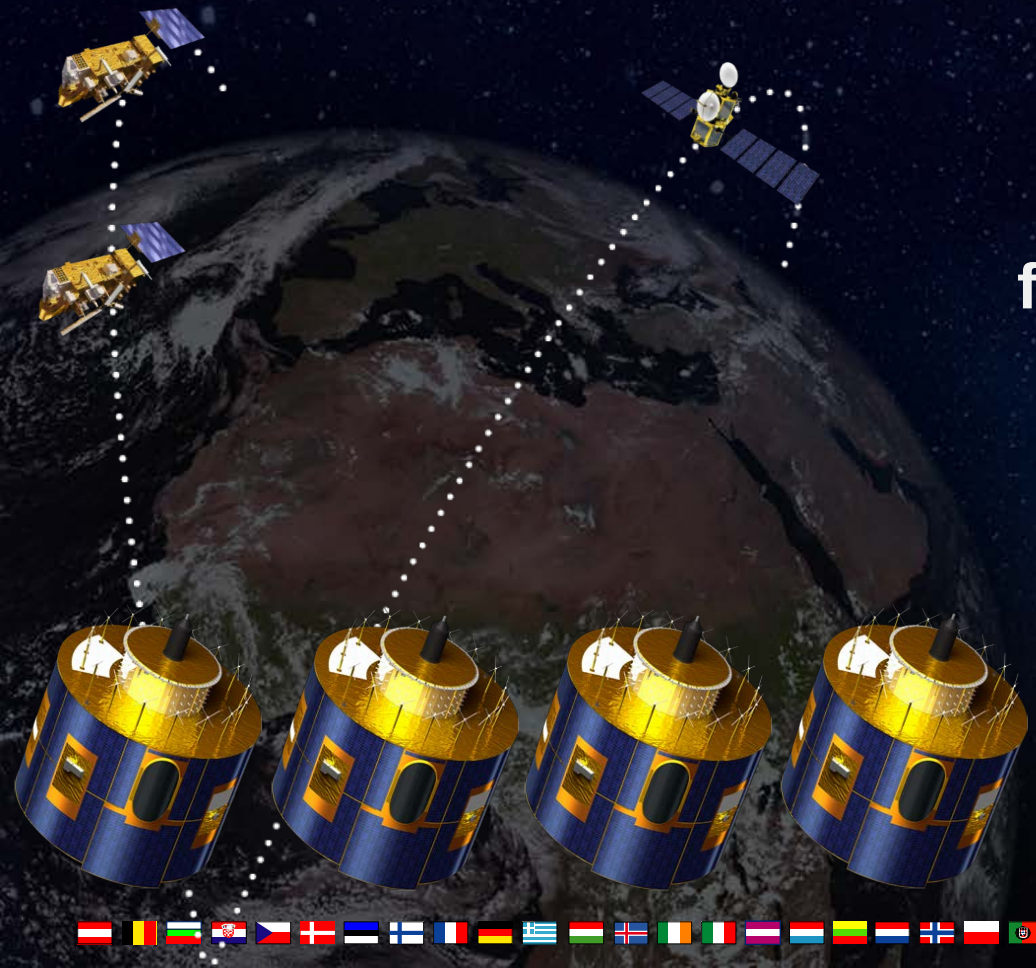
THE EUMETSAT SATELLITE PROGRAMMES

AN OVERVIEW FROM NOW TO THE FUTURE

EUMETSAT



Kenneth Holmlund
EUMETSAT
And many other contributors from EUMETSAT and its partners

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)

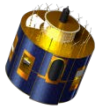
TWO-SATELLITE SYSTEM:
- MSG-4 (METEOSAT-11) under commissioning

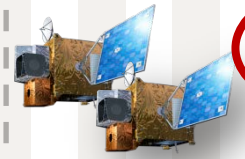
- METEOSAT-10: FULL DISK IMAGERY MISSION AT 0° (15 MN)
- METEOSAT-9: RAPID SCAN SERVICE OVER EUROPE AT 9.5°E (5 MN)
- METEOSAT- 8: BACK UP AT 3.5°E

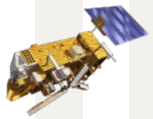
METEOSAT – 7 (1st GENERATION)
(GEOSTATIONARY ORBIT)

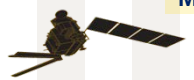
INDIAN OCEAN DATA COVERAGE MISSION
AT 57°5 E (UNTIL END 2016)

EUMETSAT programmes overview









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 FIRST GENERATION

METEOSAT-7

METEOSAT SECOND GENERATION

METEOSAT-8 …Extended lifetime .....

METEOSAT-9 …Extended lifetime .....

METEOSAT-10 …Extended lifetime ...

MSG-4/METEOSAT-11 ....

New dates
First launch 2020

METEOSAT THIRD GENERATION

MTG-I-1 : IMAGERY

MTG-S-1: SOUNDING

MTG-I-2: IMAGERY

MTG-I-3: IMAGERY

MTG-S-2: SOUNDING

MTG-I-4: IMAGERY

Mandatory Programmes

EUMETSAT POLAR SYSTEM (EPS)

METOP-A …Extended lifetime .....

METOP-B …Extended lifetime .....

METOP-C …Extended lifetime .....

METOP SECOND GENERATION

METOP-SG-A1

METOP-SG-B1

METOP-SG-A2

METOP-SG-B2

METOP-SG-A3

METOP-SG-B3

Operational Development

JASON

JASON-2

JASON-3

JASON CONTINUITY OF SERVICE (JASON-CS)

Optional and Third Party Programmes

COPERNICUS

SENTINEL-3

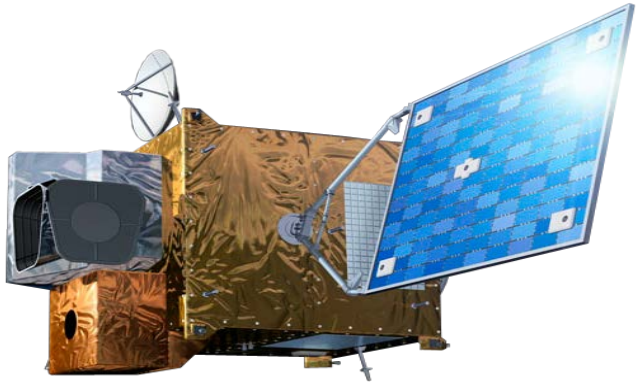
SENTINEL-4 ON MTG-S

SENTINEL-5 ON EPS-SG

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

EUMETSAT

Future programmes shape the 2020 – 2040 timeframe



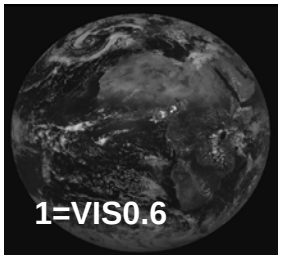
MTG: Approved, under development
Sentinel-4 approved (funded by Copernicus)

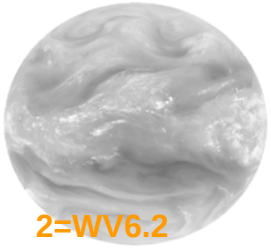
Jason-CS/Sentinel-6:
Approval process ongoing

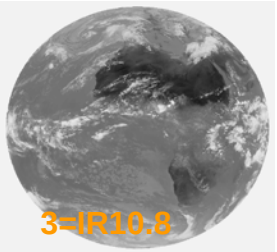
EPS-SG: Approved, under development
Sentinel-5 approved (funded by Copernicus)

From MVIRI on MTP...

Meteosat-7 is the last
Located over
- **Indian Ocean**
- **until end of 2016**







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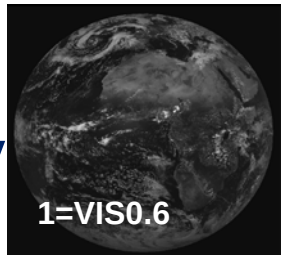
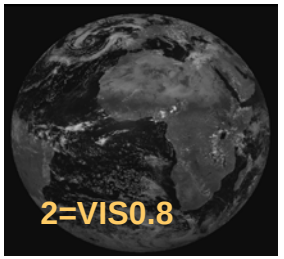
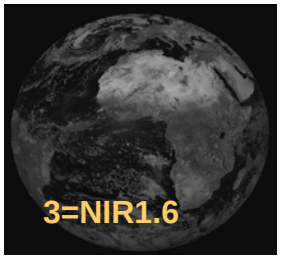
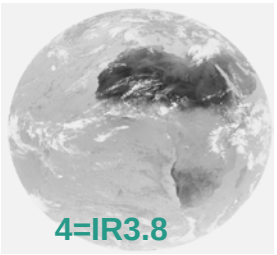
From MVIRI on MTP to SEVIRI on MSG...

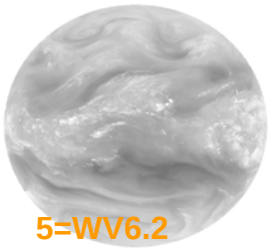
MSG-4 (Meteosat-11)
- is the last
- in-orbit storage 2.5 y
Indian Ocean Data is coverage is considered using Meteosat-8

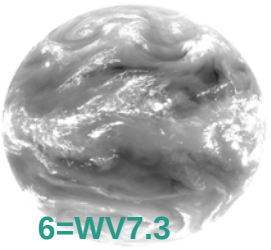


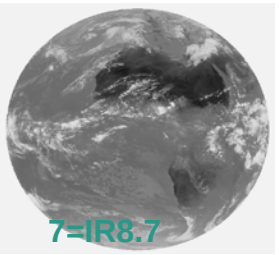


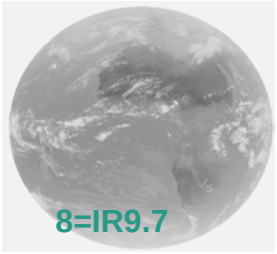


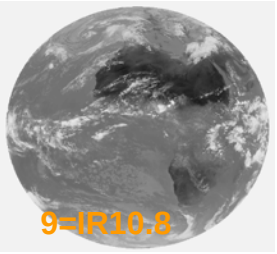


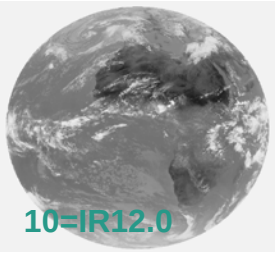


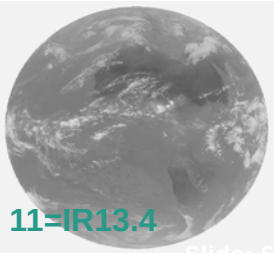






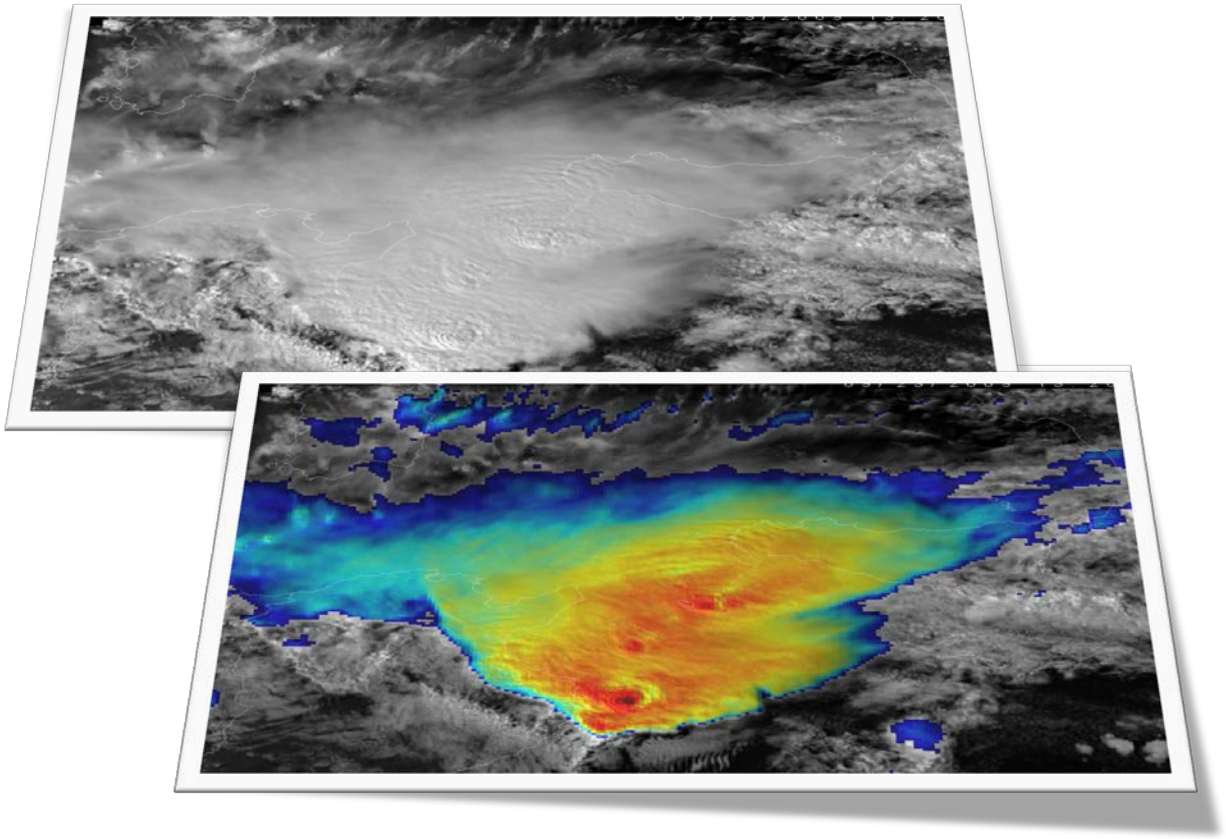




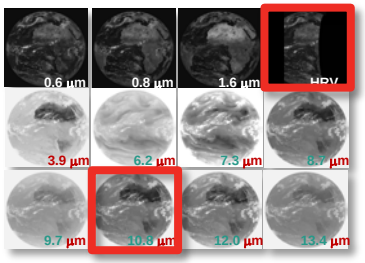


EUMETSAT

Visual Analysis: Monitoring Stages of Convection



23. September 2009
Mediterranean Sea



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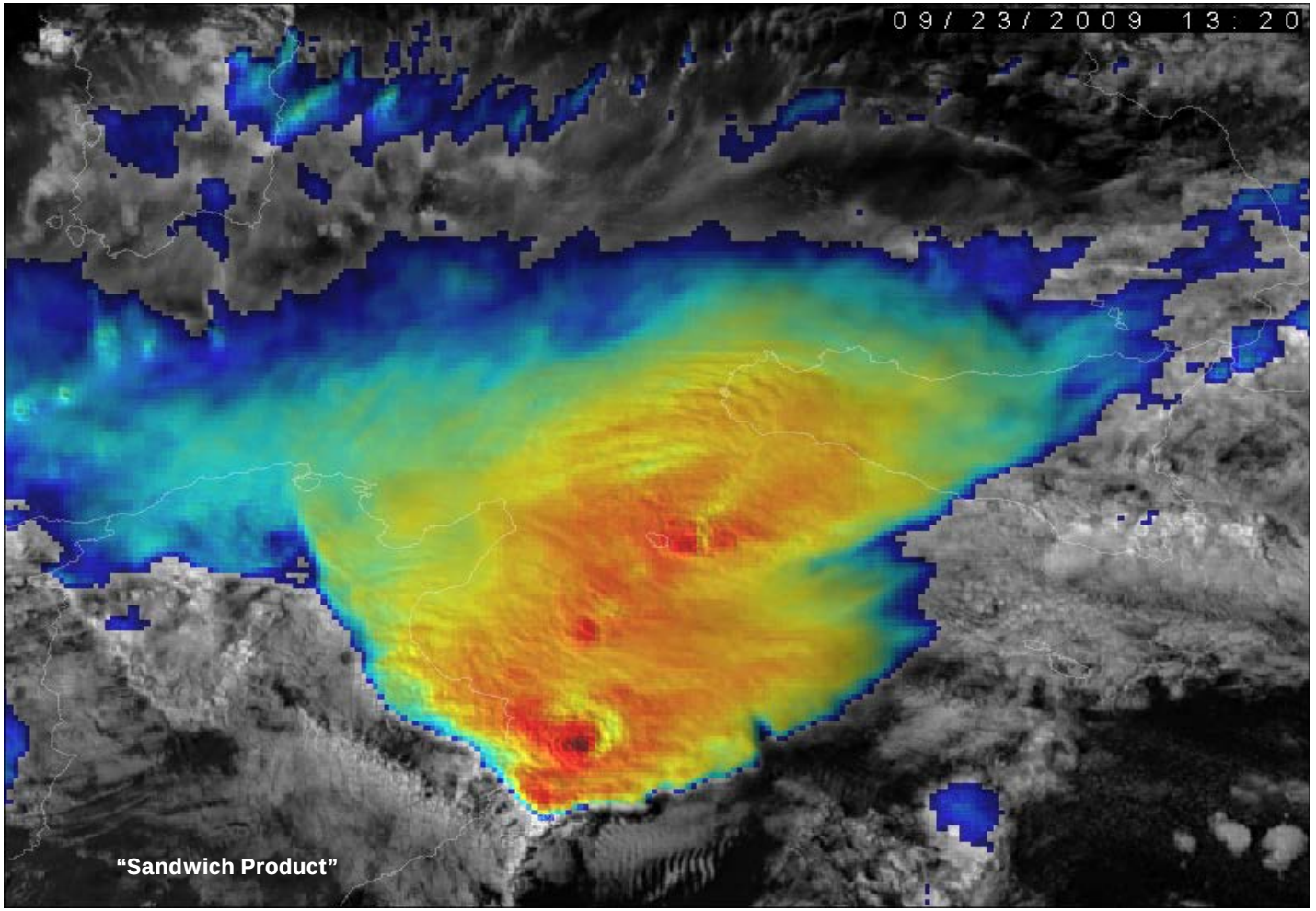
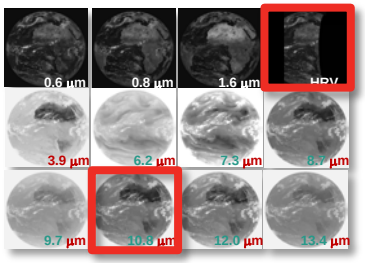
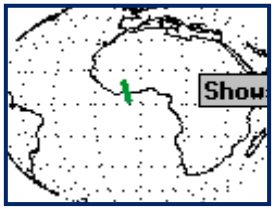
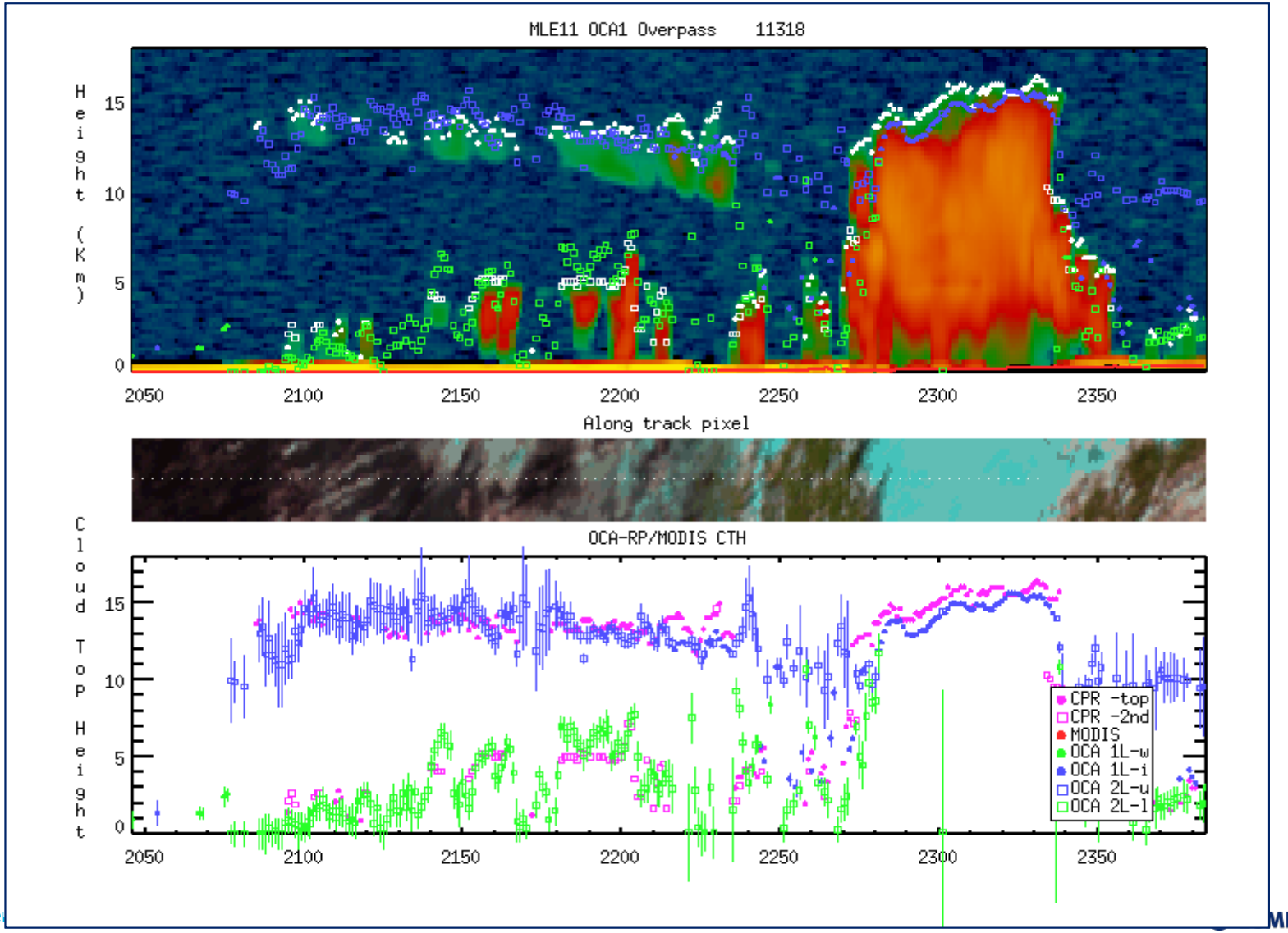




EUMETSAT

Cloud Processor Optimal Estimation : 2-layer cloud retrievals

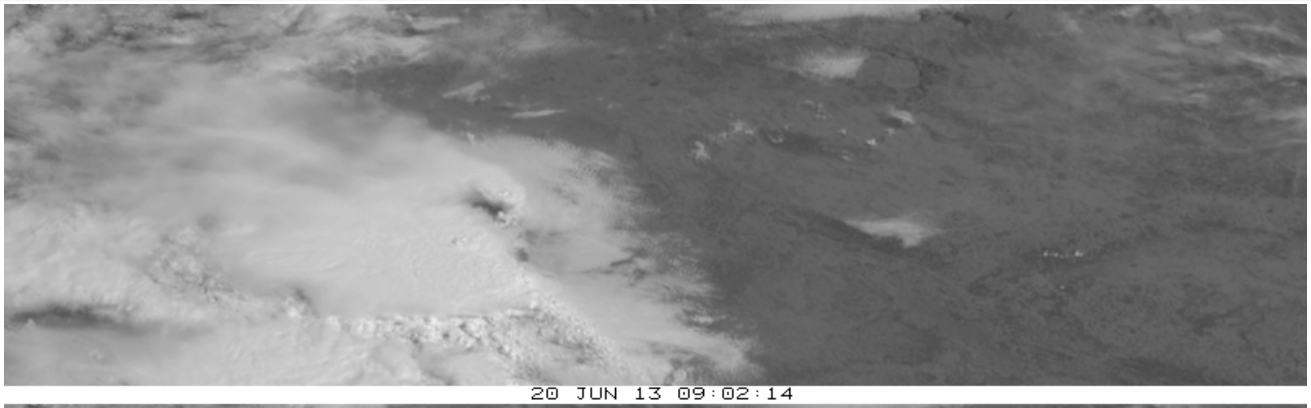




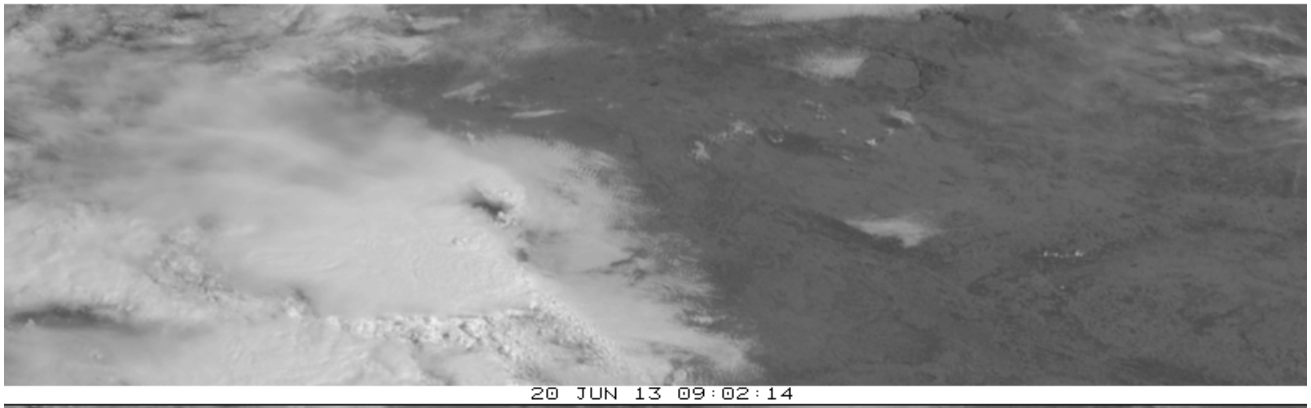
METSAT

Met-8 super-rapid scans 2.5 min experiment

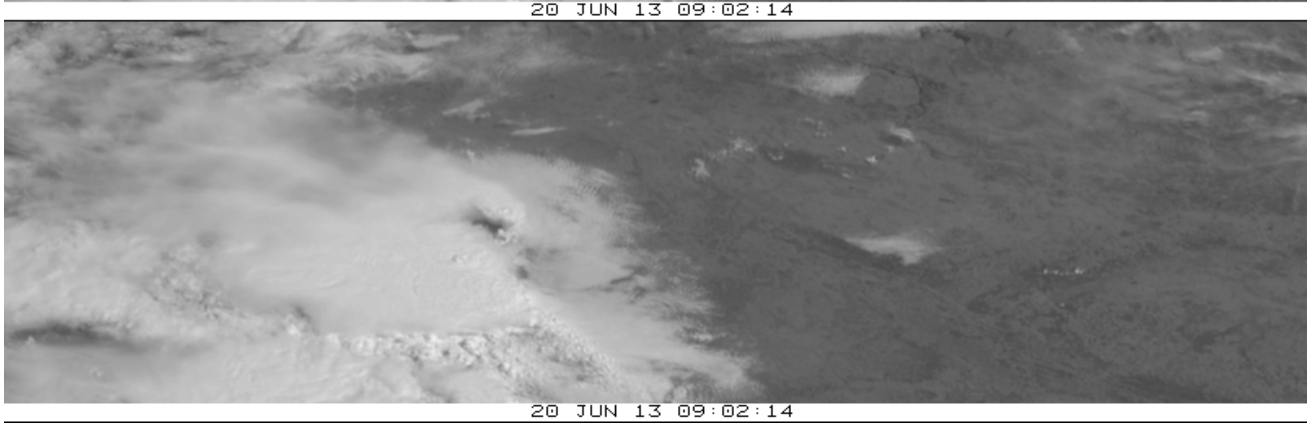
2.5 minutes Repeat Cycle



5 minutes Repeat Cycle



15 minutes Repeat Cycle



EUMETSAT

Meteosat Third Generation: Mission overview

- Imagery mission implemented by a two-satellite MTG-I system:
  1. Full disk imagery every 10 minutes in 16 spectral bands
  2. Fast imaging of European weather every 2.5 minutes
  3. Lightning Imager (LI)
- Hyperspectral Infrared (IRS) Sounding mission:
  4. 3D mapping of water vapour, temperature, O3 every 1 hour
  5. Air quality monitoring and atmospheric chemistry in synergy with Sentinel-4 Ultraviolet Visible
- start of operations in 2021 and 2023
- operational exploitation: 2020 – 2040

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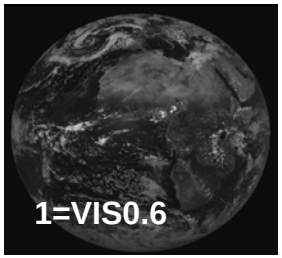

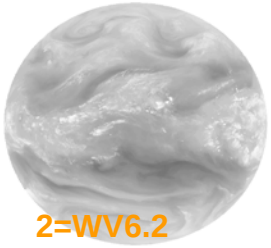

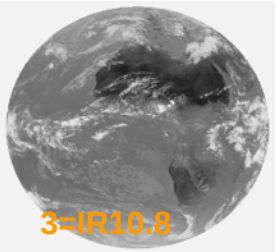

EUMETSAT

From MVIRI on MTP to SEVIRI on MSG...

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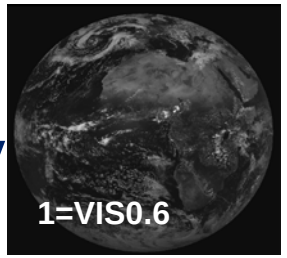
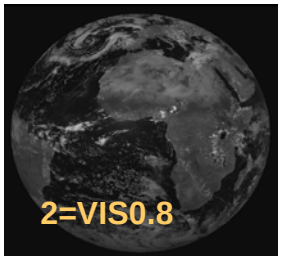
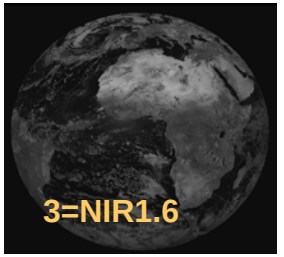
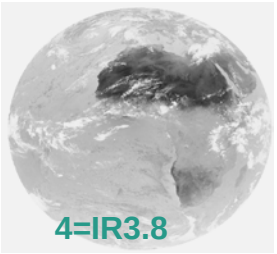
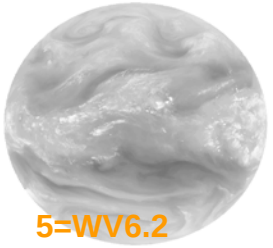
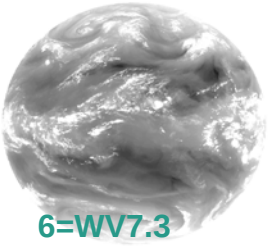


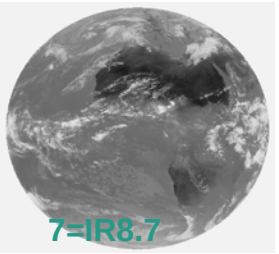


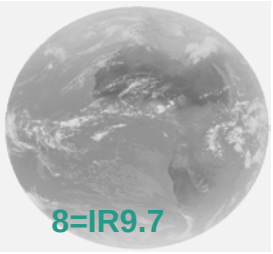


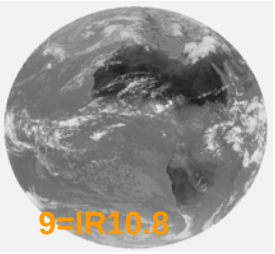


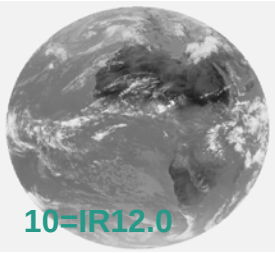


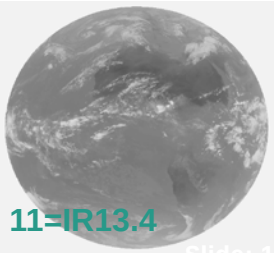






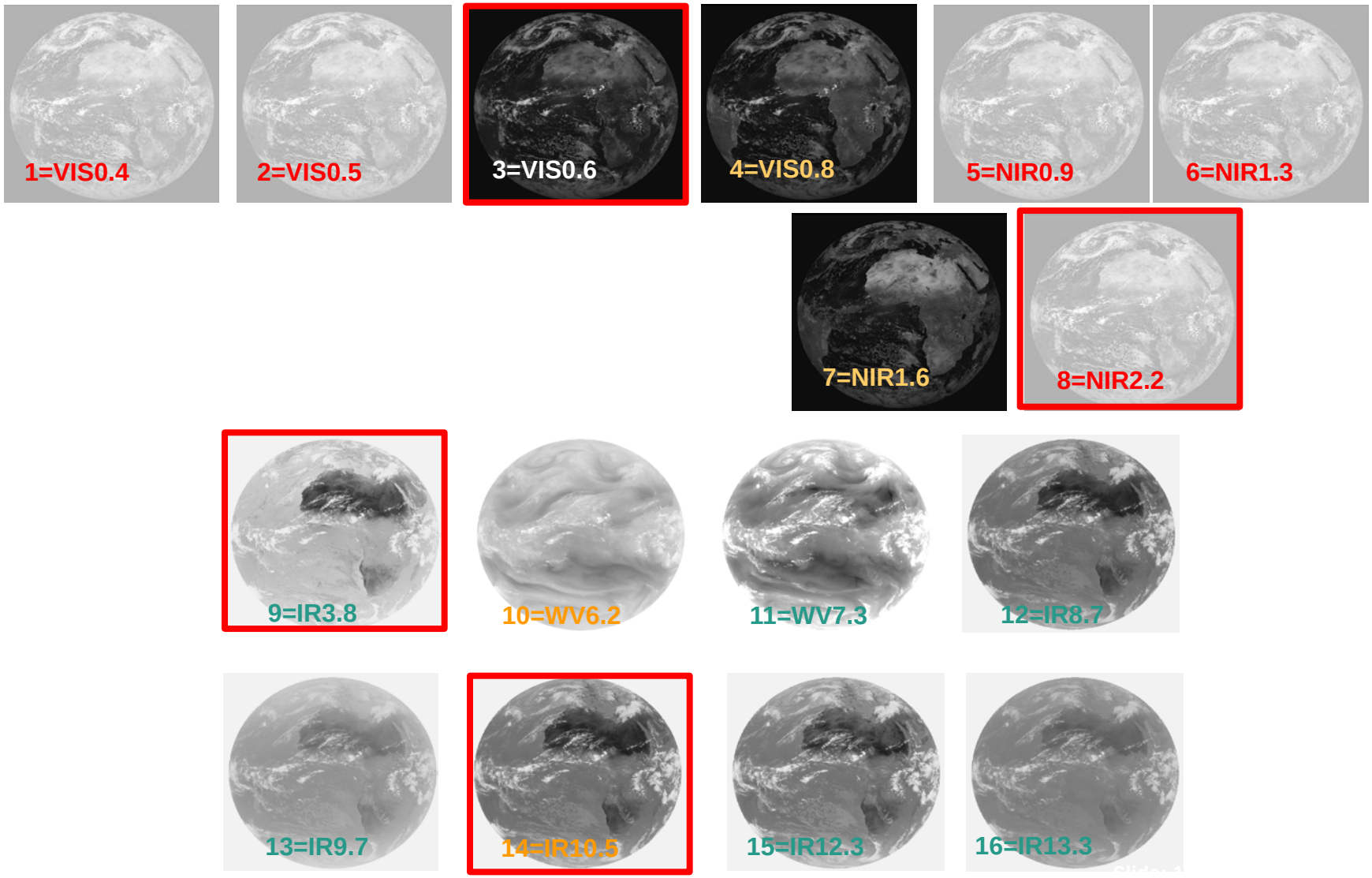






EUMETSAT

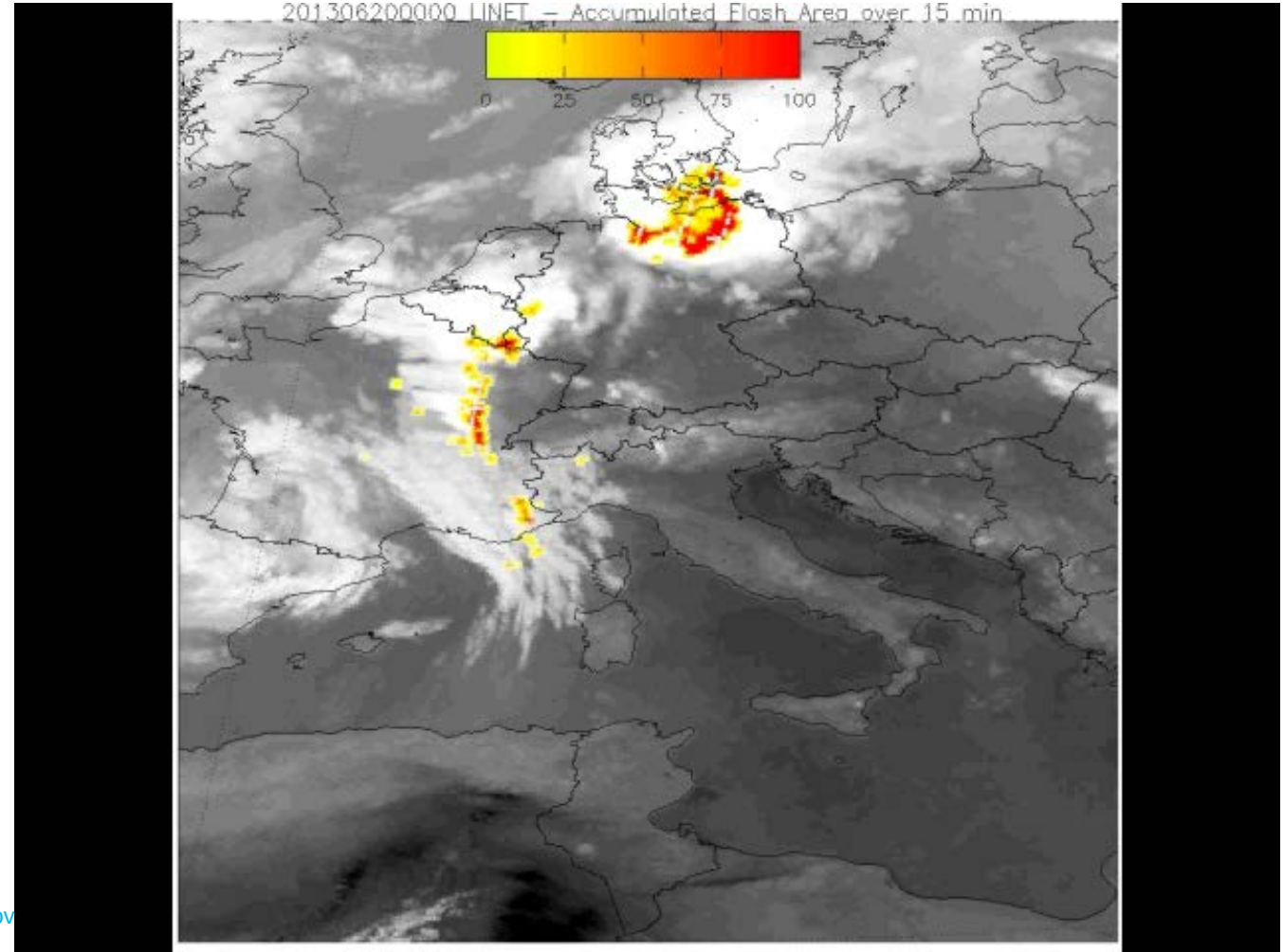
From MVIRI on MTP to SEVIRI on MSG to MTG FCI



EUMETSAT

LI reference processor development – product example

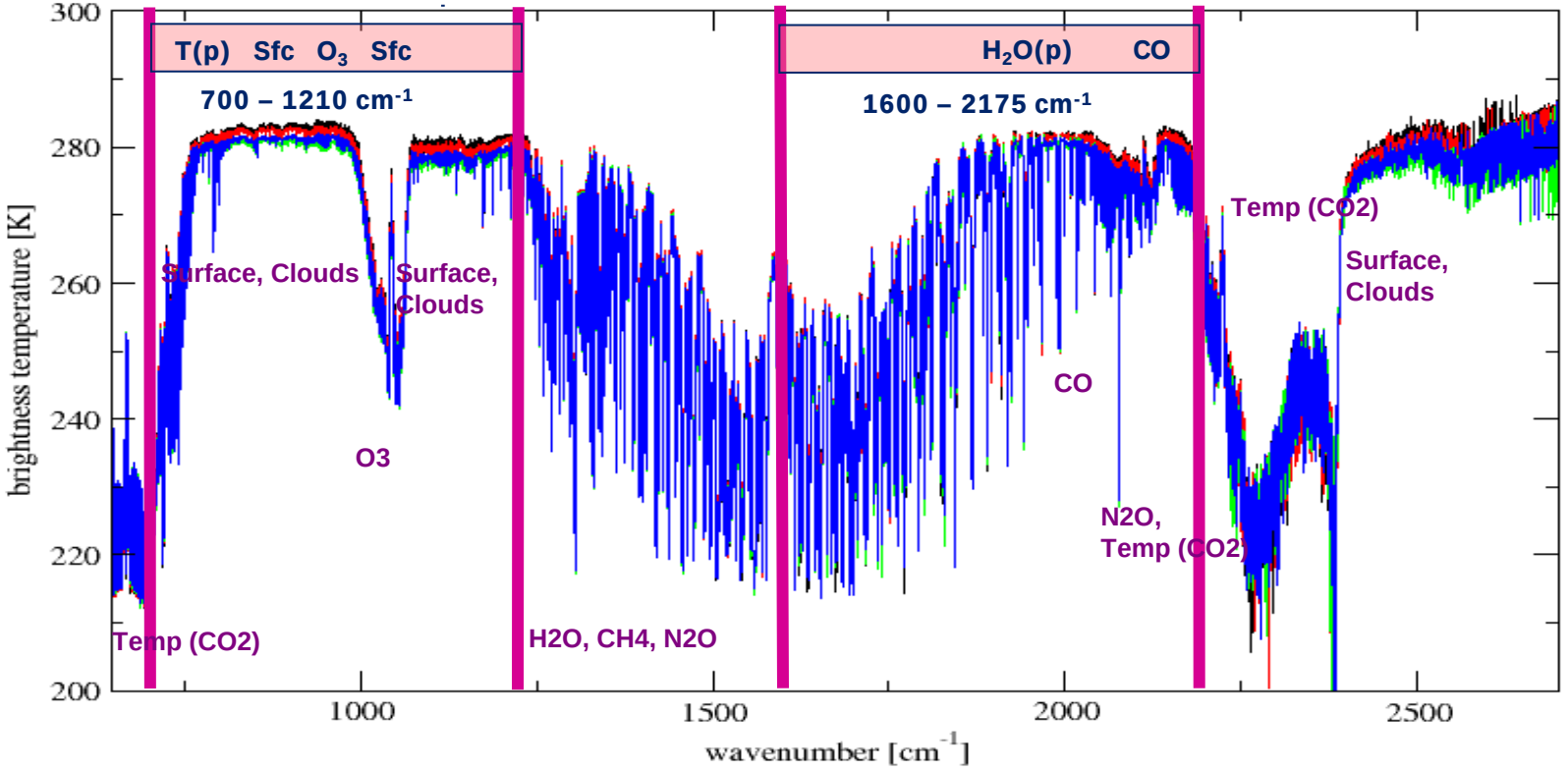
“Accumulated flash area” product, integrated over 15 minutes and updated every 30 seconds
Date: 20 June 2013.



EUMETSAT

MTG Mission: InfraRed Sounder (IRS)

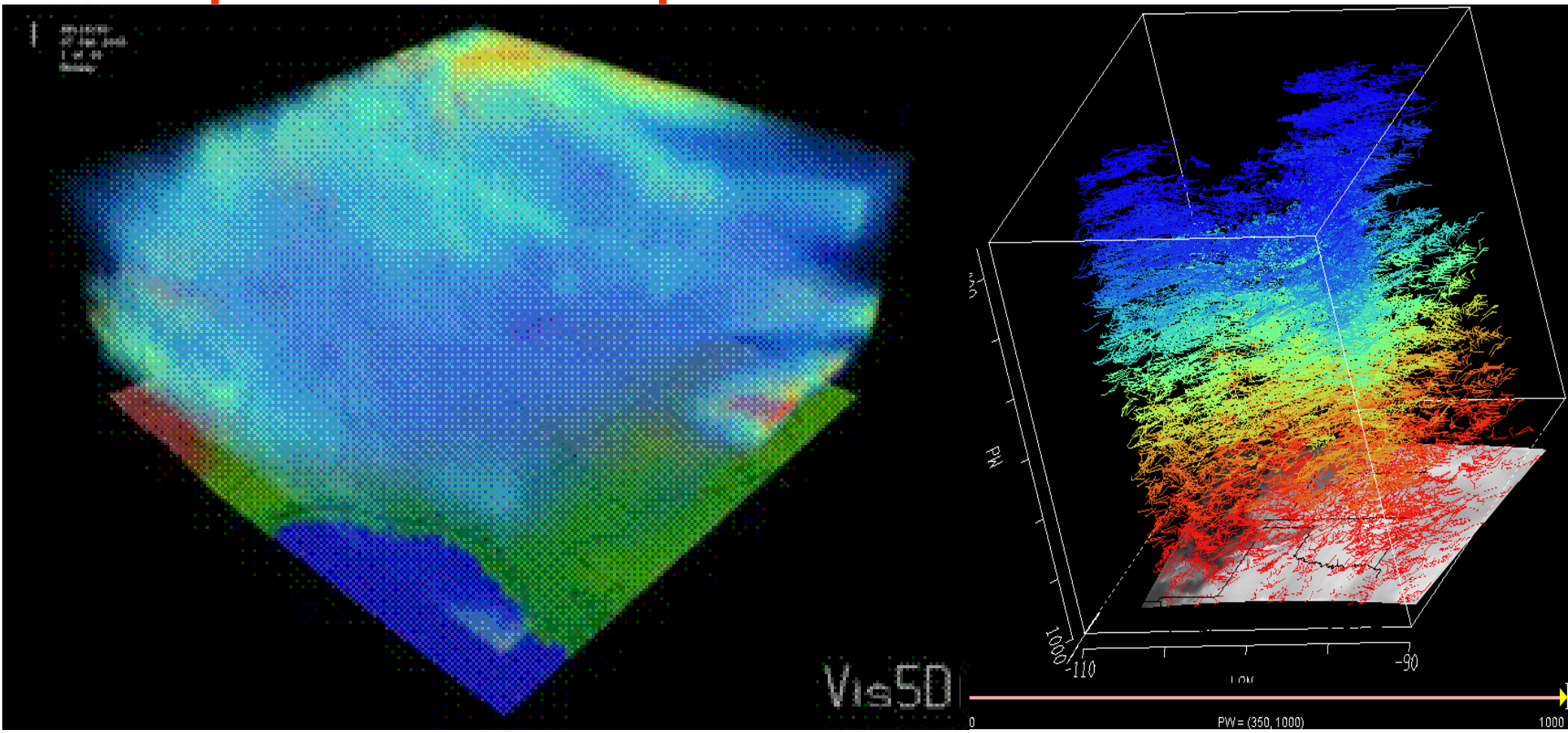
- MTG-IRS will deliver unprecedented information on horizontal and vertical gradients of moisture, wind and temperature from the geostationary orbit:
  - Full Disk Sounding;
  - Repeat Cycle = 60 min;
  - spatial resolution of 4 km,
  - hyperspectral soundings at 0.625 cm-1 spectral sampling in two bands:
    - Long-Wave-IR (LWIR: 700 – 1210 cm-1 ~820 spectral samples)
    - Mid-Wave-IR (MWIR: 1600 – 2175 cm-1 ~920 spectral samples)



EUMETSAT

MTG-IRS observations

time sequence of water vapour structures **simulated AMVs**

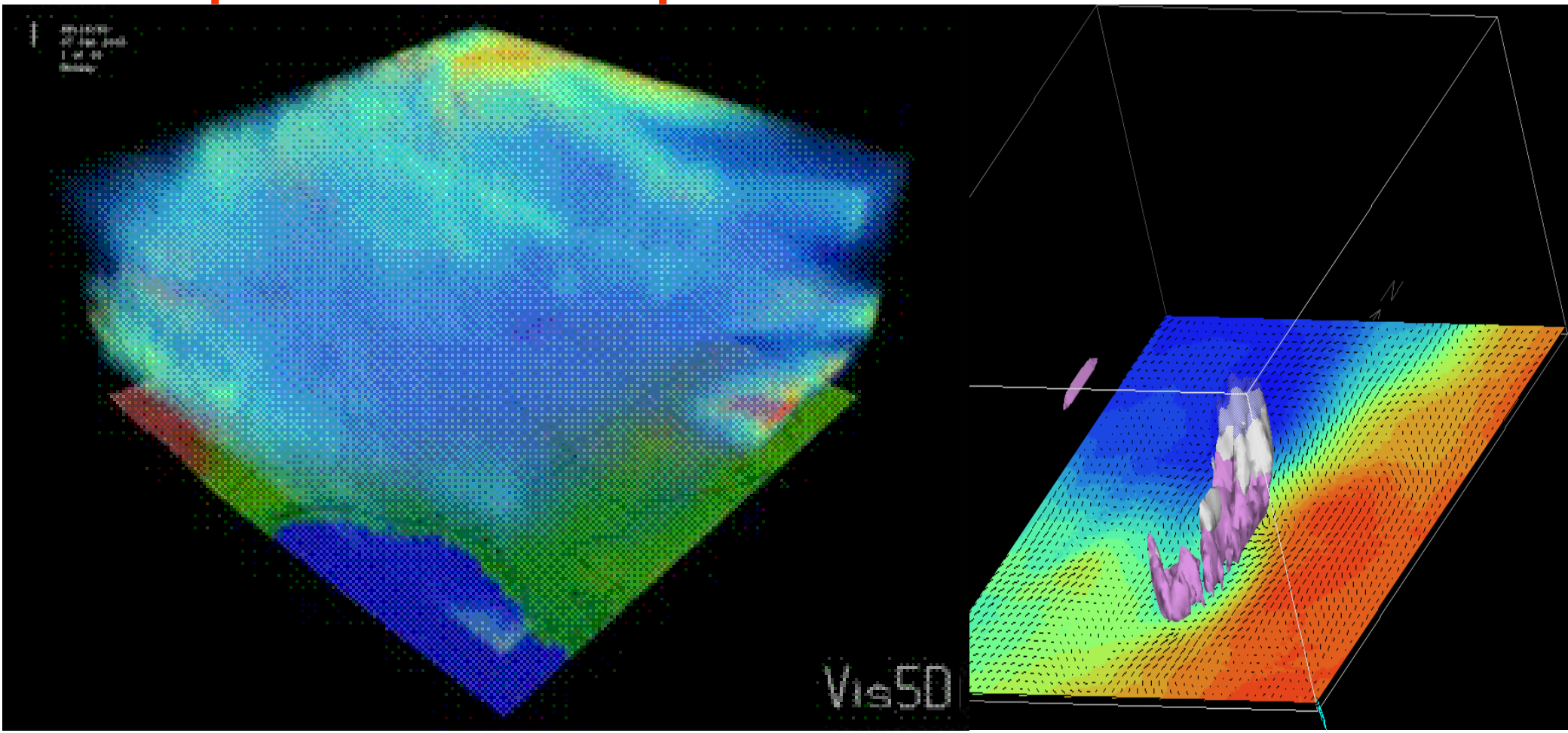


EUMETSAT

MTG-IRS and short range NWP

time sequence of water vapour structures

model convection

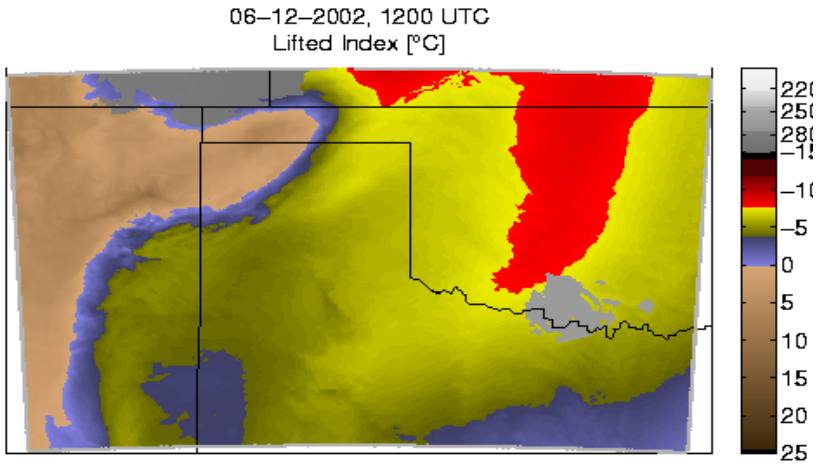


EUMETSAT

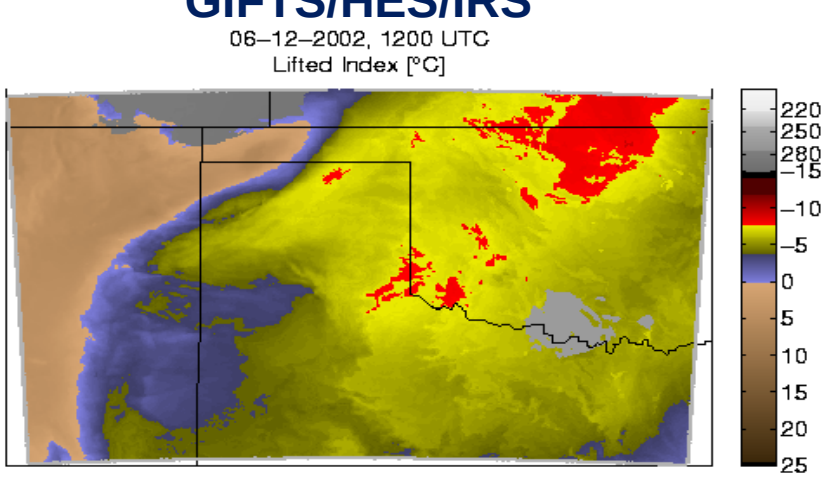
Simulating the Geo-IRS perspective

University of Wisconsin-Madison Space Science and Engineering Center
Cooperative Institute for Meteorological Satellite Studies

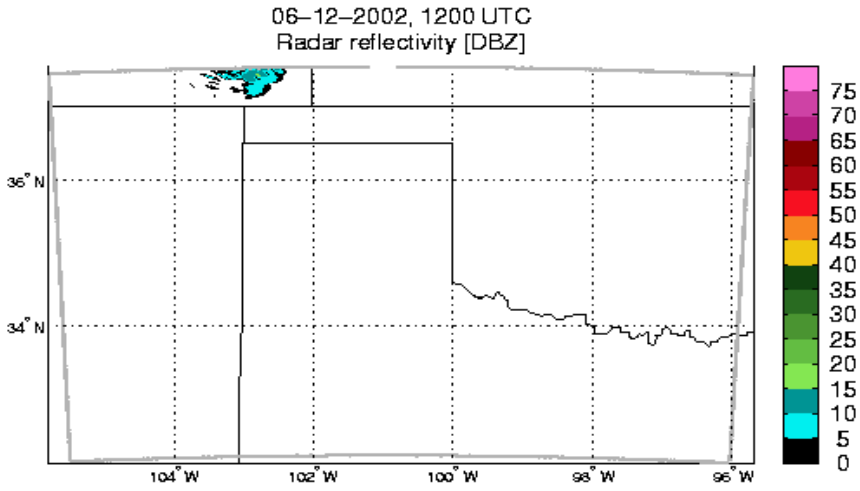
True



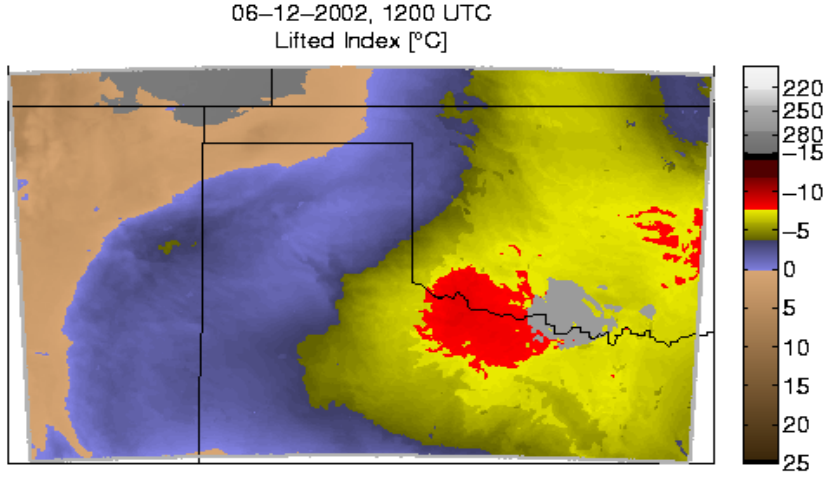
GIFTS/HES/IRS



Red = extreme instability



UW/CIMSS



UW/CIMSS

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From MSG-SEVIRI to MTG-IRS (R. Petersen)

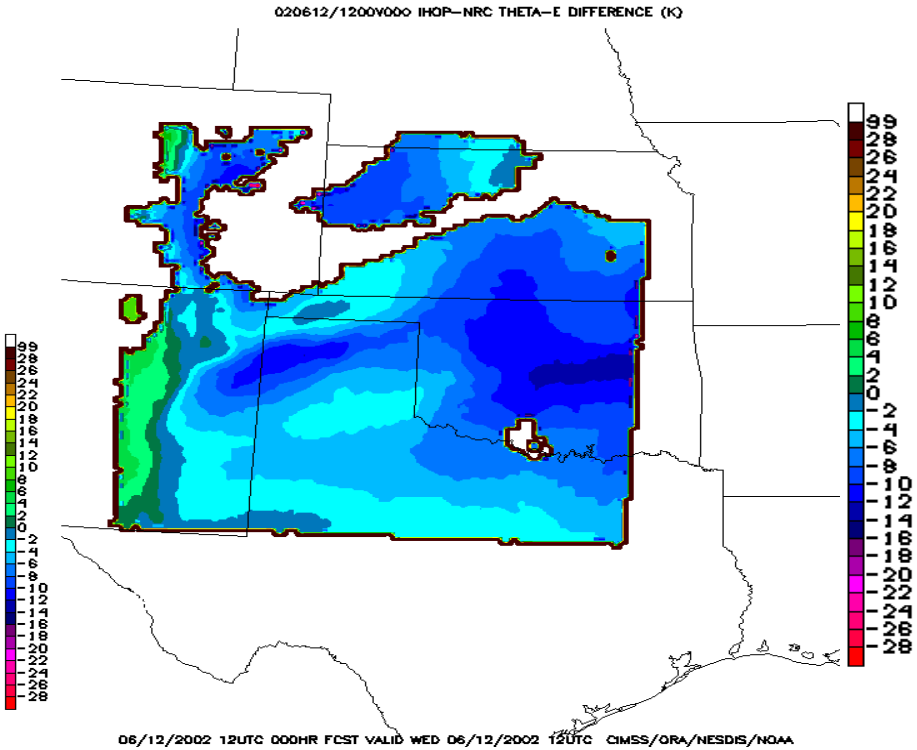
University of Wisconsin-Madison Space Science and Engineering Center
Cooperative Institute for Meteorological Satellite Studies
CIMSS

vertical Theta-E Difference [Theta-E@~500hPa – Theta-E@~780hP]

MTG-IRS provides a thinner and lower layer of Theta-E@~780hPa

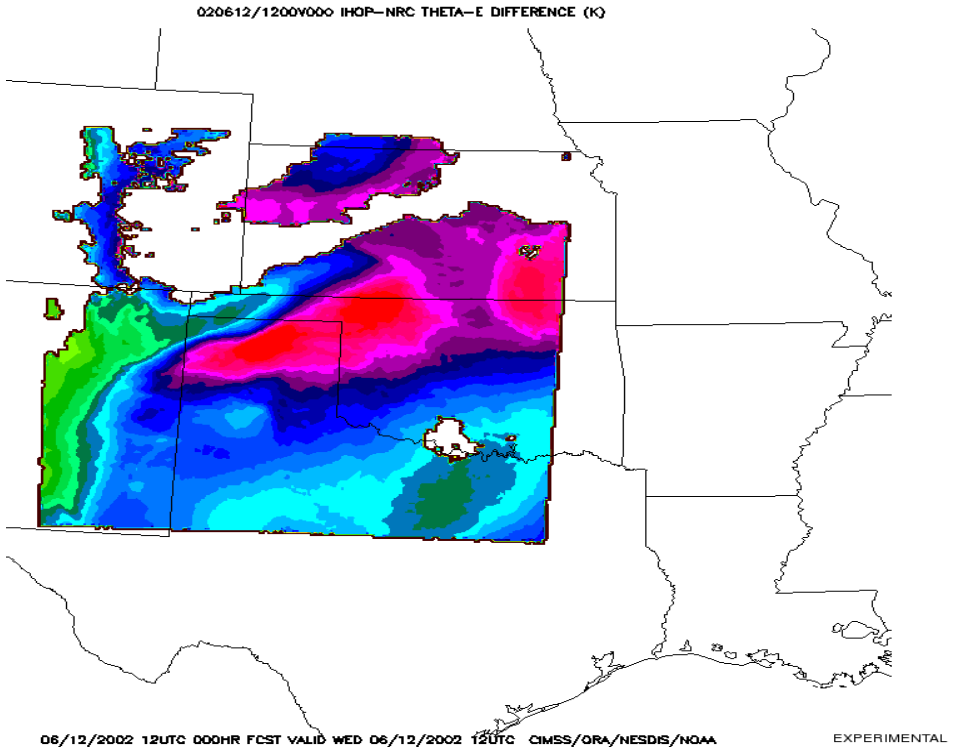
Lagrangian NearCast using Simulated ABI data from 1200 UTC 12 June 2002

MSG-SEVIRI like



Lagrangian NearCast using Simulated HES data from 1200 UTC 12 June 2002

MTG-IRS like



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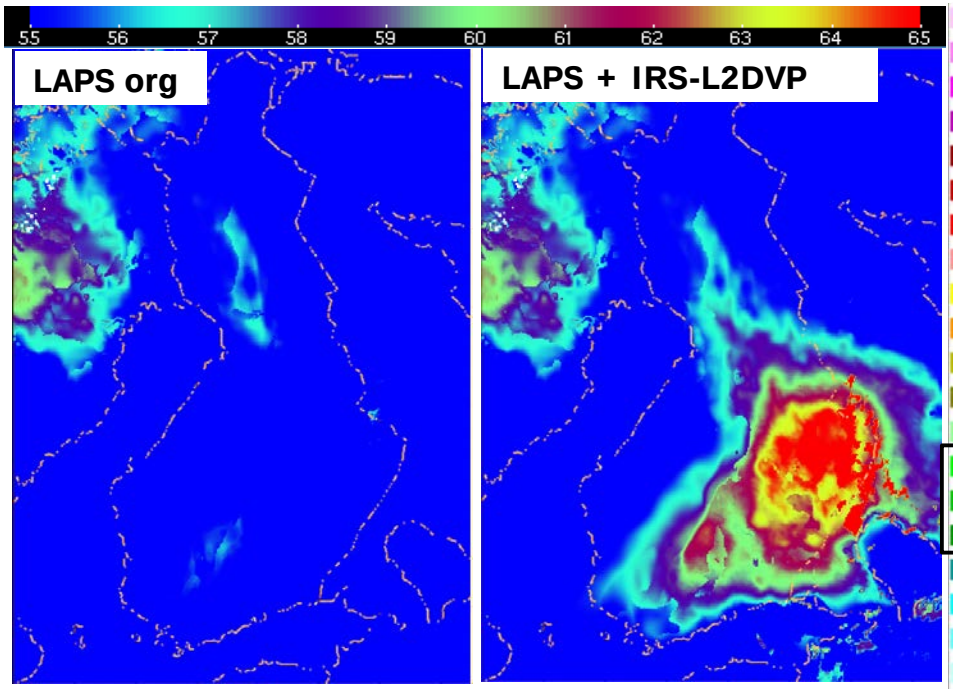
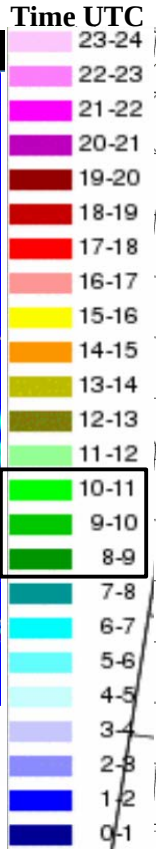
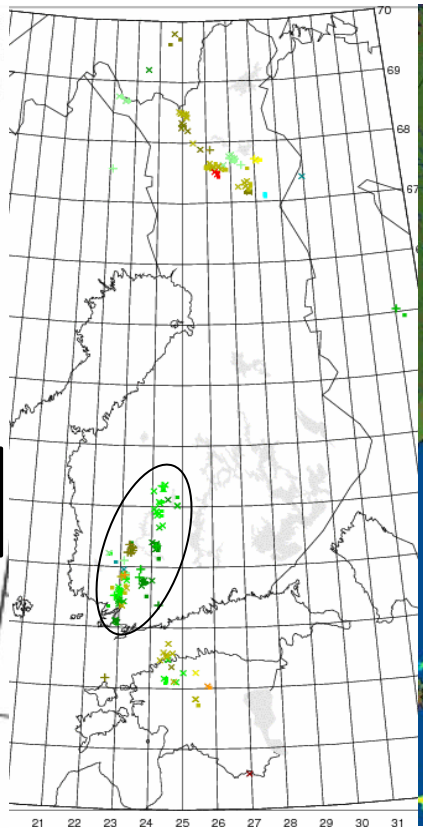
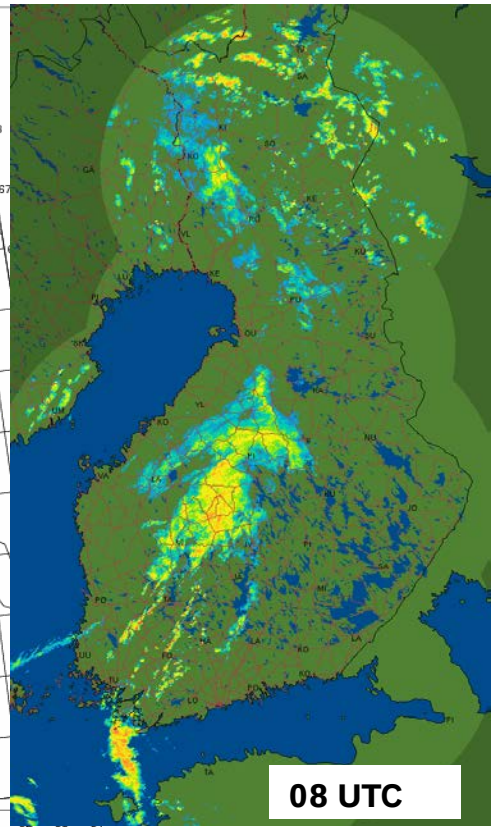
FMI Demonstration Project (E. Gregow)

- IRS-L2DVP retrieved atmospheric state as additional input to LAPS for two cases of convective activities over Finland (01 June 2012 and 29 July 2012)









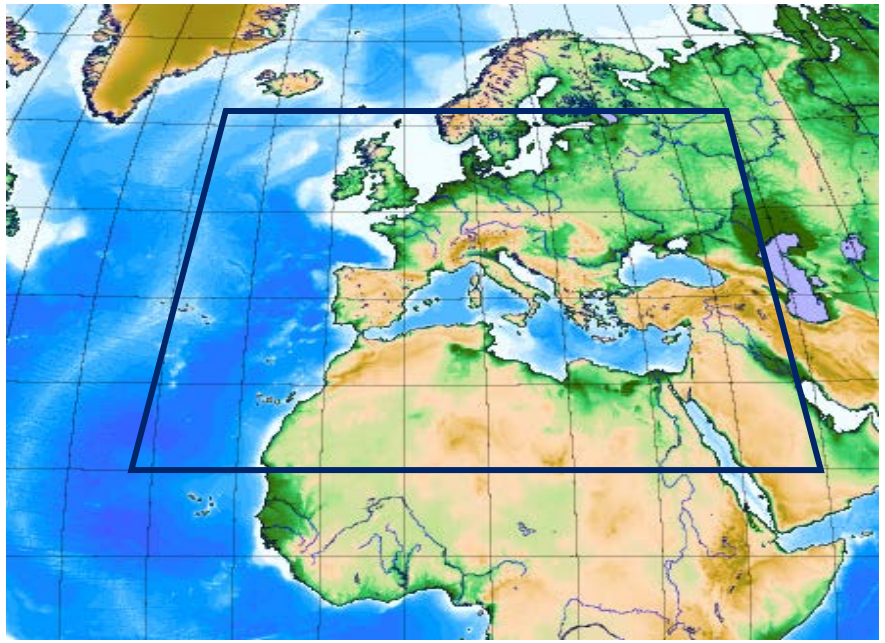
TT-index values:

> 50 moderate-severe thunderstorms

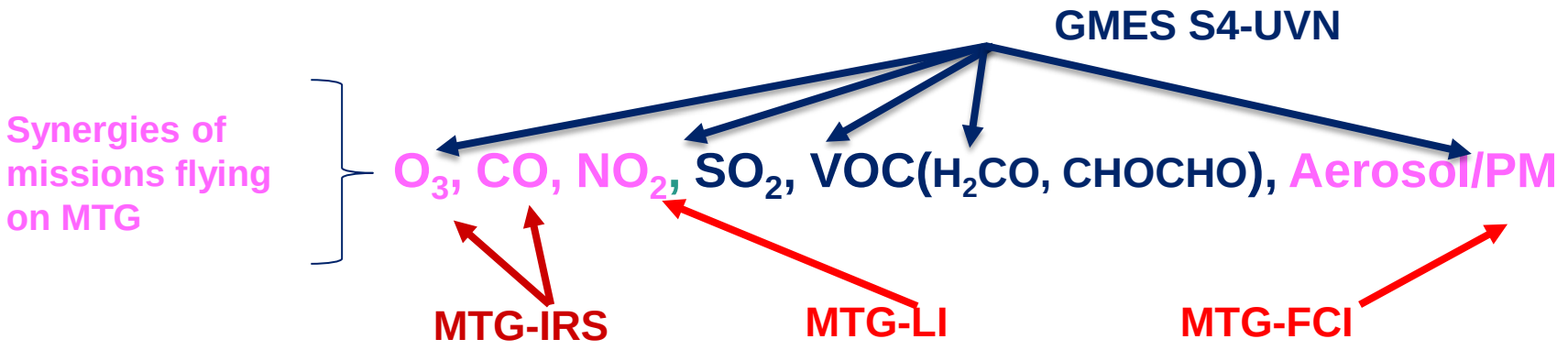
> 60 severe thunderstorms

TOTAL TOTALS INDEX, TT = T*850* + Td*850* - 2T*500*

MTG Mission: hosting GMES Sentinel-4



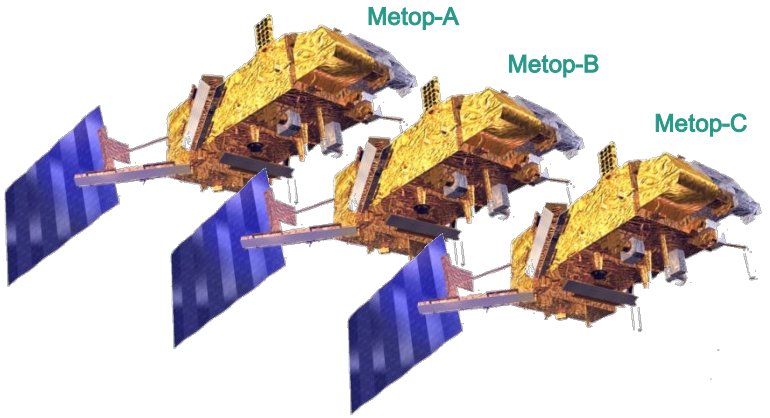
- The GMES Sentinel-4 sounding mission is achieved through the Ultraviolet, Visible & Near-infrared (UVN) Instrument accommodated on the MTG-S satellites
  - covering Europe every hour
  - taking measurements in three spectral bands (UV: 305 - 400 nm; VIS: 400 - 500 nm, NIR: 750 - 775 nm)
  - with a resolution around 8km.
- The primary data products are O3, NO2, SO2, HCHO and aerosol optical depth.



EUMETSAT Polar System Programme

Polar Stations
Svalbard, 78 deg North

Launcher Service
(Soyuz, Baikonur)



LEOP Service
(ESOC)

EUMETSAT
Mission Control Centre

Satellite Application
Facilities (SAF)
8 Meteorological Themes

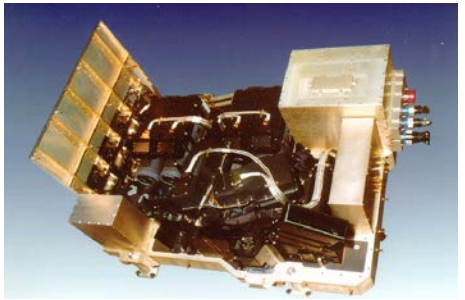
- Metop-A launched in 2006
- Metop-B launched in 2012
- Metop-C launch scheduled for 2019
- Sun Synchronous orbit
- 820 km, 9h30 LST,100 min
- Sole source of mid-morning orbit data
- 11 Instruments
- Soyuz Launcher Service (Baikonur/Kourou)
- ESOC LEOP Service (Darmstadt)
- Central & distributed Ground 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

EUMETSAT

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

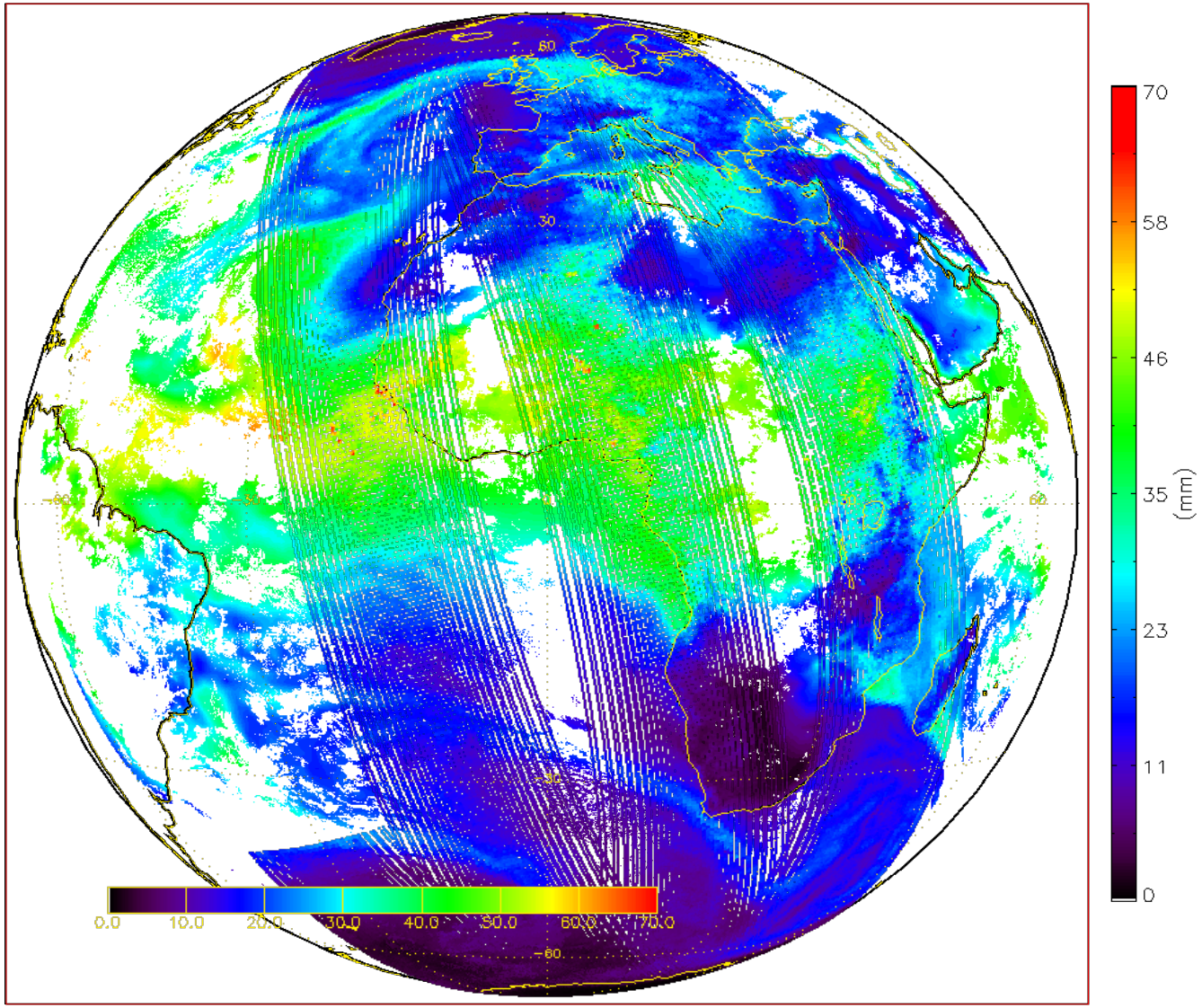
AMSU-A2
Advanced Microwave Sounding Unit-A2

ASCAT
Advanced SCATterometer

Atmospheric Profiling

Hyperspectral Infrared L2 - IASI L2 v6 TCWV vs MSG

MSG TPWV + IASI v6



Results: M. Koenig (EUMETSAT)

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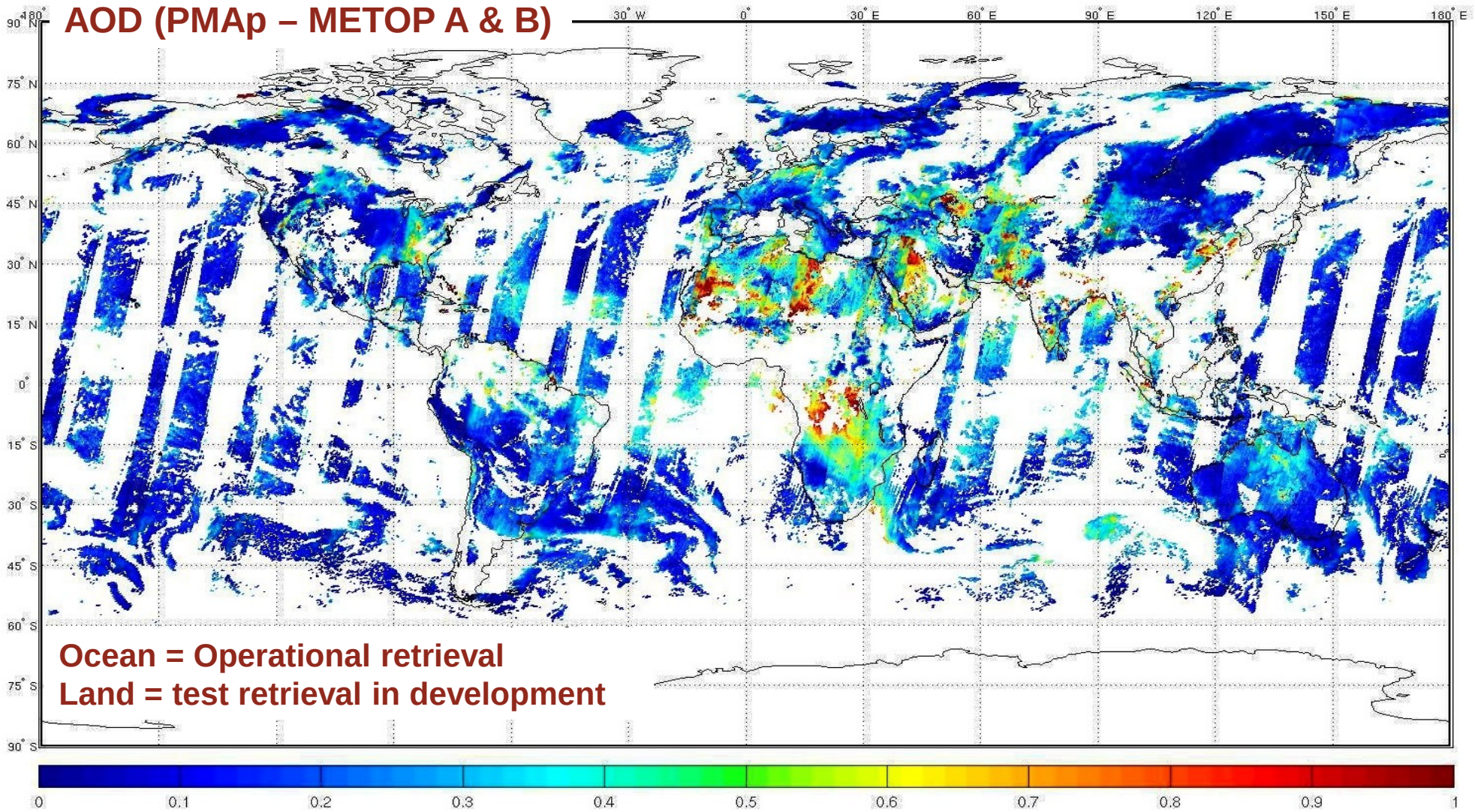
Aerosol: PMAp (GOME-2 + AVHRR) Metop A & B combined



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

Morning Orbit

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

Metop-C in 2018

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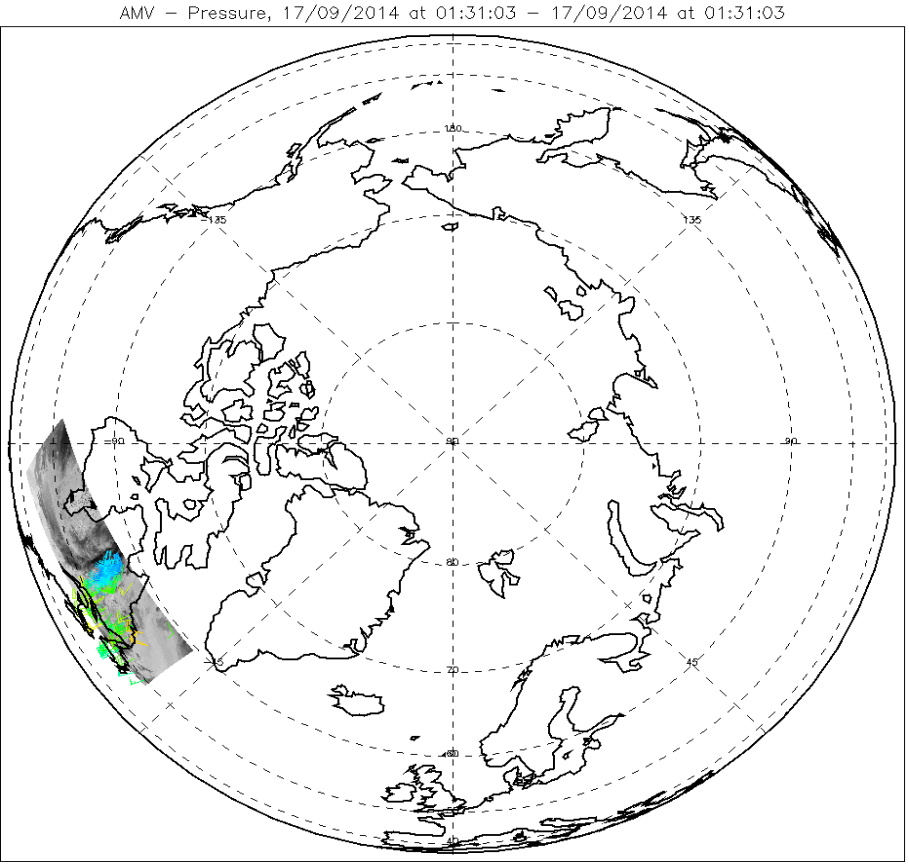
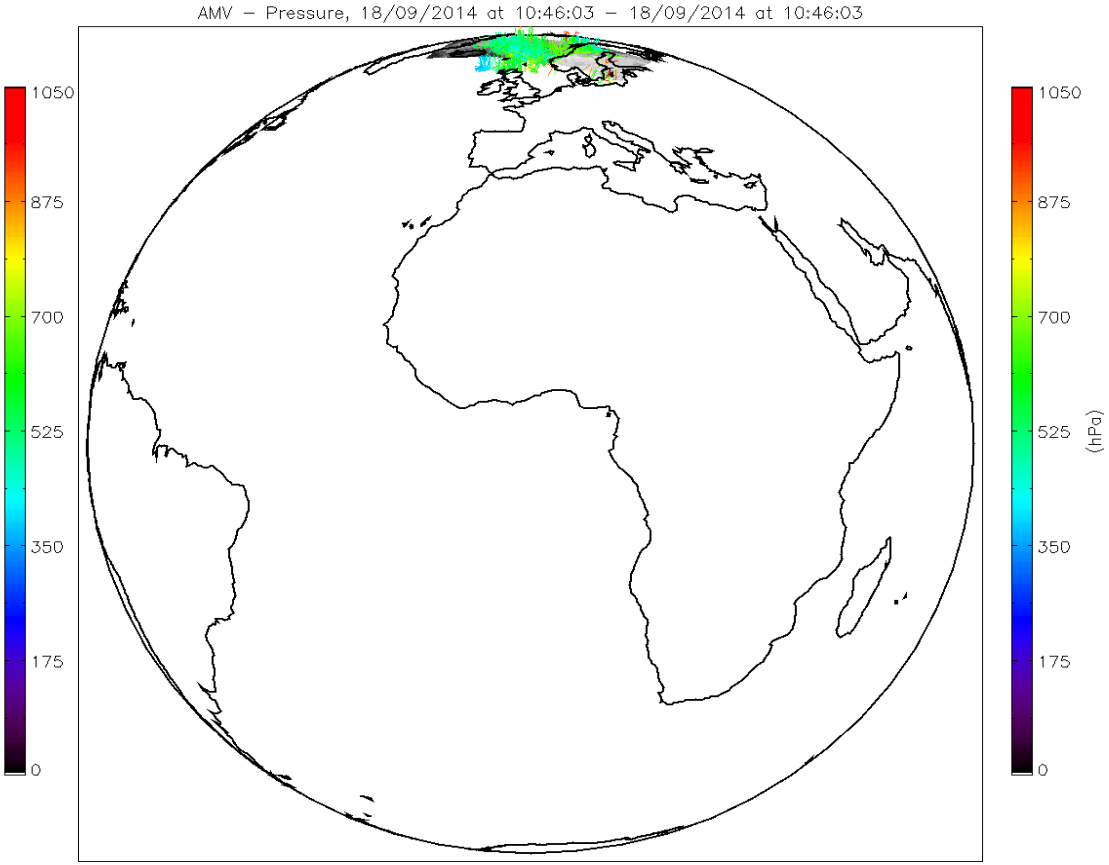
AVHRR winds

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



Global AVHRR, 18/09/2014, 9:04-9:46



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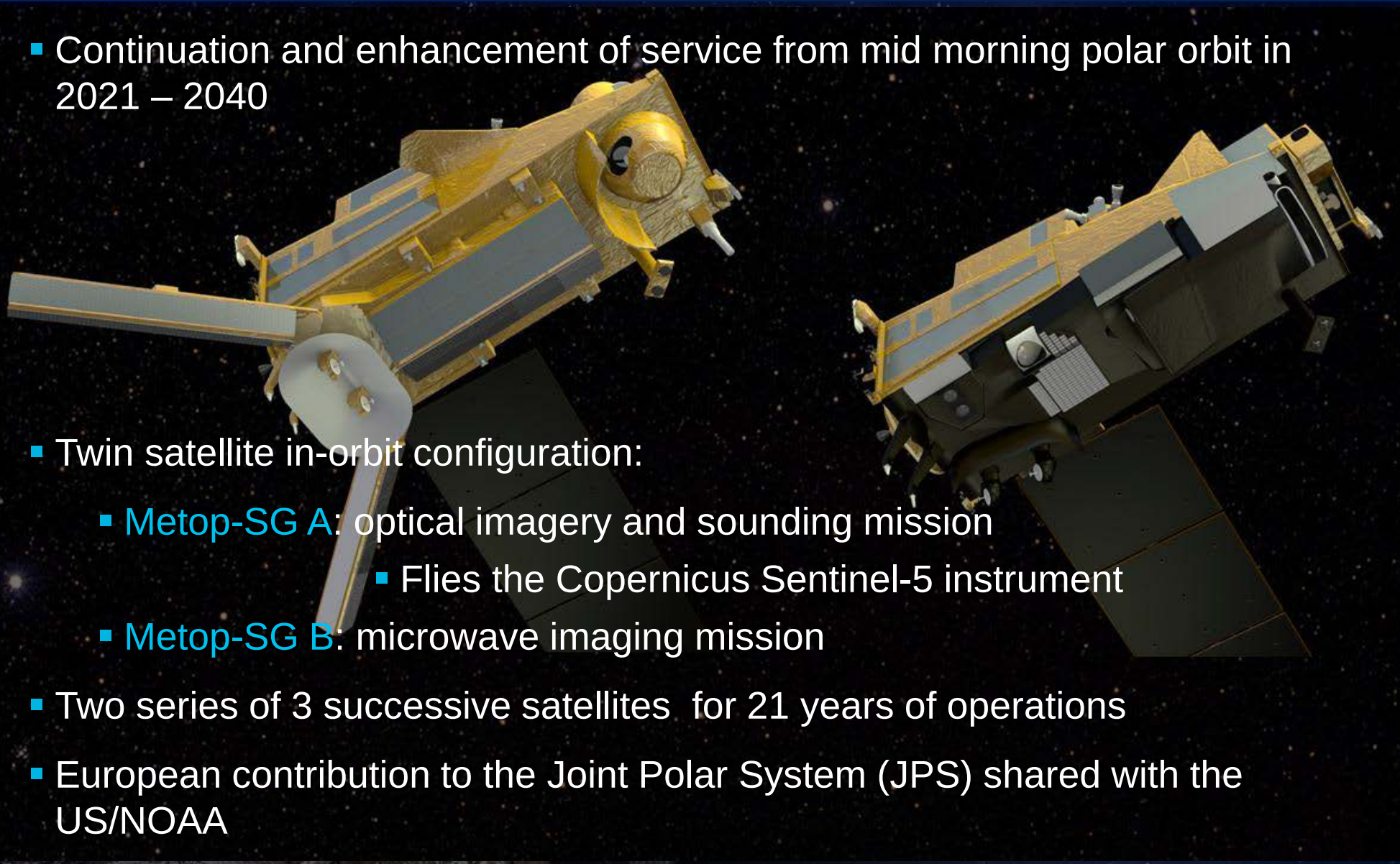
EPS Second Generation

- Primary mission: further improve observational inputs to Numerical Weather Prediction models

- Significant contributions to other real time applications:
  - Nowcasting at high latitudes
  - Marine meteorology and operational oceanography
  - Operational hydrology
  - Air quality monitoring

- Climate monitoring: expand by 20+ years the climate data records initiated in 2006 with EPS

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

EPS Second Generation

Satellites at a glance

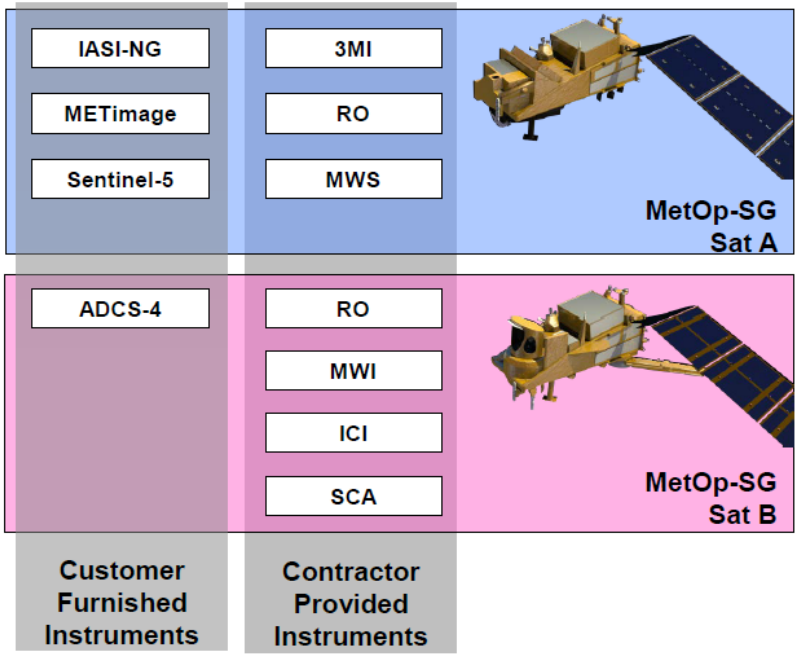
- Launch mass = 3.79 tons
- Mean power consumption = 2.7 kW
- Data rate = day / night / peak
  14 / 14 / 17 Mbps

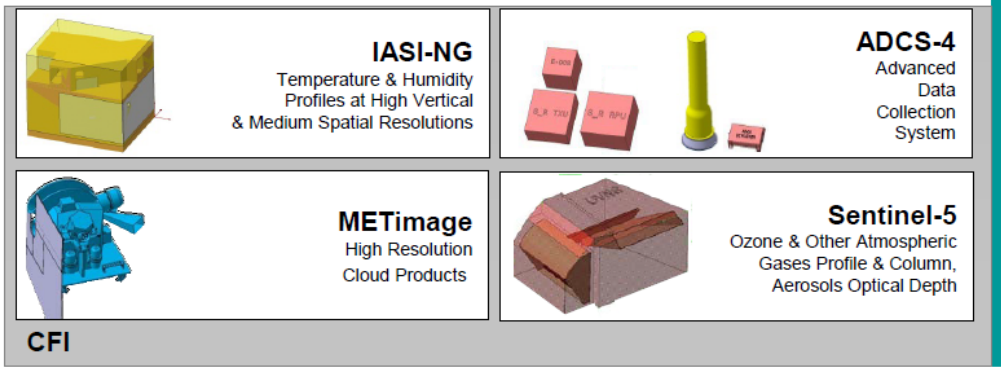
- Launch mass = 4,08 tons
- Mean power consumption = 3.4 kW
- Data rate = day / night / peak
  60 / 22 / 77 Mbps

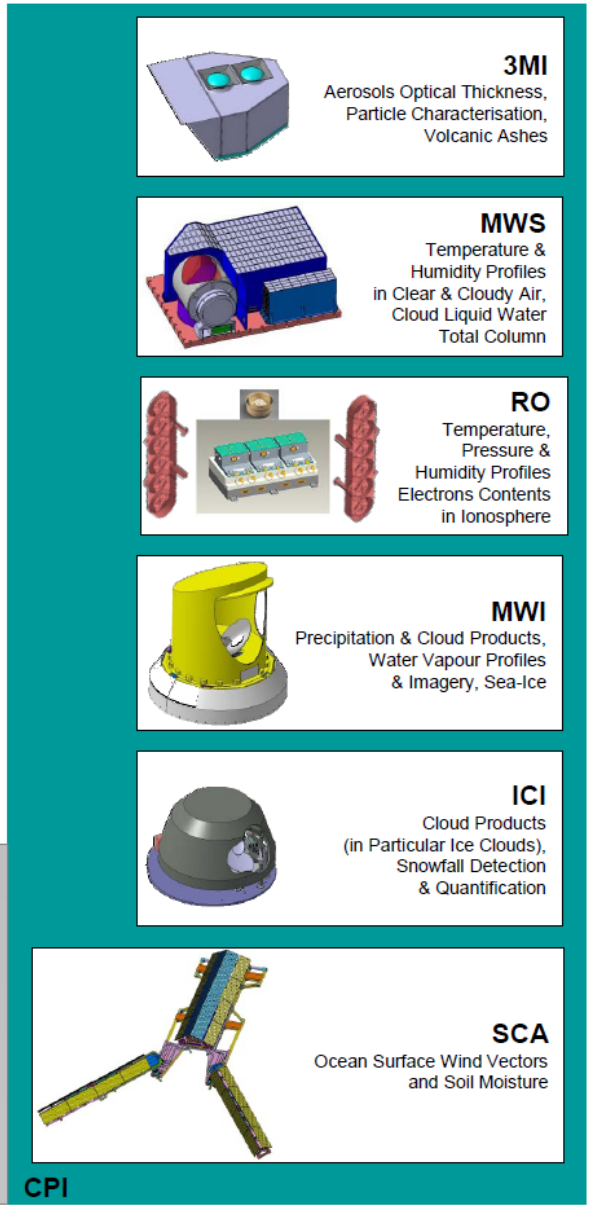
- Launcher: Soyuz in Kourou / Falcon 9 / Ariane 5
- Orbit: MetOp Sun Synchronous Orbit 817 km, 9h30 Local Time at Descending Node
- Controlled re-entry into the South Pacific Ocean Uninhabited Area

EPS Second Generation Instruments' Overview

Distribution of Instruments per Satellite





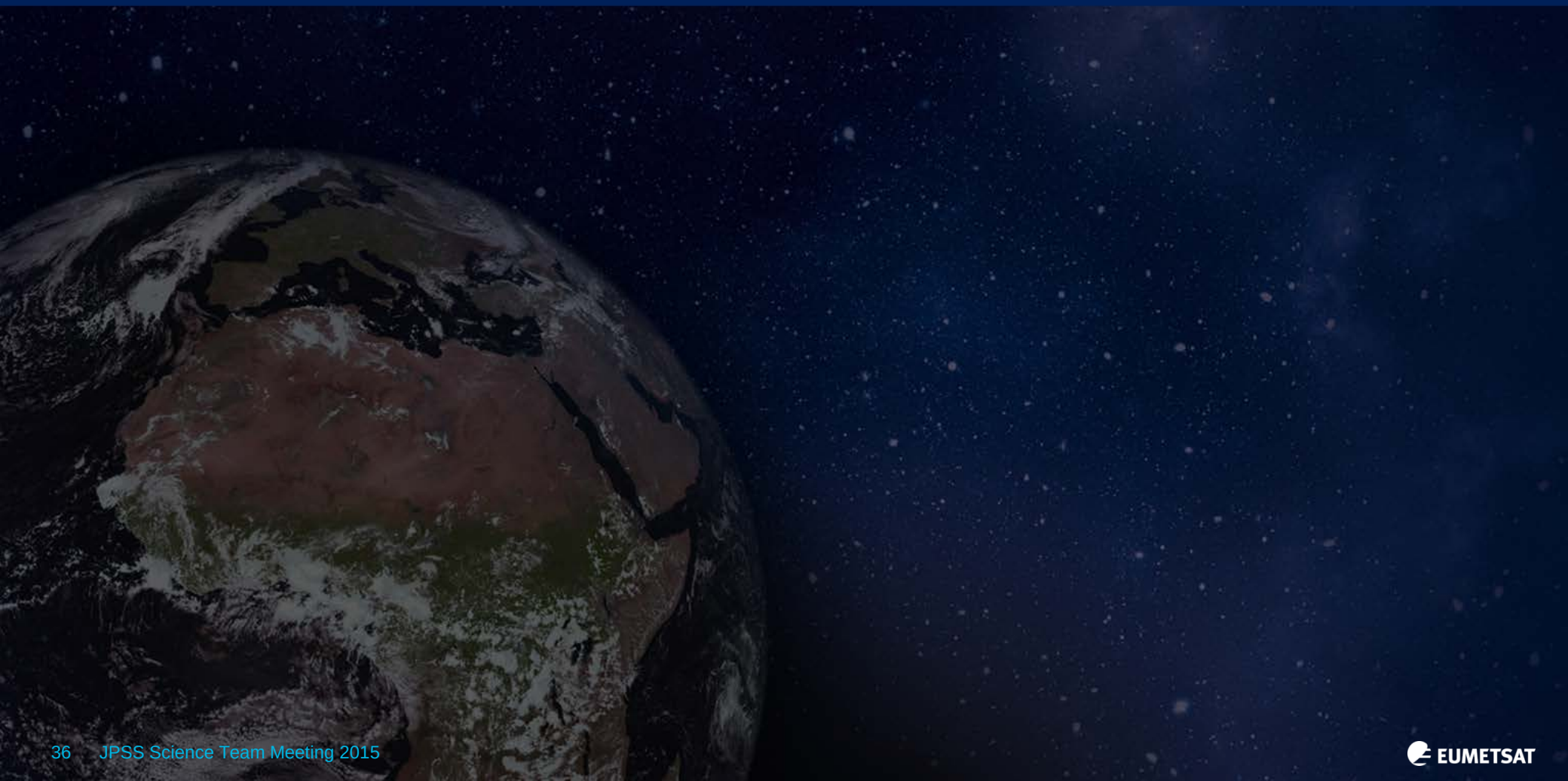


EUMETSAT

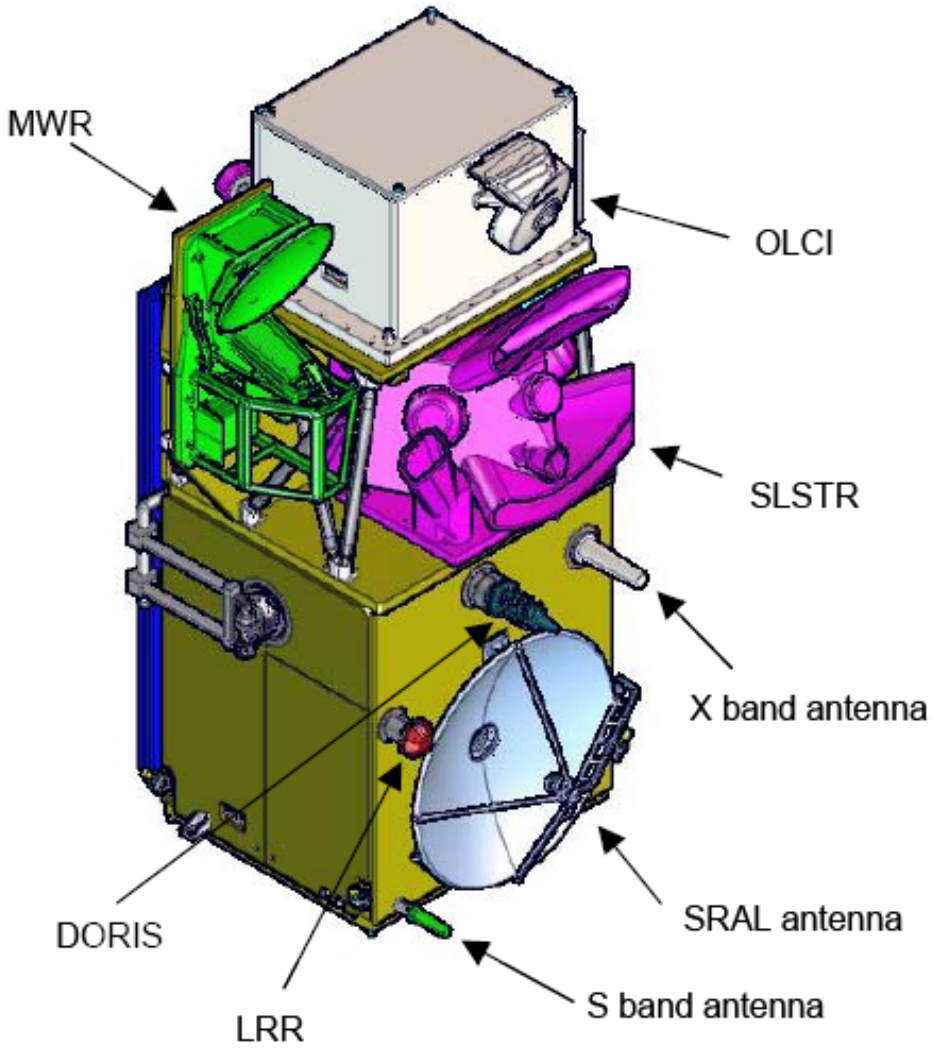
EPS-SG Current Status

- Achieved approval of the scope and contents of the EPS-SG Programme Proposal which includes the draft cooperation agreements with ESA, CNES, DLR and NOAA
- Achieved in June 2015 approval of full EPS-SG programme from January 2016 onwards
- System Preliminary Design Review (PDR) successfully completed in June 2015
- ESA: Prime contractors for the Metop-SG A and B satellites selected and Phase B2 kicked off in June 2014, PDR planned for September 2015
- CNES: IASI-NG PDR successfully completed in May 2015
- CNES: The first flight model of A-DCS4 for EPS-SG is under assembly
- DLR: METimage instrument PDR successfully completed in July 2015
- EUM: Overall Ground Segment PDR planned for September 2015

MONITORING THE OCEAN IN SUPPORT OF COPERNICUS



Sentinel-3 Satellite and Payload
First launch Early 2016

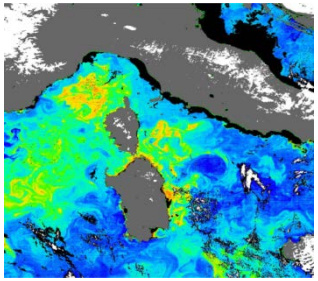


- SLSTR: Sea and Land Surface Temperature Radiometer
- SRAL: Synthetic Aperture Radar Altimeter
- OLCI: Ocean and Land Colour Instrument
- MWR: Micro-Wave Radiometer
- LRR: Laser Retro-Reflector
- DORIS: Doppler Orbitography and Radiopositionning Integrated by Satellite
- STM: Surface Topography Mission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

Sentinel-3 Marine product contents

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

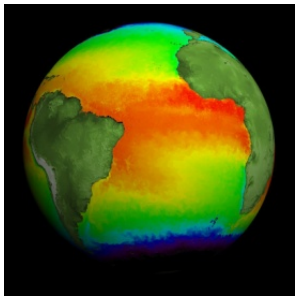
(ESA and EUMETSAT)



Level 2 SLTSR:

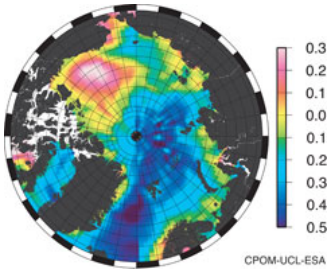
- Sea surface temperature

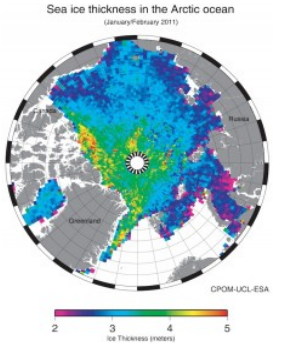
(L2P GHRSST standard)



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



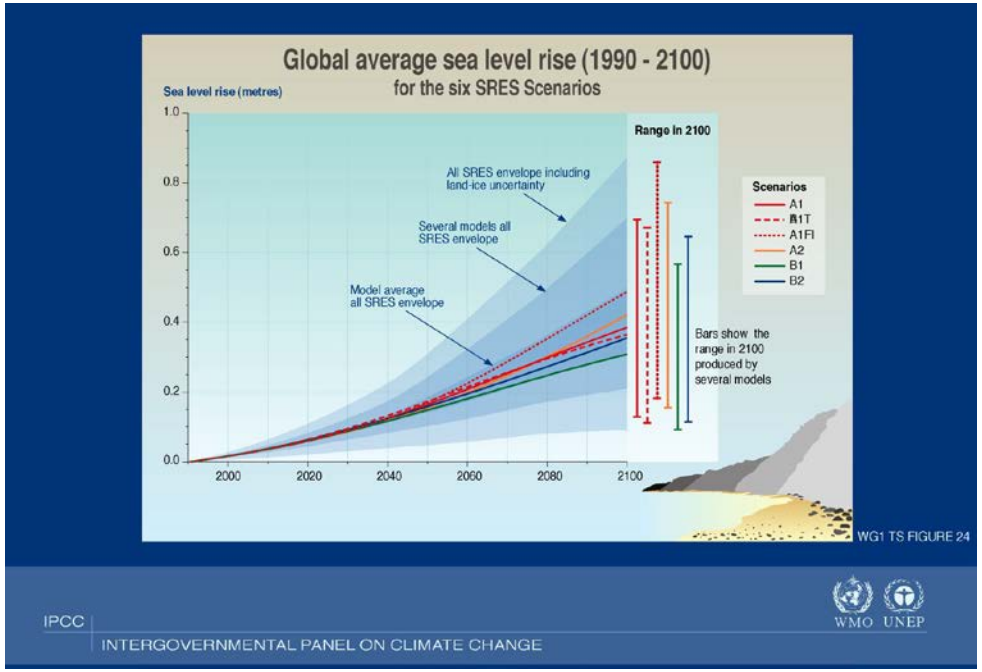


Level 2 SRAL:

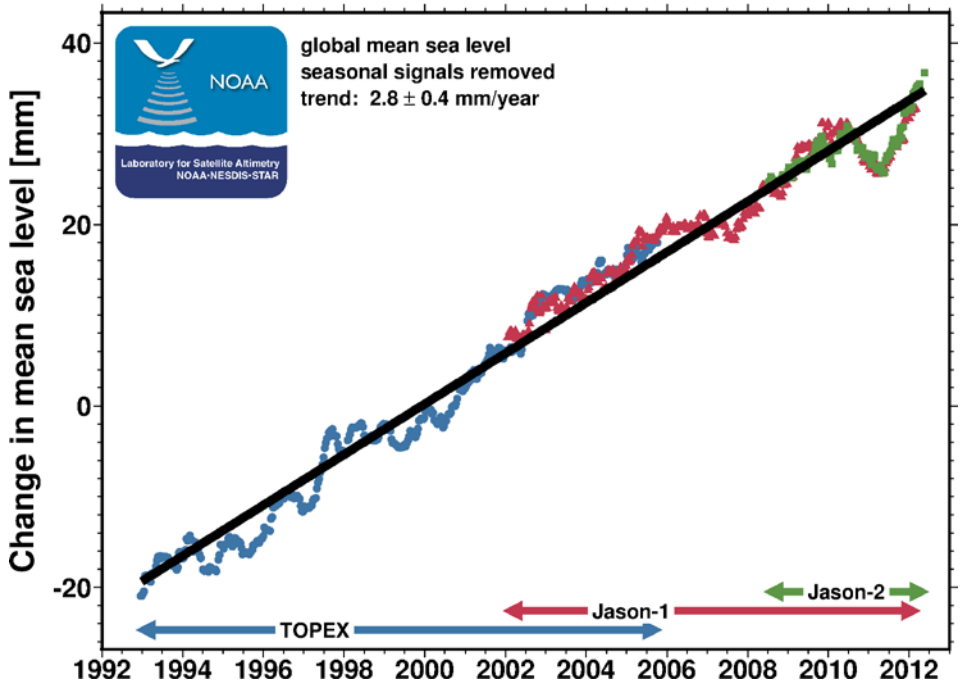
- Sea/coastal zone surface height
- Significant wave height
- Wind speed
- Backscatter coefficient σ_0
- Sea ice height, freeboard
- Total water, liquid water (from MWR)

From Jason-2 to Jason-3 (launch 12/2015), Jason-CS: Global sea level rise

IPCC projections: Uncertainties



Observational evidence: Unique Climate Data Record

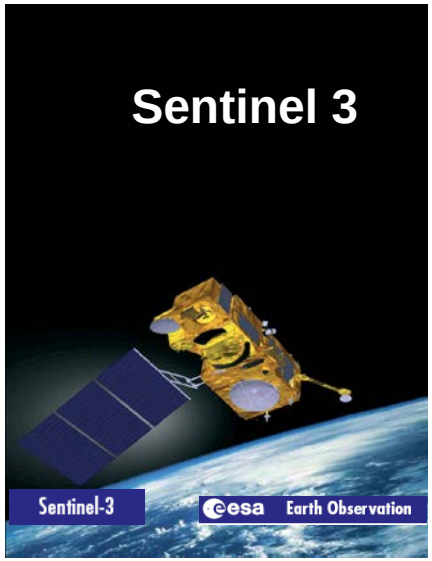


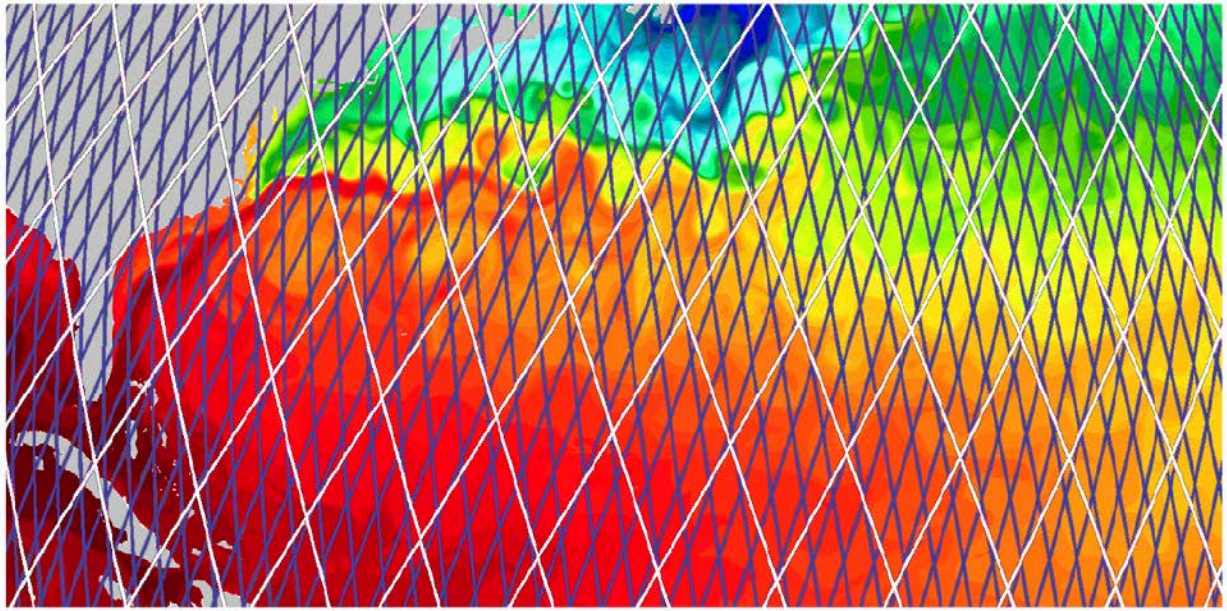
Global mean sea level during the altimetry era has risen at a nearly constant rate since 1993 (+- 3 mm/year) .

Relatively consistent despite large regional interannual variations and accelerations in the melting of land ice.

EUMETSAT

Combining Sentinel-3 & Jason altimetry for operational oceanography and climate change monitoring





(Courtesy CNES/CLS/ESA)

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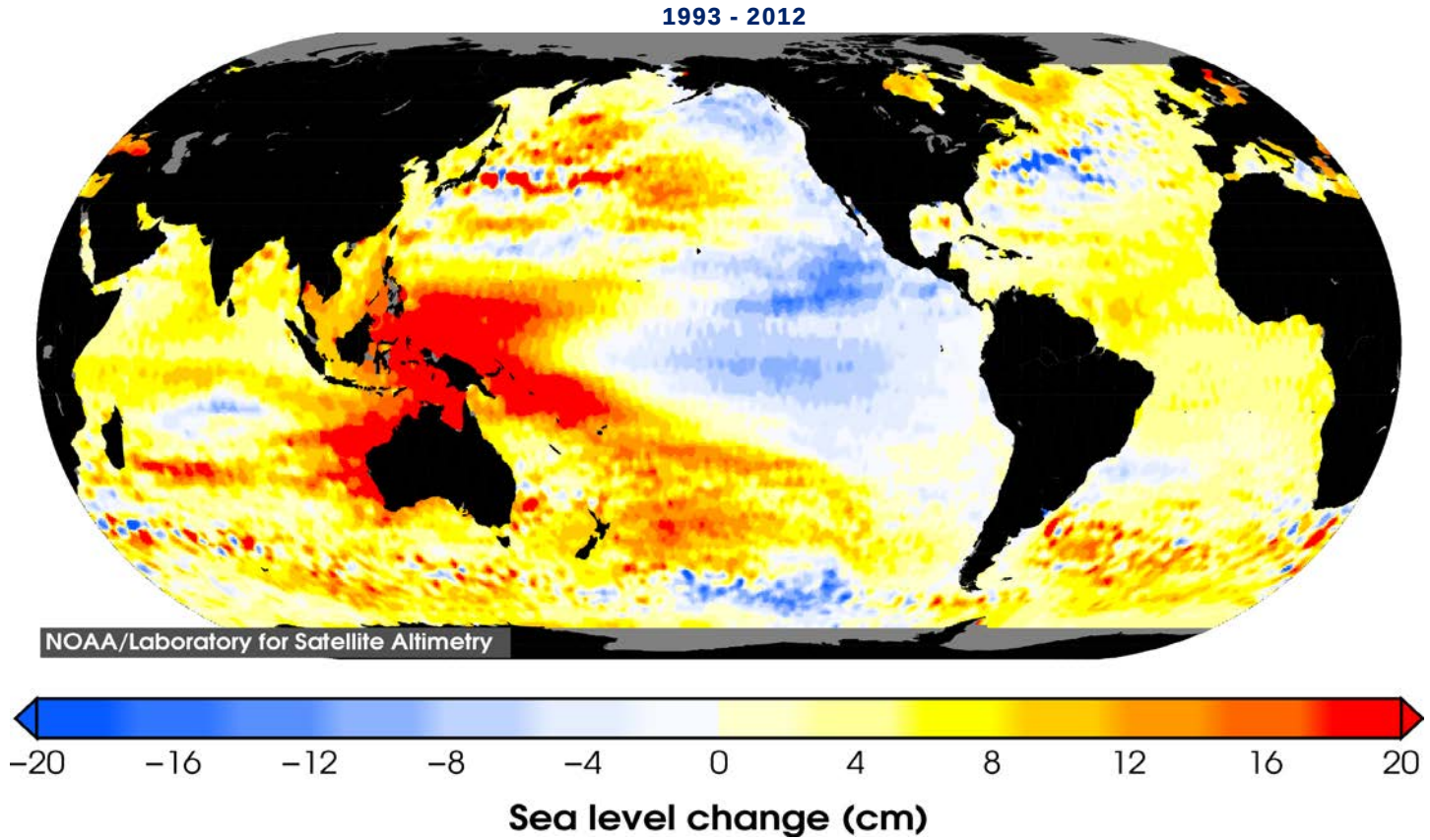
Mean sea level trends : regional differences



- 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?