THE EUMETSAT SATELLITE PROGRAMMES

AN OVERVIEW FROM NOW TO THE FUTURE

EUMETSAT

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EUMETSAT

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Current EUMETSAT satellite fleet – Extrapolated to 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

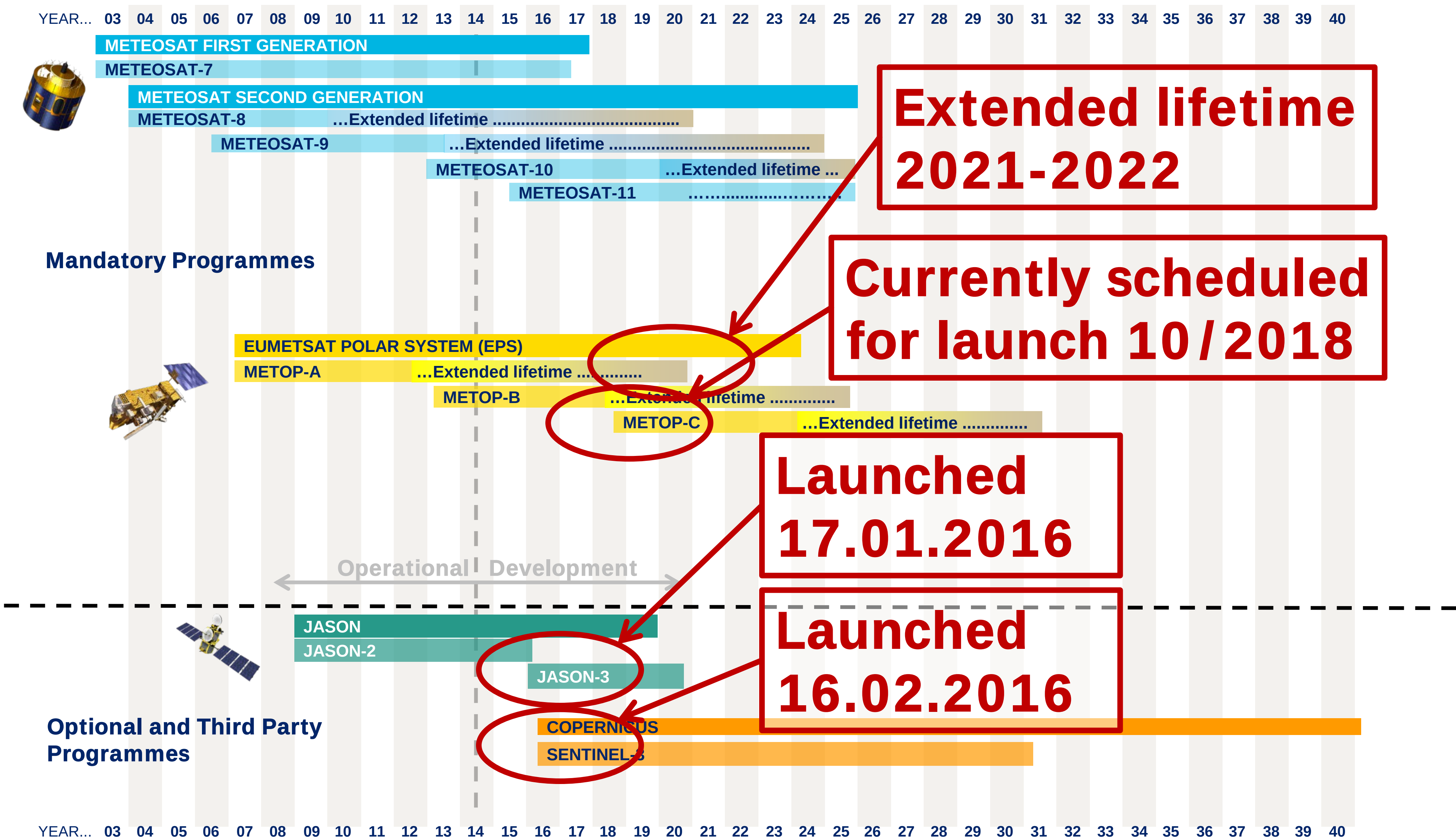
METEOSAT SECOND GENERATION -9, -10, -11
(GEOSTATIONARY ORBIT)

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)

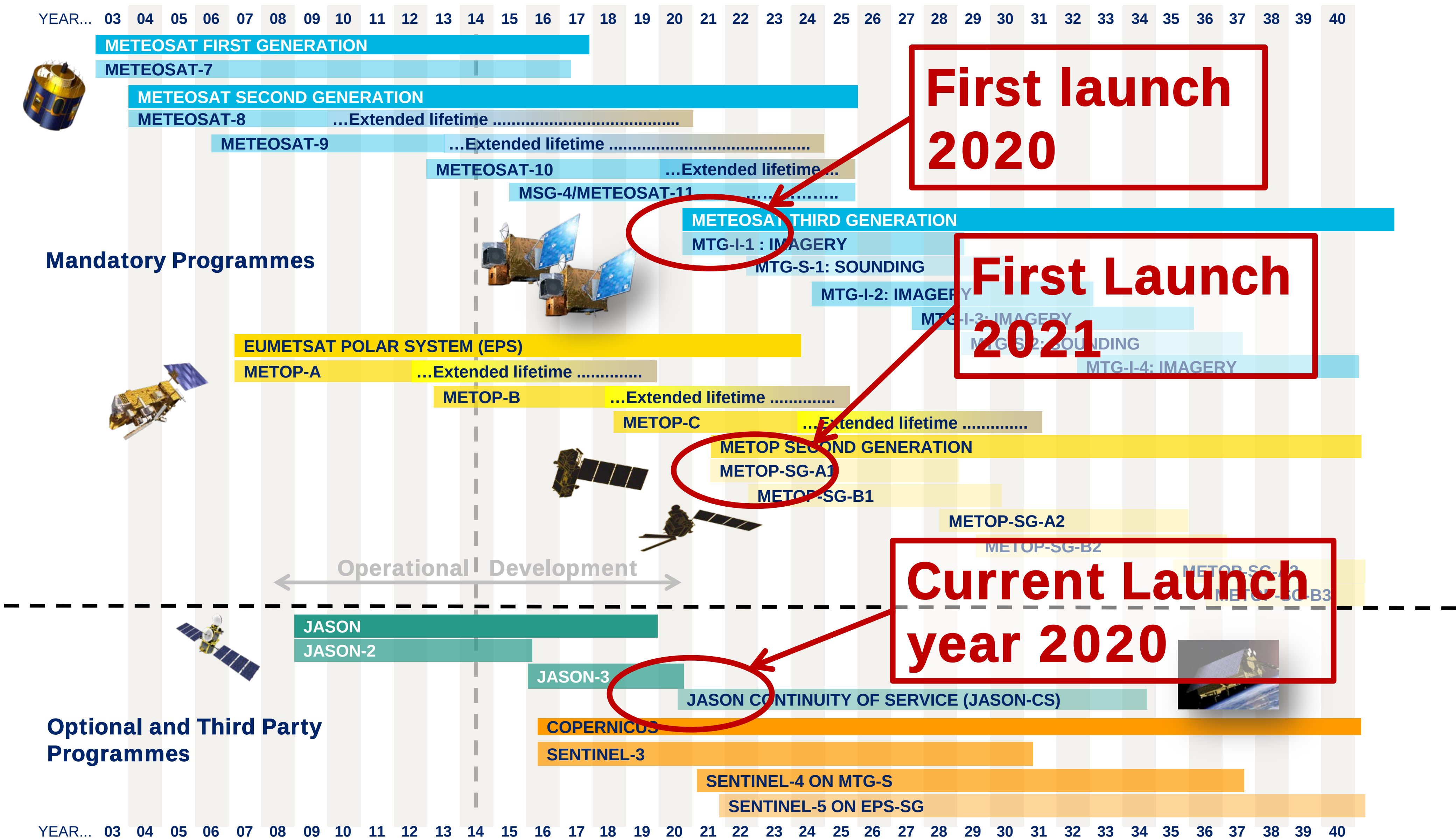
METEOSAT -8 (2nd GENERATION)
(GEOSTATIONARY ORBIT)

INDIAN OCEAN DATA COVERAGE MISSION
AT 40° E (TBD June 2016)

EUMETSAT programmes overview



EUMETSAT programmes overview



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MTG Programme – Space Segment

Twin satellite concept – based on 3-axis platforms:

4 geostationary imaging satellites **(MTG-I)**

2 geostationary sounding satellites **(MTG-S)**

Established through a cooperation between:

esa

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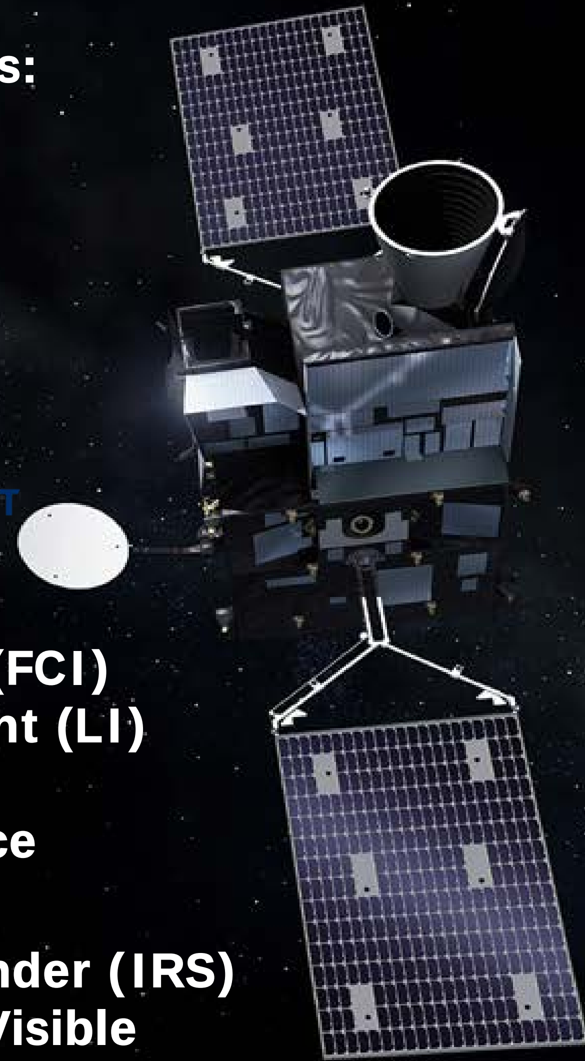


MTG-I: - Flexible Combined Imager (FCI)

- Lightning Imager Instrument (LI)

20 years of operational service

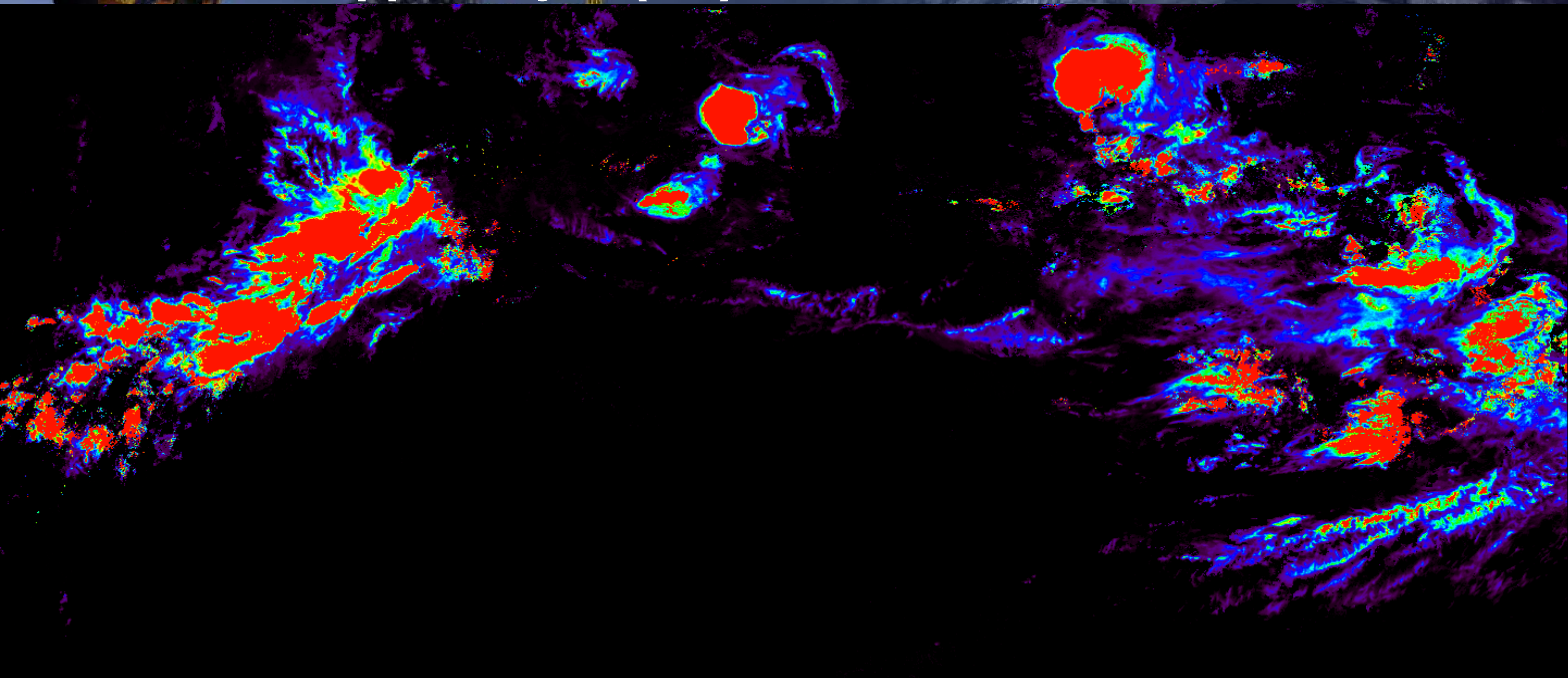
MTG-S: - Infrared Sounder (IRS)

- Ultra-violet, Visible and Near-infrared Sounder (UVN)

15.5 years of operational service

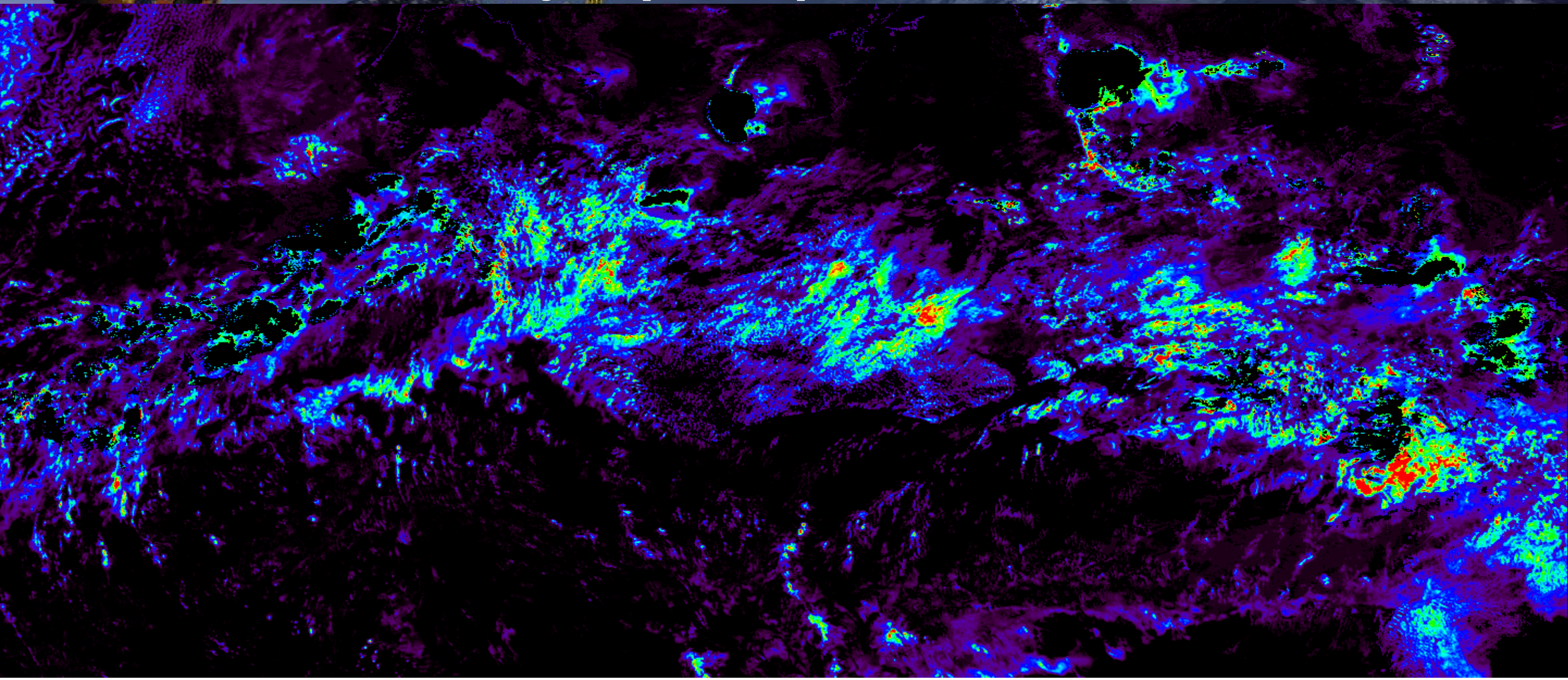
Upper Layer (ice) COT scaled 0-11

2011 July 25 11:30-12:30



2011 July 25 11:30-12:30

Lower Layer (water) COT scaled 0-42



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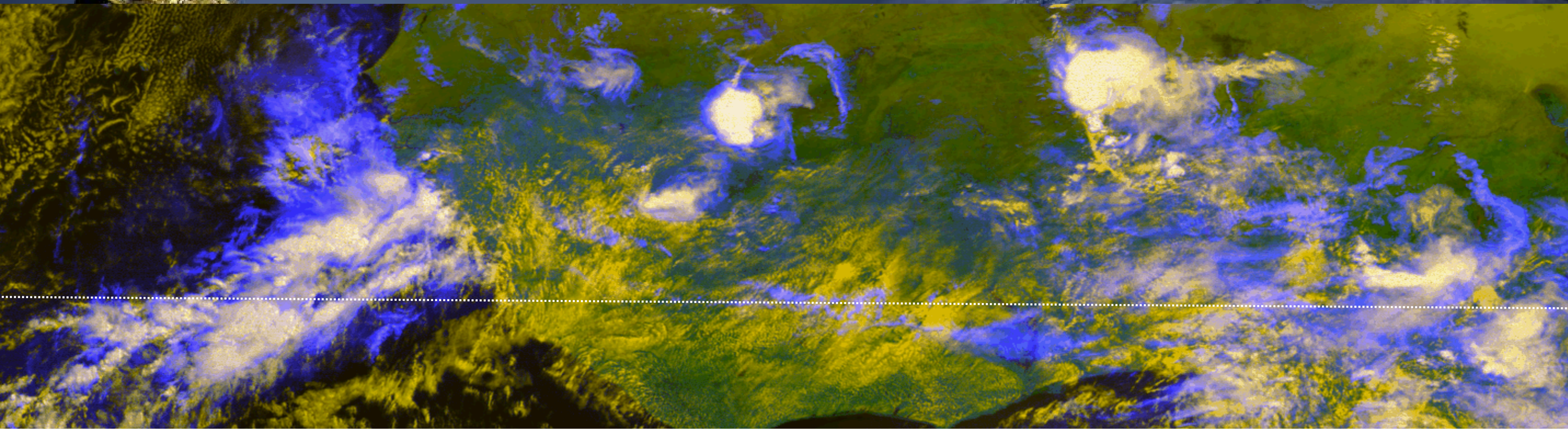
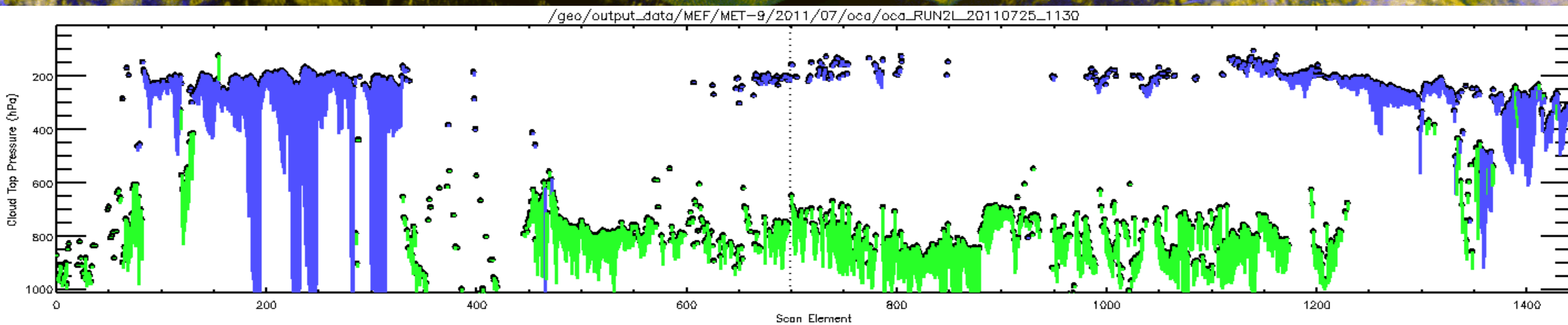
2-Layer Winds?

2011 July 25 11:30-12:30

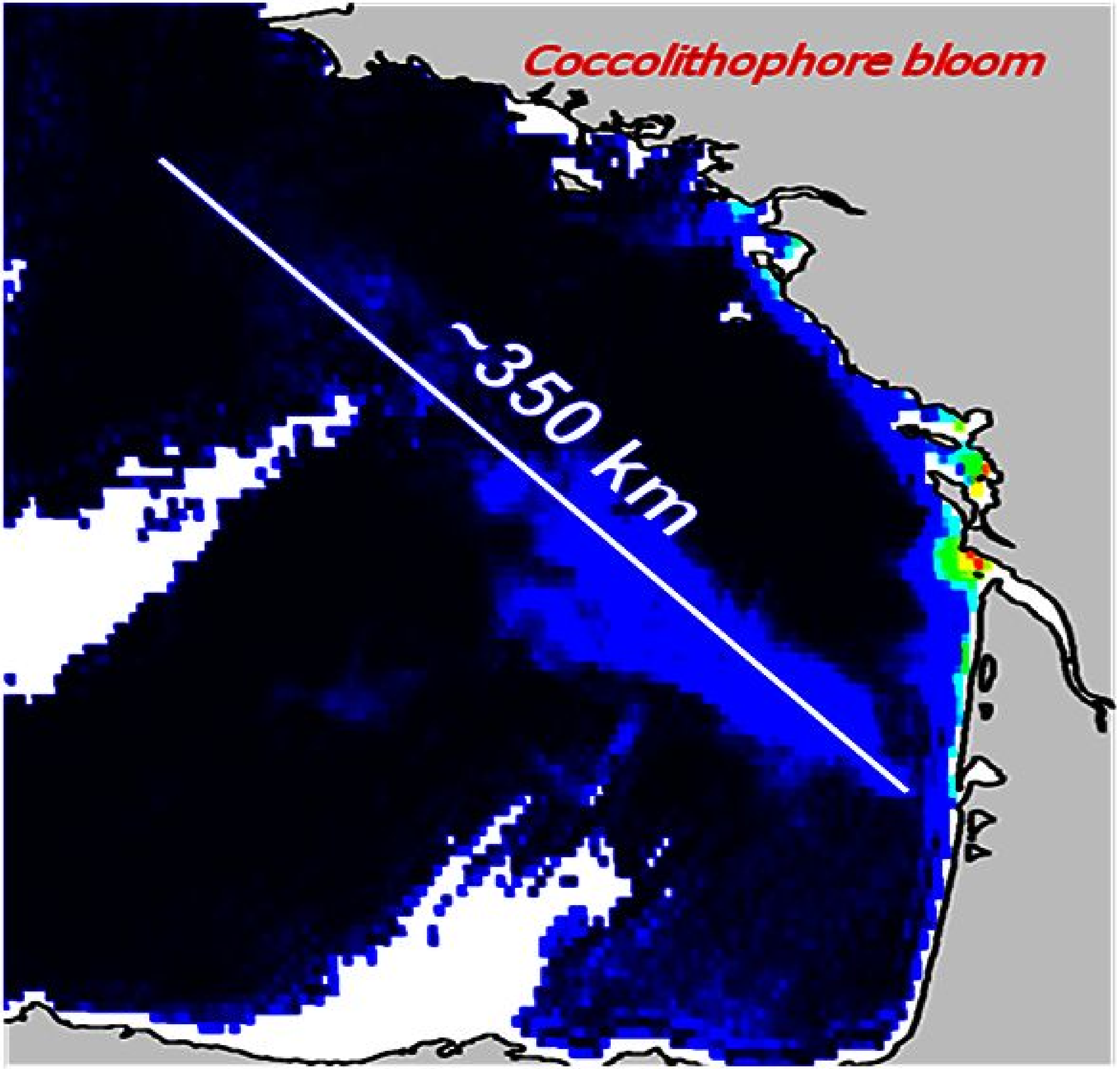
RGB 0.6, 0.8, 8-7-11





Ice blue water green

Scientific development for future / enhanced products (3) Coccolithophore blooms from the geostationary orbit ?



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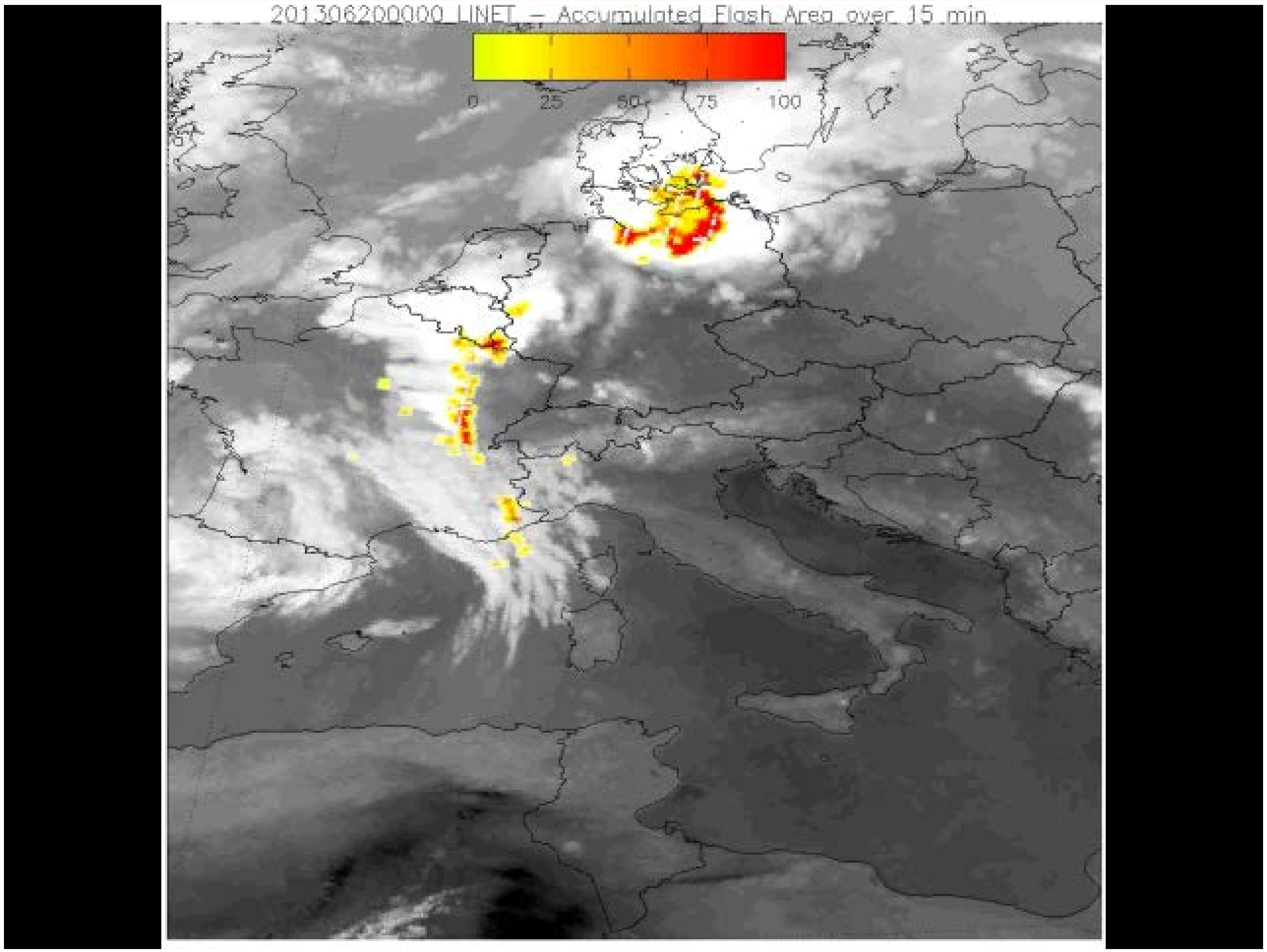
Observing lightning
Reference processor product example

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



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IRS NRT Demonstration service for Europe

- IRS Nowcasting Workshops
- Assimilation Workshop
  - Very High Resolution Limited Area Moel

- IRS NRT Demonstration service for Europe
  - Aims to involve potential operational users of MTG-IRS Level 2 products in the development of the level 2 processor.
  - The results of this evaluation will be used to identify limitations of the envisaged products and where possible to start mitigation actions in light of the experience with the proxy data.
  - Based on level 2 products from IASI and CrIS
  - Derived vertical profiles (T/H) and T_{surf} with their uncertainty

- For more on IRS see Tjemkes Wednesday 09:40.

The EUMETSAT polar system is part of the joint polar system shared with the US

- A two pillar backbone system:
- NOAA with Suomi-NPP and JPSS provides the afternoon orbit data
- EUMETSAT provides mid-morning data
- Coordination of products and services

•A third pillar? China has committed to the early morning orbit

EPS Second Generation

Continuing the European contribution to the Joint Polar System (JPS)

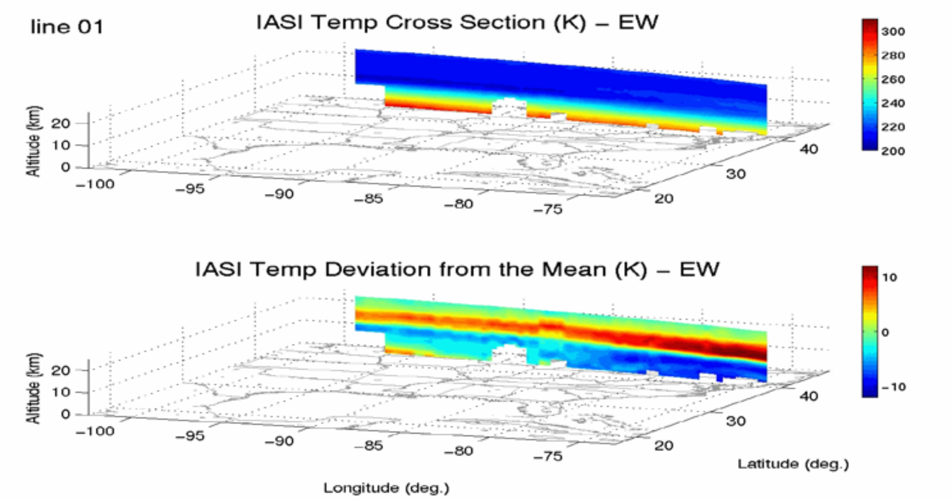
- Emhanced service from mid morning polar orbit in 2021 – 2040
- Twin satellite in-orbit configuration:
  - Metop-SG A: optical imagery and sounding mission
    - Flies the Copernicus Sentinel-5 instrument
  - Metop-SG B: microwave imaging mission
- Two series of 3 successive satellites for 21 years of operations
- Orbit @ 09:30 LTDN (Same as Metop)
- Phasing of Sat-a and Sat-b 180°

	Satellite a	**Satellite b**
Payload	METImage, IASI-NG, MWS, 3MI, S-5, RO	SCA, MWI, ICI, ARGOS-4, RO
Launch mass	3661 kg	3339 kg
Power	2.3 kW	2.0 kW
P/L data rate	54 Mb/s	6.3 Mb/s

Observation Missions

Mission	Instrument	Applications Benefitting
Hyper-spectral Infrared Sounding	IASI-NG	NWP, NWC, Air Quality, CM
Visible/Infra-red Imaging	METimage	NWC, NWP, CM, Hydrology, Oceanography
Microwave Sounding	MWS	NWP, NWC, CM
Radio Occultation Sounding	RO	NWP, CM
Nadir viewing UV/VIS/NIR/SWIR Sounding	Sentinel 5	Ozone-UV, Air Quality, CM, Composition-Climate interactions
Multi-viewing, -channel, -polarisation Imaging	3MI	Air Quality, CM, NWC
Scatterometry	SCA	NWP, NWC, Oceanography, Hydrology
Microwave Imaging	MWI	NWP, NWC, Hydrology, CM, Oceanography
Ice Cloud Imaging	ICI	NWP, NWC, Hydrology, CM

Hyper-spectral infrared sounding: IASI – NG



- **Objectives**
- Temperature/humidity profile at high vertical resolution
- Clouds, trace gases (O_3, CO, CH_4, CO_2,...)
- Sea/land/ice surface temperature
- Aerosols, Volcanic Ash

- **Implementation**
  - Development of Fourier Transform
  - Spectrometer IASI-NG by CNES

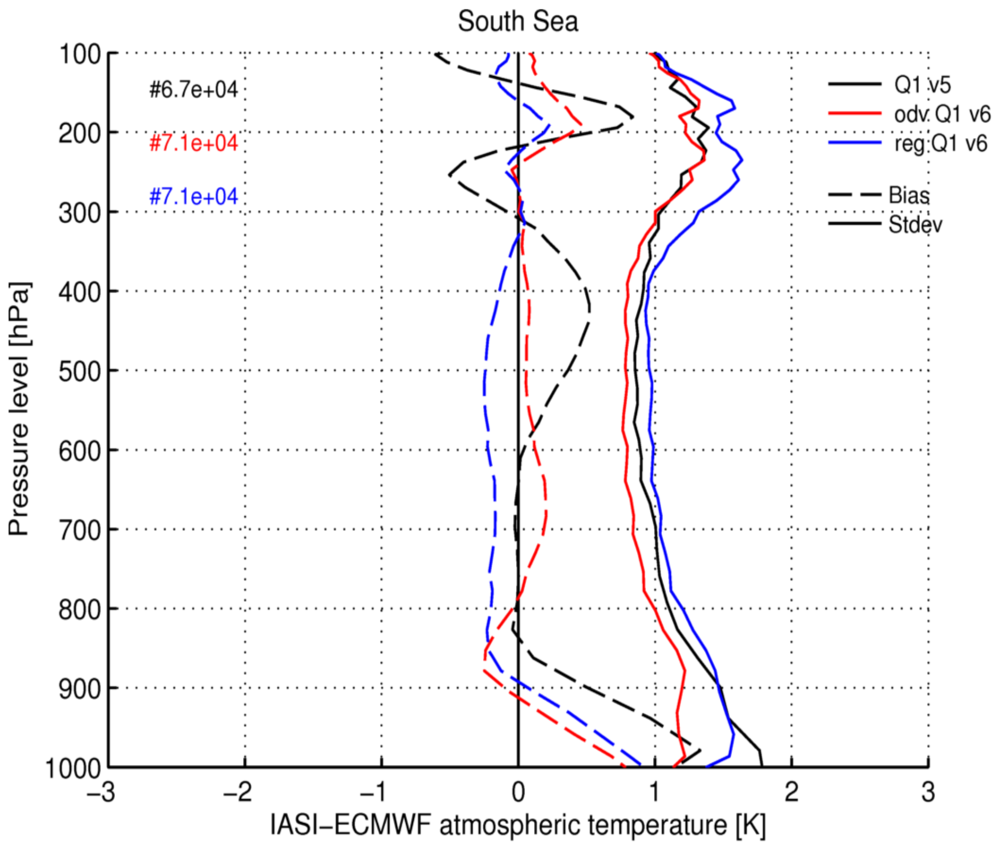
- **Key performances**
- spectral range: 645 – 2760 cm-1
- spectral resolution: 0.25 cm-1
- radiometric calibration: 0.25 K
- stability: 0.1 K
- Radiometric noise: 0.045 – 1.1 K
- pixel size: 12 km
- spatial sampling: 25 km
- cross-track scan

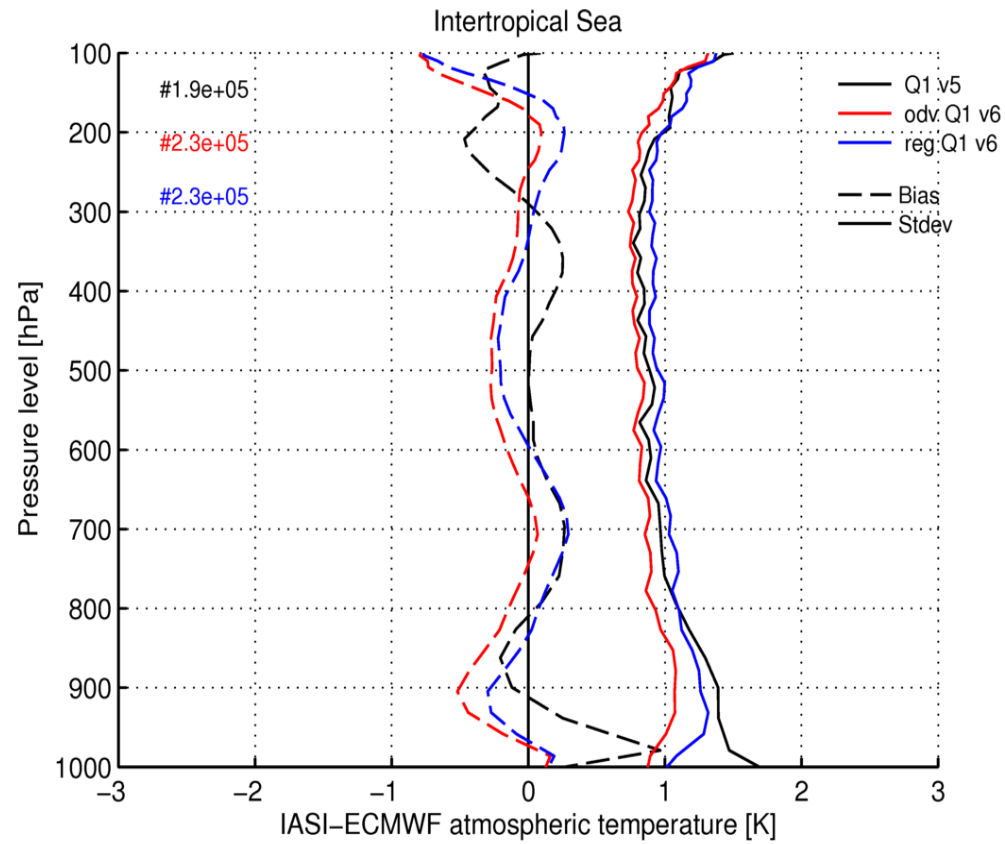
Breakthrough

- **Doubling of radiometric and spectral resolution of IASI for the benefit of weather forecast and atmospheric composition**
  - 75% more information in temperature profiling, particularly PBL
  - 30 % more information in water vapour profiling
  - Quantification of trace gases which are currently only detected
  - Vertical resolution of trace gases instead of columnar amounts only

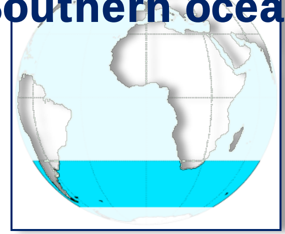
Atmospheric Profiling

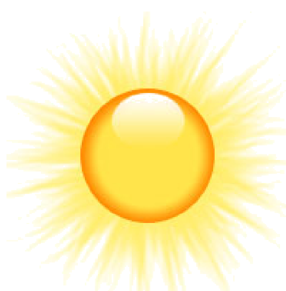
Hyperspectral Infrared L2 - IASI L2 v6 Temperature vs ECMWF ANA





21-25/02/2014
Southern oceans





Q1 PPF v5

Q1 OEM v6

Q1 First Guess v6

21-25/02/2014
Intertrop. oceans

Results: T. August, M. Crapeau, T. Hultberg, X. Calbet

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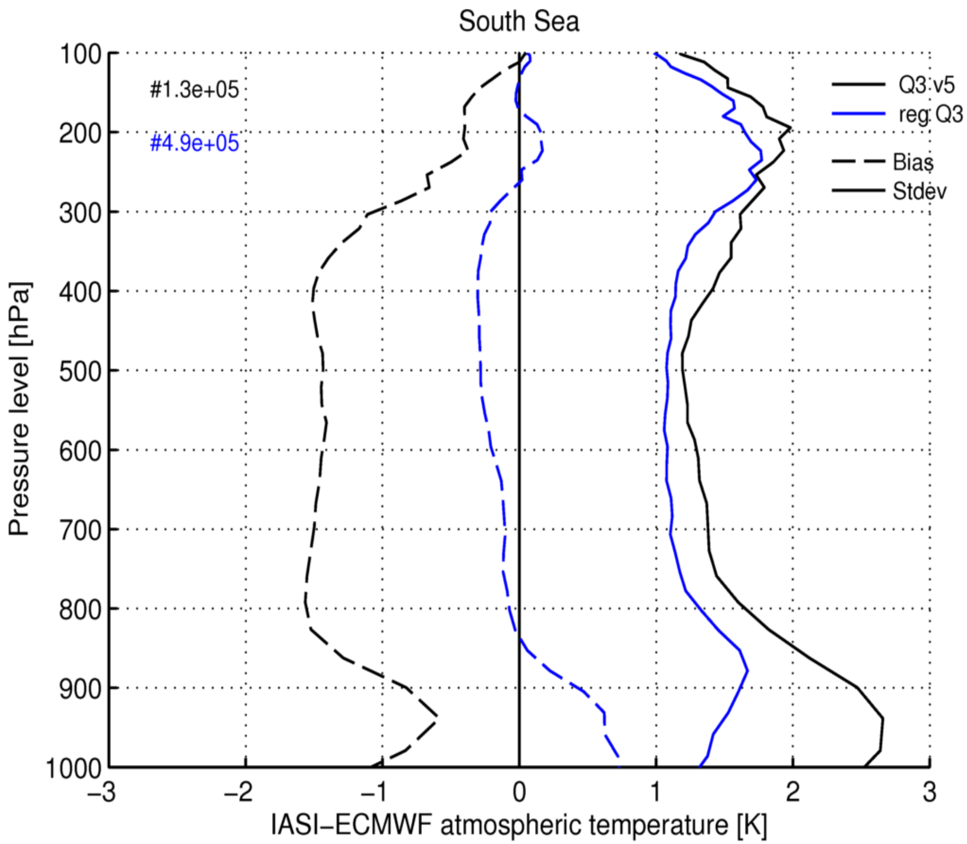
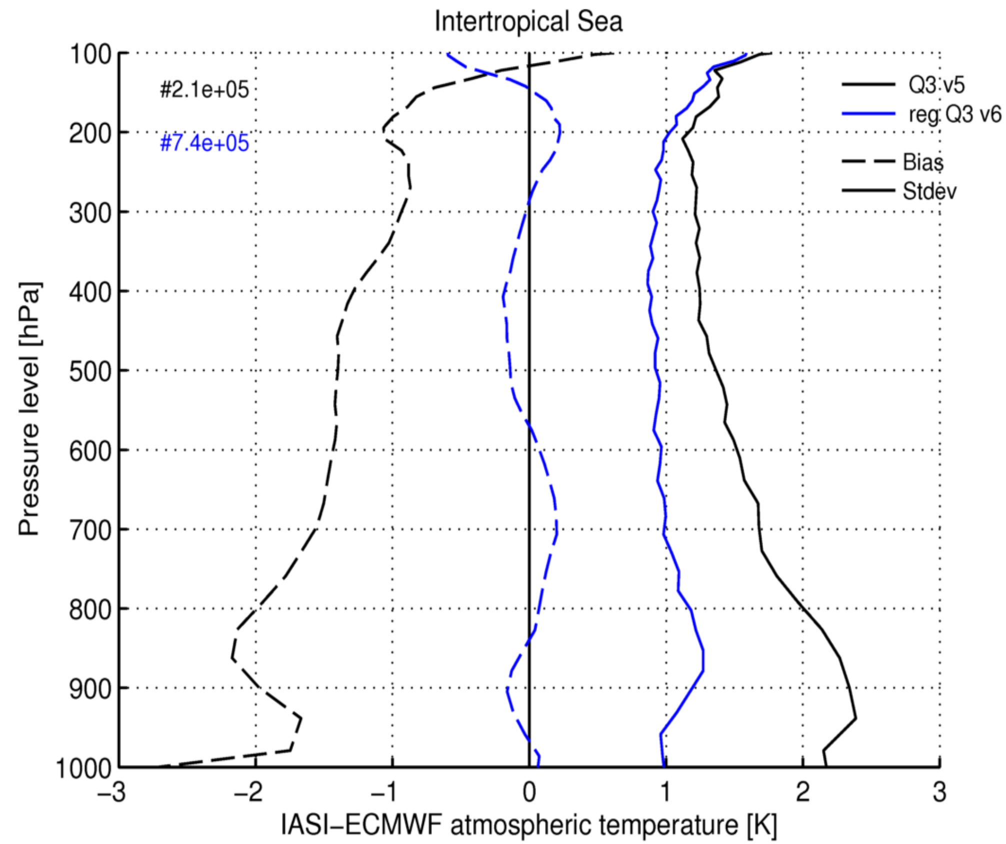
Atmospheric Profiling

Hyperspectral Infrared L2 - IASI L2 v6 Temperature vs ECMWF ANA





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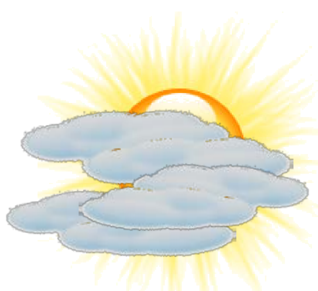

Q3 PPF v5

Q3 First Guess v6

21-25/02/2014
Intertrop. oceans

Results: T. August, M. Crapeau, T. Hultberg, X. Calbet

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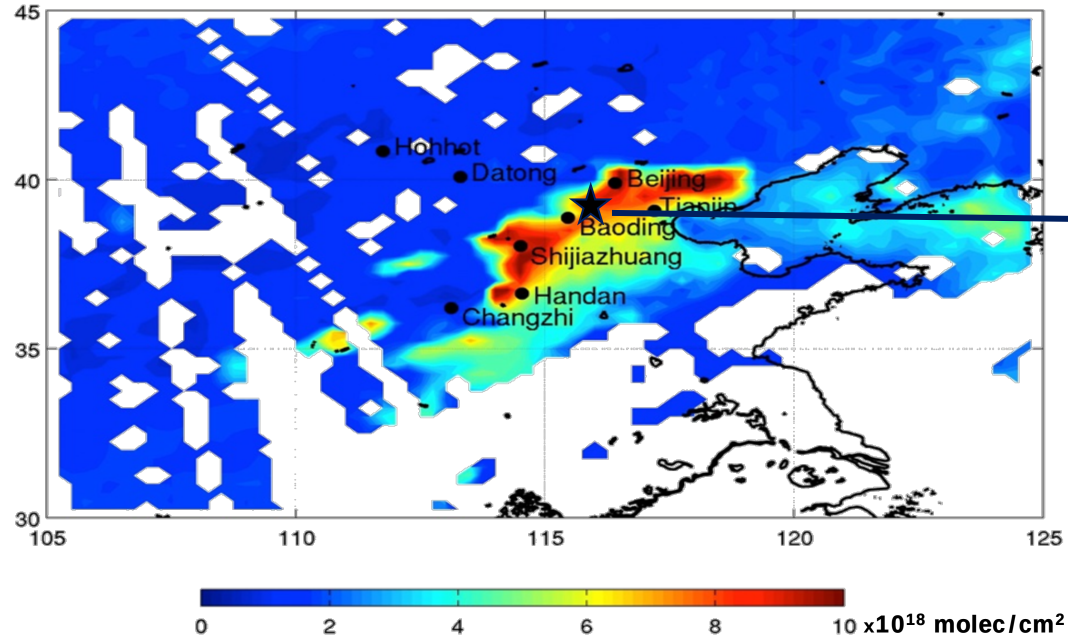
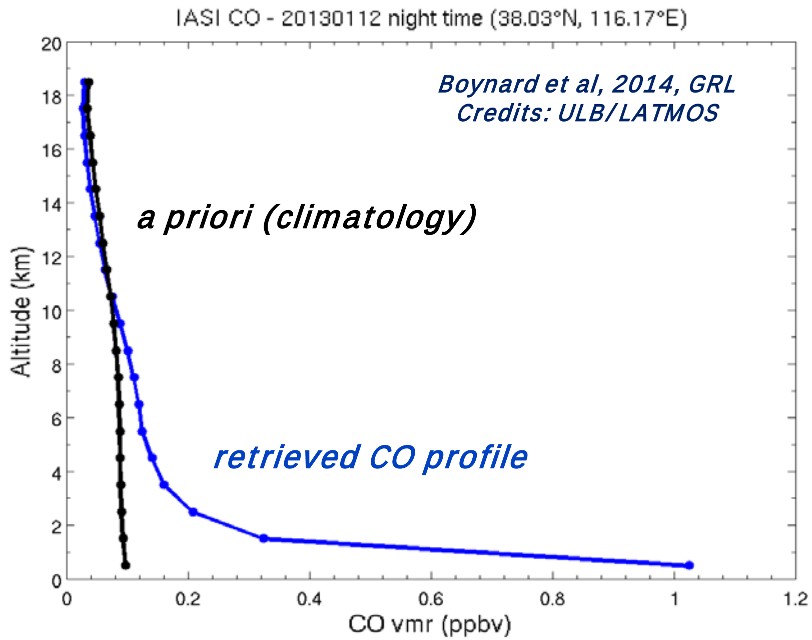
Towards a IASI CO Profile product: a premiere

CO Total column - Pollution over China, 12 January 2013





The IASI L2 processor v6 implements the FORLI-CO algorithm developed at ULB/LATMOS (O3M-SAF CDOP-2)

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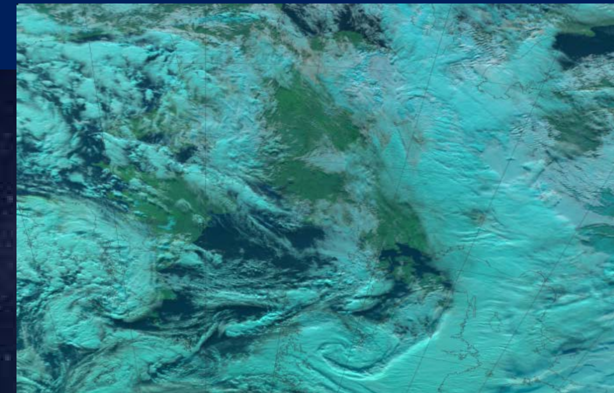
Optical imaging

METimage



- **Objectives**
- Hi-res cloud products, incl. microphysics
- Aerosols
- Polar AMVs
- Vegetation, snow, fire
- Sea/ice/land surface temperature
- Support to sounding missions

- **Implementation**
  - Development of *METimage* by DLR
- **Key performances**
- 20 channels: 0.443 – 13.345 µm
- absolute calibration: 5% (short-wave)
- 0.5 K (long-wave)
- radiometric sensitivity:
- SNR 60 – 500 (short-wave)
- 0.05 – 0.2 K (long-wave)
- spatial sampling: 500 m
- cross-track scan

Breakthrough

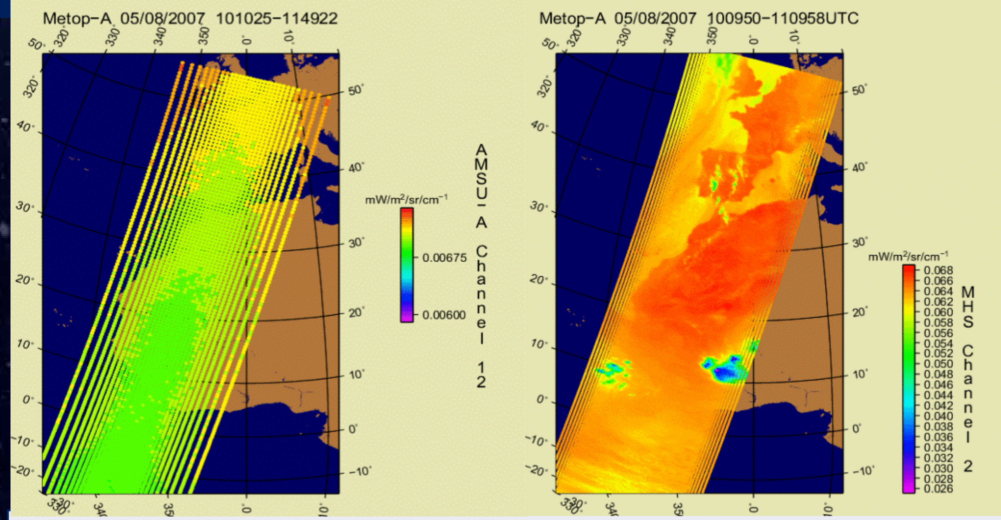
- **Far more spectral channels than AVHRR for the benefit of measuring more variables**
- **Higher spatial resolution (500 m):**
  - more complete coverage through greater likelihood to measure surface variables in partly cloud conditions
- **Better radiometric resolution for more accurate quantification of many variables**

Microwave Sounding

- **Objectives**
  - Temperature/humidity profiles in clear and cloudy air
  - Cloud liquid water total column
  - Imagery: precipitation

- **Implementation**
  - ESA development

- **Key performances**
  - 24 channels: 23.8 – 229 GHz
  - absolute calibration: 0.5 K
  - radiometric noise: 0.2 – 1.6 K
  - footprint size: 17 – 40 km
  - cross-track scan



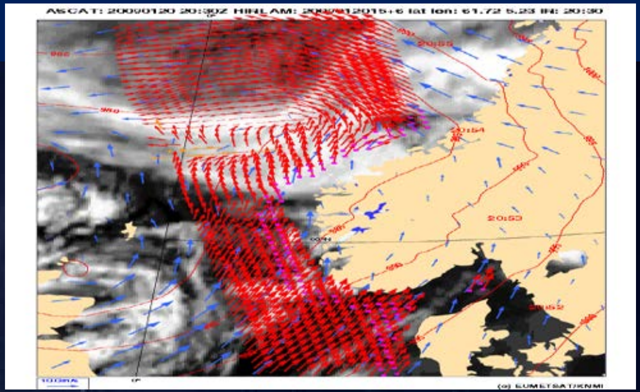
Breakthrough

- **Addition of a quasi-window channel at 229 GHz (recommended by ITSC-11)**
  - Cirrus cloud information giving a better humidity retrieval performance

- **Addition of sounding channels**
  - **+ 2 channels at 53-54 GHz**
  - **+ 3 channels at 183.31 GHz**

  - More information on temperature and water vapour profiles

Scatterometry



- **Objectives**
- ocean surface wind vectors
- soil moisture
- snow equivalent water
- sea-ice type

- **Implementation**
  - ESA development

- **Key performances**
- C-band carrier frequency
- VV + VH polarisation
- measurement range: 4 – 40 m/s
- Radiometric resolution: 3%
- spatial resolution: 25 km
- dual swath: 550 km each

Breakthrough

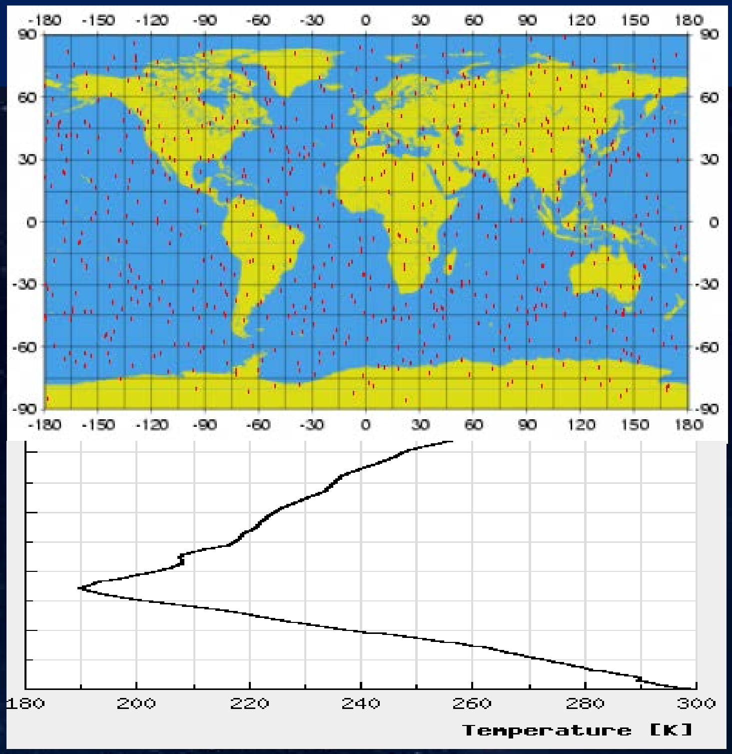
- **Increase of spatial resolution to 25 km**
  - Better approach of coast lines
- **Increase of swath width to >1100 km**
  - Enhanced coverage
- **Addition of VH polarisation**
  - Covers higher wind speeds without saturation, will benefit observation of tropical and extra-tropical storms

Radio-Occultation

- **Objectives**
  - Refractivity profiles at high vert. resolution
  - Temperature / humidity profiles
  - PBL top and tropopause height
  - Ionospheric electron content

- **Implementation**
  - ESA development

- **Key performances**
- tracking of GPS and Galileo satellites
  - optional: GLONASS and COMPASS
- RO on two satellites: > 2600 occultations per day
- bending angle accuracy: 0.5 µrad or 0.2%

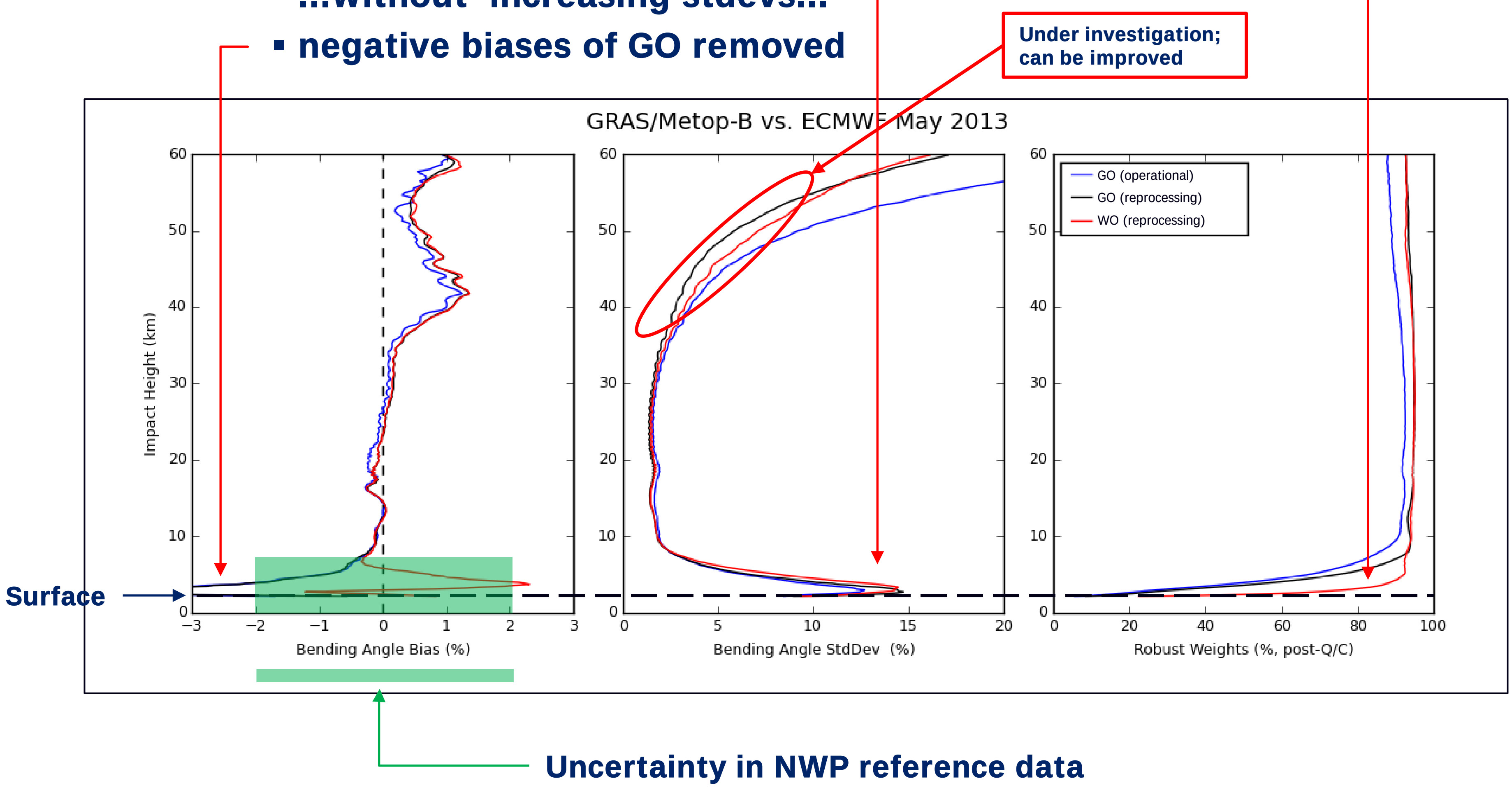


Breakthrough

- **Tracking of GPS and Galileo satellites to double the number of occultation measurements**
- **Equipment of both Metop-SG satellites with RO in case of a dual satellite configuration**

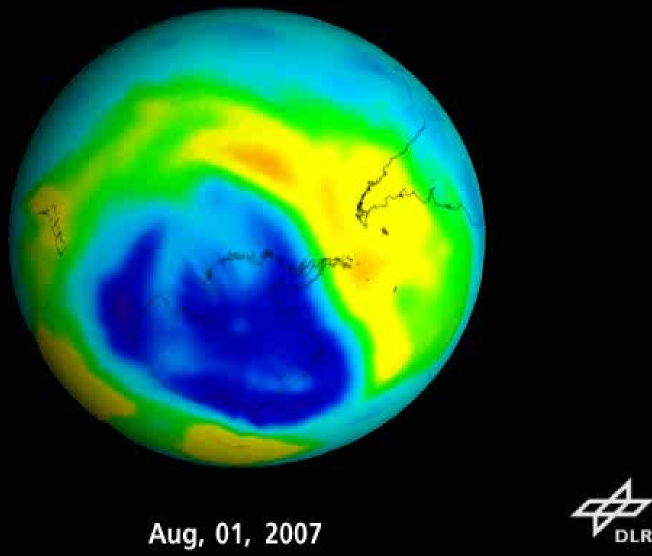
Scientific development for future / enhanced products
Wave optics for retrieval of GRAS profiles

- **Wave optics gives more data in the lowest 5 km…**
- **…without increasing stdevs…**
- **negative biases of GO removed**



UVNS Nadir Viewing UV/VIS/NIR/SWIR sounding

- **Objectives**
- Ozone profile and column
- Columns of CO_2,SO_2, NO_2, H_2O, CO, CH_4,
- Aerosol optical depth
- Columns of BrO, HCHO, OCHCHO
- Volcanic Plumes
- **Implementation**
  - GMES Sentinel-5 to be embarked
- on Metop-SG, ESA development
- **Key performances**
- spectral range: 0.27 – 2.385 µm
- spectral resolution: 0.25 – 1 nm
- radiometric calibration: 1 – 2%
- SNR: 120 - 1500
- spatial sampling: 7 km
- Cross-track scan



Breakthrough

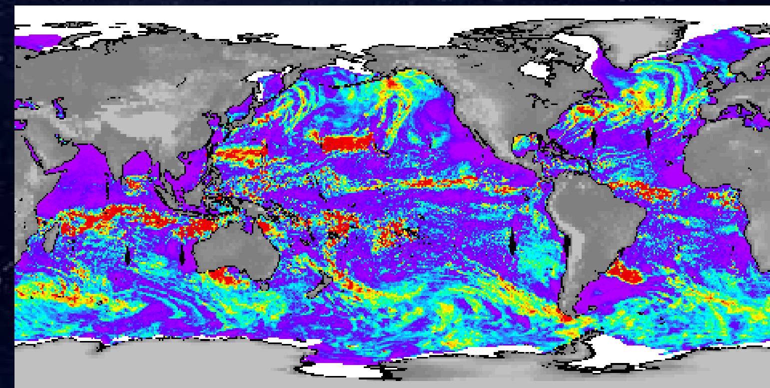
- **Drastically increased spatial sampling (7 km)**
  - for the benefit of air quality monitoring
- **Extended spectral range into the near and shortwave infrared regions**
  - to measure aerosols as well as methane and carbon monoxide in the PBL

Microwave Imaging

- **Objectives of a new mission**
  - precipitation and cloud products
  - water vapour profiles and imagery
  - sea-ice, snow, sea surface wind

- **Implementation**
  - ESA development

- **Key performances**
  - 18 channels: 18.7 – 183 GHz
  - dual polarisation (V, H) up to 89 GHz
  - V polarisation at higher frequencies
  - radiometric accuracy: 1 K
  - radiometric sensitivity: 0.6 – 1.2 K
  - Footprint size: 10 – 50 km
  - spatial sampling: 7 km
  - conical scan



Breakthrough: 18 channels

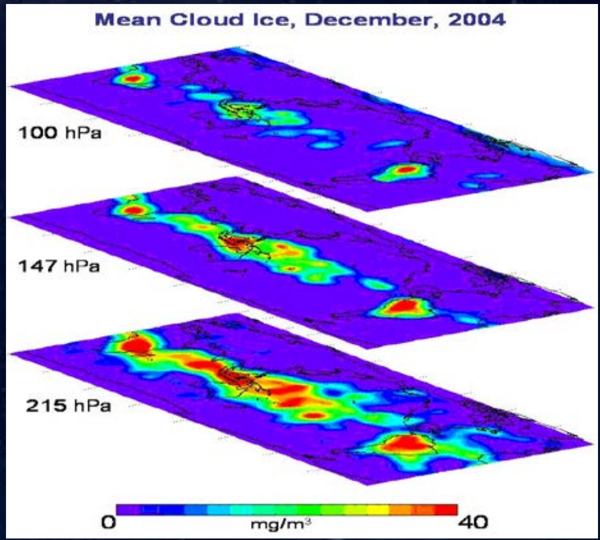
- **Continuity of key microwave imager channels for weather forecast**
- **Inclusion of dedicated sounding channels (118.75 GHz)**
  - Enhanced precipitation measurements through inclusion of dedicated sounding channels
- **Extended suite of 183.31 GHz channels**
  - water-vapour and cloud profiling

Ice Cloud Imaging

- **Objectives of a new mission**
- Cloud products, in particular ice clouds
- Snowfall detection and quantification
- Water-vapour profiles and imagery

- **Implementation**
  - ESA development

- **Key performances**
- 11 channels: 183 – 664 GHz
- single polarisation (V) for all channels
- dual polarisation (V, H) at 243 and 664 GHz
- radiometric accuracy: 1 – 1.5 K
- radiometric sensitivity: 0.6 – 1.9 K
- Footprint size: 15 km
- spatial sampling: 7.5 km
- conical scan



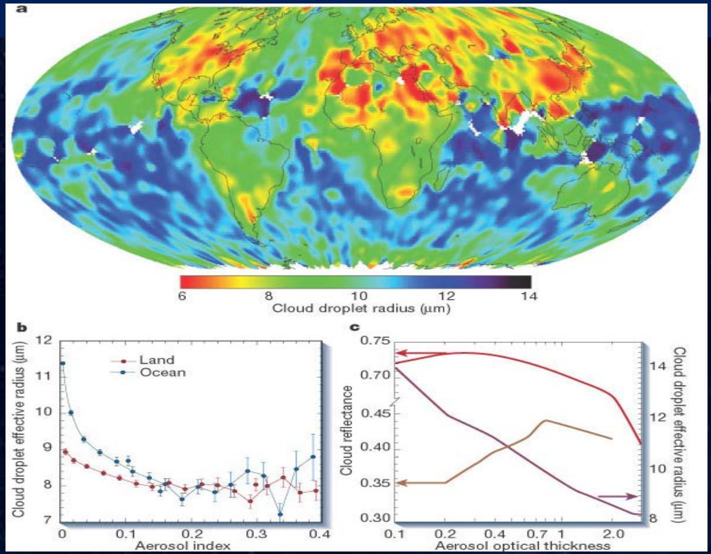
Breakthrough: 11 channels

- **Establishes operational ice-cloud imaging mission**

- **Support of weather forecast, hydrology, and climate monitoring**

Multi-viewing multi-channel multi-polarisation Imaging

- **Objectives of a new mission**
  - Aerosol – optical thickness, particle size, type, height, absorption
  - Volcanic Ash
  - Cloud phase, height, optical depth
  - Surface albedo



Kaufman et al. (2002)

- **Implementation**
  - ESA development

- **Key performances**
  - 12 channels: 0.41 – 2.13 µm
  - 3 polarisations: 0°, 60°, -60°
  - 14 views
  - radiometric bias: 3%
  - SNR: 200
  - spatial sampling: 4 km
  - push-broom scan (2200 km swath)

Breakthrough:

- **Enhanced spatial sampling (4 km)**
  - Improves separation of cloudy areas
- **12 spectral channels (9 polarised), extending into the UV and SWIR**
  - Better aerosol characterisation
- **Higher angular resolution (14 views)**
  - Better phase function characterisation

EPS Second Generation
Synergy of observation missions

Observation missions are highly complementary

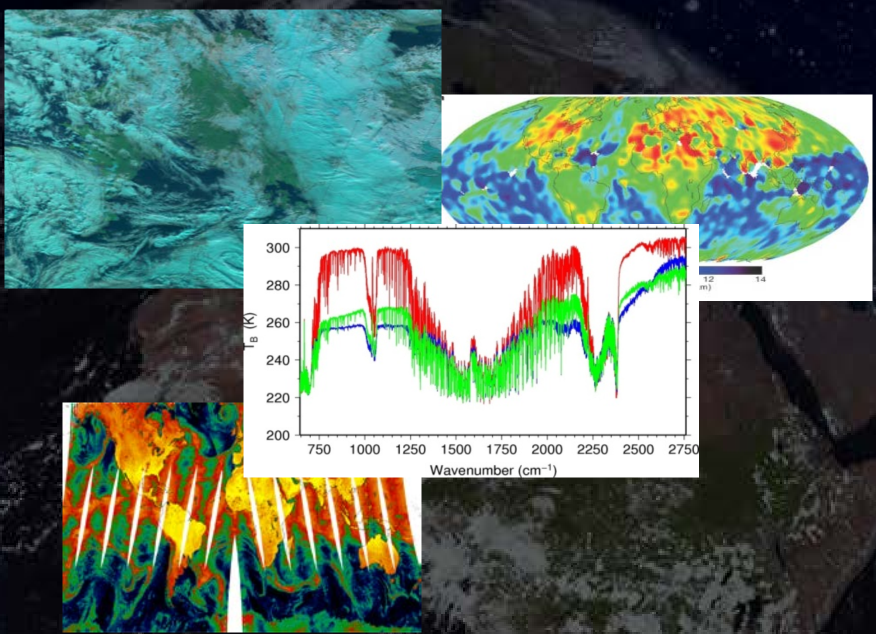
- Co-registration of measurements will allow to optimise the information extraction
- Synergy to be considered in payload distribution of a dual satellite configuration

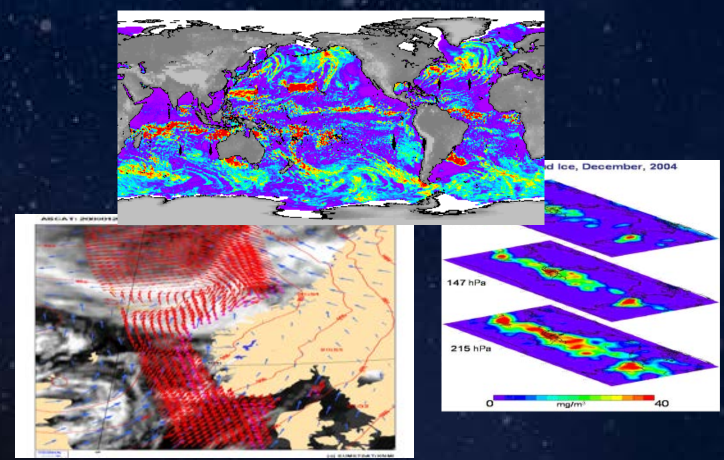
Essential co-registrations

- IAS – VII – UVNS
- MWI - ICI

Desired co-registrations

- IAS – MWS
- VII – 3MI
- IAS – UVNS – 3MI
- MWI – SCA – VII





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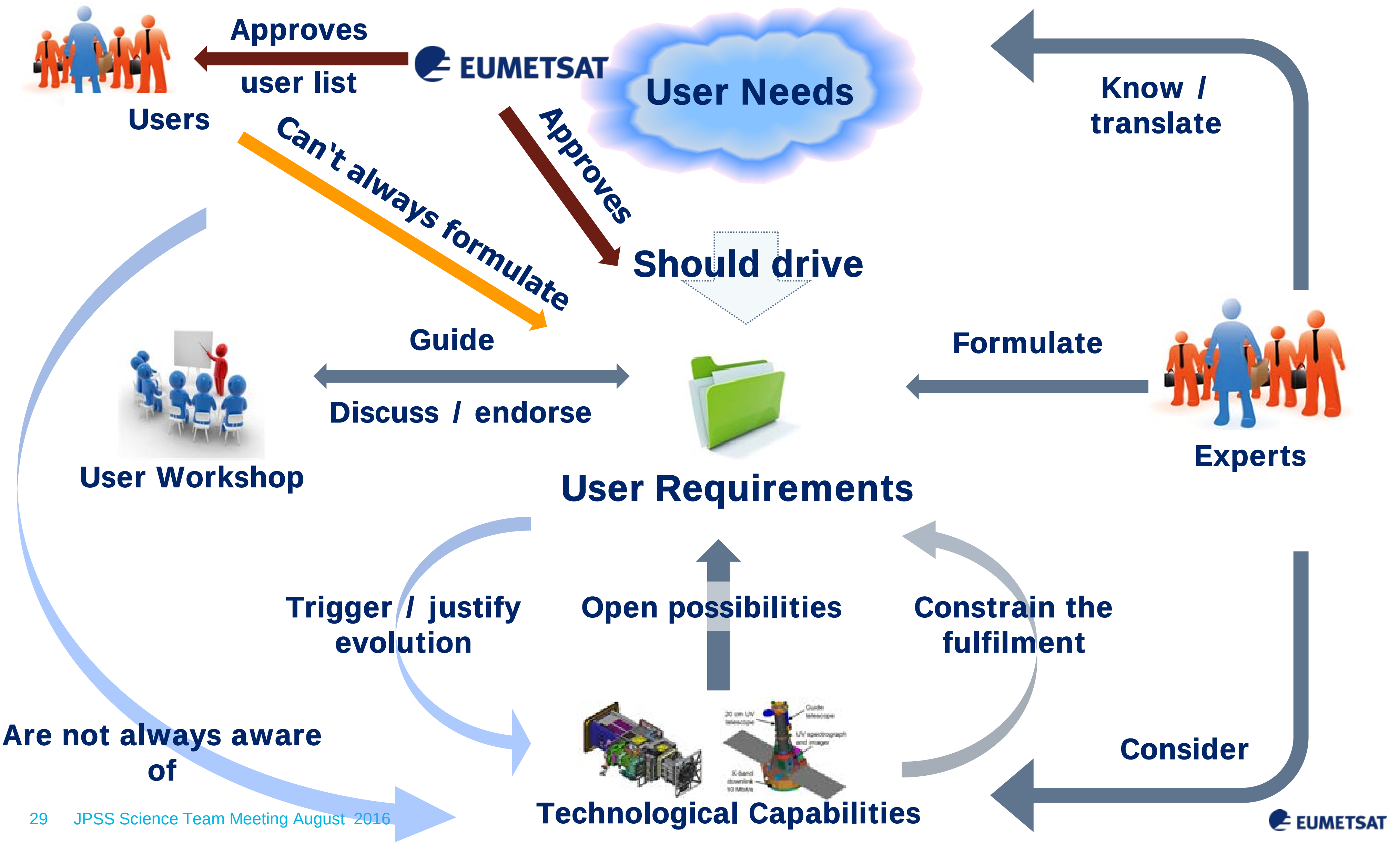
Process for user requirements elaboration



User Preparation: MTG as an example

- A dedicated project in EUMETSAT
  - Including representatives from the Member States
- MTGUP Project objectives are to:
  - Support users in a smooth transition from Meteosat Second Generation (MSG) to MTG for all comparable services, noting that the MSG and MTG availability may have a longer period of overlap;
  - Assist users in the early adoption of MTG services into operational forecasting;
  - Assist and encourage users to take advantage of the new services and capabilities offered by MTG in the early stages of MTG operations;
  - Establish a communication platform for the exchange of user feedback on MTG Programmatic and general user preparation issues.

User Preparation: Schedule

- Once established, the project will continue until the start of MTG-I2 operations + 1 year to cover the transition and the early operations phases, until such time when the full MTG services are in place;

- The various project phases and milestones shall be linked to the availability of the future MTG services (0 degree, RSS, Sounding).

- Consider operational transition scenarios

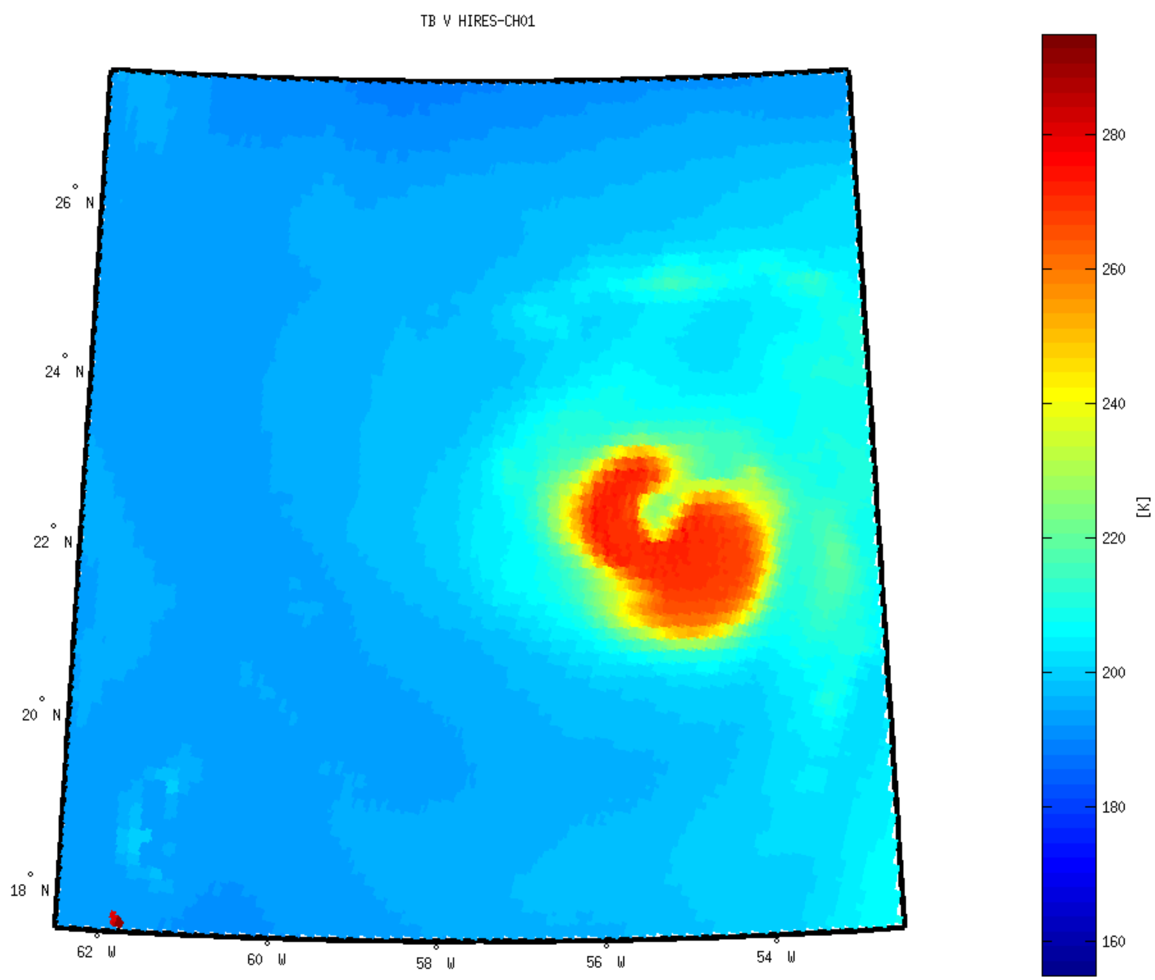
User Preparation: Work packages

- Establish and validate user expectations
- Ensure User engagement
- Monitor user preparedness
- Training Support
- Communication and information!

User Preparation: Work packages

- Test Data Support
- Science interaction and collaboration
  - Science studies and activities supporting the new capabilities of MTG, e.g. NWC-IRS Demonstration project
  - Research Announcement Collaboration, etc.,
  - Review the portfolio of existing meteorological products
  - Propose enhancements to the existing products based on changing user requirements
- Build on experiences from our partners
  - US/Europe collaboration is exemplary!!

Test Data: MWI-1 HiRes



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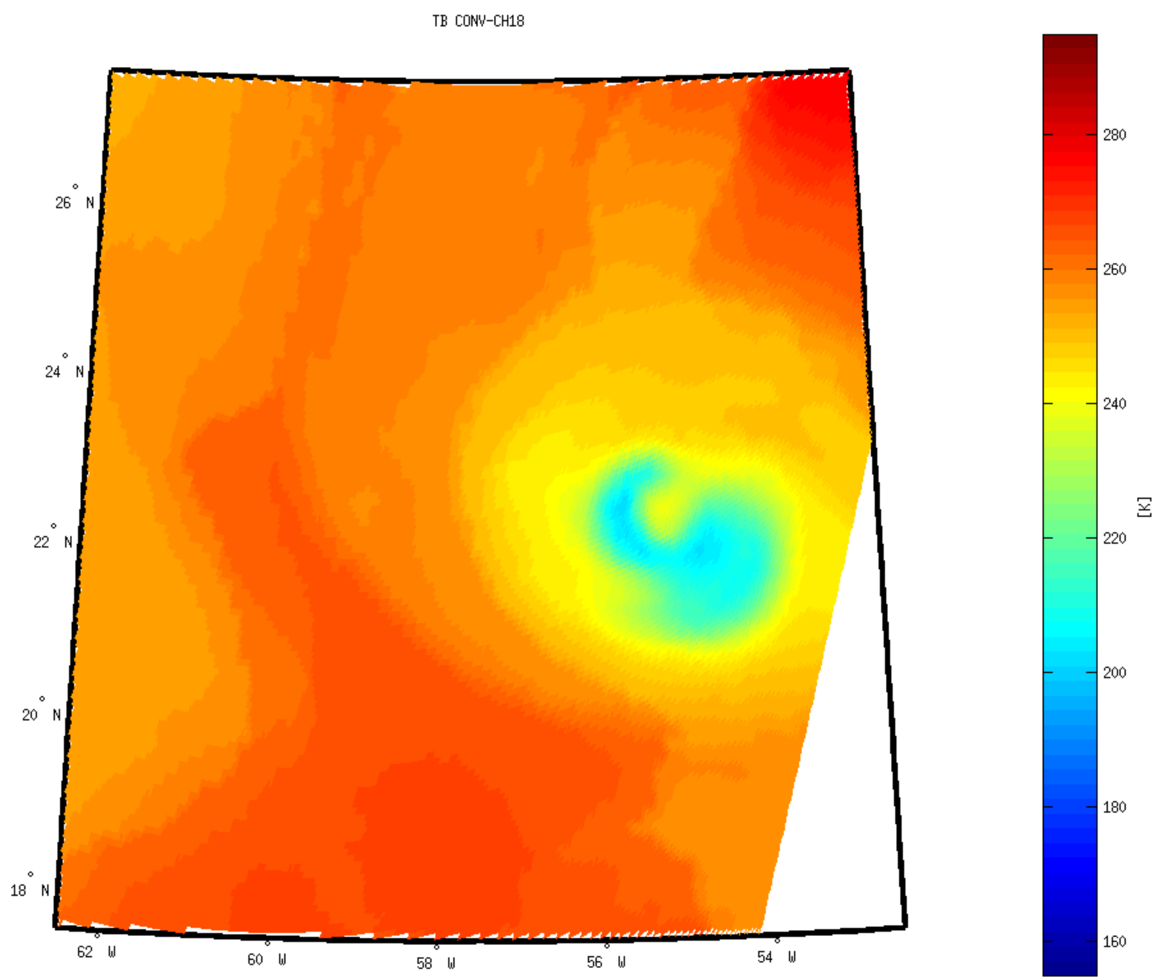
Test Data: MWI Channels 1 - 18

Channel	Frequency (GHz)
MWI-1	18.7
MWI-2	23.8
MWI-3	31.4
MWI-4	50.3
MWI-5	52.610
MWI-6	53.24
MWI-7	53.750
MWI-8	89.0
MWI-9	118.7503±3.20
MWI-10	118.7503±2.10
MWI-11	118.7503±1.4
MWI-12	118.7503±1.2
MWI-13	165.5±0.75
MWI-14	183.31±7.0
MWI-15	183.31±6.1
MWI-16	183.31±4.9
MWI-17	183.31±3.4
MWI-18	183.31±2.0



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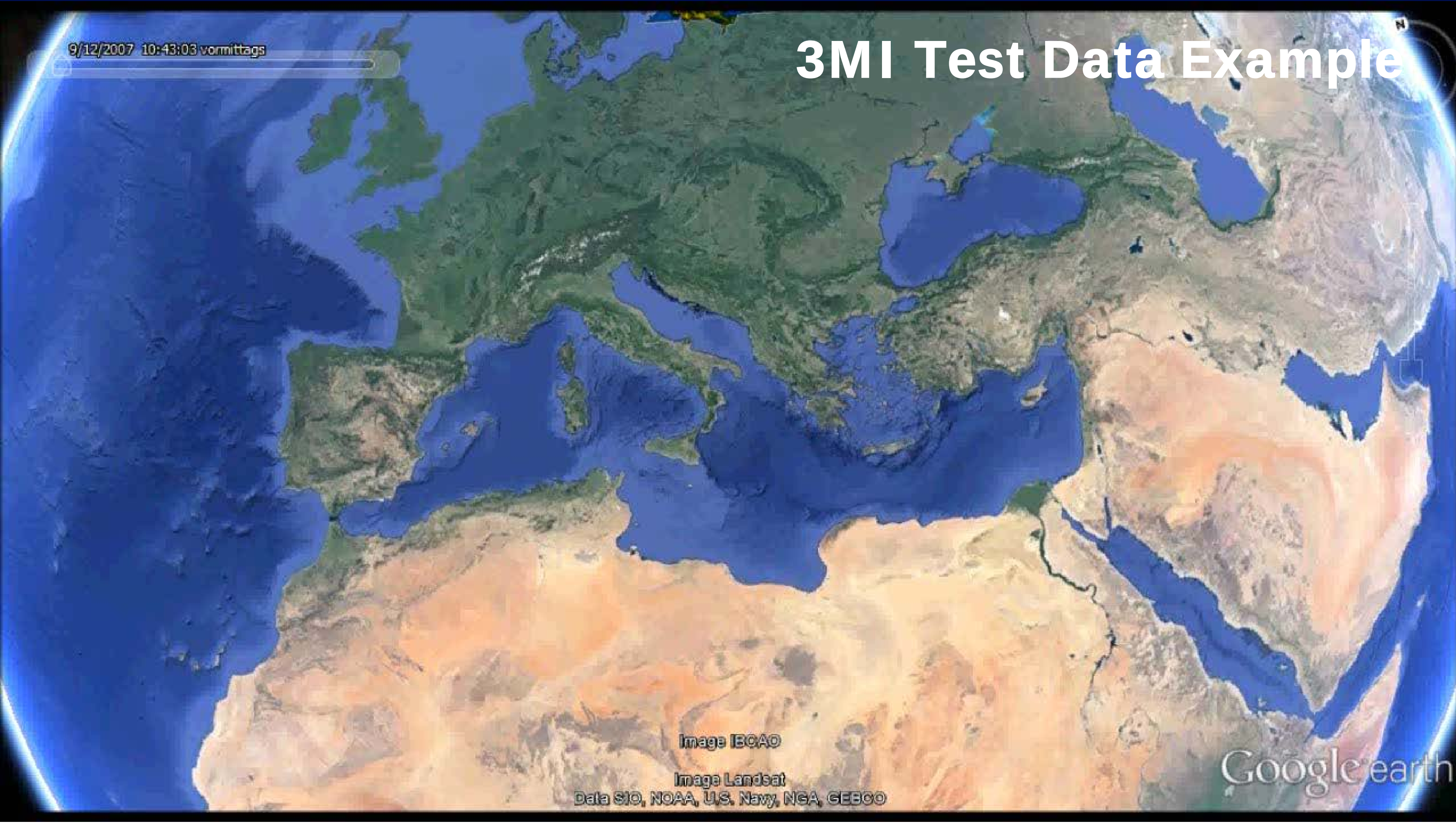
Thank You – Any Questions



Thank You For Inviting Me!

Questions?