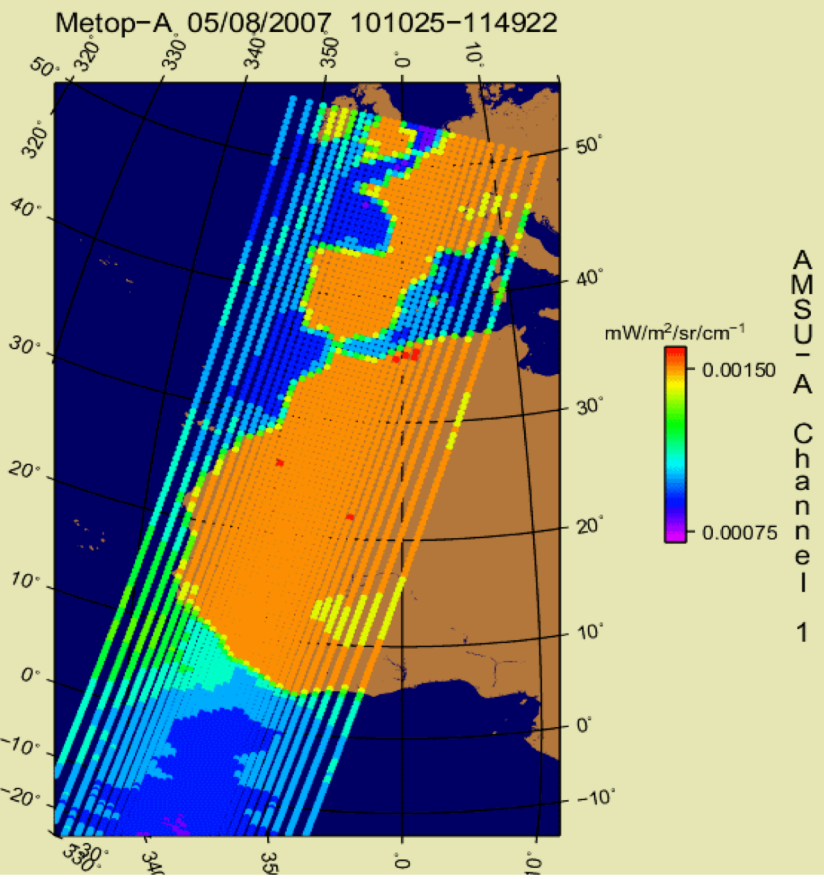
EUMETSAT Polar System: EPS / Metop

- The **EUMETSAT Polar System (EPS)** consists of a series of **three** low flying Metop satellites in polar orbit, along with ground-based infrastructure. The system will operate nominally over a period of at least 14 years.
- **Metop-A** was launched in **October 2006** and **Metop-B** was launched in **September 2012**, together they provide support to operational meteorology and climate change monitoring. **Metop-C** is planned to be launched on the **7 November 2018**.
- Their instruments deliver key **imaging** and atmospheric **sounding** data e.g. temperature and humidity, wind speed, ozone and trace gases - with unprecedented accuracy and resolution.
- EPS data contribute to **oceanography, environmental sciences** and **Earth system research**.

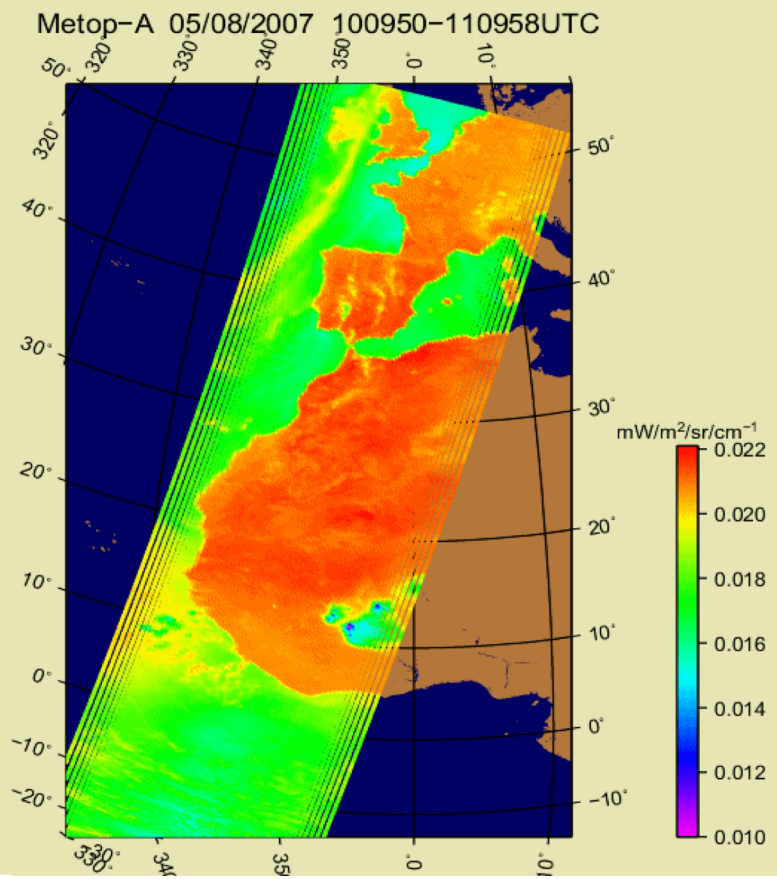
- Established in co-operation with **ESA, CNES and NOAA**
- Hyperspectral IR Interferometer in operational use (IASI)
- Common instruments with NOAA satellites (AVHRR, ATOVS)
- Heritage instruments from ERS missions in operational use (ASCAT, GOME-2)
- First operational RO instrument (GRAS)

…Sounding data from ATOVS demonstrate HRPT…

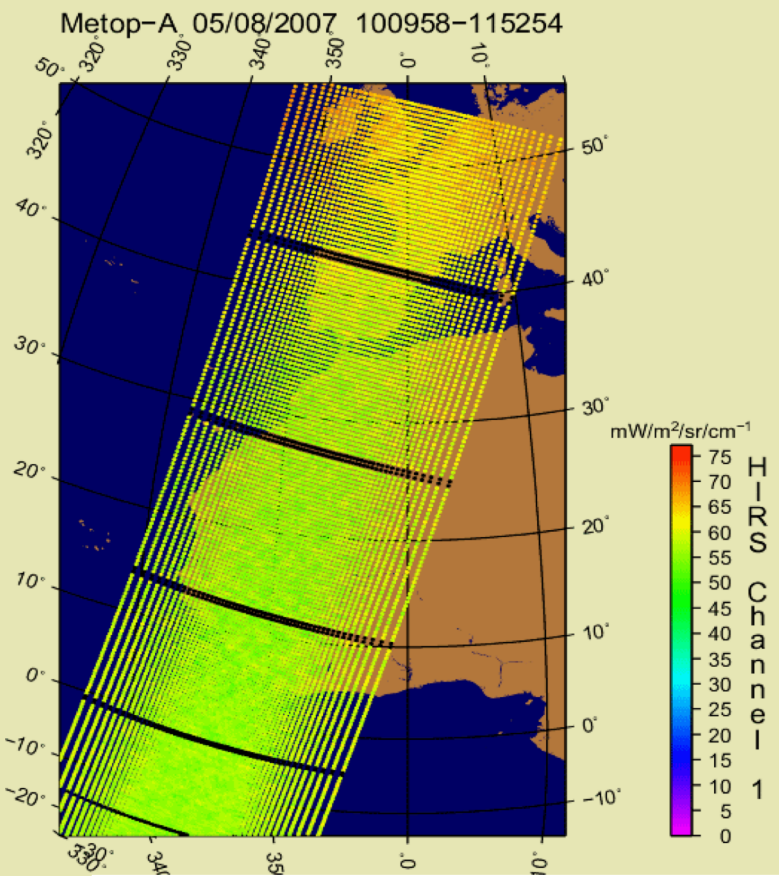
AMSU-A



MHS

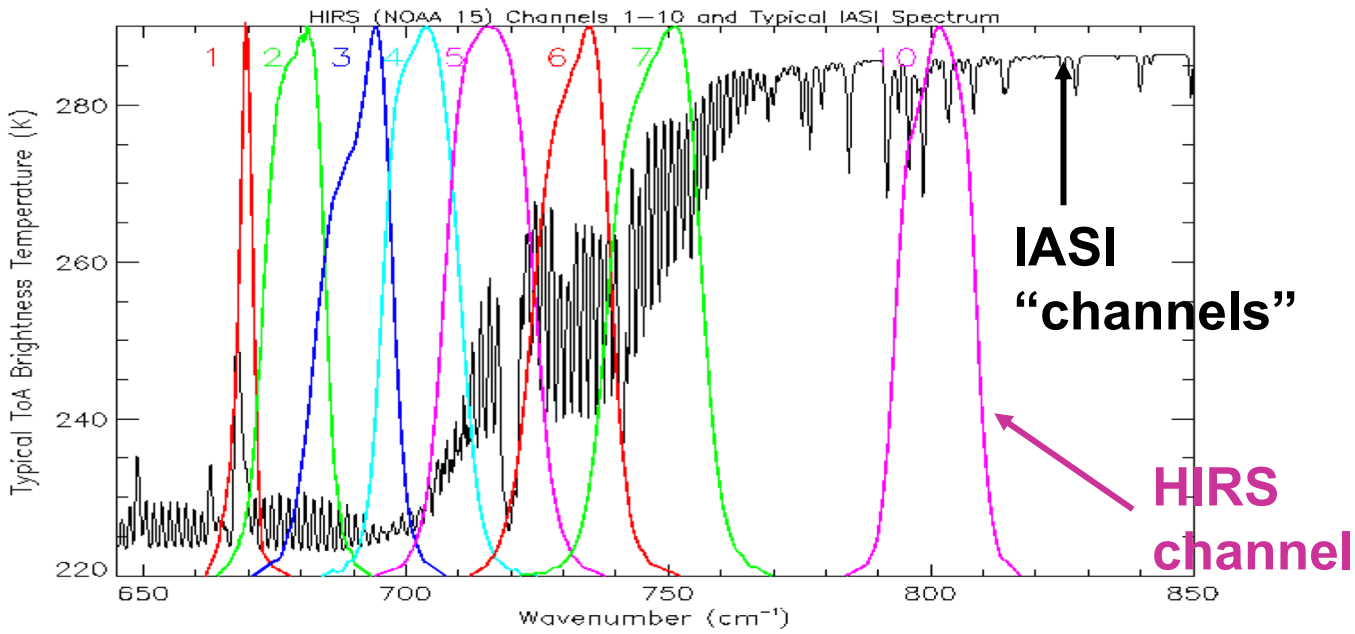


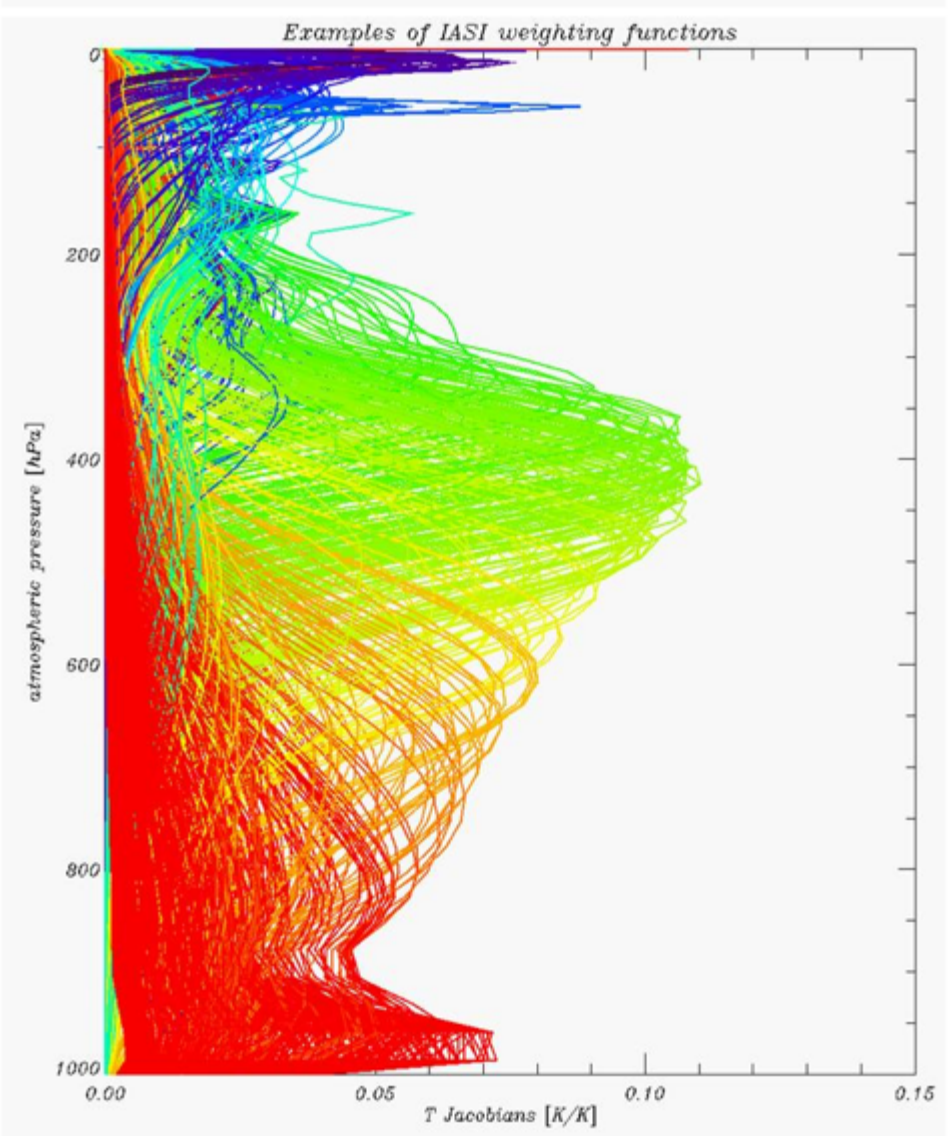
HIRS/4



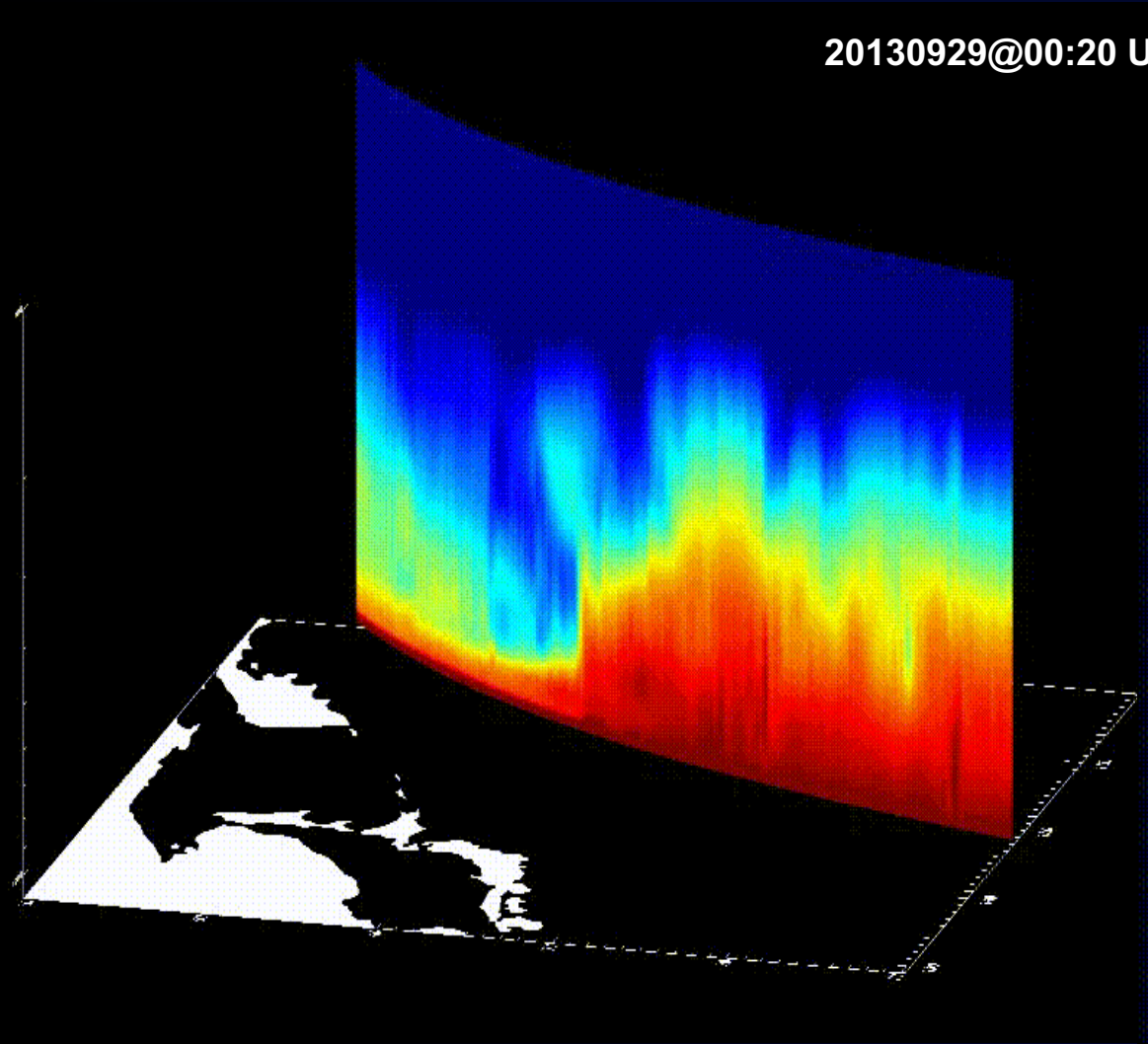
…is a Major Step Forward In Infrared Sounding

HIRS 19 channels vs IASI 8461 spectral samples





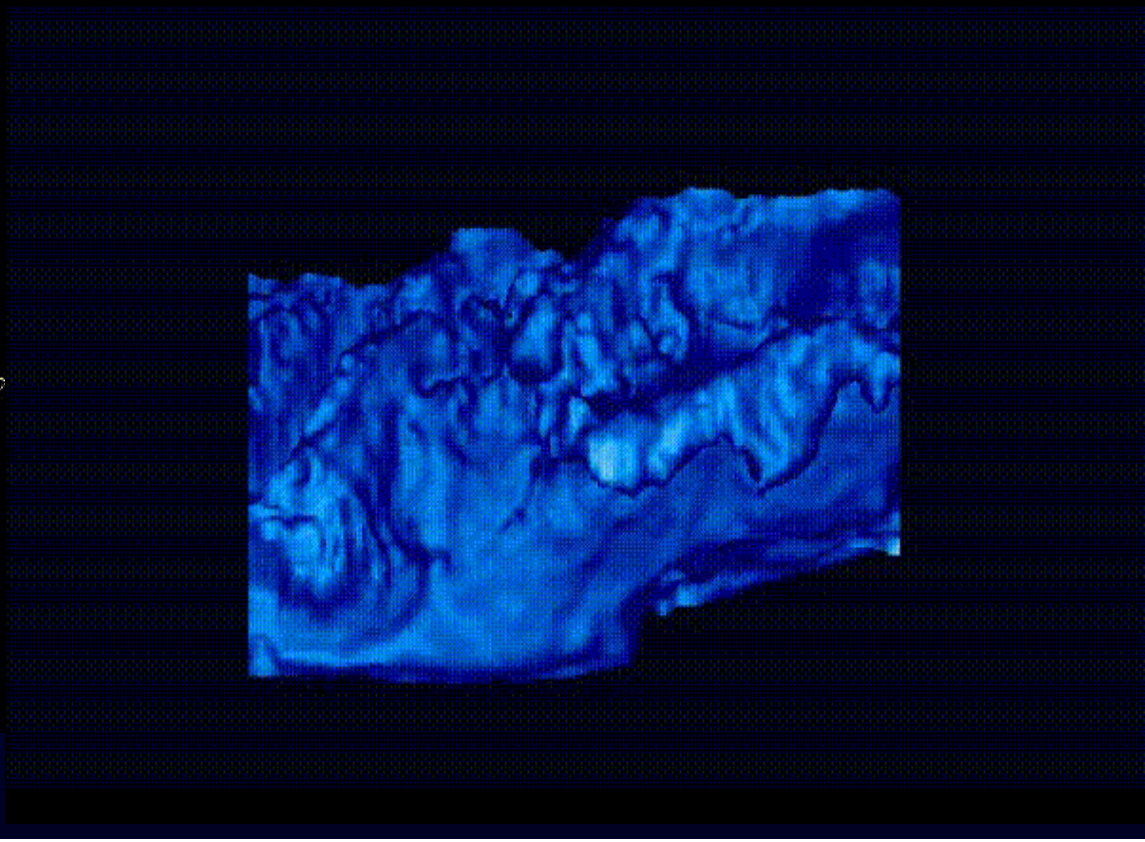
Atmospheric Profiling: IASI–Total Column Water Vapour



T. August and T. Hultberg, 2014

29/09/2013 ~00UTC

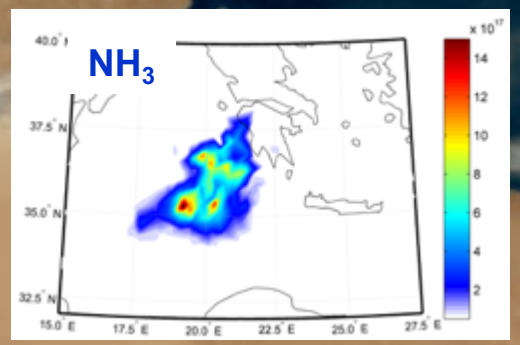
The PWLR^3 enables accurate “all-sky” retrievals of 3D WV fields, nominally exploiting MW and IR.

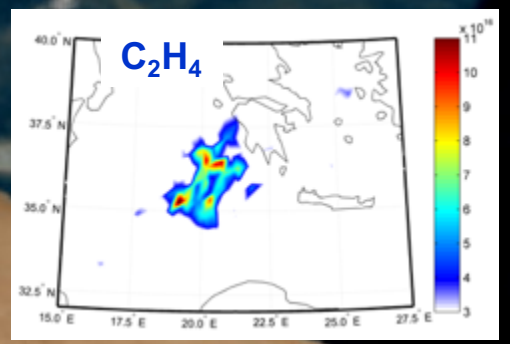


Forest fires and resulting air quality related trace gases ....beyond expectations...

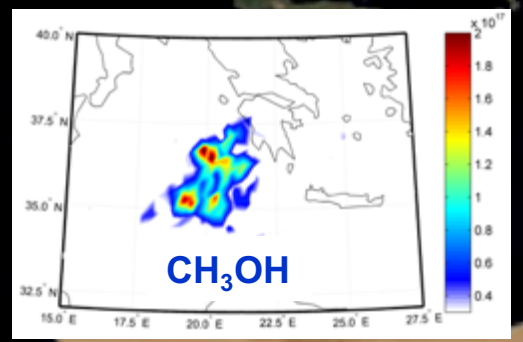
Greek fires, August 2007 – IASI data

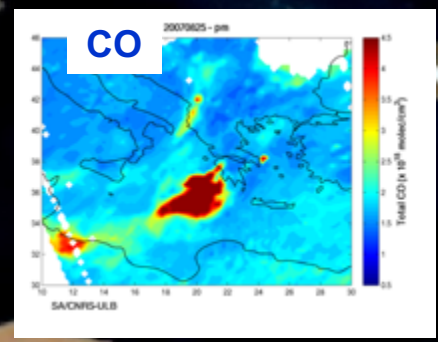
Coheur et al., ACP IASI Special Issue, 2009





Turquety et al, ACP IASI Special Issue, 2009

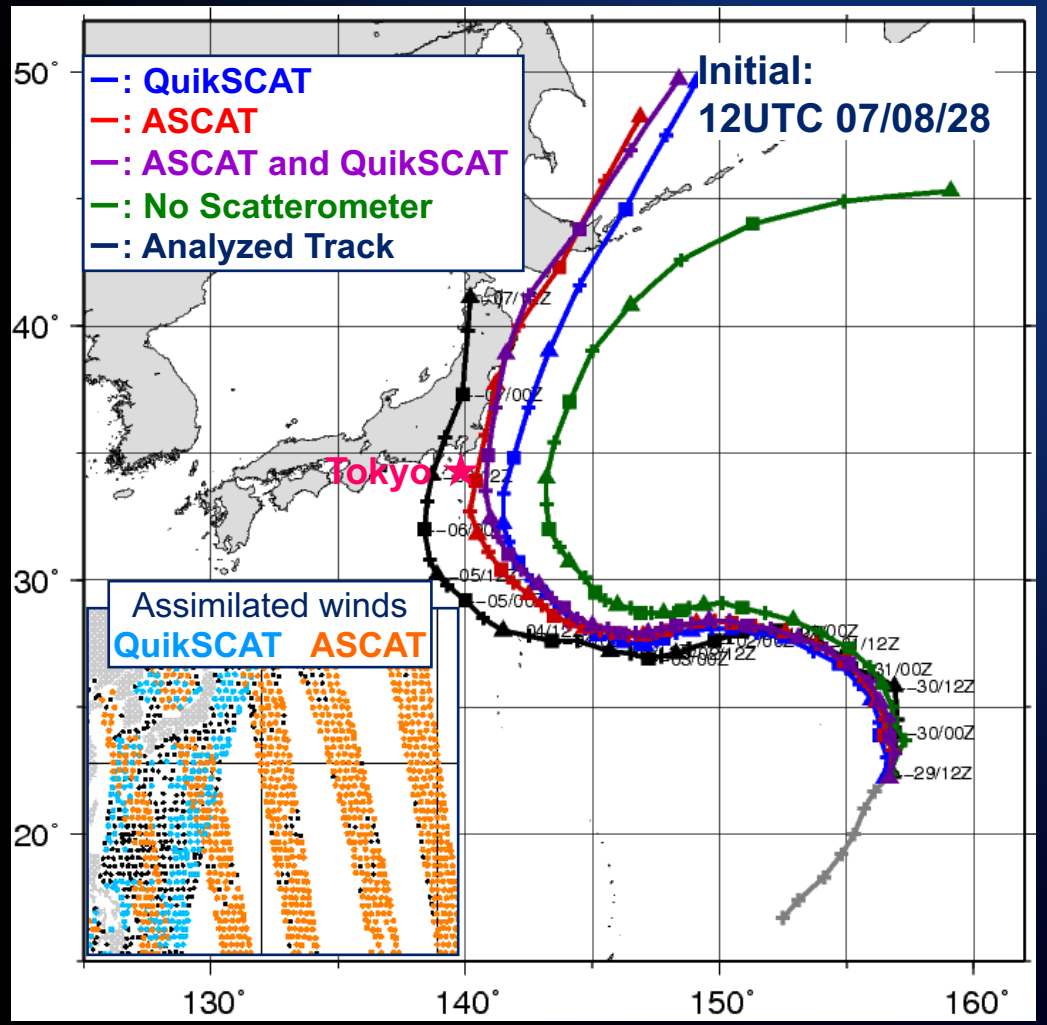


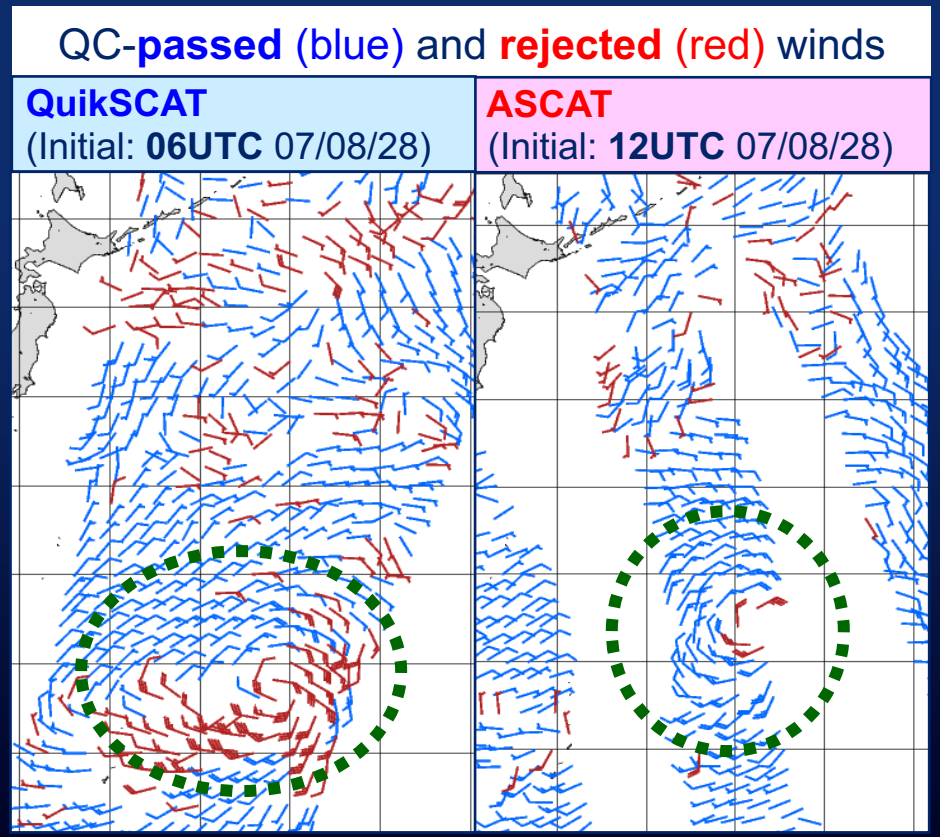


Marine Application: Use of ASCAT to track typhoon FITOW 2007

In addition to the increase of data coverage, assimilation of less contaminated winds by rainfall has a positive impact on typhoon position forecasts.

Slide content courtesy of Masaya Takahashi, JMA

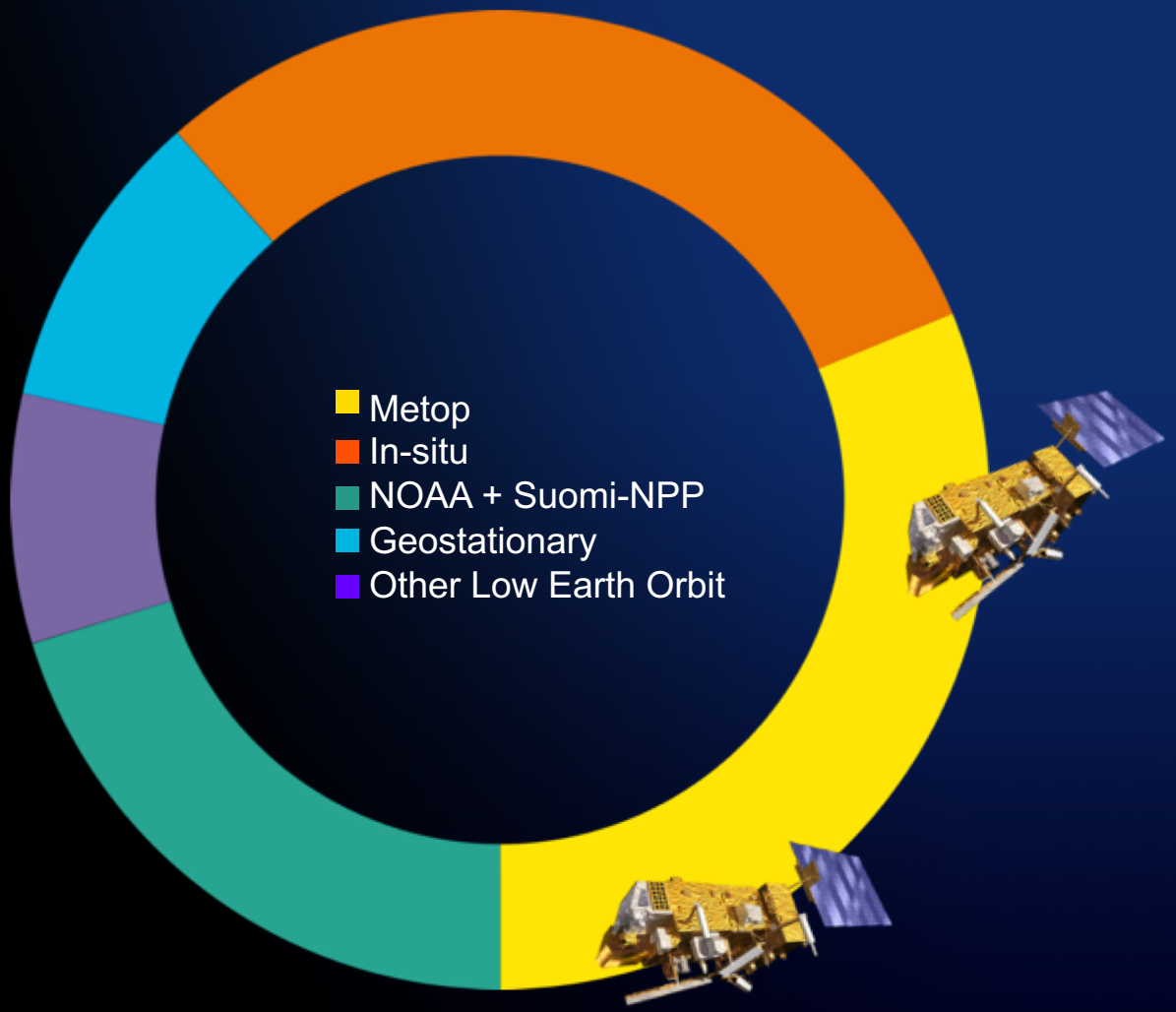




Example of Benefits

Numerical Weather Prediction (NWP)

Contribution of IJPS satellites to reduction of day-1 forecasts



Metop satellites : 44.45%

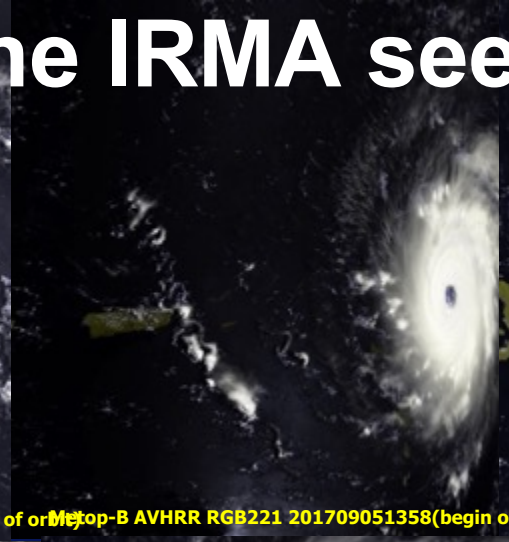
SNPP and NOAA satellites : 29.36 %

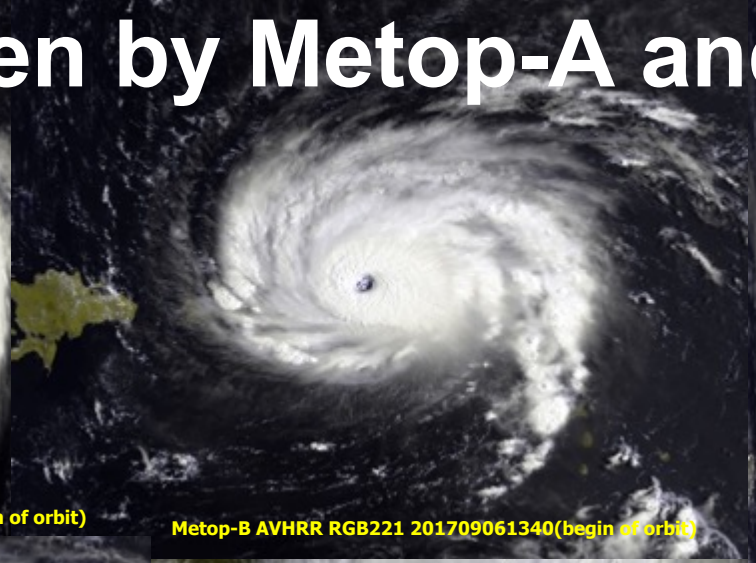
IJPS satellites : 73.81 %

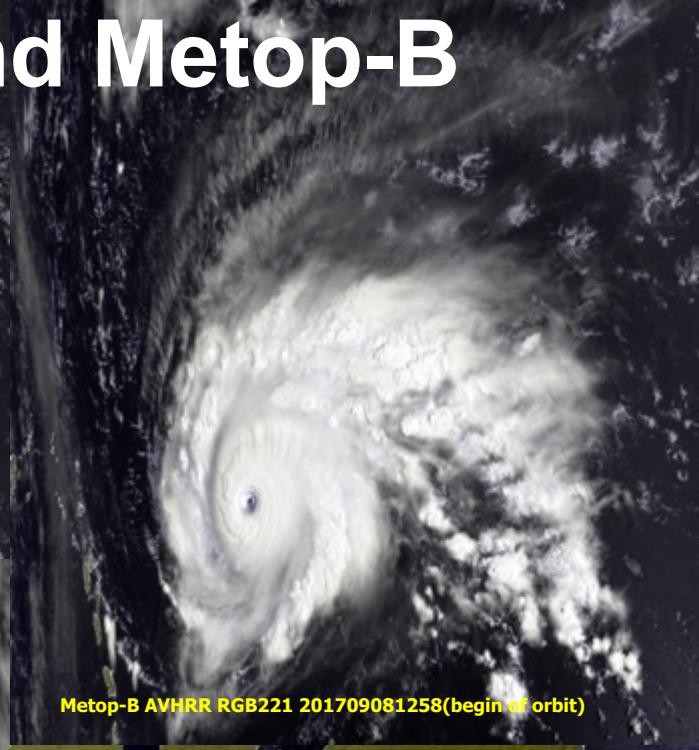
Source: Met Office, UK

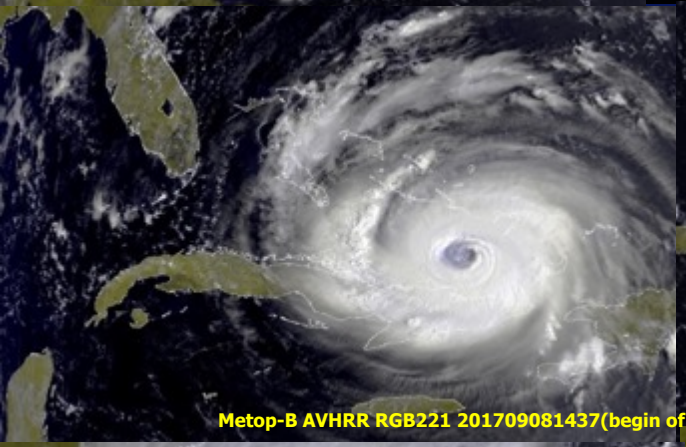
Hurricane IRMA seen by Metop-A and Metop-B


Metop-A AVHRR RGB221 201709051307(begin of orbit)

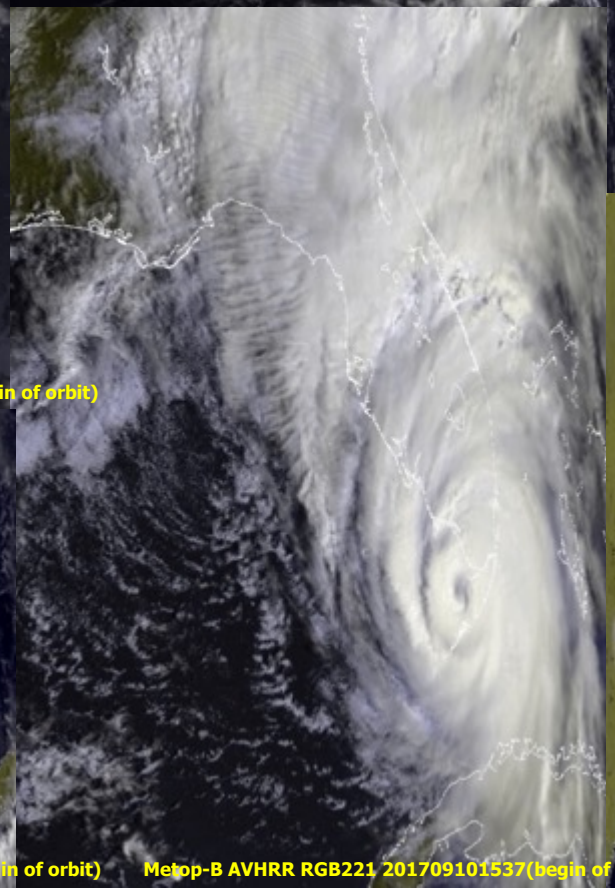

Metop-B AVHRR RGB221 201709051358(begin of orbit)

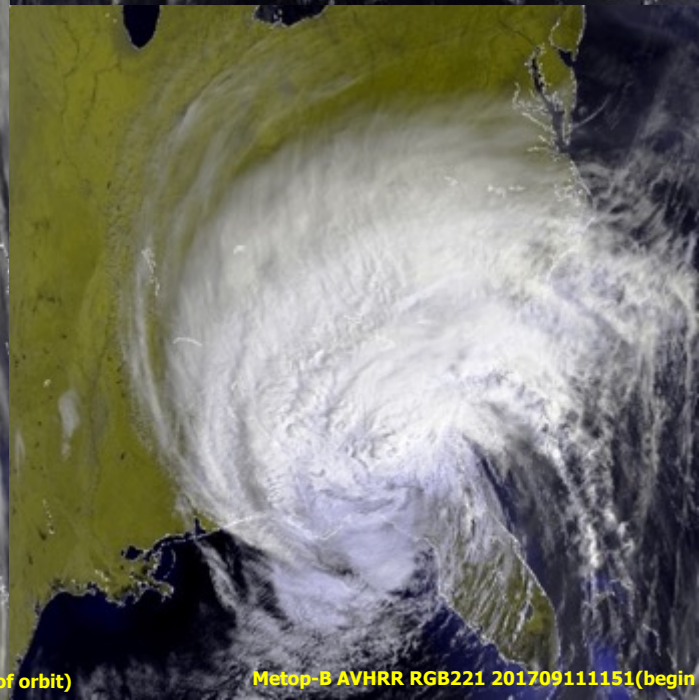

Metop-B AVHRR RGB221 201709061340(begin of orbit)

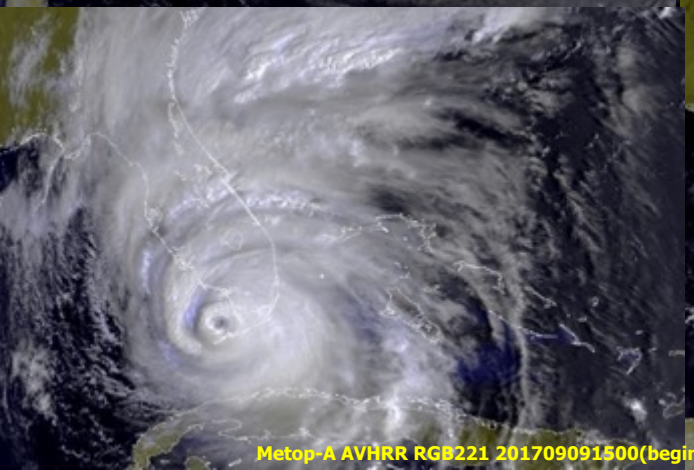

Metop-B AVHRR RGB221 201709081258(begin of orbit)

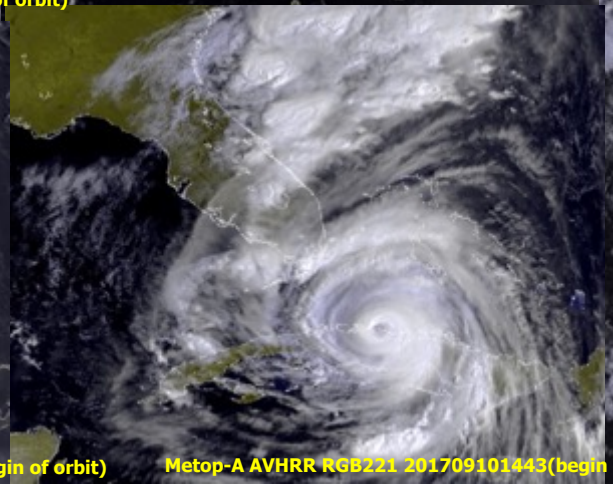

Metop-B AVHRR RGB221 201709081437(begin of orbit)


Metop-A AVHRR RGB221 201709091322(begin of orbit)



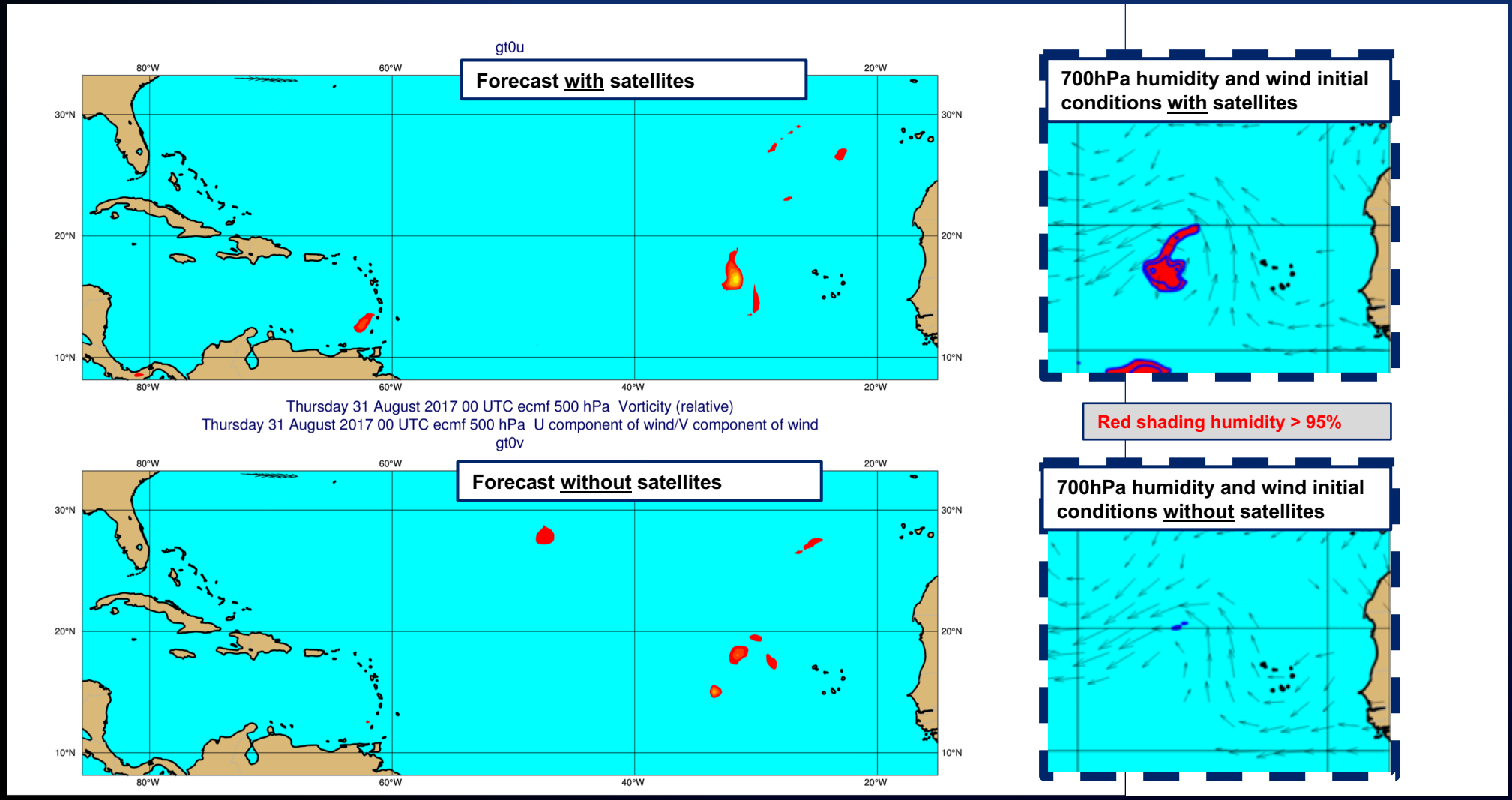

Metop-B AVHRR RGB221 201709111151(begin


Metop-A AVHRR RGB221 201709091500(begin of orbit)


Metop-A AVHRR RGB221 201709101443(begin of orbit)

Metop-B AVHRR RGB221 201709101537(begin of orbit)

IJPS contribution to forecasting IRMA



Source: ECMWF

EUMETSAT satellite systems

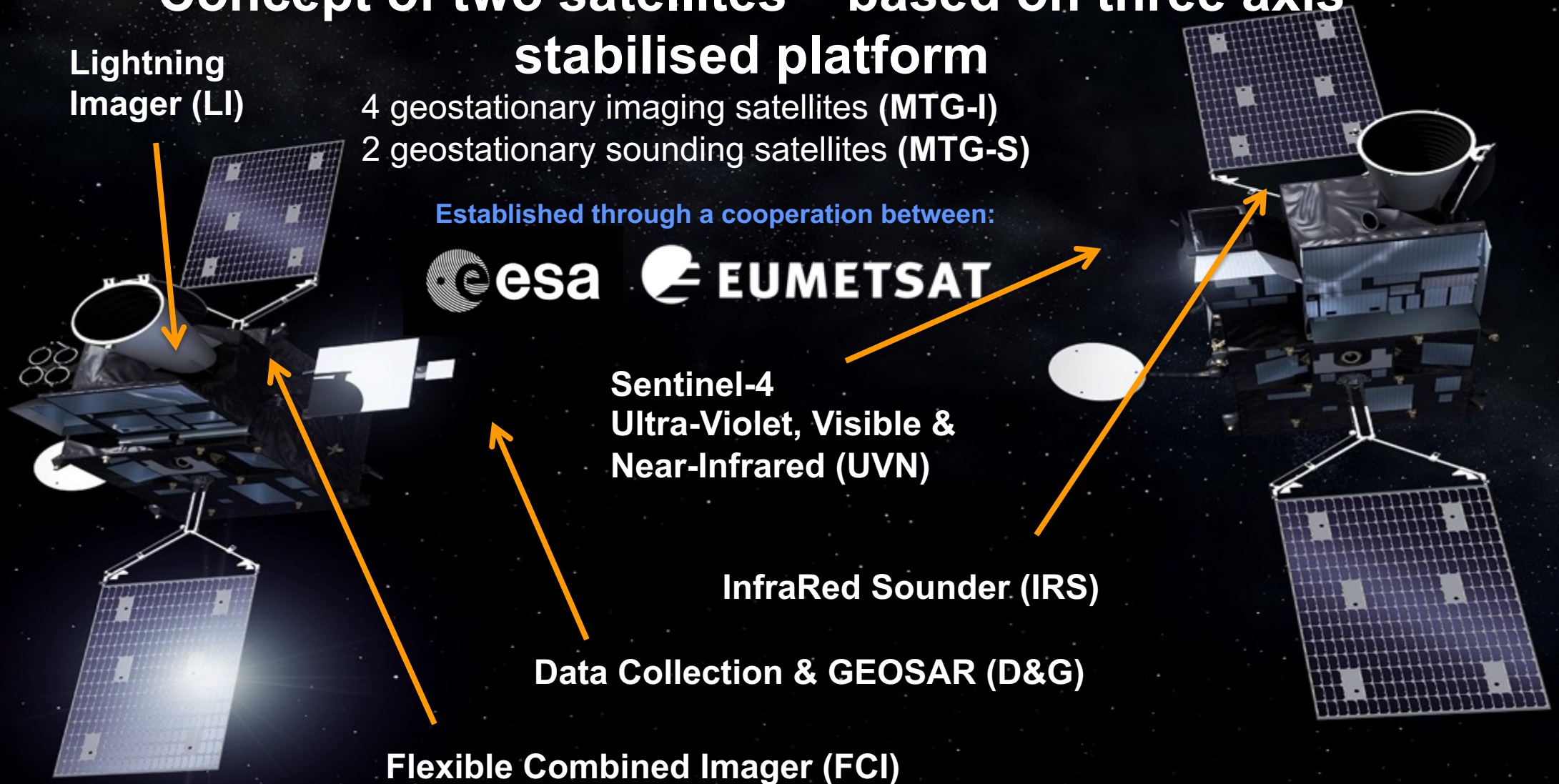
Future mandatory programmes assure continuity until the 2040+ time frame

Meteosat Third Generation (MTG)
Concept of two satellites – based on three axis stabilised platform

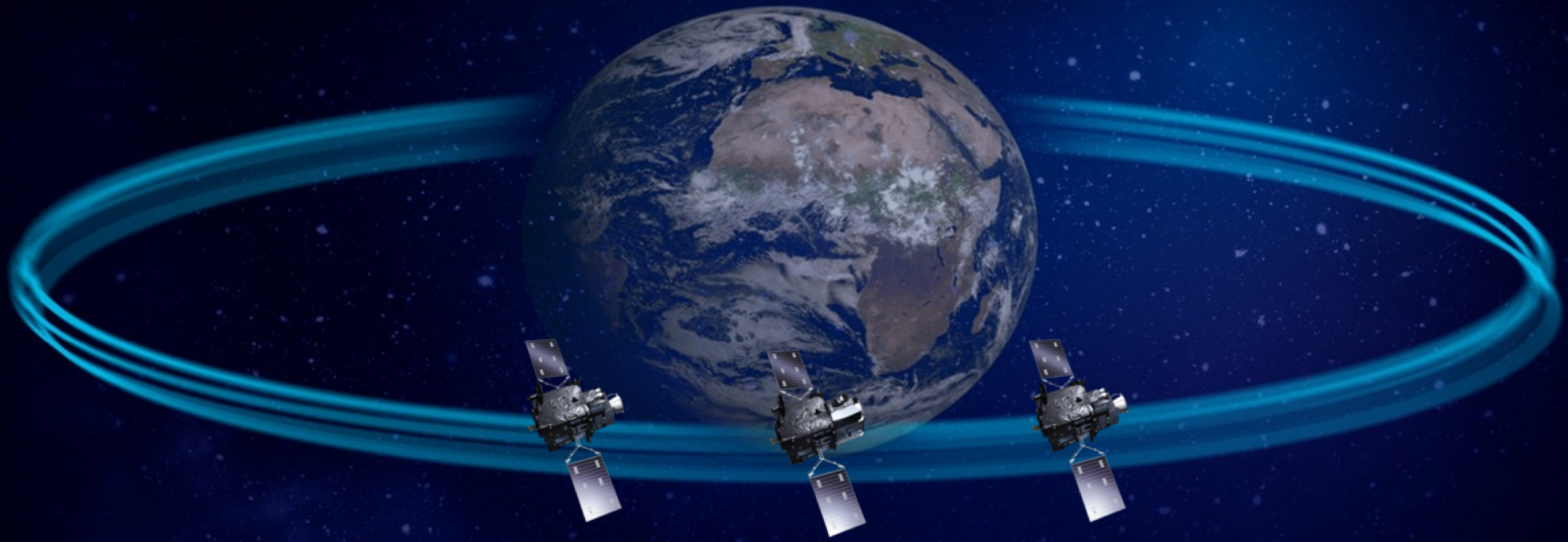
4 geostationary imaging satellites **(MTG-I)**
2 geostationary sounding satellites **(MTG-S)**

Established through a cooperation between:

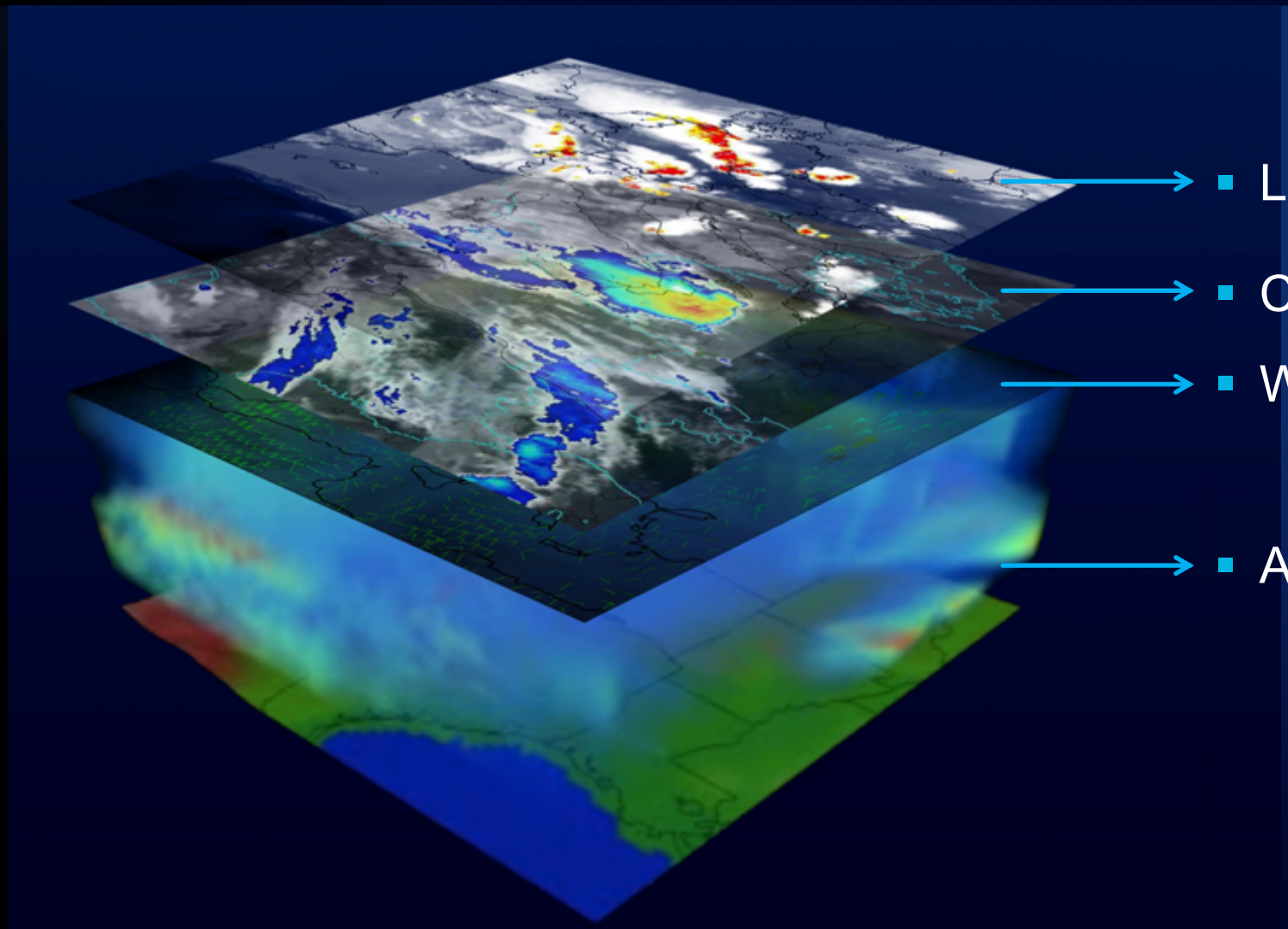
esa EUMETSAT



MTG full operational configuration



4D weather cube with MTG-I and MTG-S



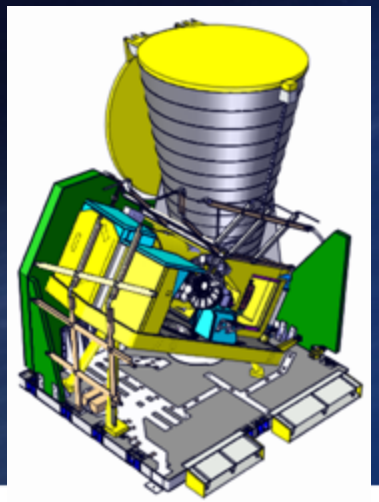
- Lightning
- Convection
- Winds
- Atmosphere

The Flexible Combined Imager (FCI) of MTG-I

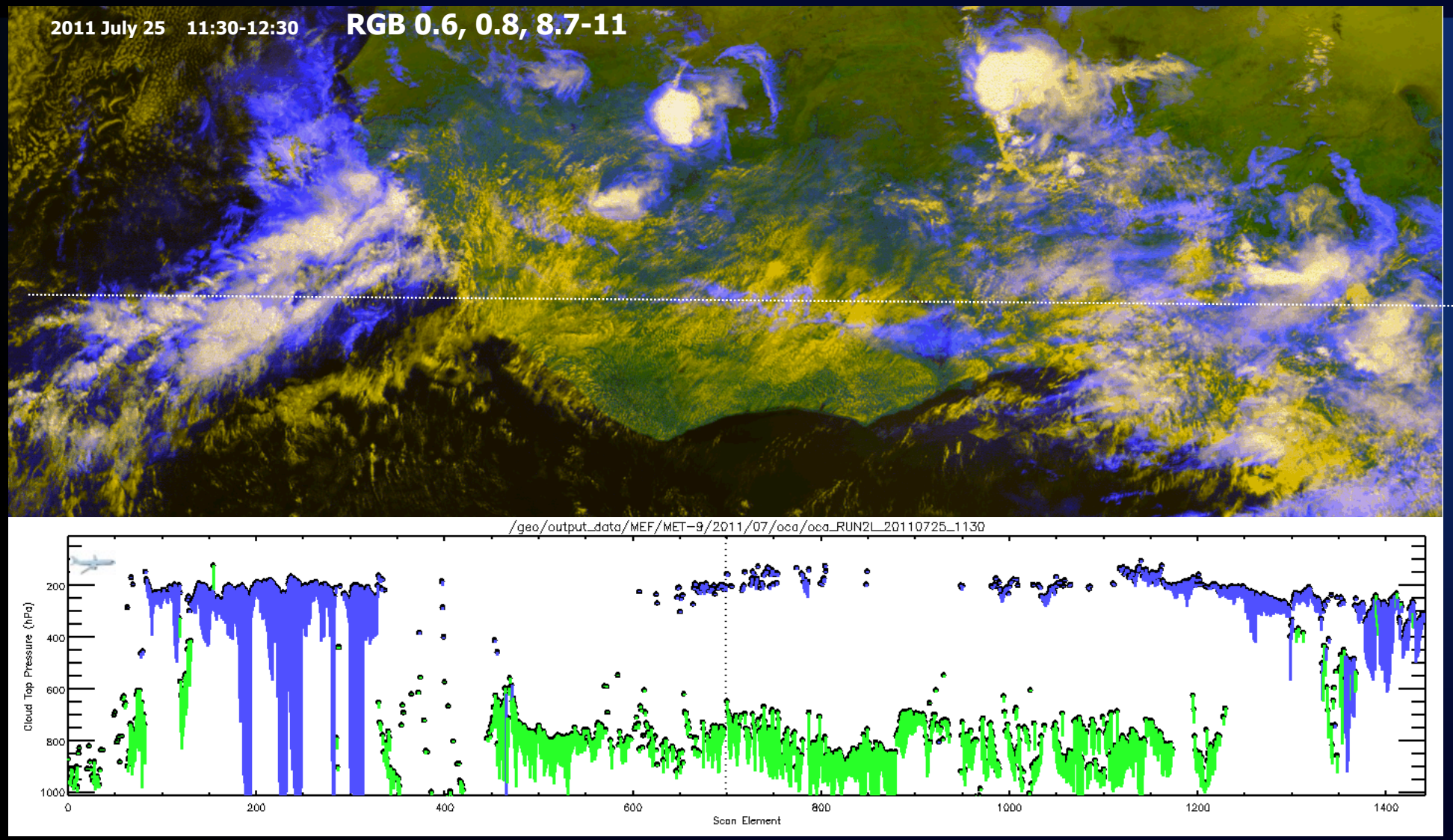
- FCI will continue the **Full Disc Scanning Service** (FDSS) and **Rapid Scanning Service** (RSS) currently provided by the MSG SEVIRI instruments.
- **Full Disc High Spectral resolution Imagery** (FDHSI) **and High Resolution Fast Imagery** (HRFI) mission requirements are established for FDSS and RSS respectively.

- **Full Disk Scan Service (FCI-FDSS):**
  - global scales: Full Disk; @ 10 min Repeat Cycle
  - 16 channels at spatial resolution:
    - 1.0 km for the 8 solar channels;
    - 2.0 km for the 8 thermal channels.

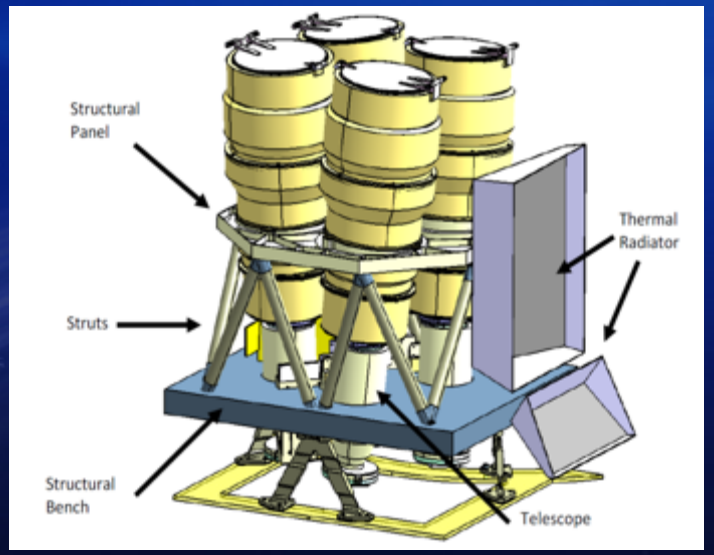
- **Rapid Scan Service (FCI-RSS):**
  - local scales: 1/4th of Full Disk; @ 2.5 min Repeat Cycle



OCA : Optimal Cloud Analysis



The LI instrument (Lightning imager)

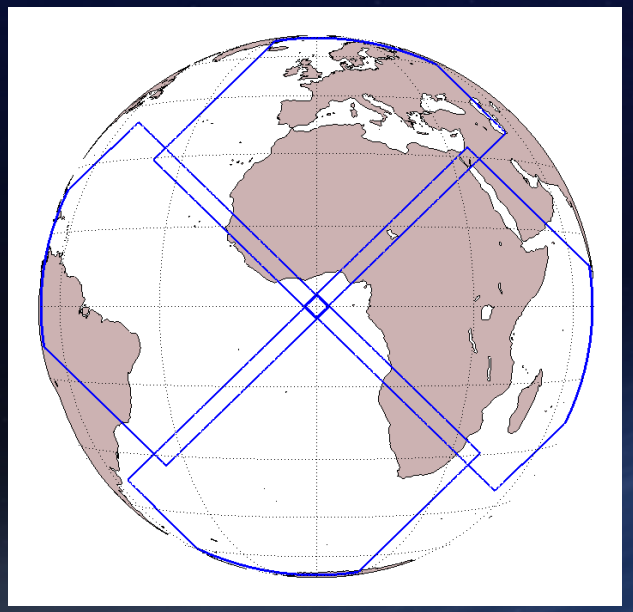


LI Main characteristics:

- Measurements at 777.4 nm
- Coverage close to “visible disc”
- Continuous measurements of (lightning) triggered events
- Spatial resolution ~ 4.5 km at SSP
- Integration time per frame 1 ms
- Background subtraction & event detection in on-board electronics

The baseline for the LI is a 4-Optical Chain solution:

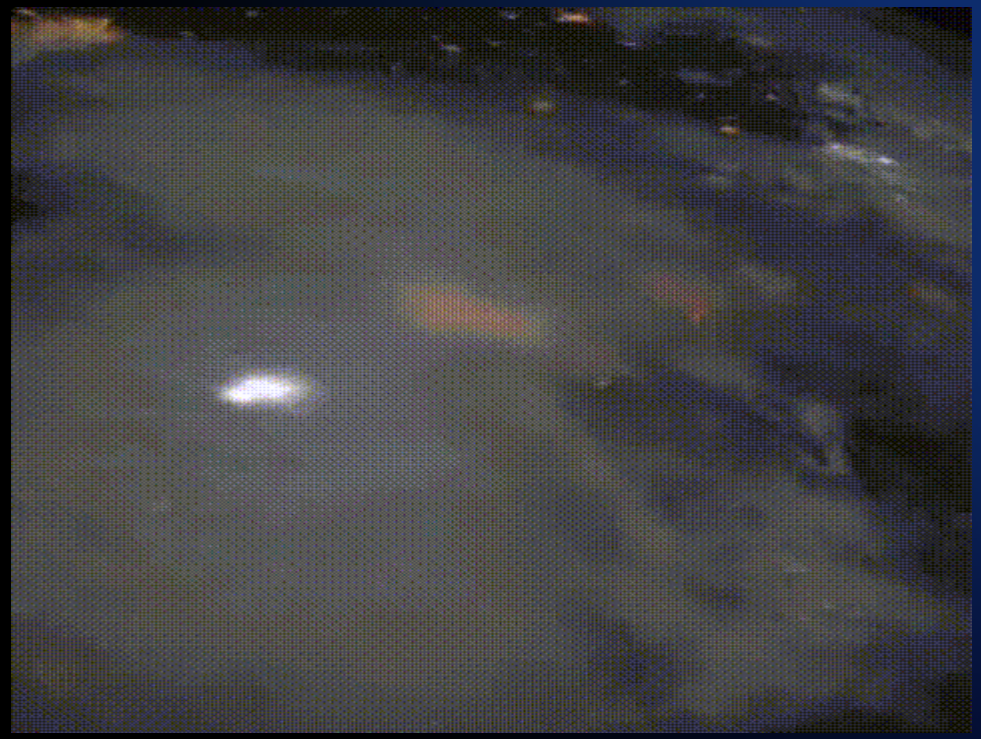
- 4 identical optical channels with CMOS back-thinned backside illuminated detectors
- 1170 x 1000 pixels per camera

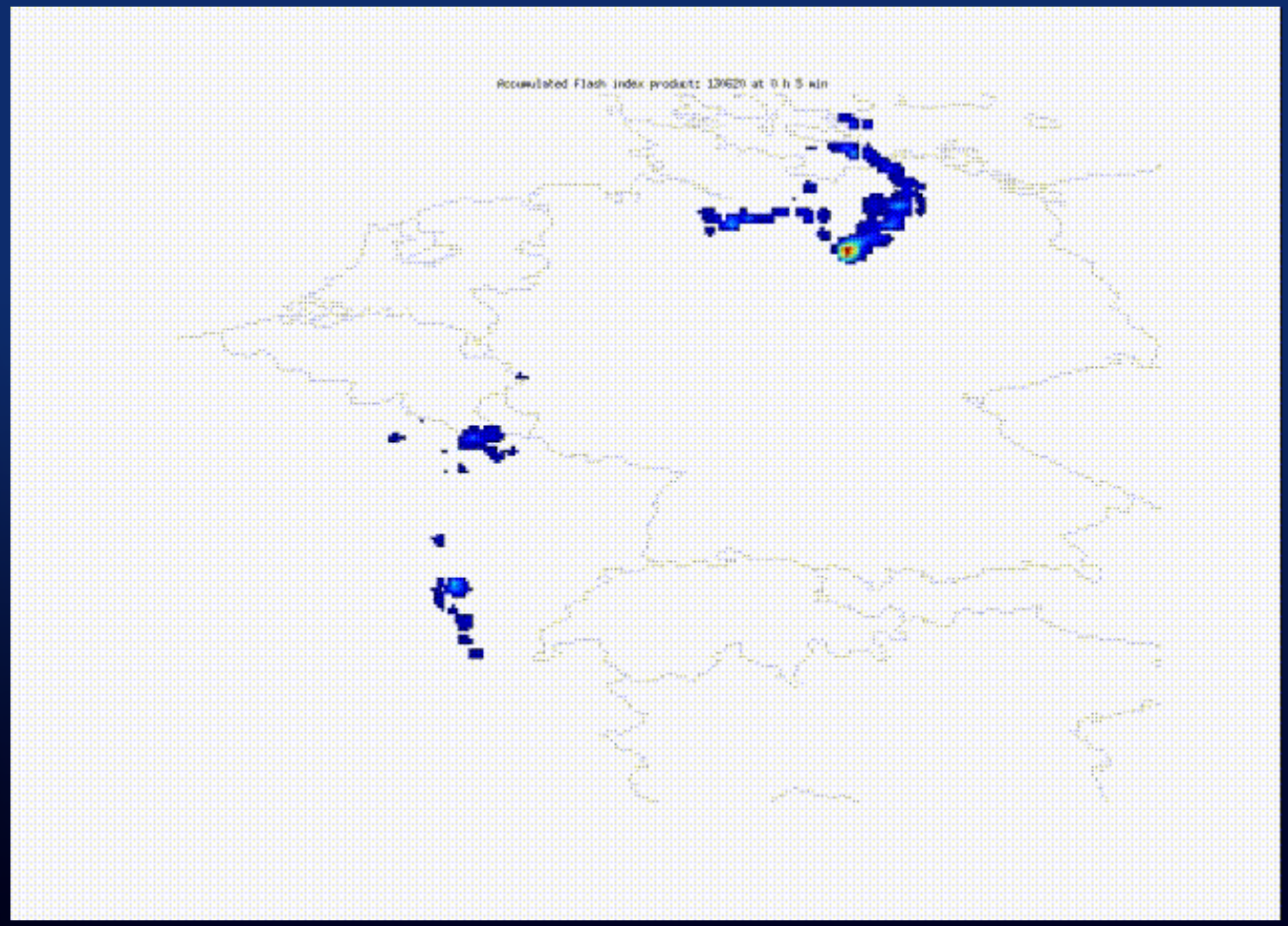


End-users (Level 2) will not see the “detector structure”

Lightning Imager on MTG-I

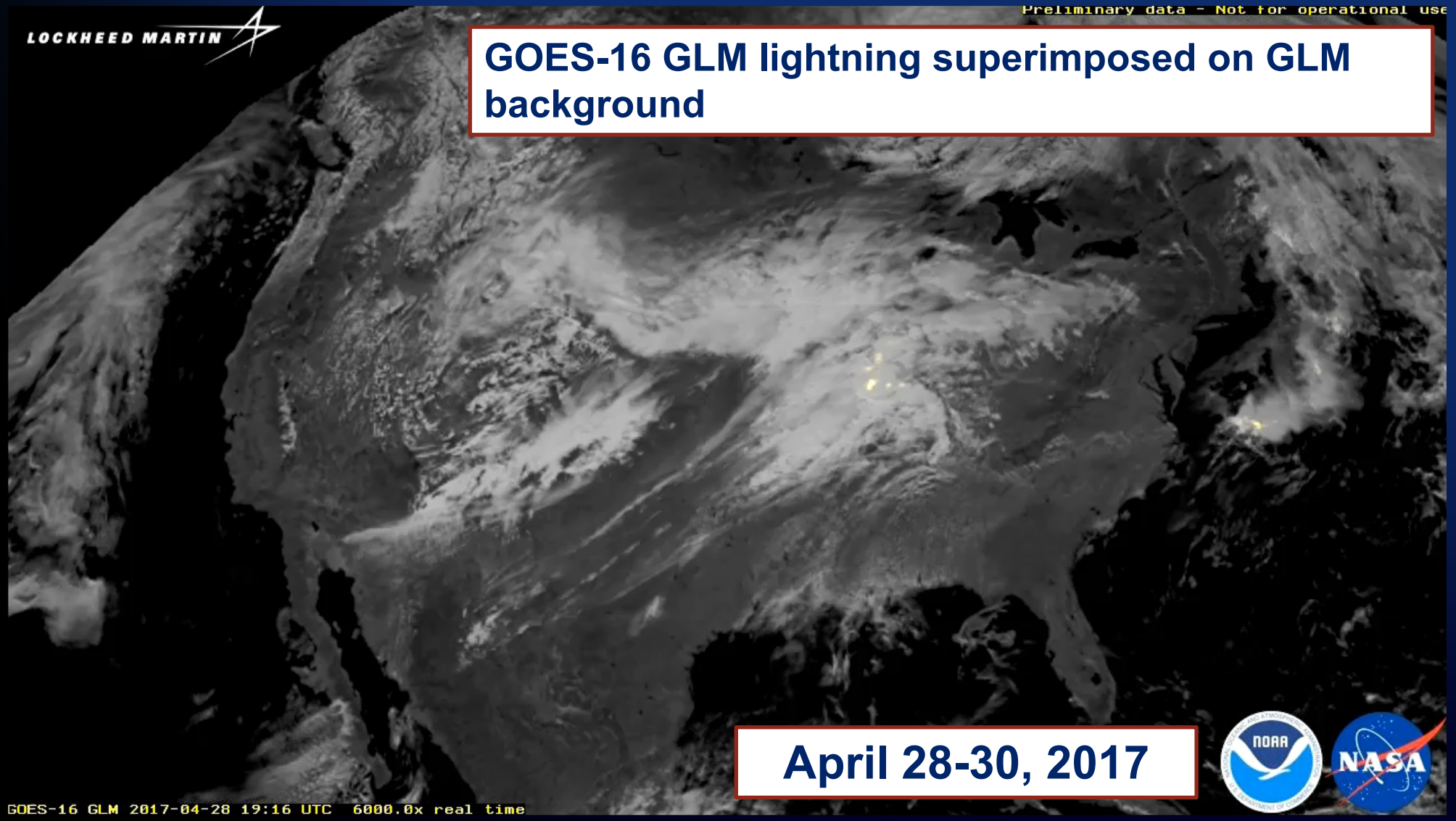
Lightning seen from space (simulated)





LI Data-Simulation
(Grandell, 2014)

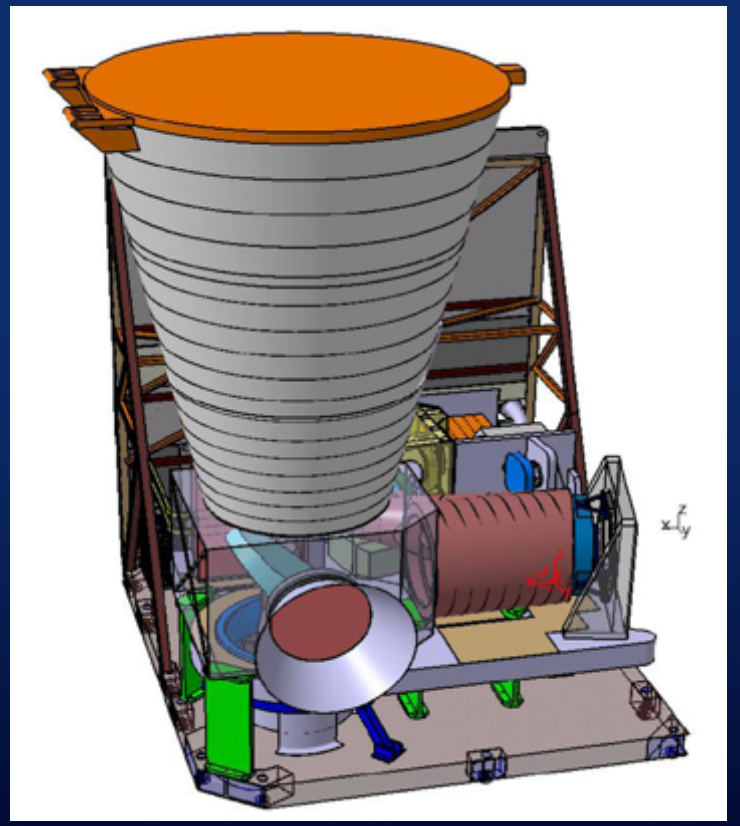
Lightning monitoring for nowcasting: an exemple on GOES-16 (R)



MTG-IRS: Hyperspectral Infrared Sounder

The InfraRed Sounder (IRS):

- Is an imaging interferometer with a hyperspectral spectral sampling of 0.625 cm^{-1} and spectral resolution of 0.754 cm^{-1}
- Has 2 detector arrays with each 160 x 160 detectors
- Is taking measurements in two bands:
  - the Mid-Wave InfraRed (MWIR, 1600–2175 cm^{-1} or 6.25–4.6 µm) with 900 spectral channels
  - the Long-Wave InfraRed (LWIR, 700–1210 cm^{-1} or 14.3–8.3 µm) with 800 spectral channels
- Has a spatial resolution of 4 km at nadir and ~10 km at the edges (~7km over Europe)



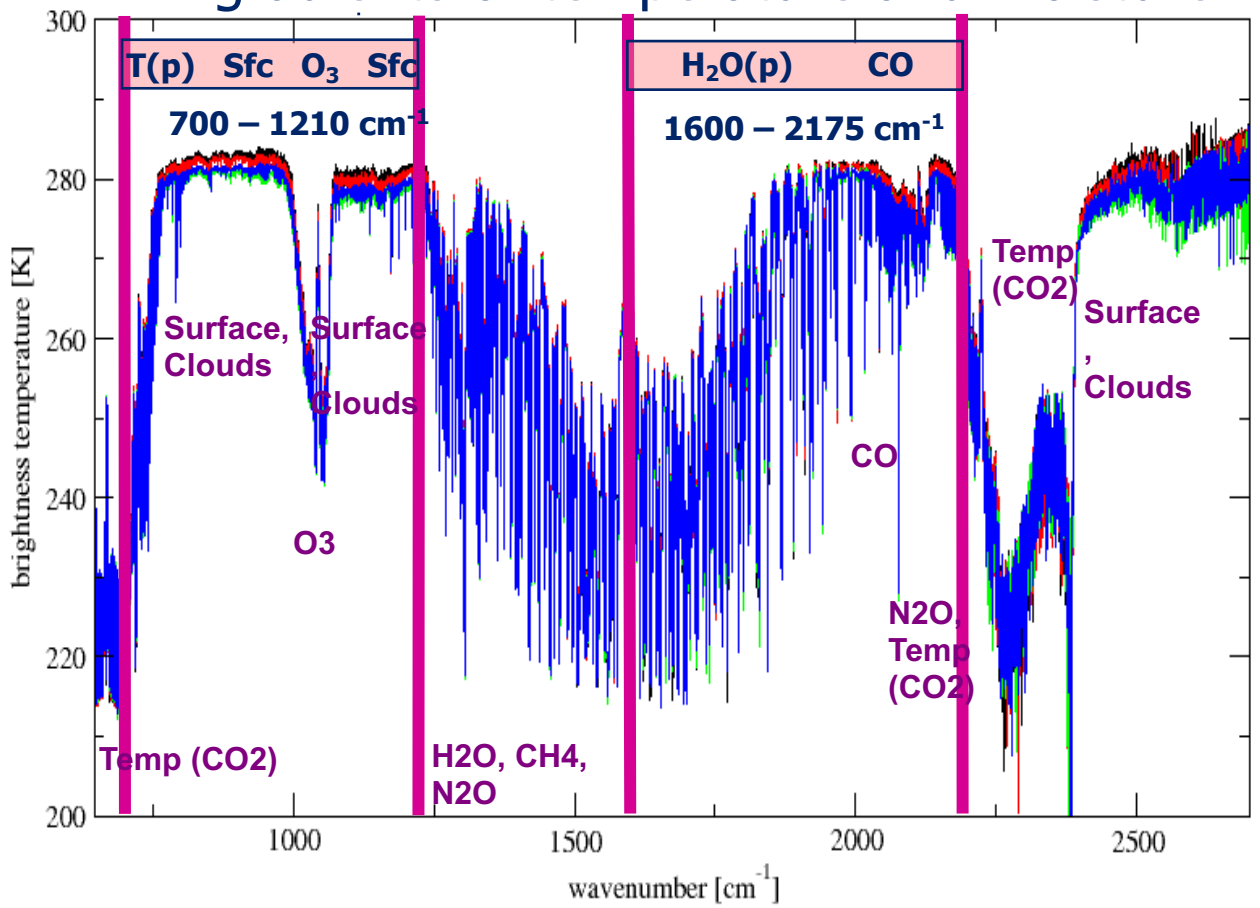
Volume: 1.4 x 1.6 x 2.2 m^3

Mass: 400 kg

Power: 750 W

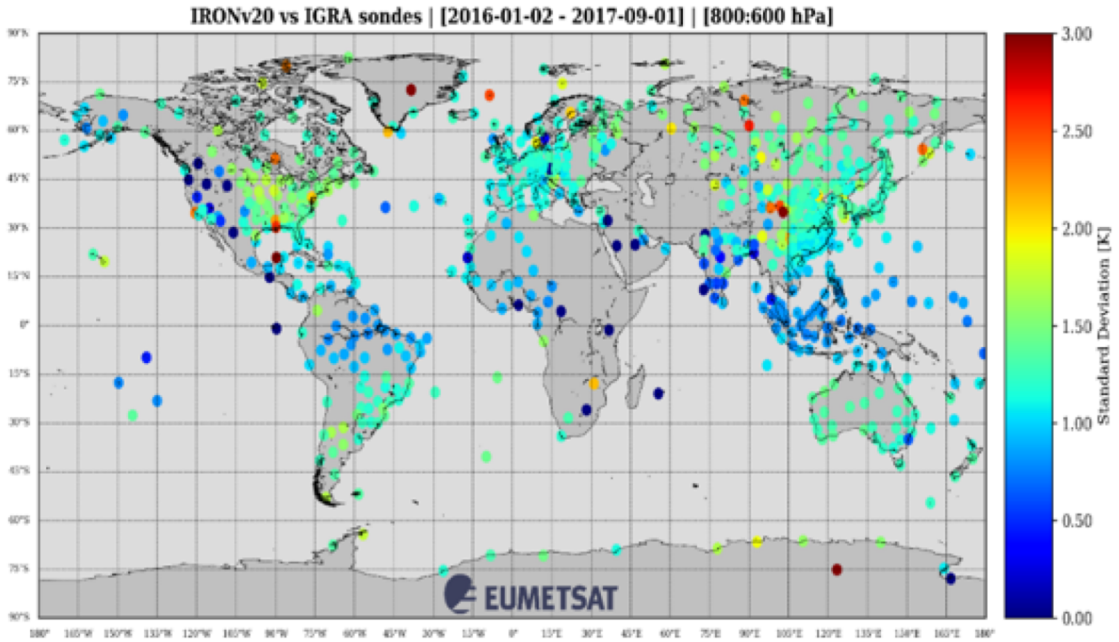
MTG-IRS: Spectral bands

MTG-IRS: information on horizontal and vertical gradients of temperature and moisture

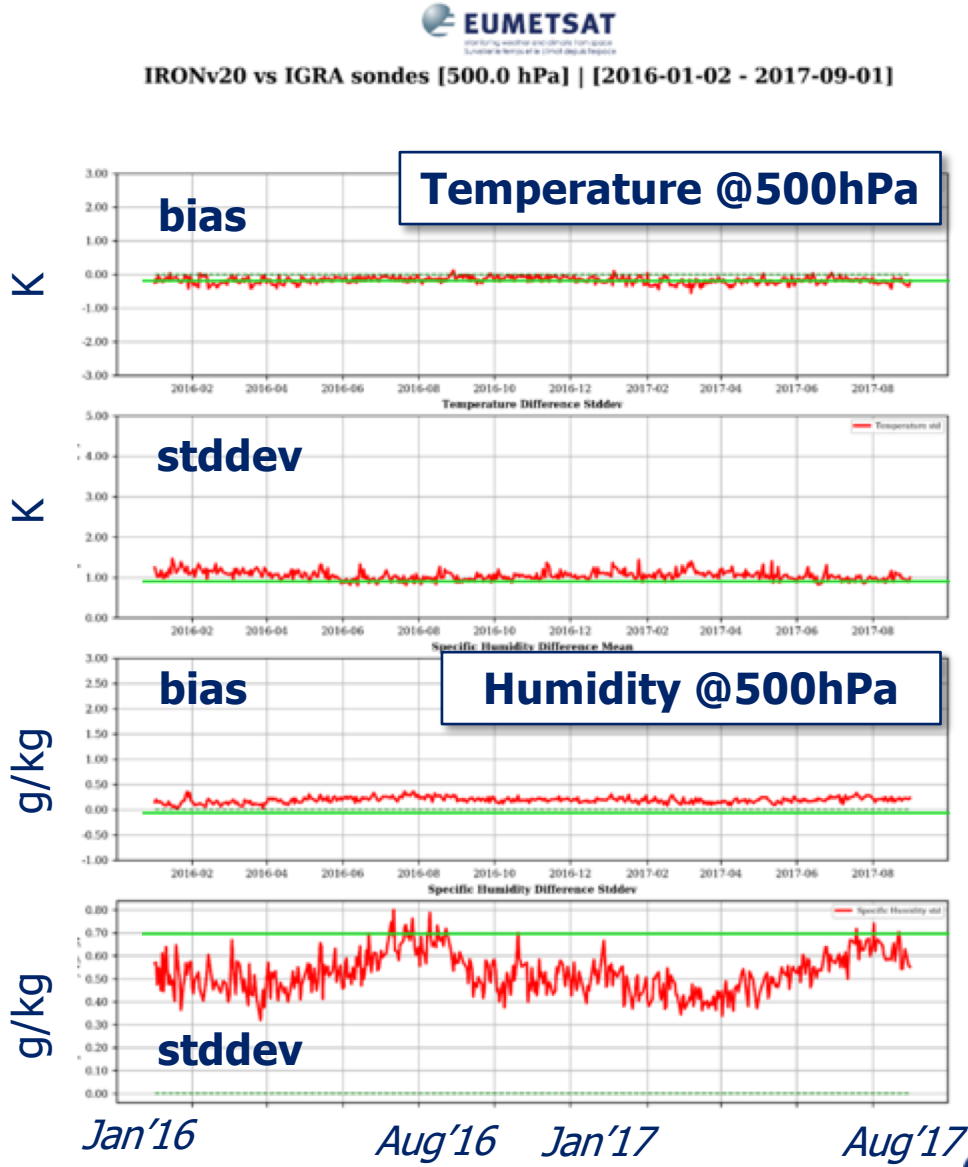


MTG-IRS Preparations: IASI in IR-only mode (v6.4)

20 months: January 2016 – August 2017
vs. **radio-sondes (±3h ; <50km)**



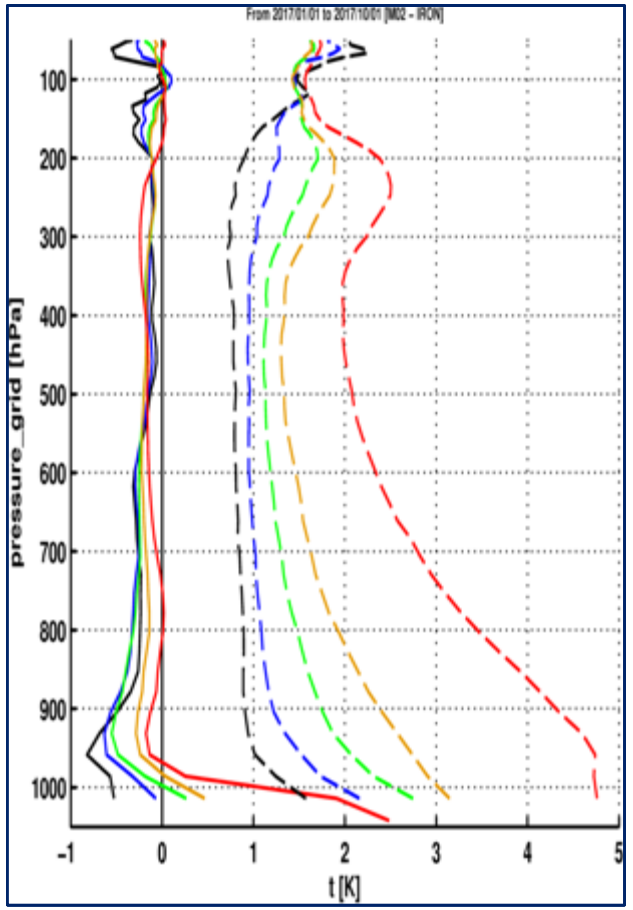
Yield ~50%,
includes some cloudy pixels



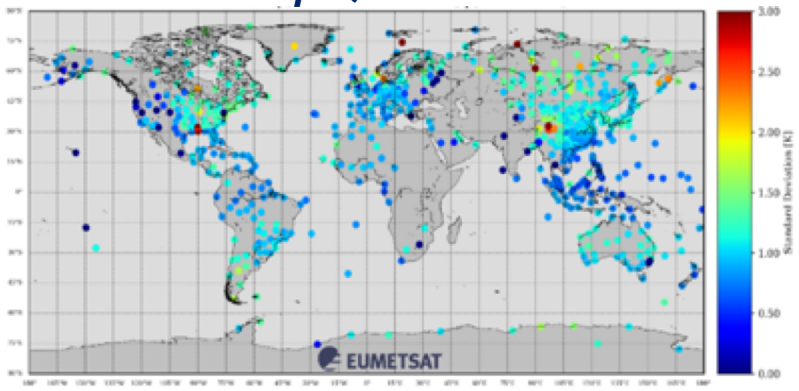
MTG-IRS Preparations: cloud impact on retrievals

Quality indicator significance *vs.* sondes [IGRA]

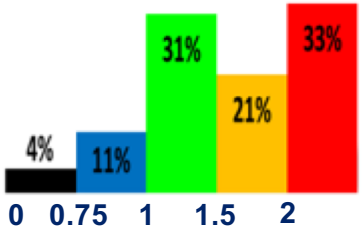
IR-only



Jan. – Oct. 2017
< 50km ; < 3h
Match-up QC still needed

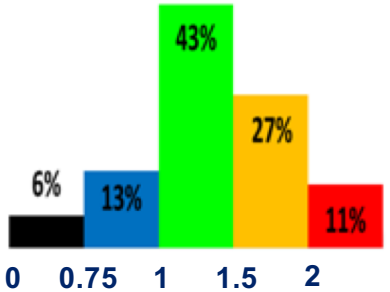


IR-only



QI T [K]

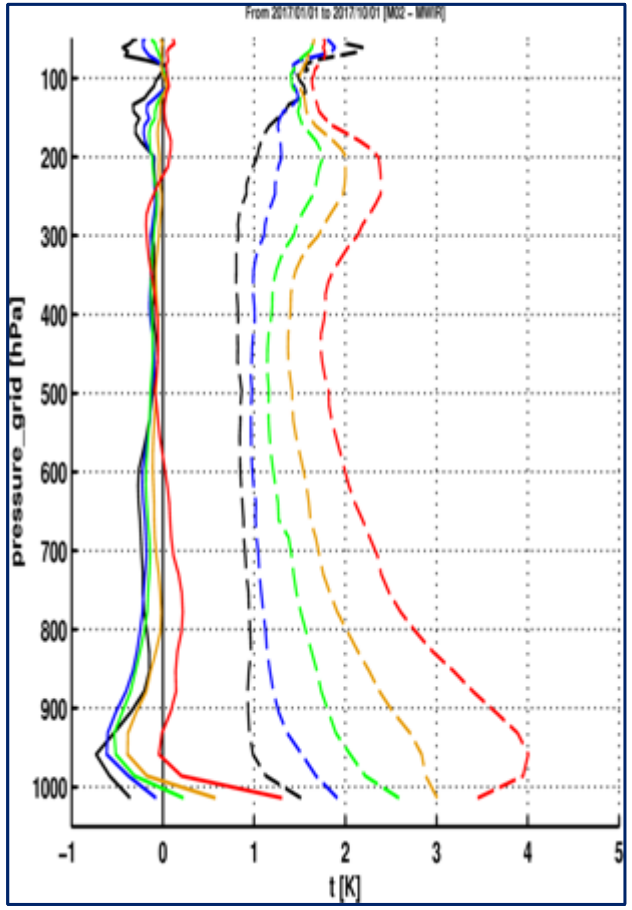
MW+IR



QI T [K]

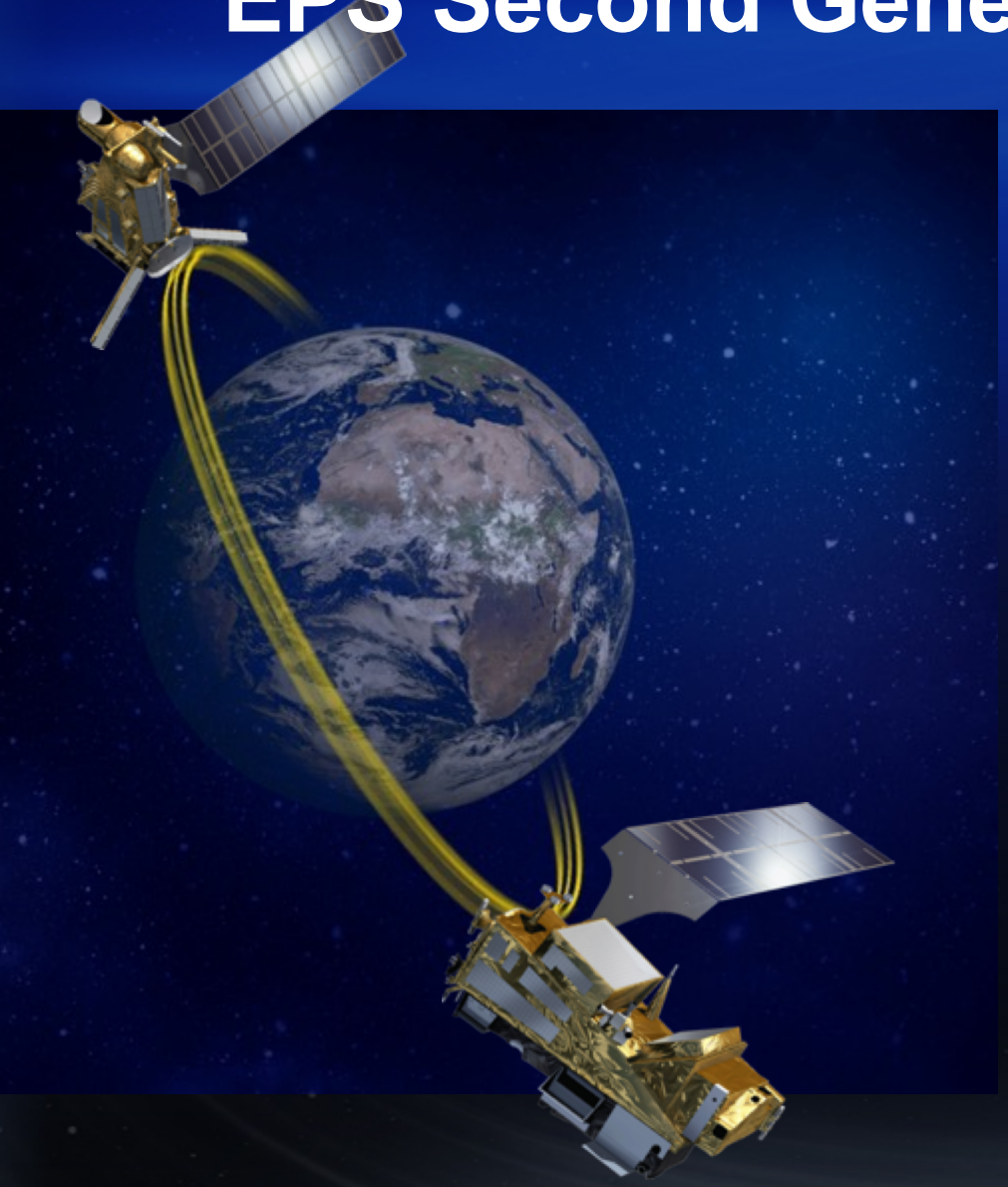
Error estimate in troposphere

MW+IR



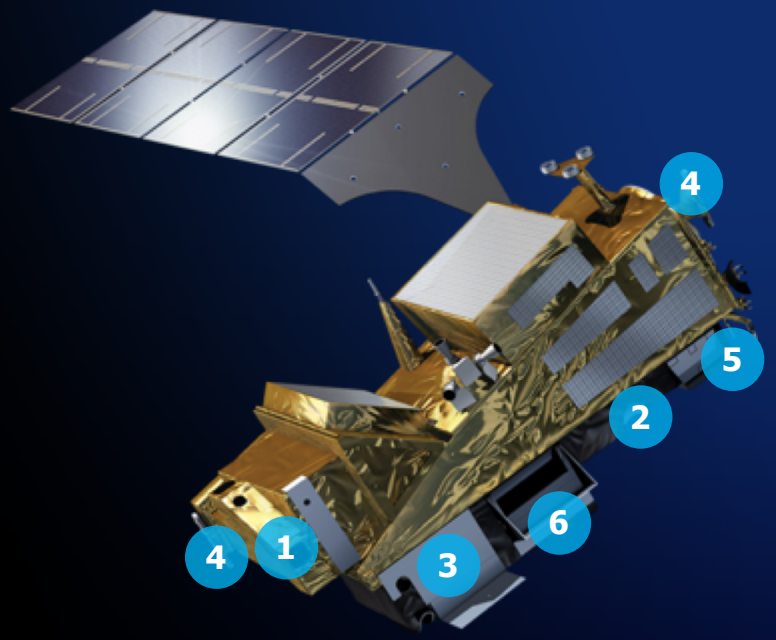
EUMETSAT Polar System Second generation (EPS-SG): From Initial Joint Polar System to Joint Polar System

EPS Second Generation - continuity beyond 2040



- Major improvements to all EPS observation missions
  - Infrared and microwave sounding (IASI-NG, CNES, MWS, ESA)
  - Optical imagery (METImage, developed by DLR)
  - Scatterometer (SCA, ESA)
  - Radio occultation (RO, ESA)
  - UVN Spectrometer (Copernicus Sentinel-5)
- New imagery missions:
  - 3MI: first operational imaging polarimeter
  - MWI: microwave imagery of precipitation
  - ICI: Ice Cloud imagery
- Two satellite System:
  - Metop-SG-A: Sounding and Imaging
  - Metop-SG-B: Microwave imaging and Scatterometry

EPS-SG A sounding and imagery mission



1. **IASI-NG**
   Infrared Atmospheric Sounding
2. **MWS**
   Microwave Sounding
3. **METImage**
   Visible-Infrared Imaging
4. **RO**
   Radio Occultation
5. **3MI**
   Multi-viewing, -channel, -polarisation Imaging
6. **Copernicus Sentinel-5**
   UN/VIS/NIR/SWIR Sounding

EPS-SG B microwave imagery mission

1. **SCA**
   Scatterometer
2. **RO**
   Radio Occultation
3. **MWI**
   Microwave Imaging for Precipitation
4. **ICI**
   Ice Cloud Imager
5. **ARGOS-4**
   Advanced Data Collection System

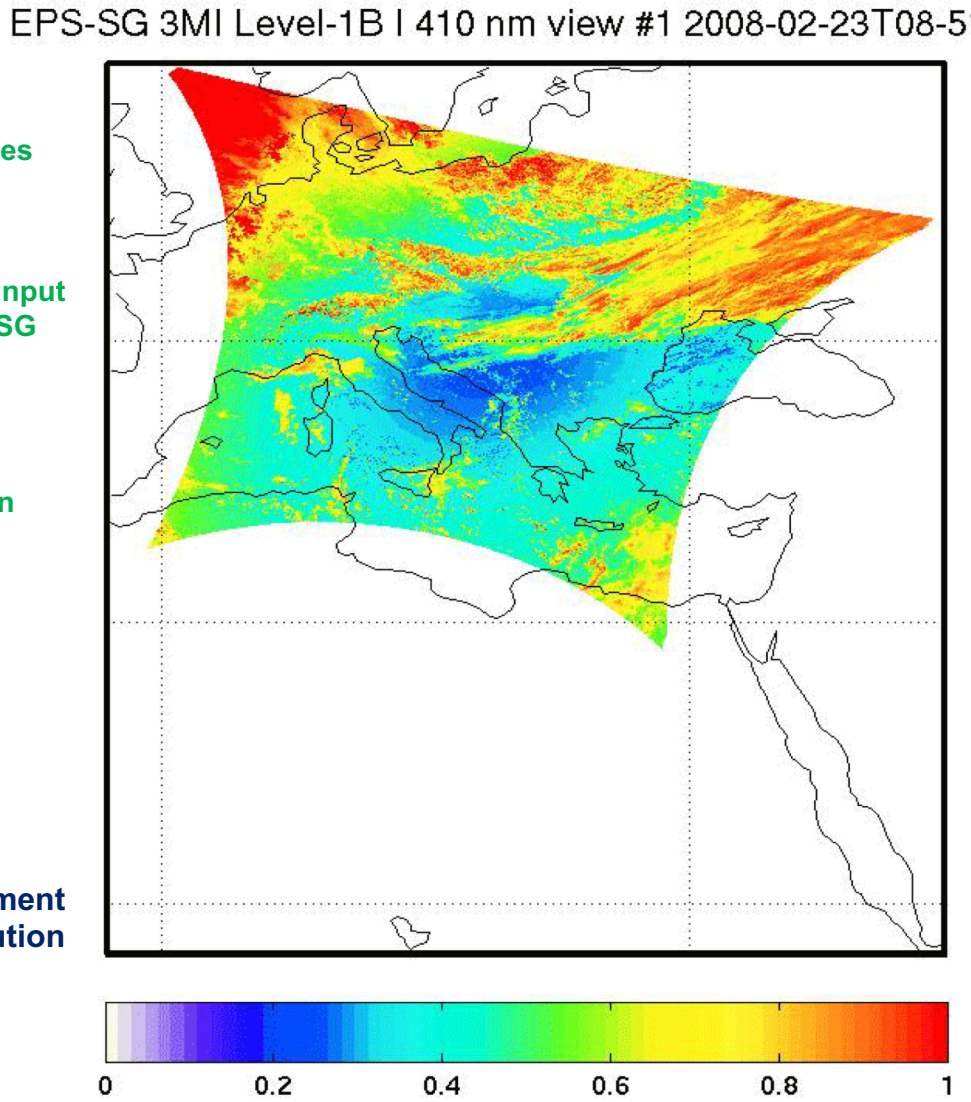
EPS-SG 3MI from L1b to L1C prototype results

Level-1B
Reflectances
410 nm
14 views

Test-Data input from EPS-SG VII/3MI TDS study

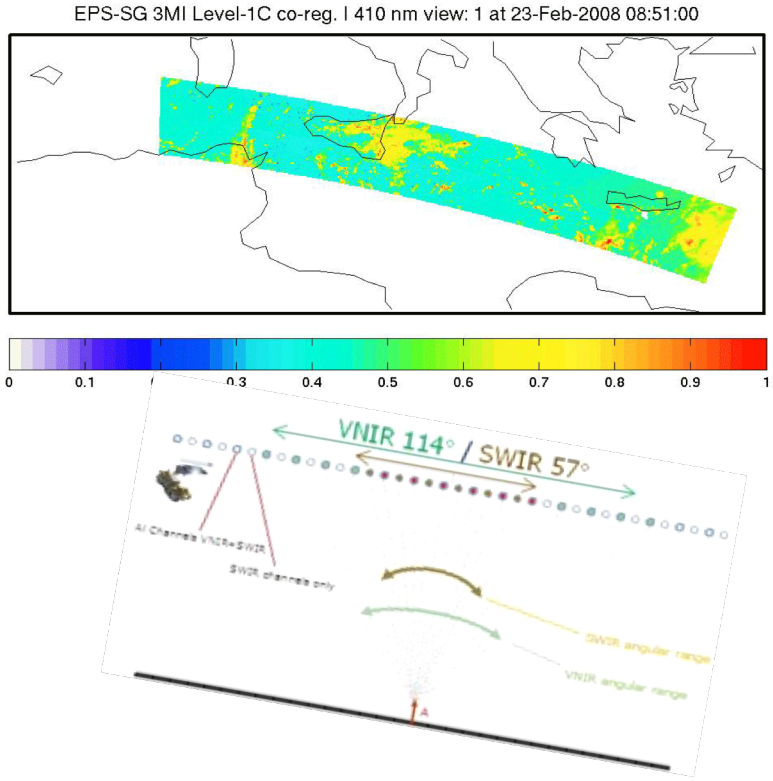
LOA/ Univ. Berlin

Instrument resolution



Level-1C
Reflectances
410 nm
14 views

Co-registered to sinusoidal fixed grid



EUMETSAT

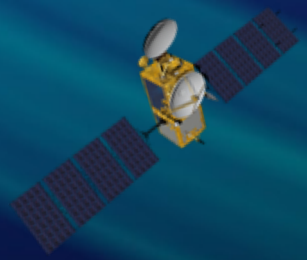
EUMETSAT Programmes

Optional Programmes

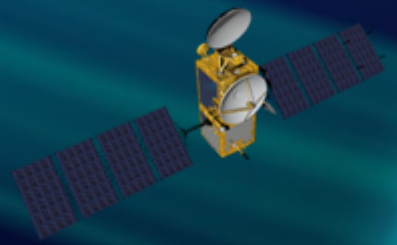
Cooperative Jason missions

TOPEX-POSEIDON
1992-2006

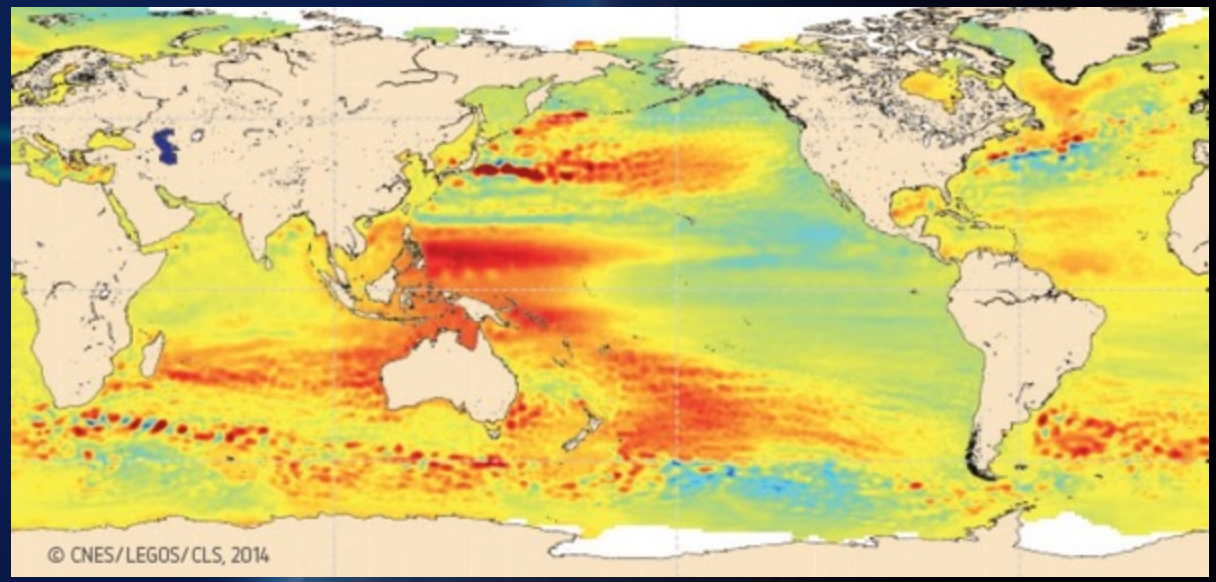
JASON-1
2001

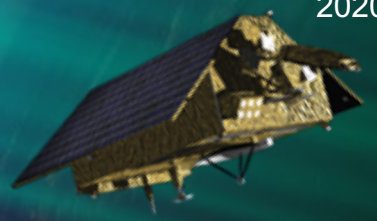


OSTM/JASON-2
2008



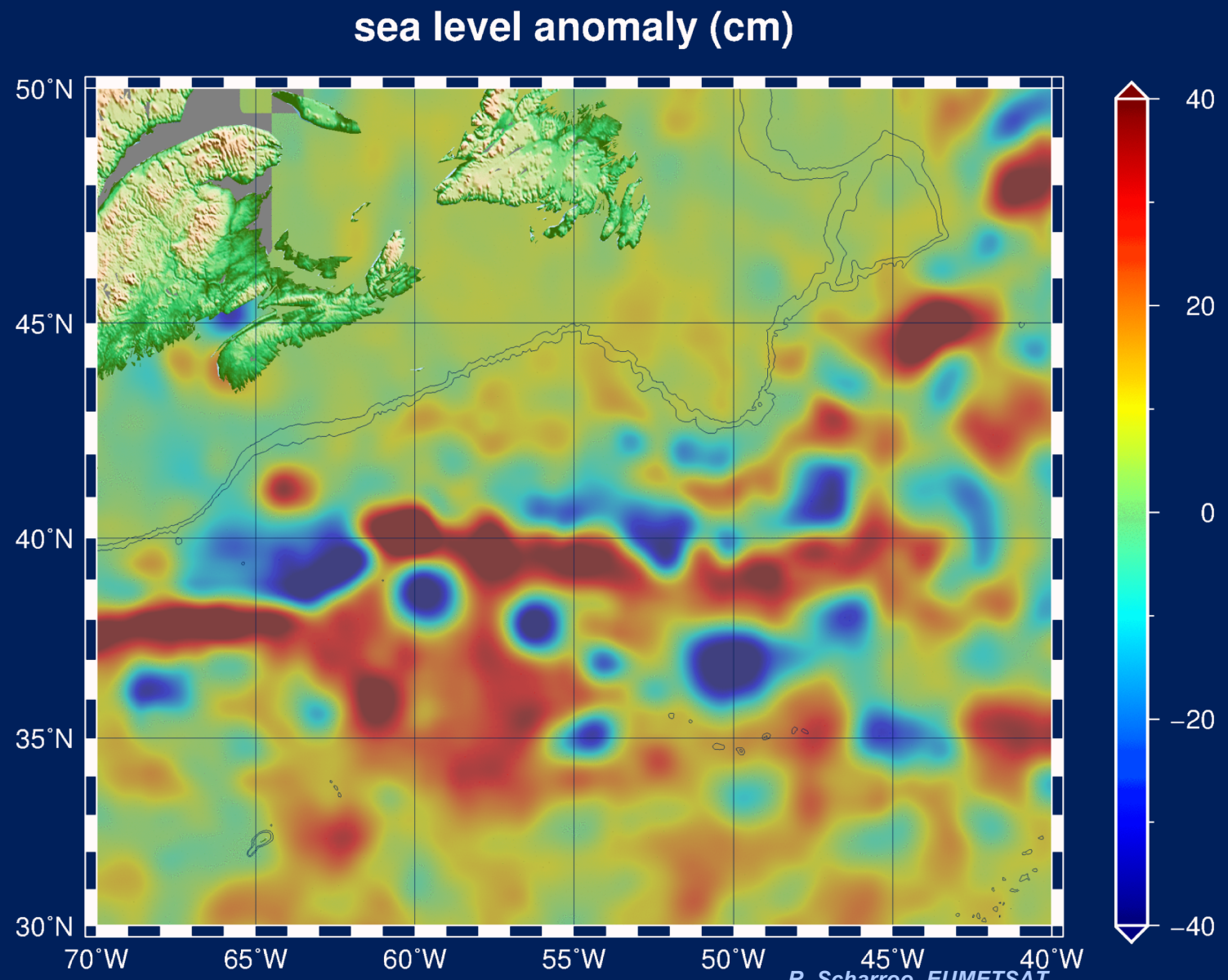
JASON-3
2016



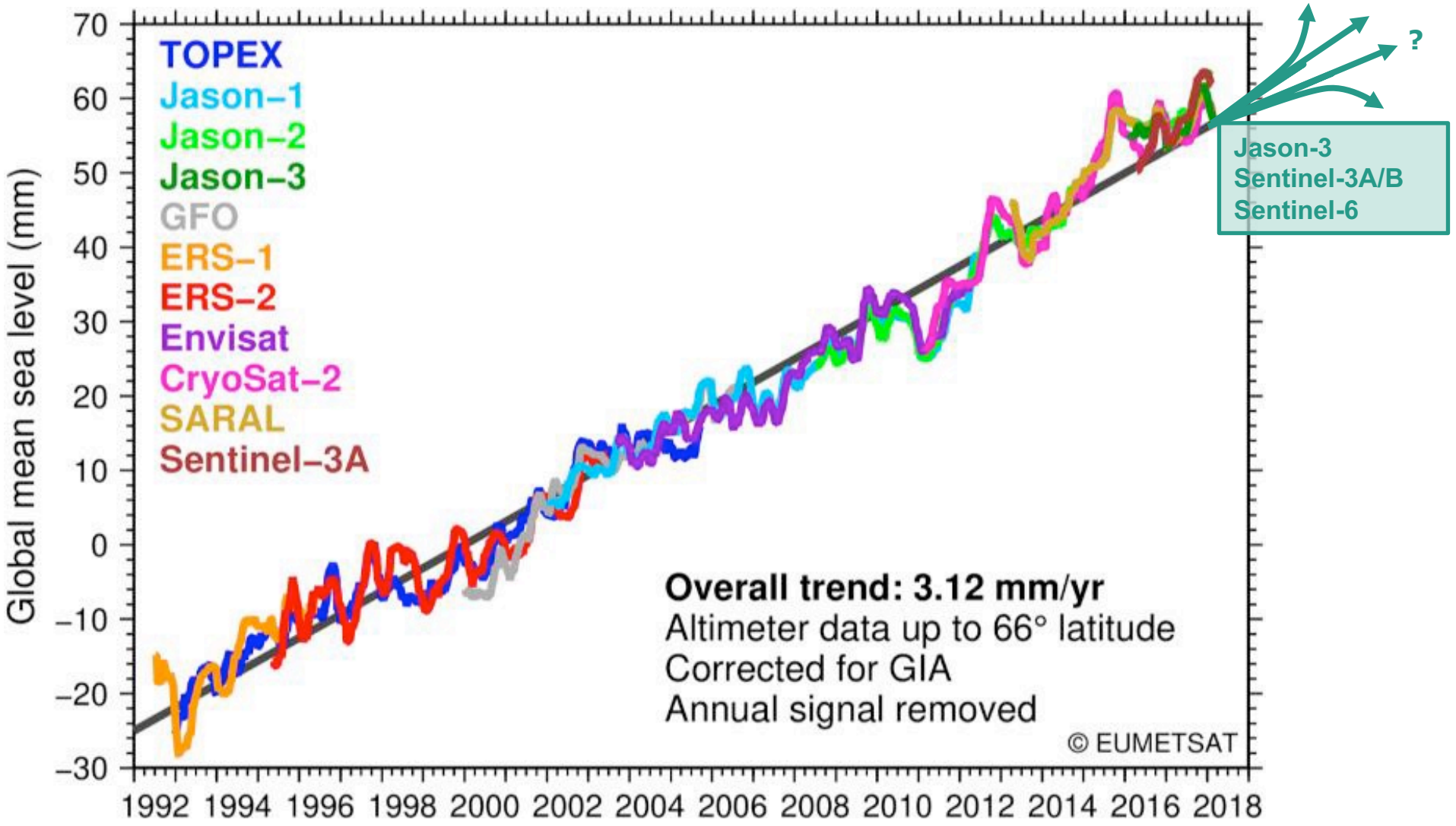


SENTINEL-6/JASON-CS
2020

Sea Surface Topography: six mission are operational and interoperable by using the same QA tools



Allowing for a multi-satellite Sea Level Rise Estimate



EUMETSAT and Copernicus

Third party programmes in support of Copernicus

YEAR... 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

METEOSAT THIRD GENERATION

MTG-S-1: SOUNDING

MTG-S-2: SOUNDING

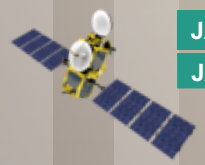
SENTINEL-4 on MTG-S

EUMETSAT POLAR SYSTEM SECOND GENERATION (EPS-SG)

METOP-SG A: SOUNDING AND IMAGERY

SENTINEL-5 on METOP-SG A

Monitoring atmospheric composition

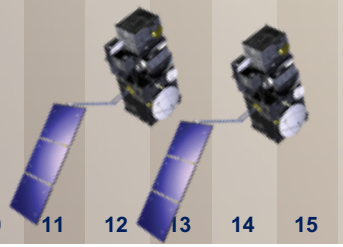


JASON (HIGH PRECISION OCEAN ALTIMETRY)

JASON-2

JASON-3

SENTINEL-6 (JASON-CS)



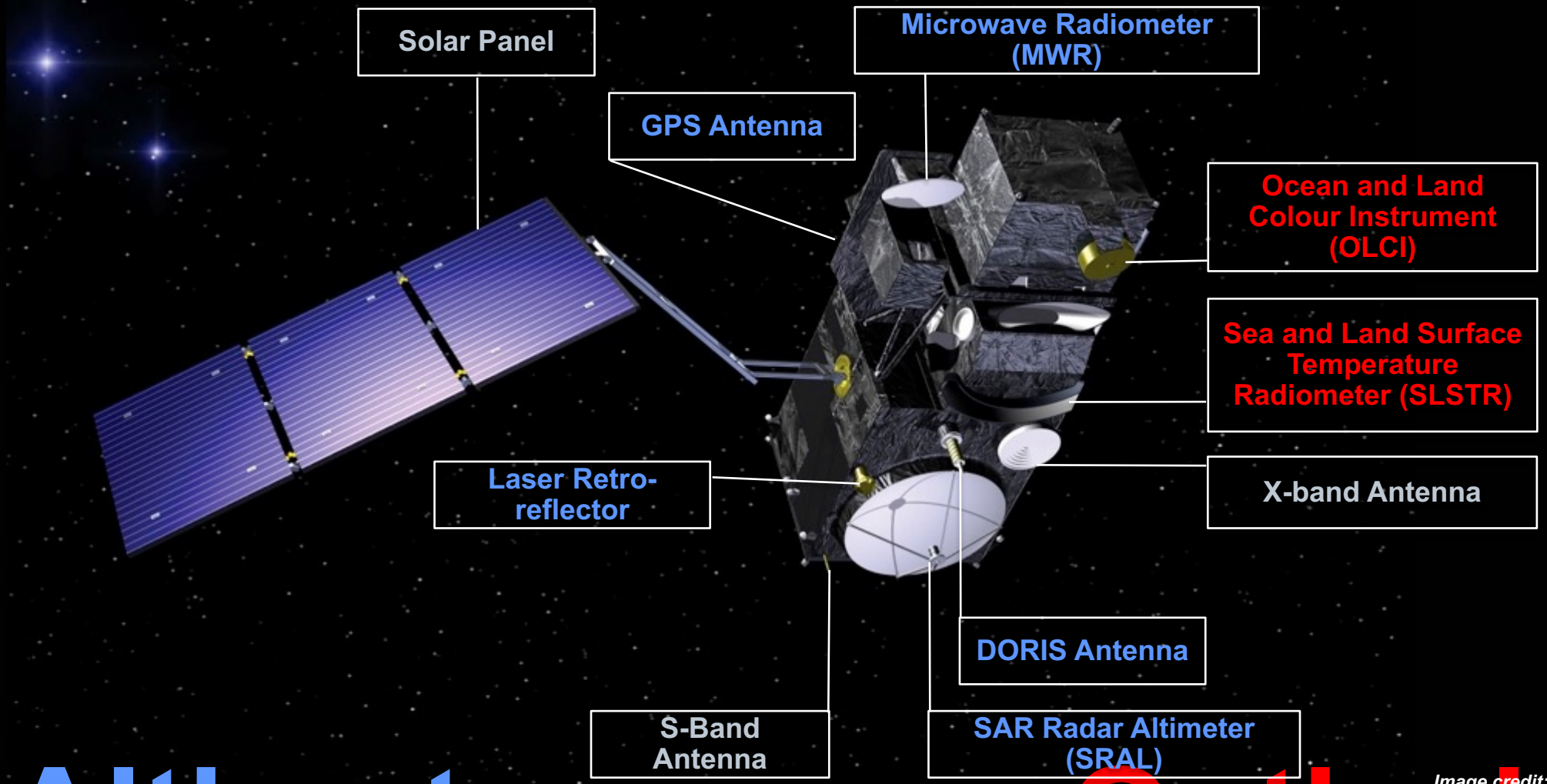
COPERNICUS

SENTINEL-3 A/B/C/D

Monitoring the ocean

YEAR... 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

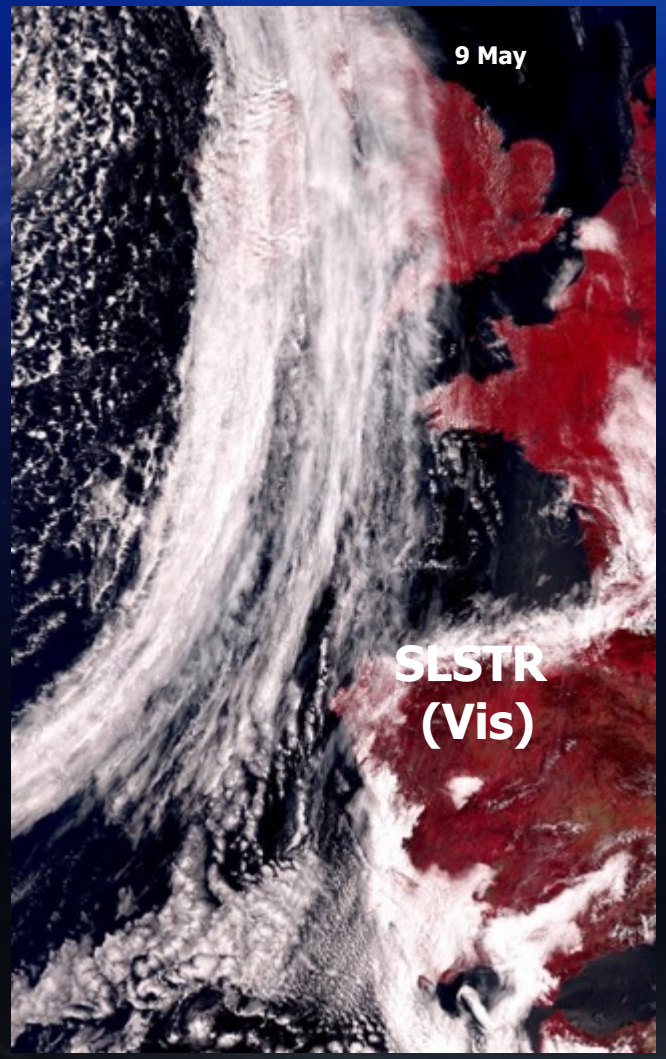
Sentinel-3 satellites: Two Missions

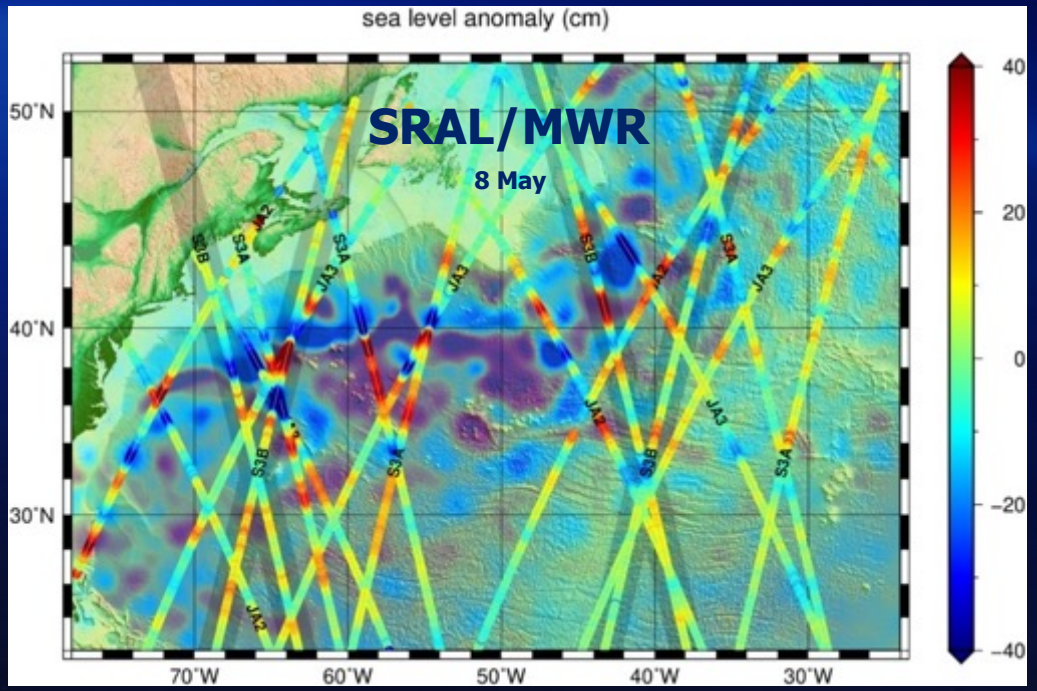


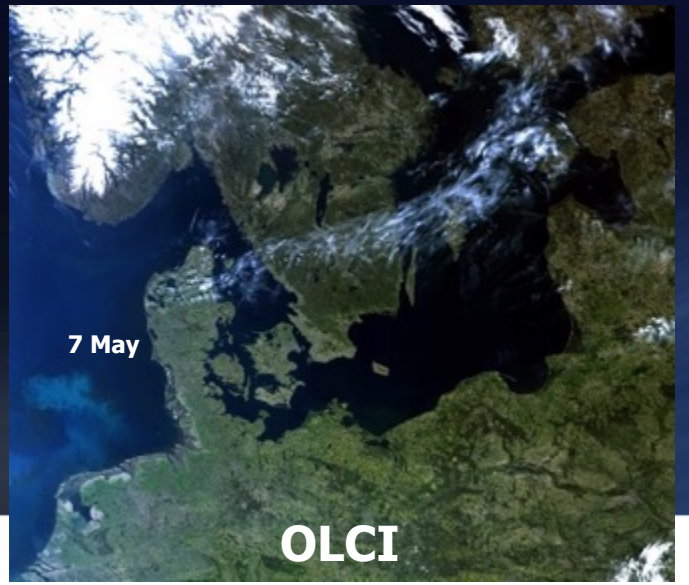
Altimetry **Optical**

Image credit: ESA

Deployment of recurrent satellites: Sentinel-3B (launch: 25/4/2018)
First data/images



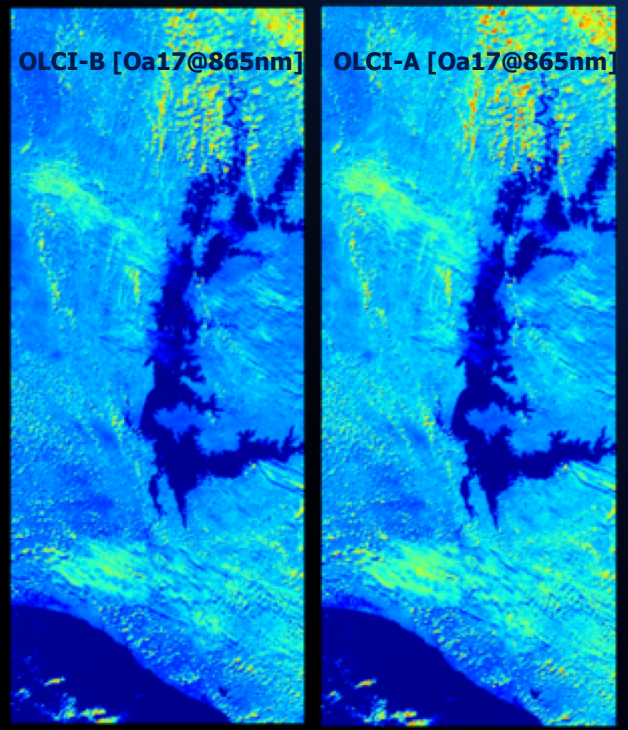


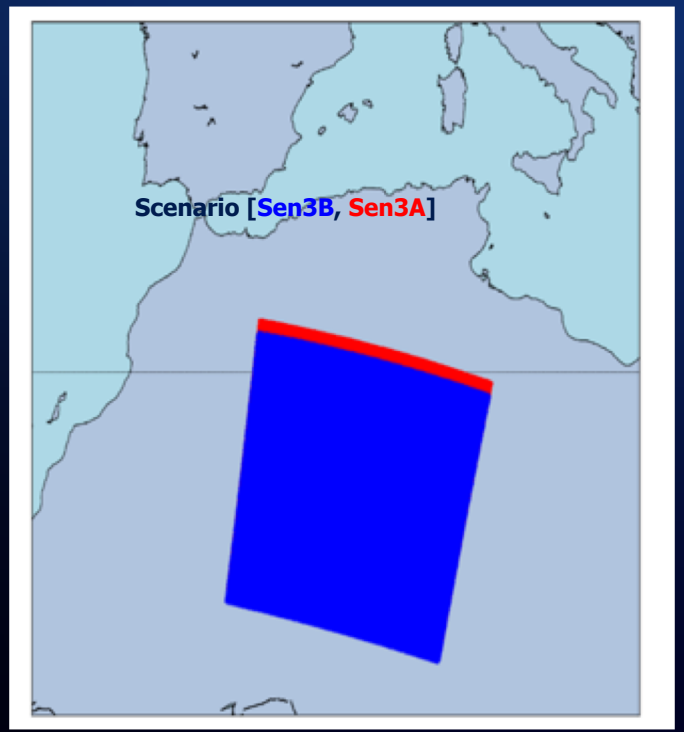


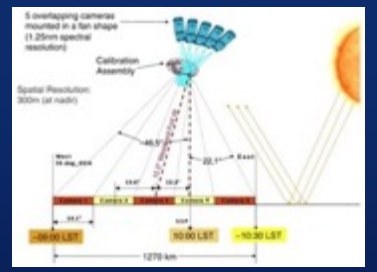
Sentinel-3B commissioning in Tandem with Sentinel-3A

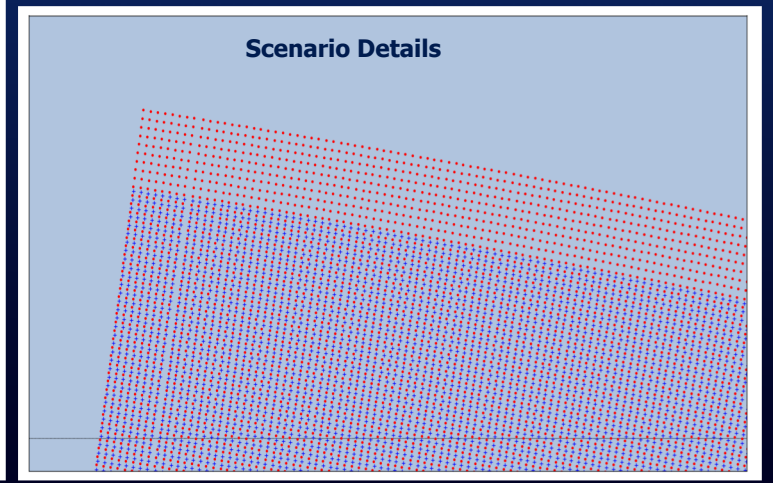
- Sentinel-3A and Sentinel-3B are in “tandem” configuration since June 2018. The two platforms are flying with ~30s separation on the same orbit.

- The main purpose of this configuration is to allow inter-calibration activities



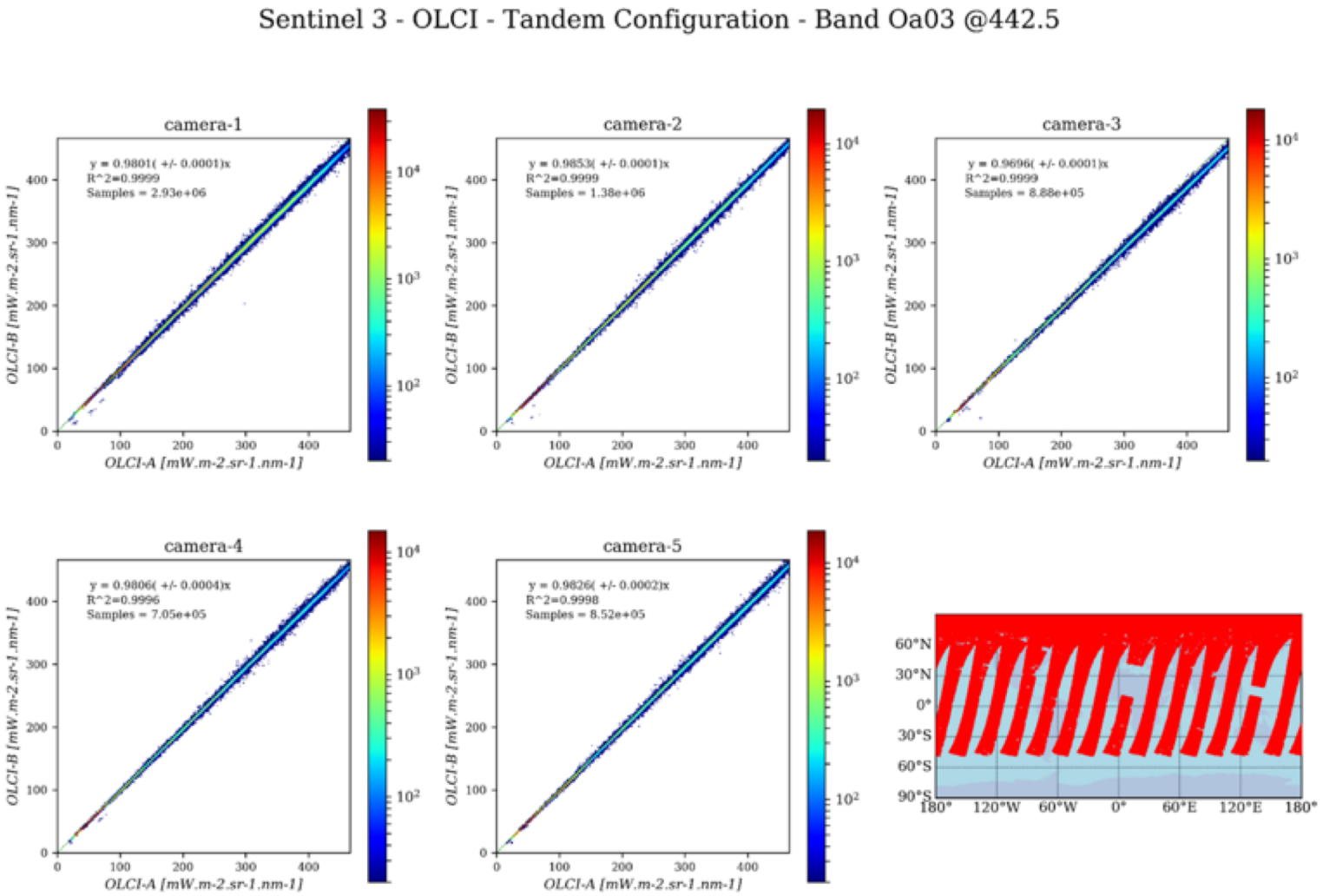






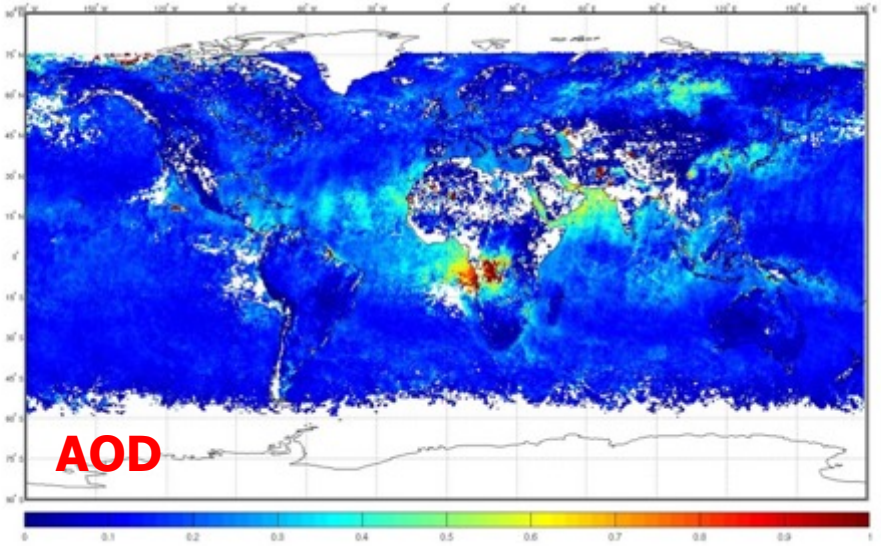
Burini, 2018

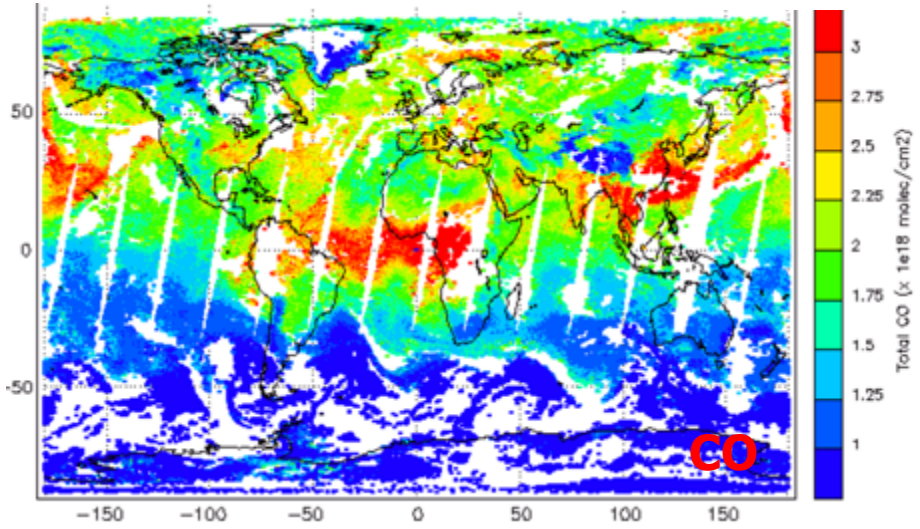
Direct comparison of OLCI-A and OLCI-B in Tandem

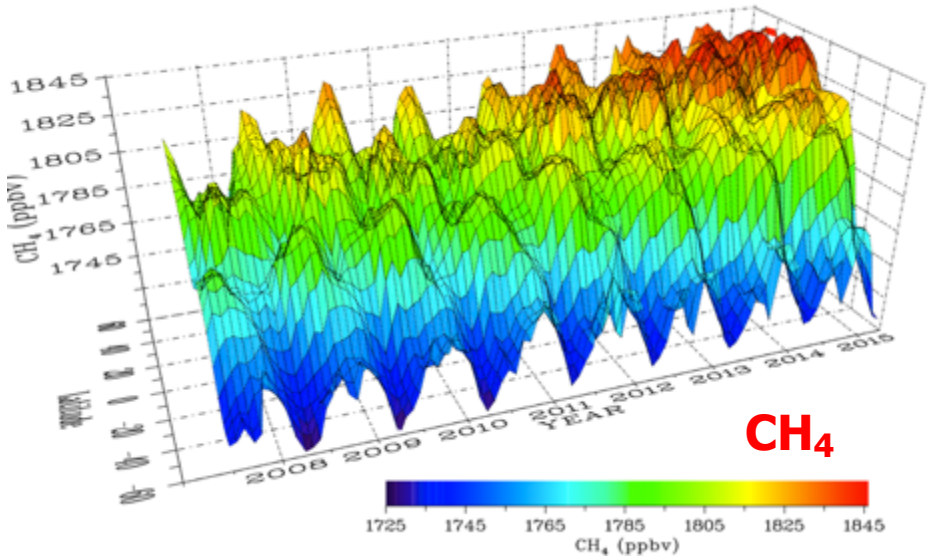


One day of data, 27/06/2018
A. Burinni, EUM

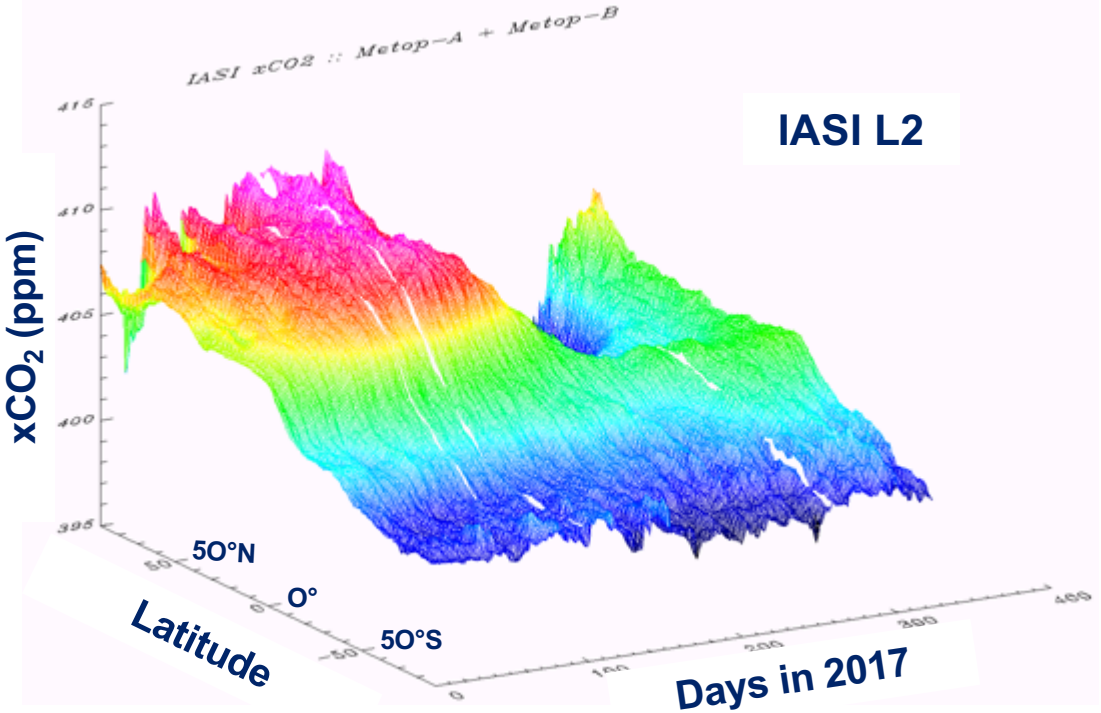
Possible future Copernicus missions: preparing for the CO_2 mission

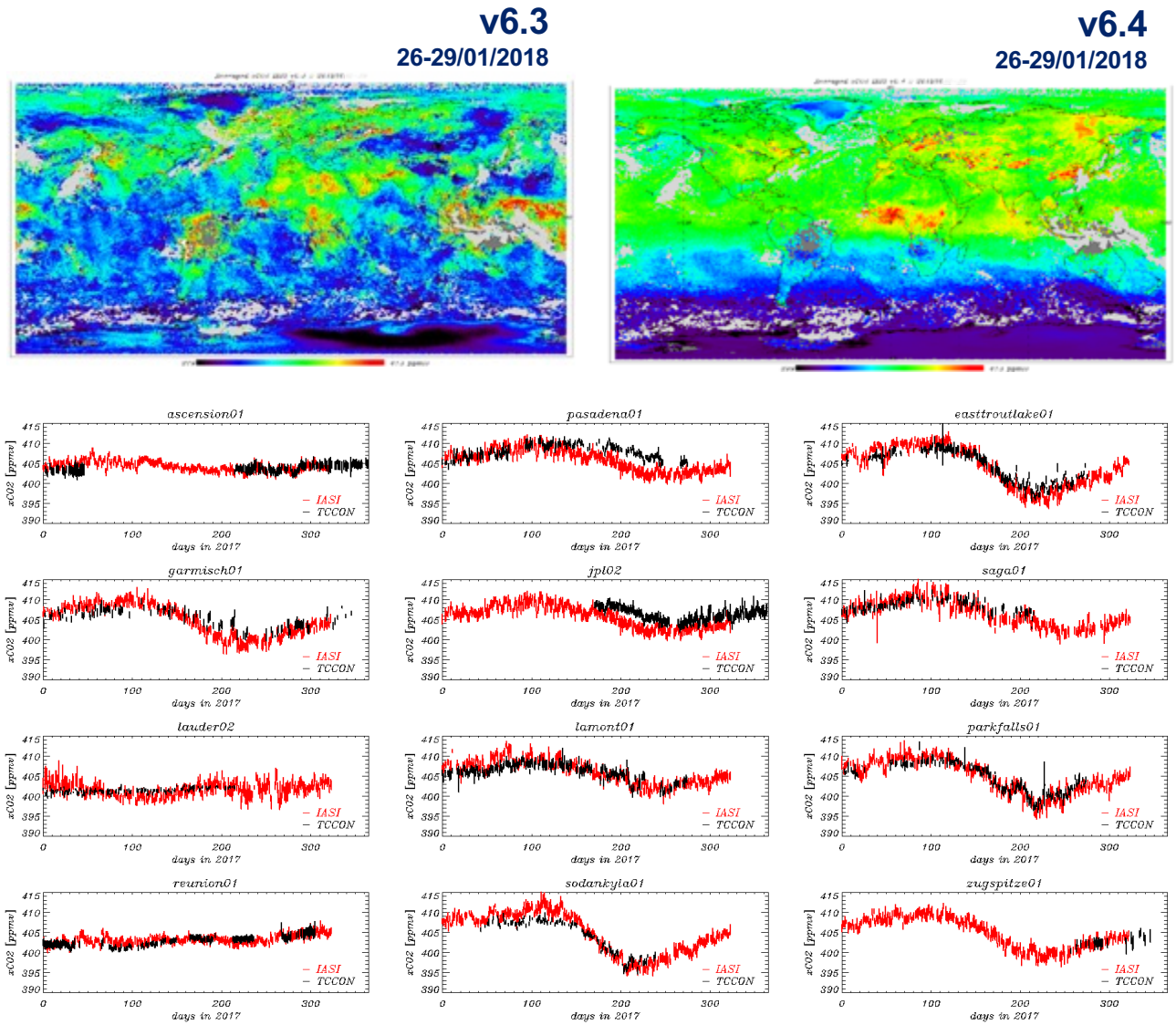






Possible future Copernicus missions: preparing for the CO_2 mission



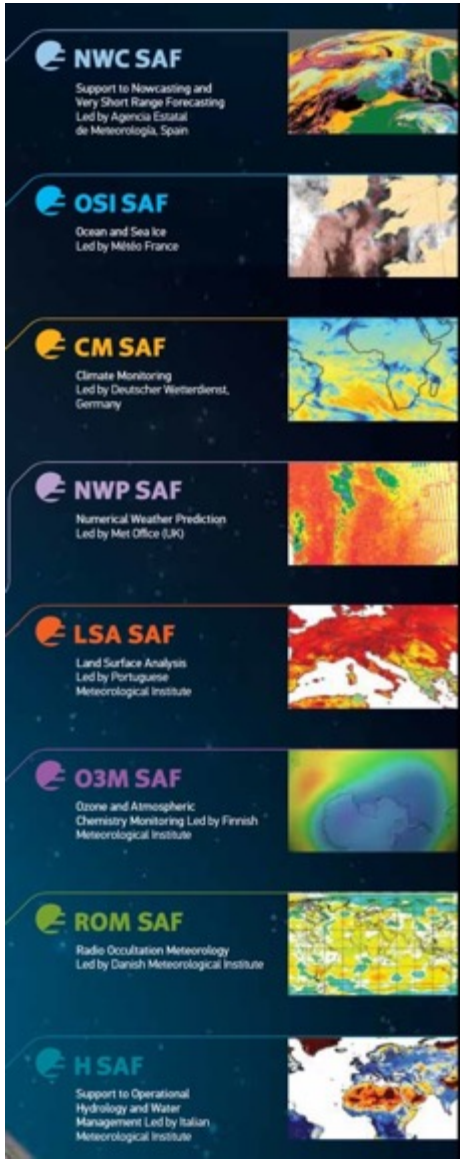


Caveats:

- *xCO_2 is auxiliary data for T & Q retrievals;*
- *These are prototype results compared to TCCON;*
- *A full & systematic validation is required;*
- *Includes some cloudy pixels.*

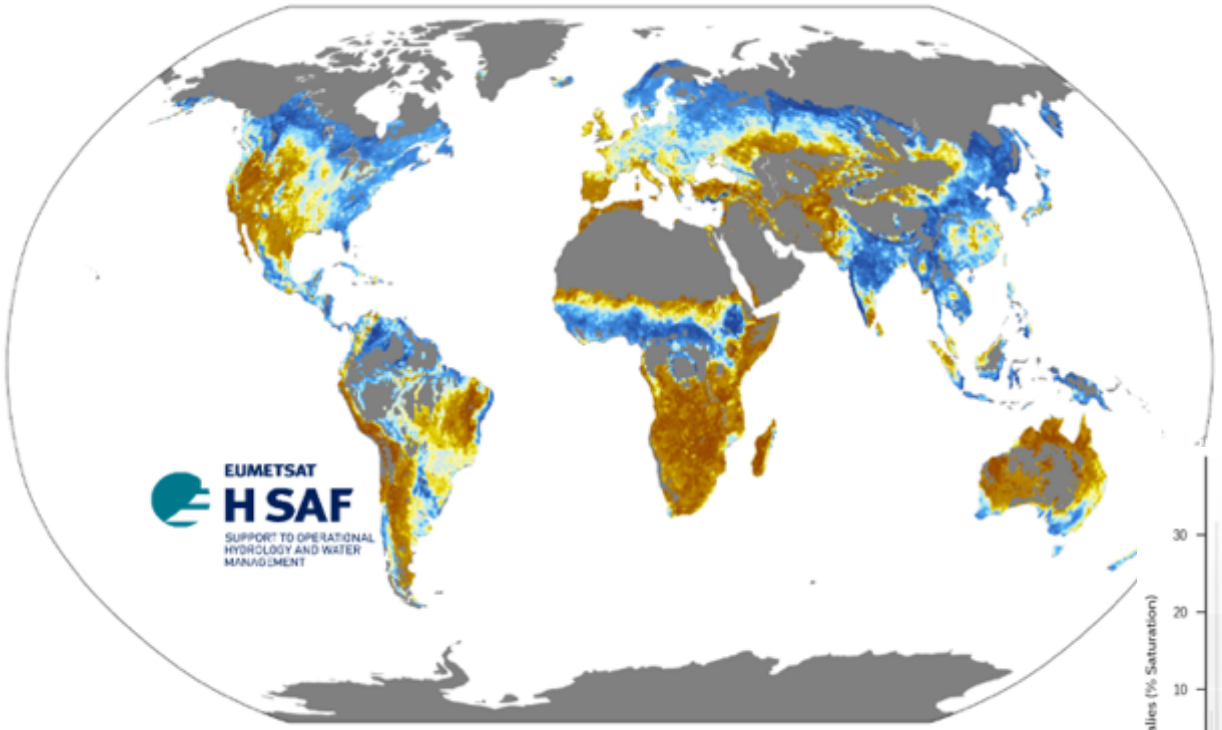
Satellite Application Facilities (SAF)

EUMETSAT SAF network across Europe



H SAF ASCAT Soil Moisture

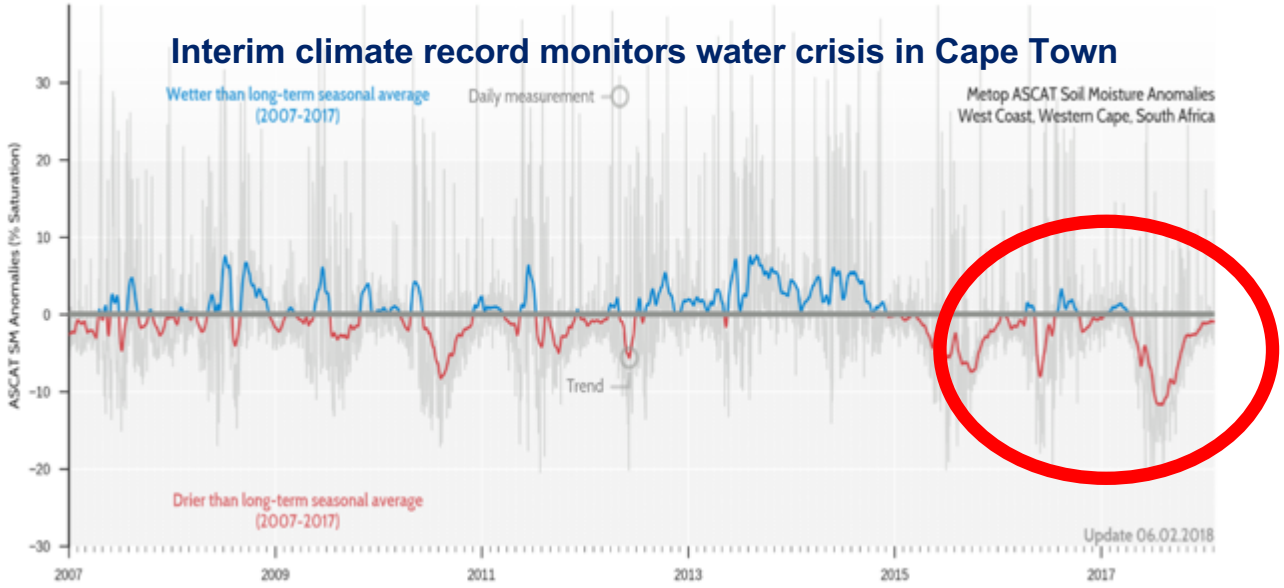
10-year ASCAT soil moisture record at 12.5 km resolution (2007-2017)



Monthly mean of ASCAT soil moisture relative to saturation in July 2013

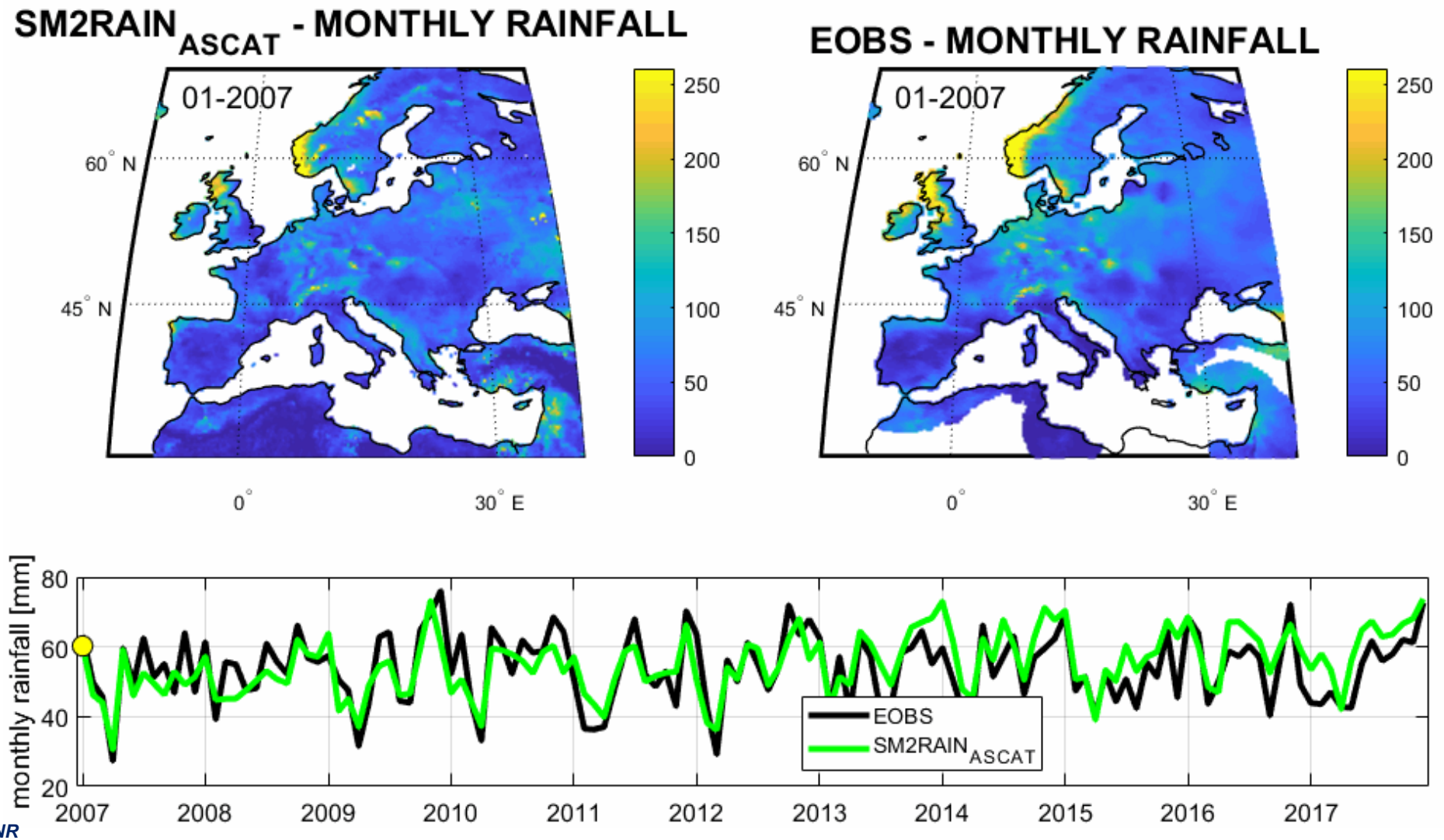
EUMETSAT
H SAF
SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

Interim climate record monitors water crisis in Cape Town



EUMETSAT

The 1st GLOBAL-SM2RAIN rainfall dataset (2007-2017)



Courtesy: Luca Brocca, CNR

Conclusion

Conclusion

- Eumetsat assures the **continuity of mandatory missions** – from today **until 2040+** by current programmes and programmes under development;
- **International cooperation** assures the availability of **Third party data** for member states;
- Looking into **further missions** according to the EUMETSAT strategy.

Thank you for your attention!