STATUS OF THE EUMETSAT SATELLITE PROGRAMMES

TOWARDS THE NEXT GENERATION METEOROLOGICAL SATELLITES

EUMETSAT

Kenneth Holmlund
EUMETSAT

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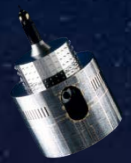
J. Schmetz, M. Cohen S. Rota, D. Klaes
R. Munro, F. Montagner, C. Hanson, J. Grandell
And many other contributors
from EUMETSAT and its partners



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

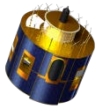
METEOSAT SECOND GENERATION -8.-9.-10, MSG-4 (-11)
(GEOSTATIONARY ORBIT)

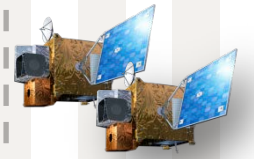
TWO-SATELLITE SYSTEM:
- METEOSAT-11: IN-ORBIT BACKUP
- METEOSAT-10: FULL DISK IMAGERY MISSION AT 0° (15 MN)
- METEOSAT-9: RAPID SCAN SERVICE OVER EUROPE AT 9.5°E (5 MN)
- METEOSAT- 8: BACK UP AT 3.5°E

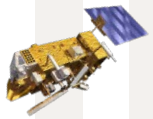
METEOSAT – 7 (1st GENERATION)
(GEOSTATIONARY ORBIT)

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

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 ...

METEOSAT-11 ……..

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)

COPERNICUS

SENTINEL-3

SENTINEL-4 ON MTG-S

SENTINEL-5 ON EPS-SG

Optional and Third Party Programmes

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

Current scheduled For launch 10/2018

Launch Date 17.01.2016

Launch Date 04.02.2016

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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)

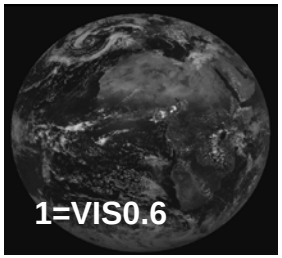
TWO-SATELLITE SYSTEM:
- METEOSAT-11: IN-ORBIT BACKUP
- METEOSAT-10: FULL DISK IMAGERY MISSION AT 0° (15 MN)
- METEOSAT-9: RAPID SCAN SERVICE OVER EUROPE AT 9.5°E (5 MN)

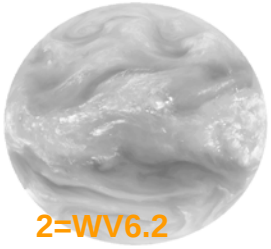
METEOSAT -8 (2nd GENERATION)
(GEOSTATIONARY ORBIT)

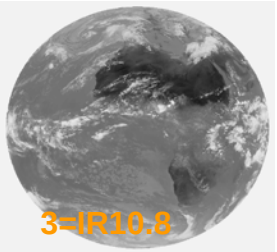
INDIAN OCEAN DATA COVERAGE MISSION
AT 40° E (TBD June 2016)

From MVIRI on MTP...

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







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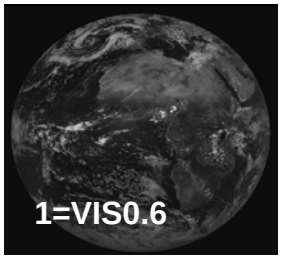
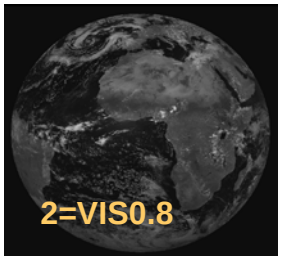
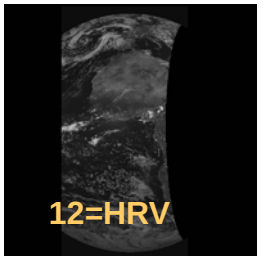
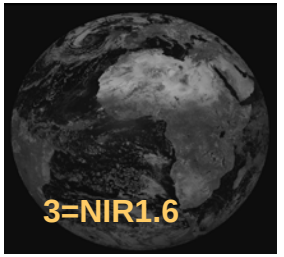
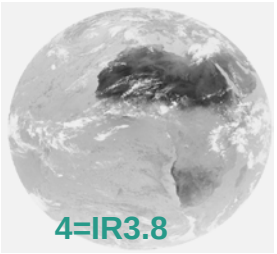
From MVIRI on MTP to SEVIRI on MSG...

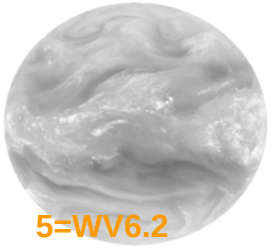


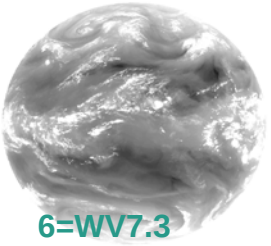


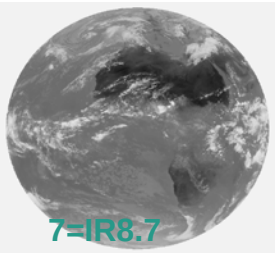


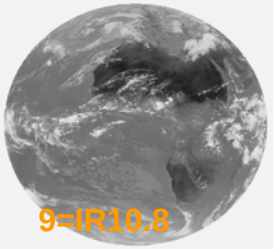


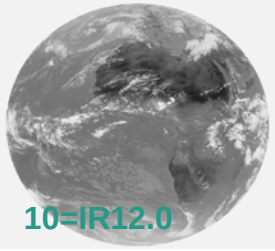


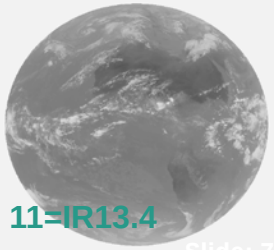




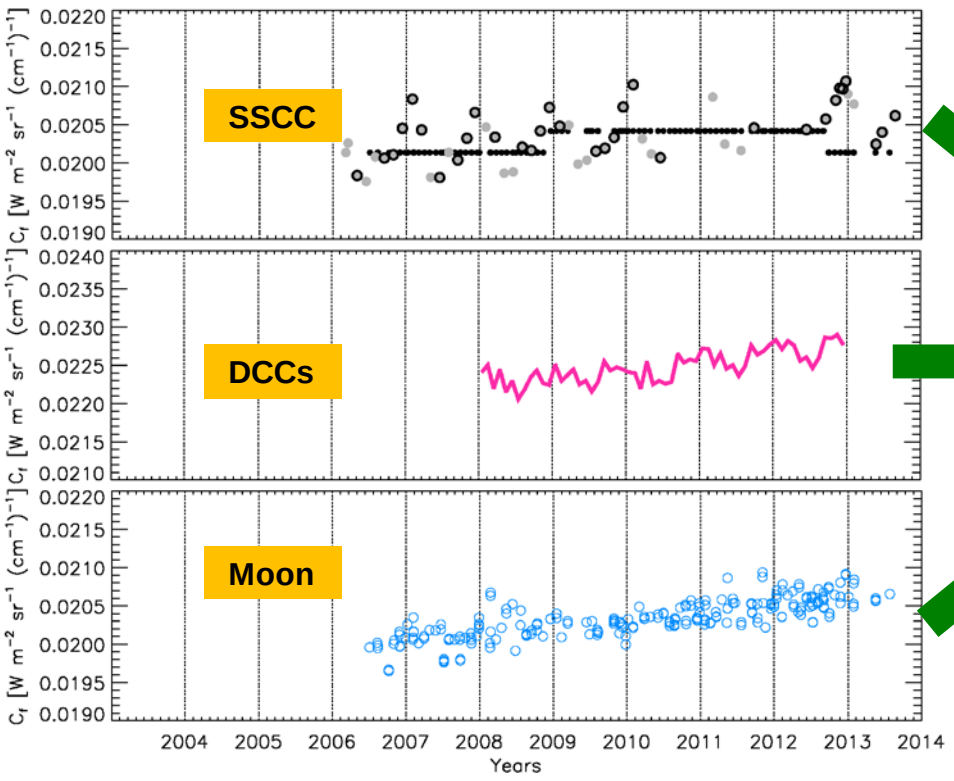




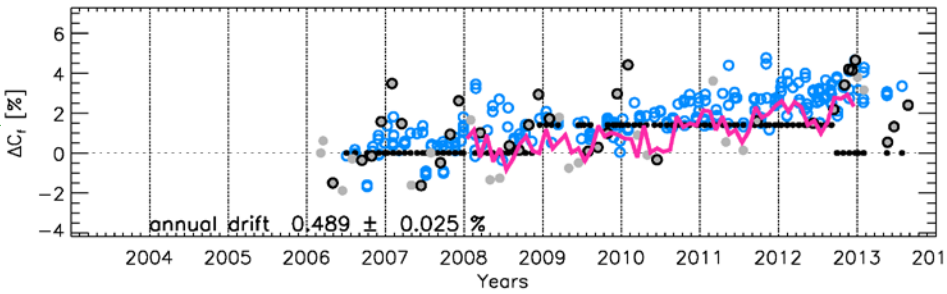




Multi-Mission Calibration and Monitoring System



Relative scale

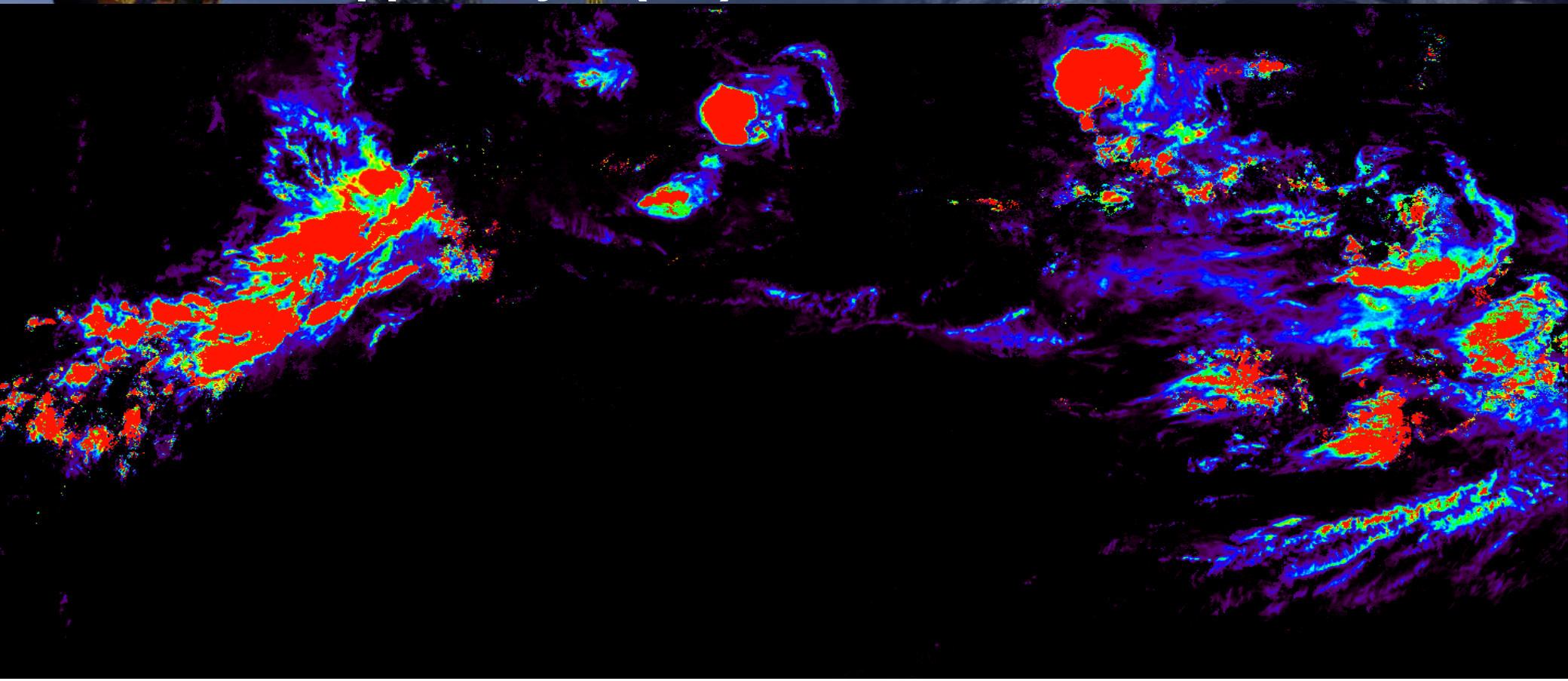


Example of the VIS06 band on MSG2/SEVIRI. Grey/black big dots: SSCC gains. Black small dots: gains as available in Level 1.5 image headers (derived from SSCC). Blue dots: lunar calibration. Magenta: DCC gains

- 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

2011 July 25 11:30-12:30

Upper Layer (ice) COT scaled 0-11



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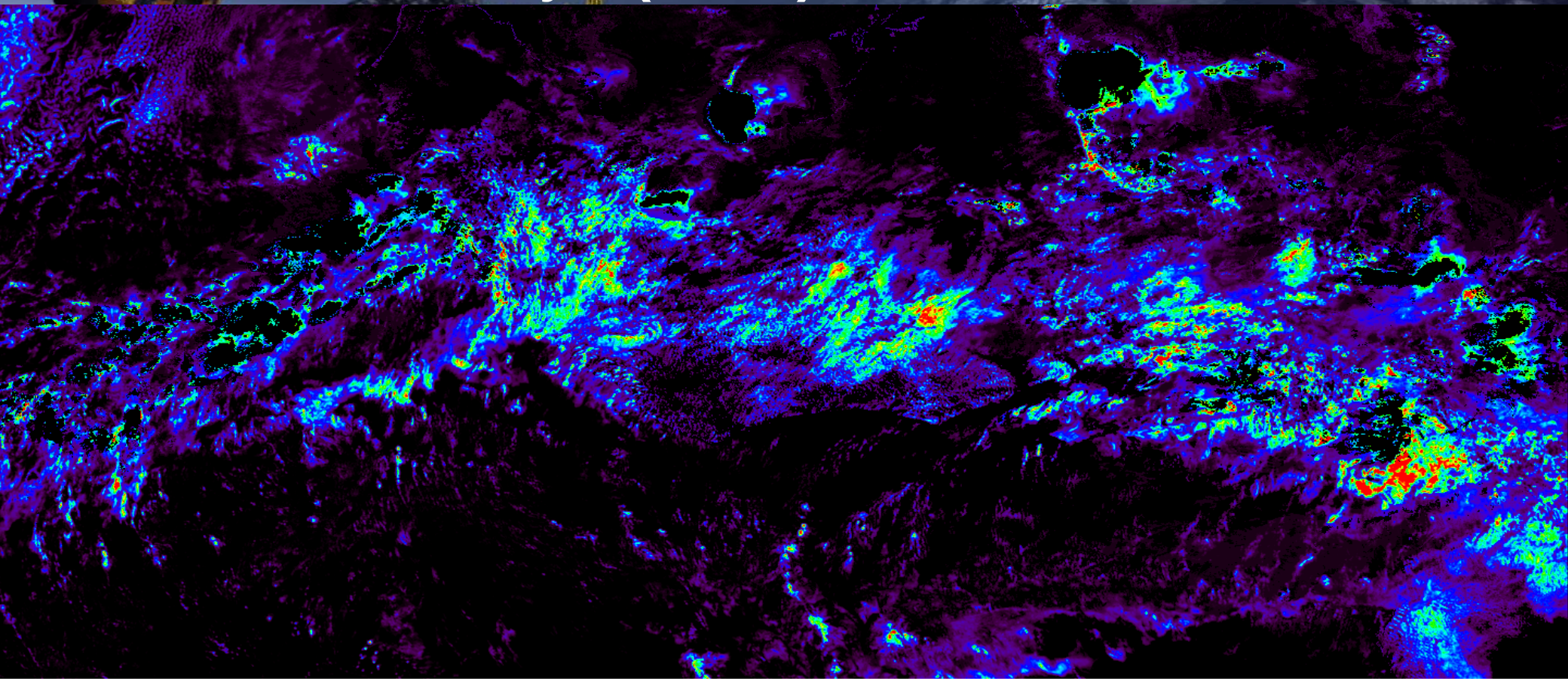
2011 July 25 11:30-12:30

Lower Layer (water) COT scaled 0-42



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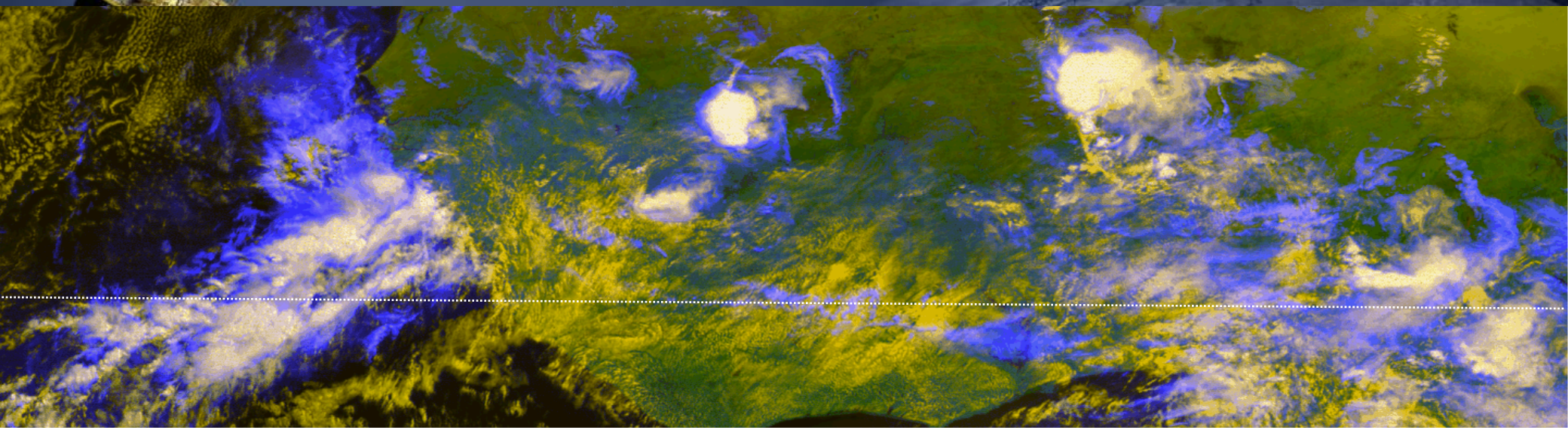
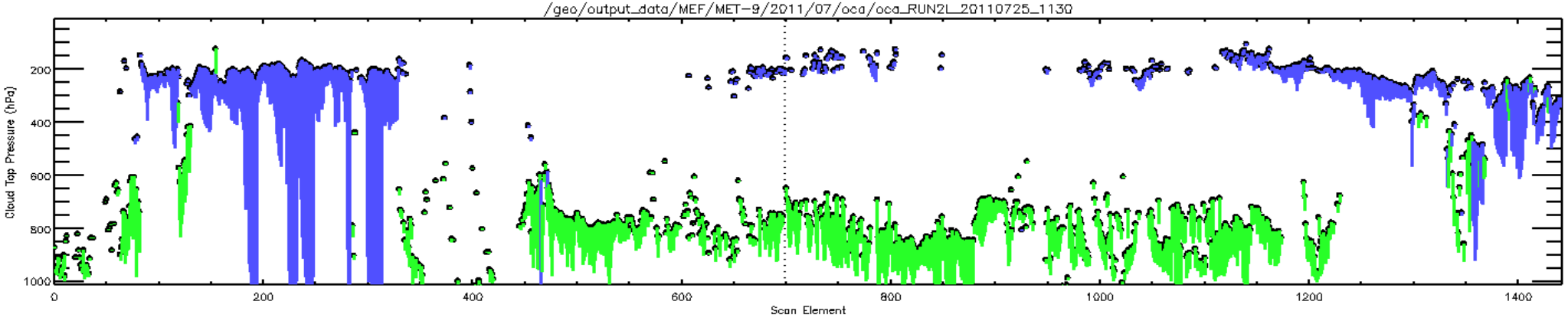
2-Layer Winds?

2011 July 25 11:30-12:30 **RGB 0.6, 0.8, 8-7-11**





Ice blue water green

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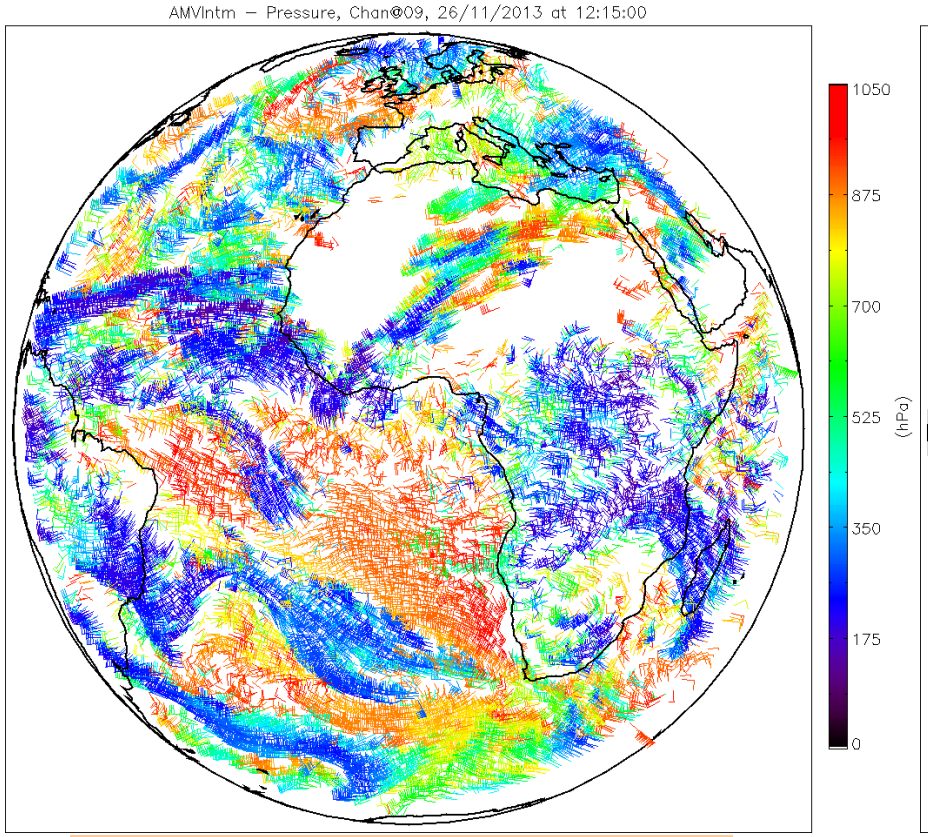
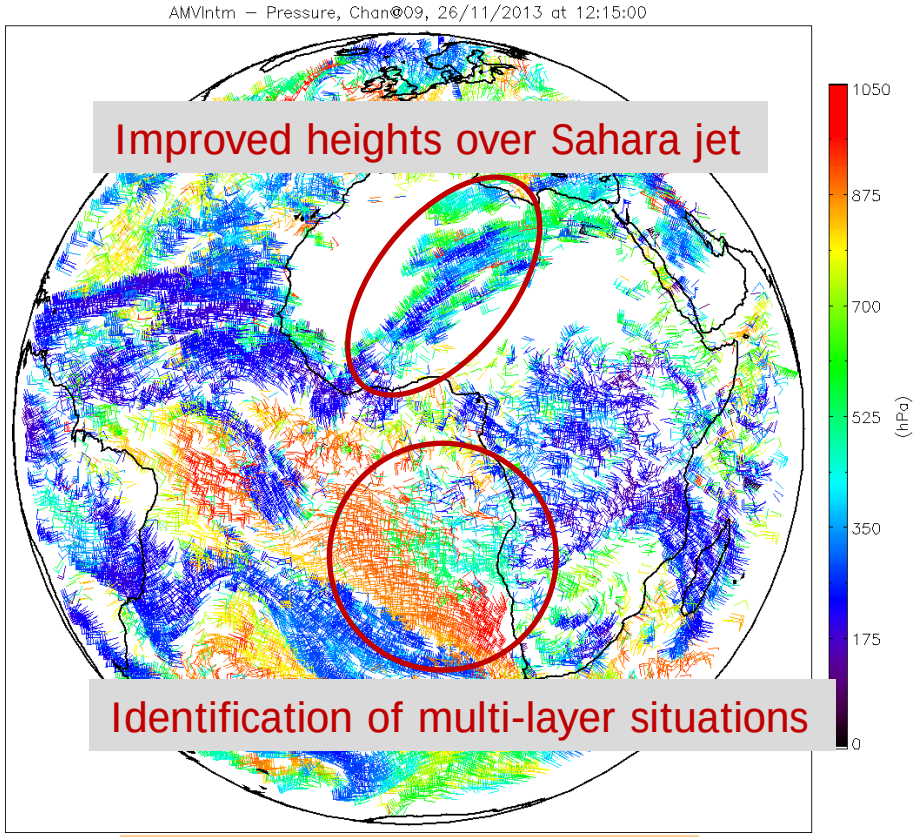
Atmospheric and Imagery Applications

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)

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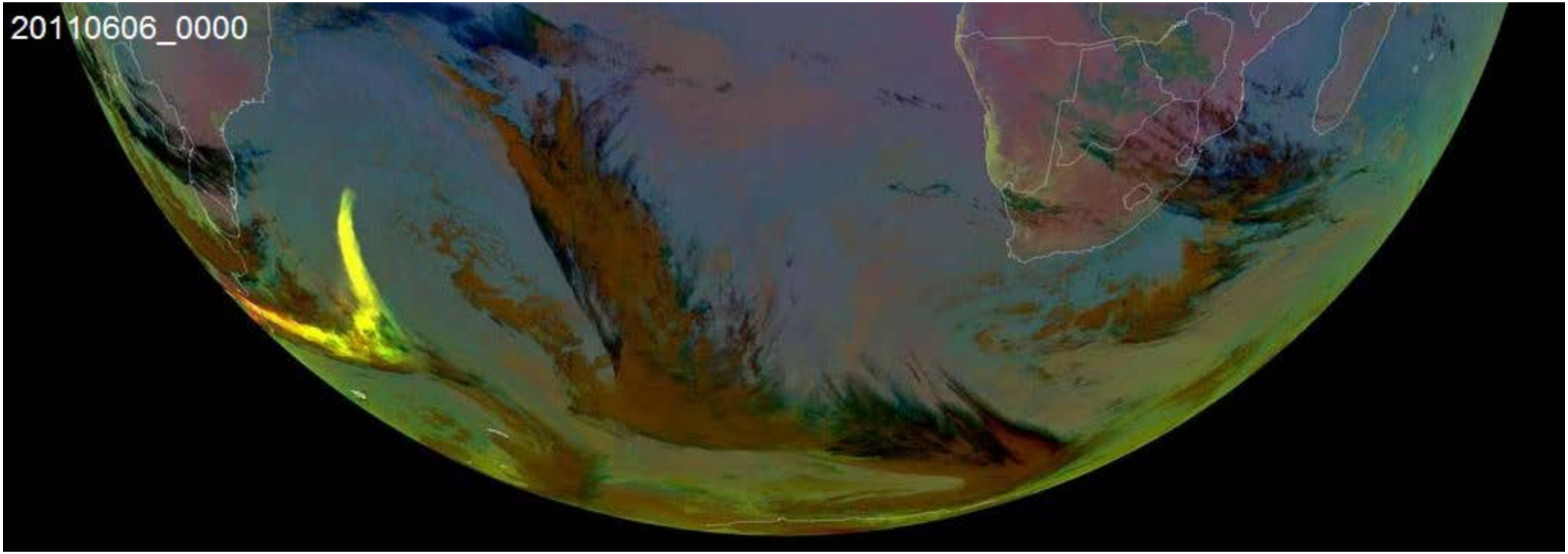
Volcanic Ash 2011 June to August



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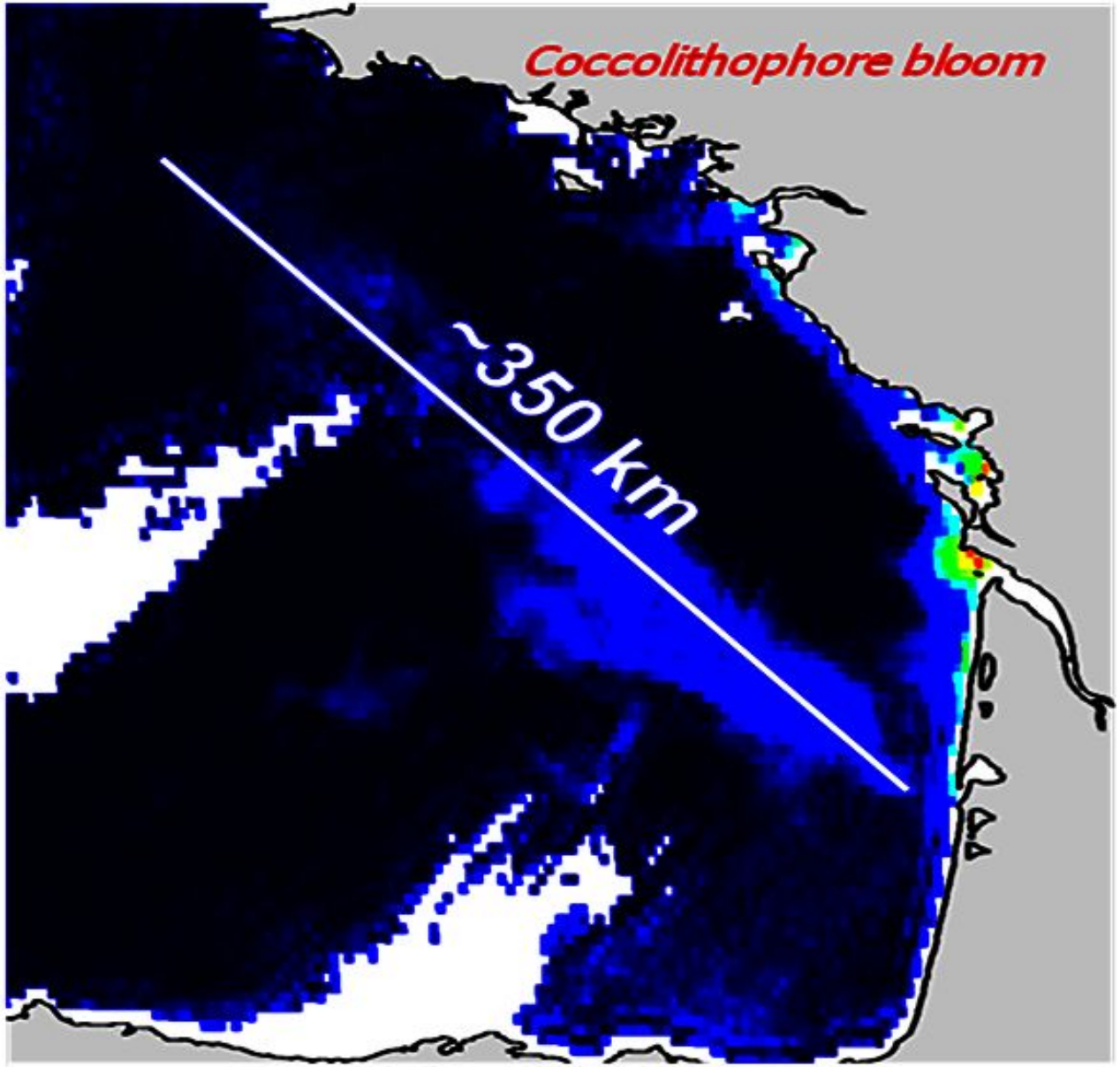
Scientific development for future / enhanced products (3)
Coccolithophore blooms from the geostationary orbit ?



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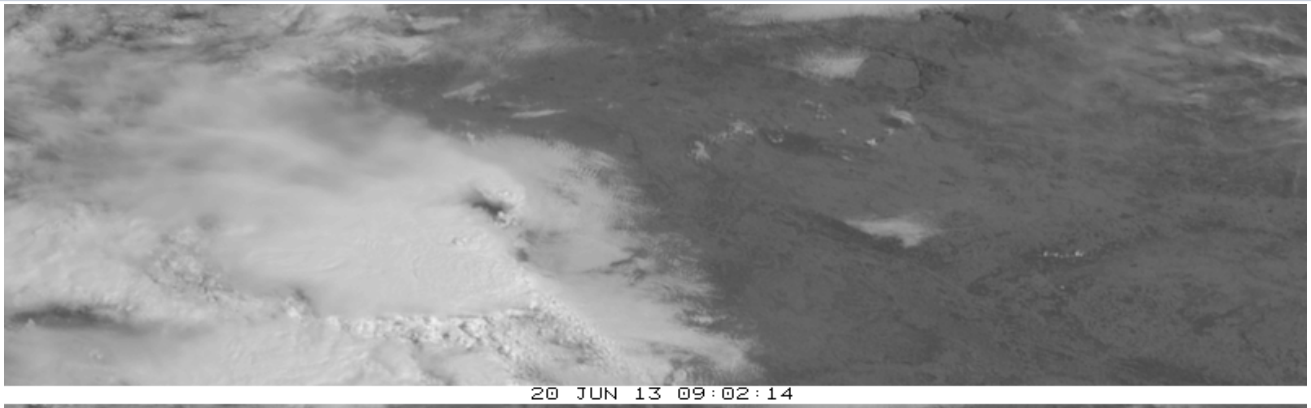
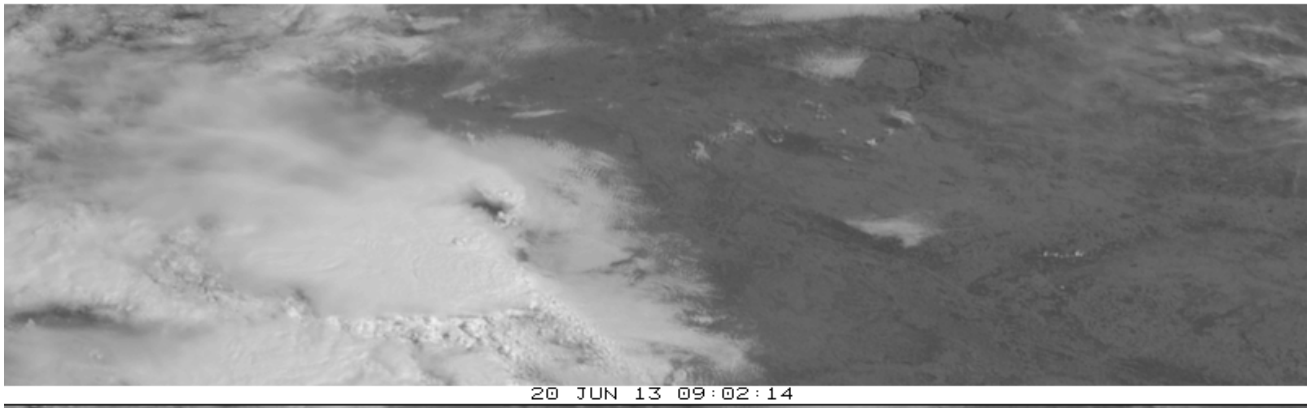
Met-8 super-rapid scans 2.5 min experiment

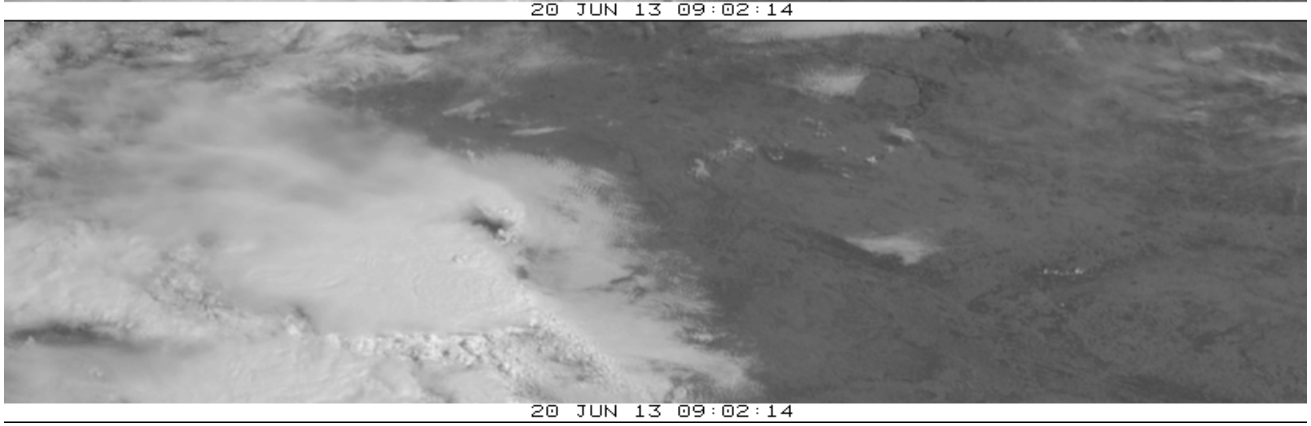
2.5 minutes Repeat Cycle



5 minutes Repeat Cycle



15 minutes Repeat Cycle



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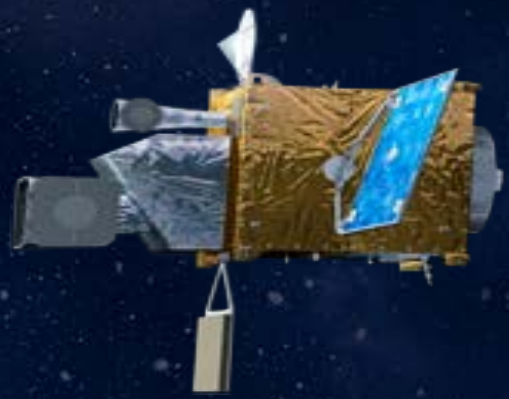
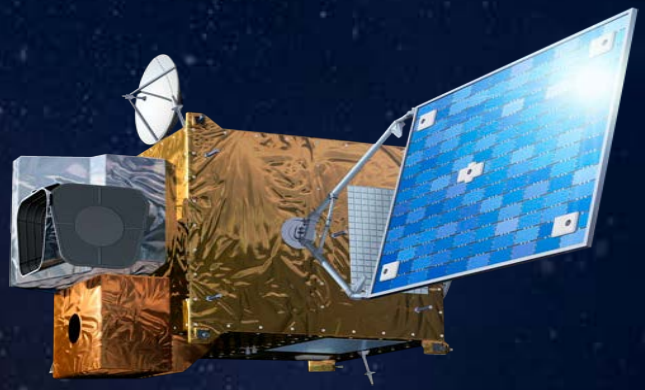
Meteosat Third Generation

- 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!

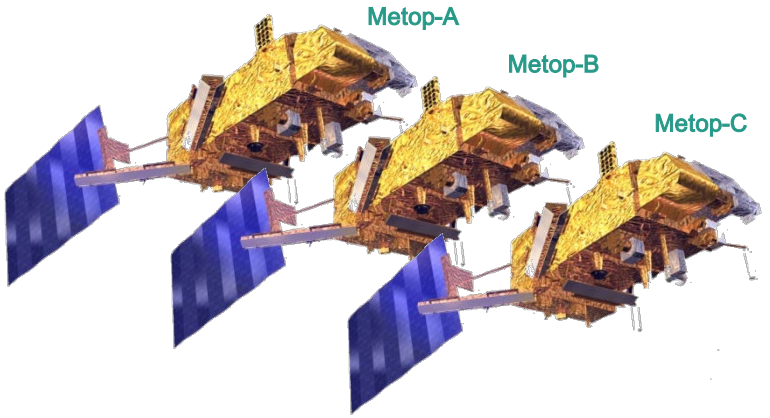




EUMETSAT Polar System Programme

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 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

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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

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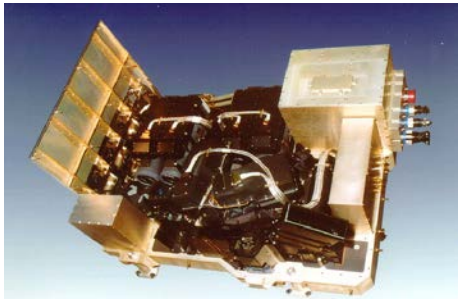
Current Capabilities - EUMETSAT Polar System



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

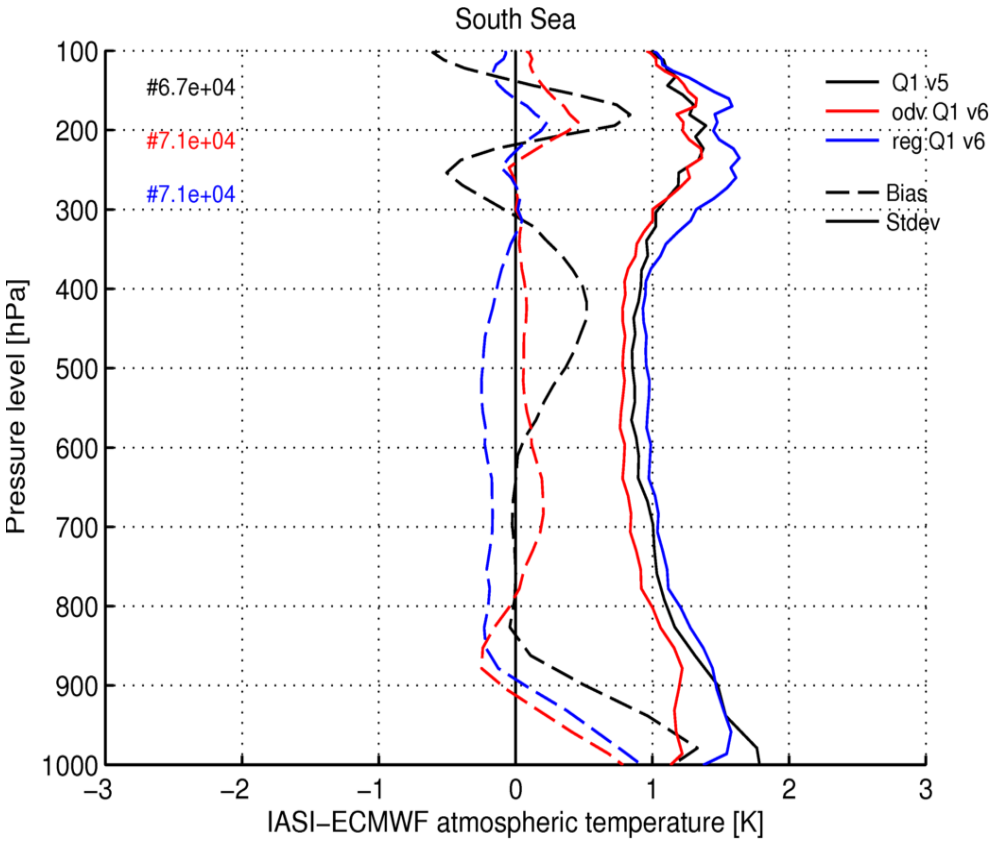
GOME-2
Global Ozone Monitoring Experiment

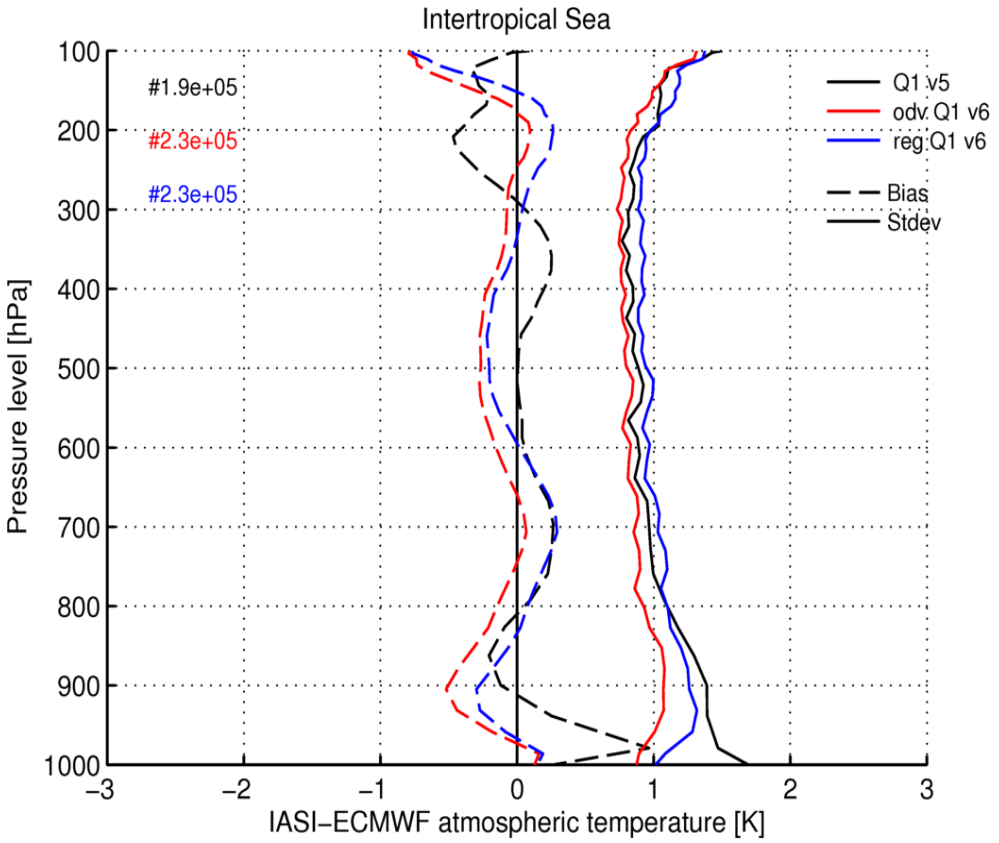
AMSU-A2
Advanced Microwave Sounding Unit-A2

ASCAT
Advanced SCATterometer

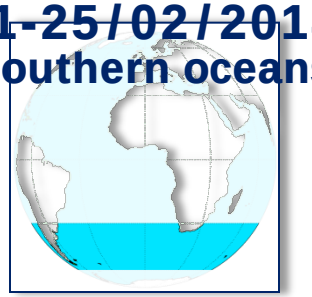
Atmospheric Profiling

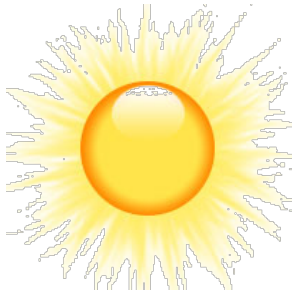
Hyperspectral Infrared L2 - IASI L2 v6 Temperature vs ECMWF ANA





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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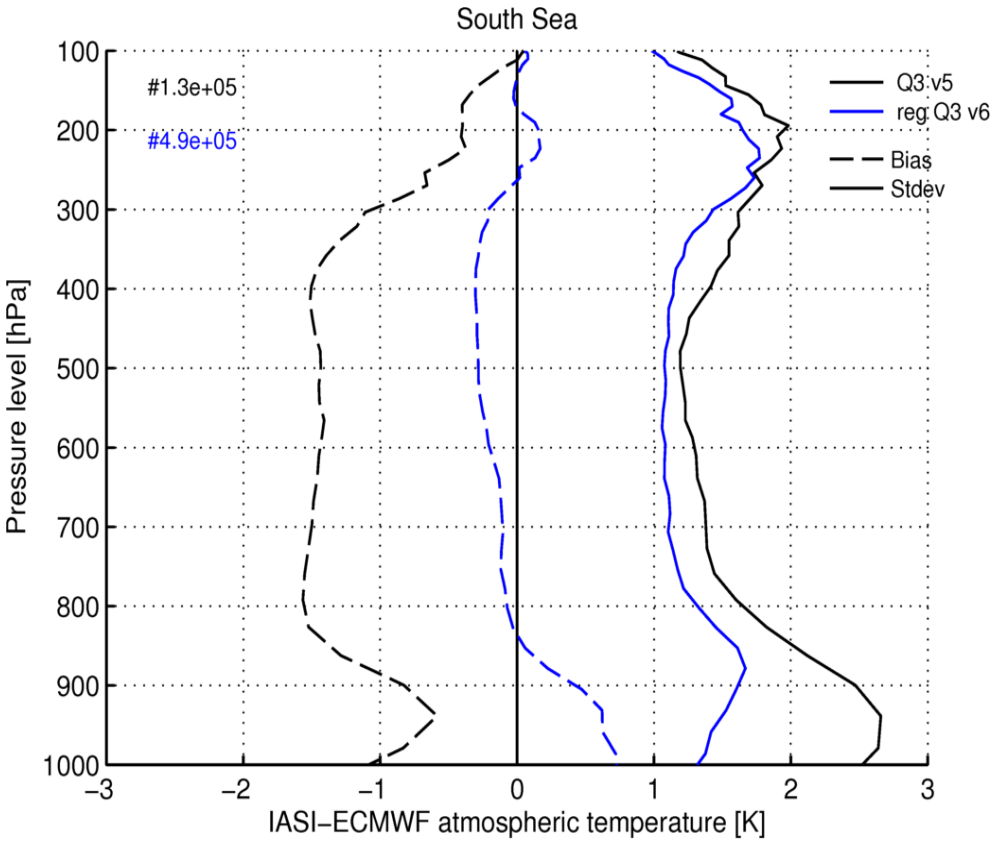
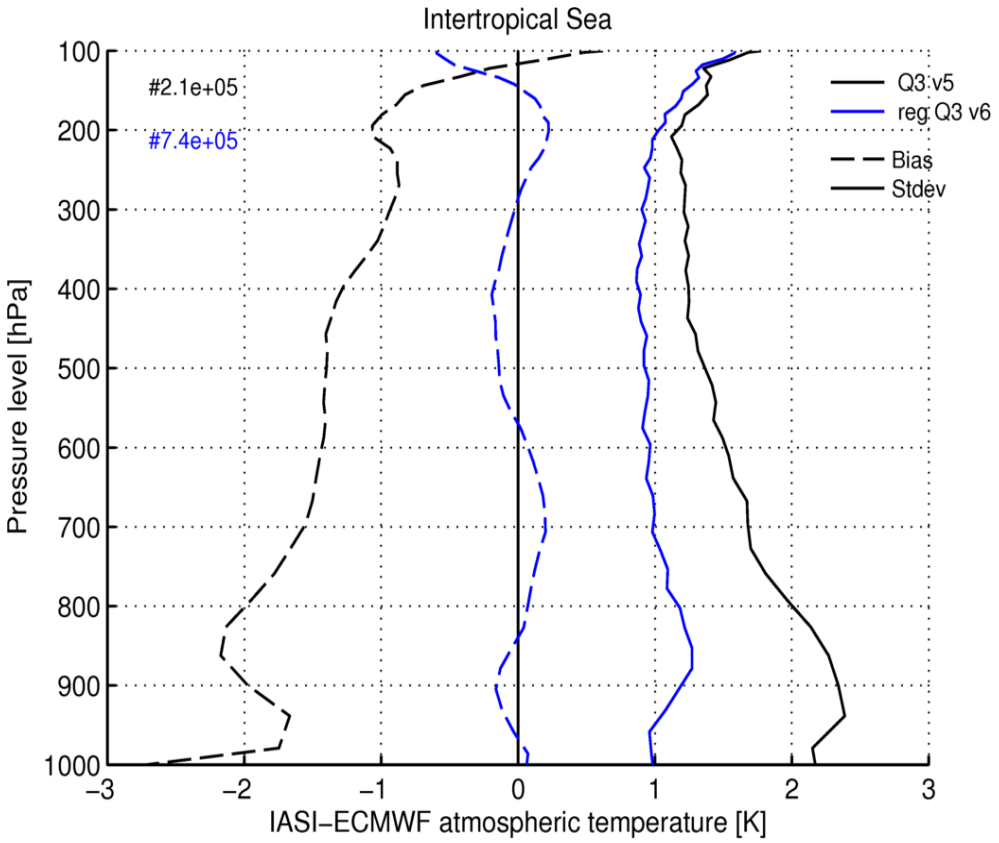
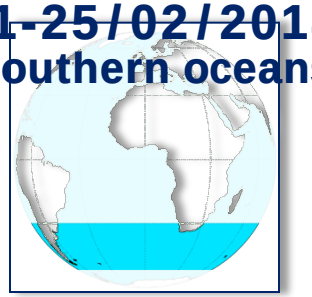
Atmospheric Profiling

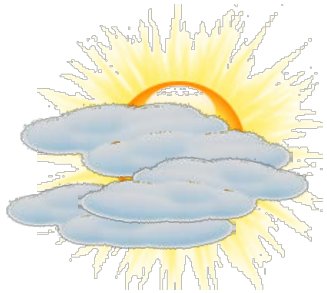
Hyperspectral Infrared L2 - IASI L2 v6 Temperature vs ECMWF ANA





21-25/02/2014
Southern oceans





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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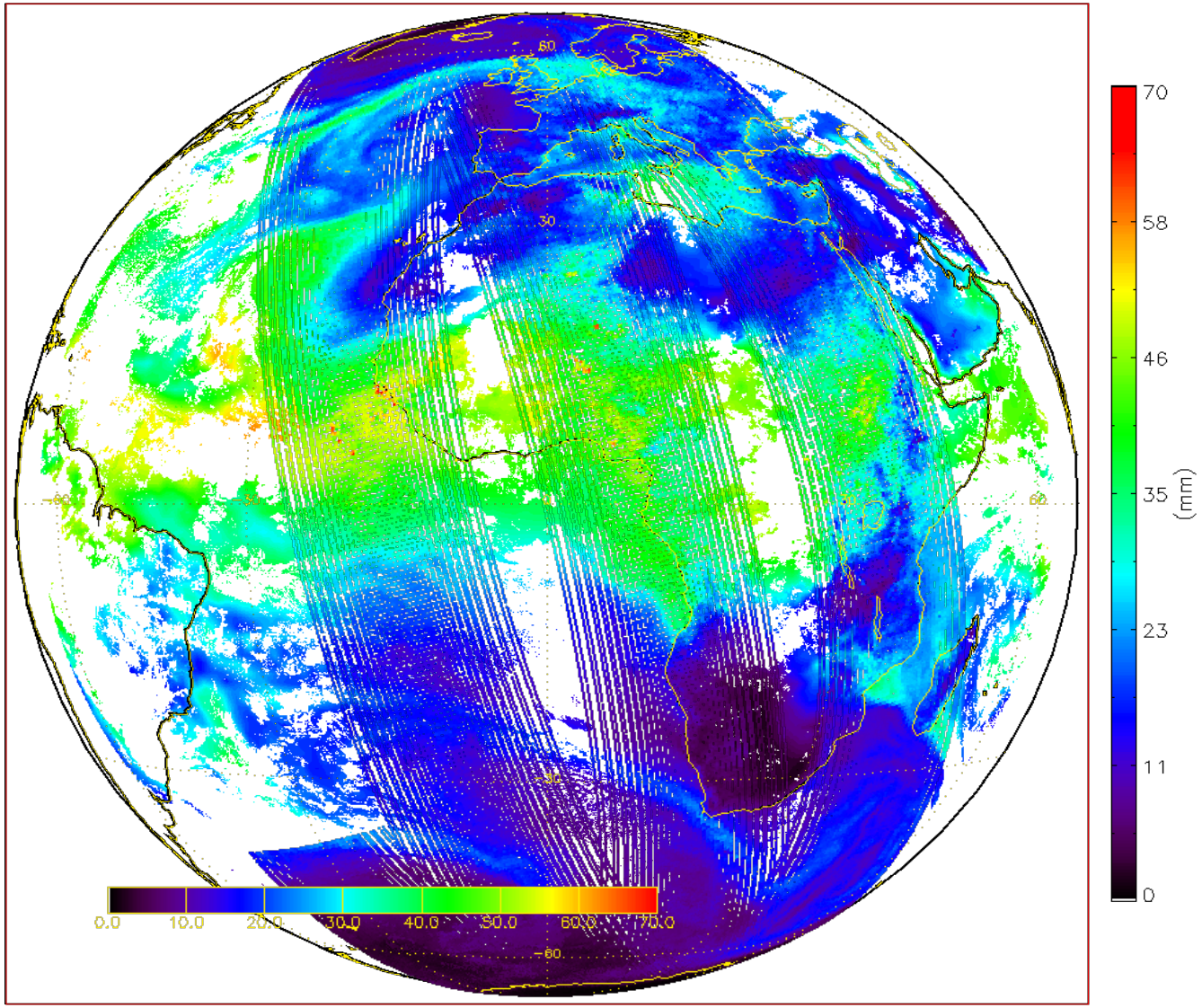
Atmospheric Profiling

Hyperspectral Infrared L2 - IASI L2 v6 TCWV vs MSG

MSG TPWV + IASI v6

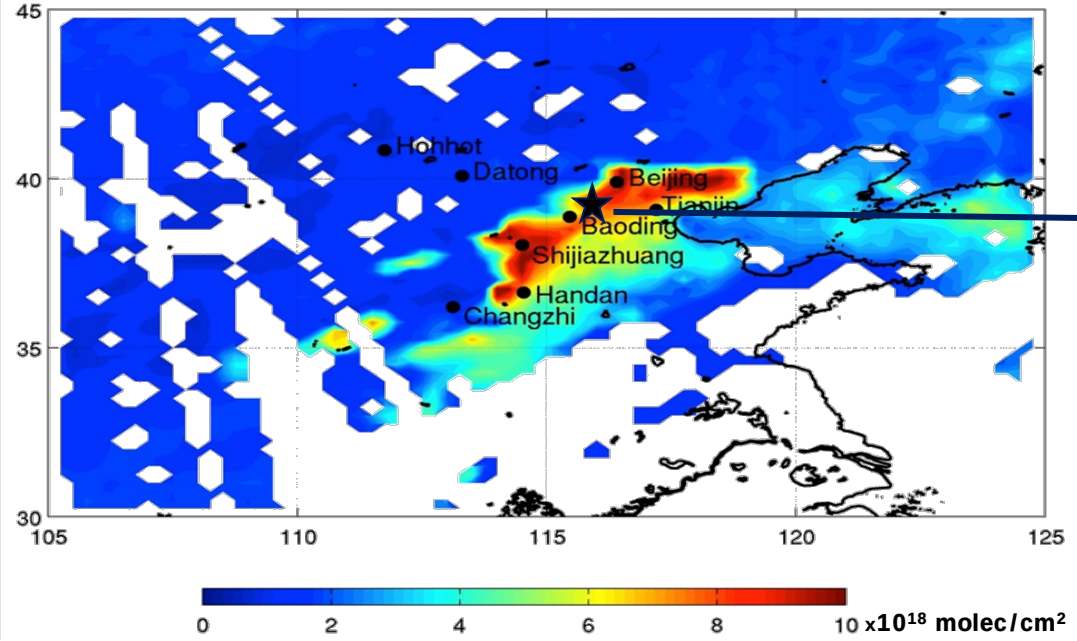


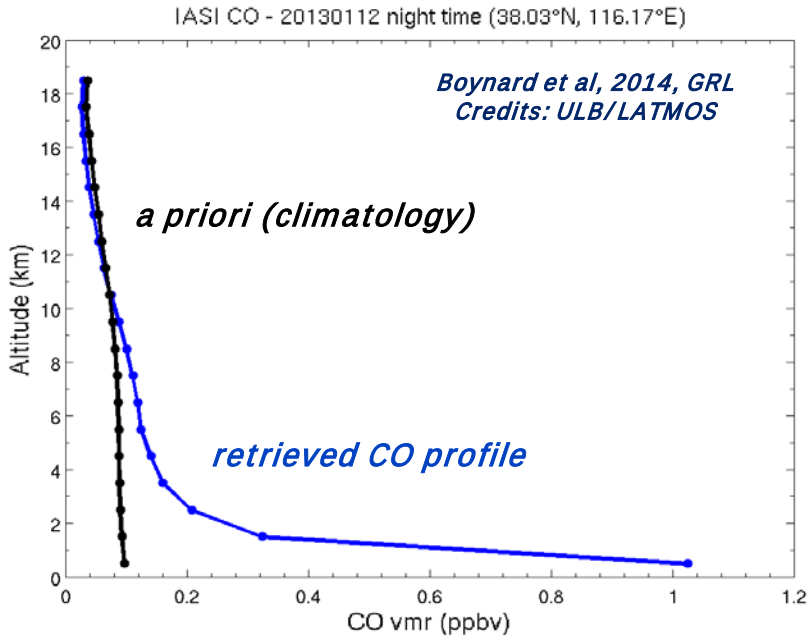
Results: M. Koenig (EUMETSAT)

EUMETSAT

Towards a IASI CO Profile product: a premiere

CO Total column - Pollution over China, 12 January 2013

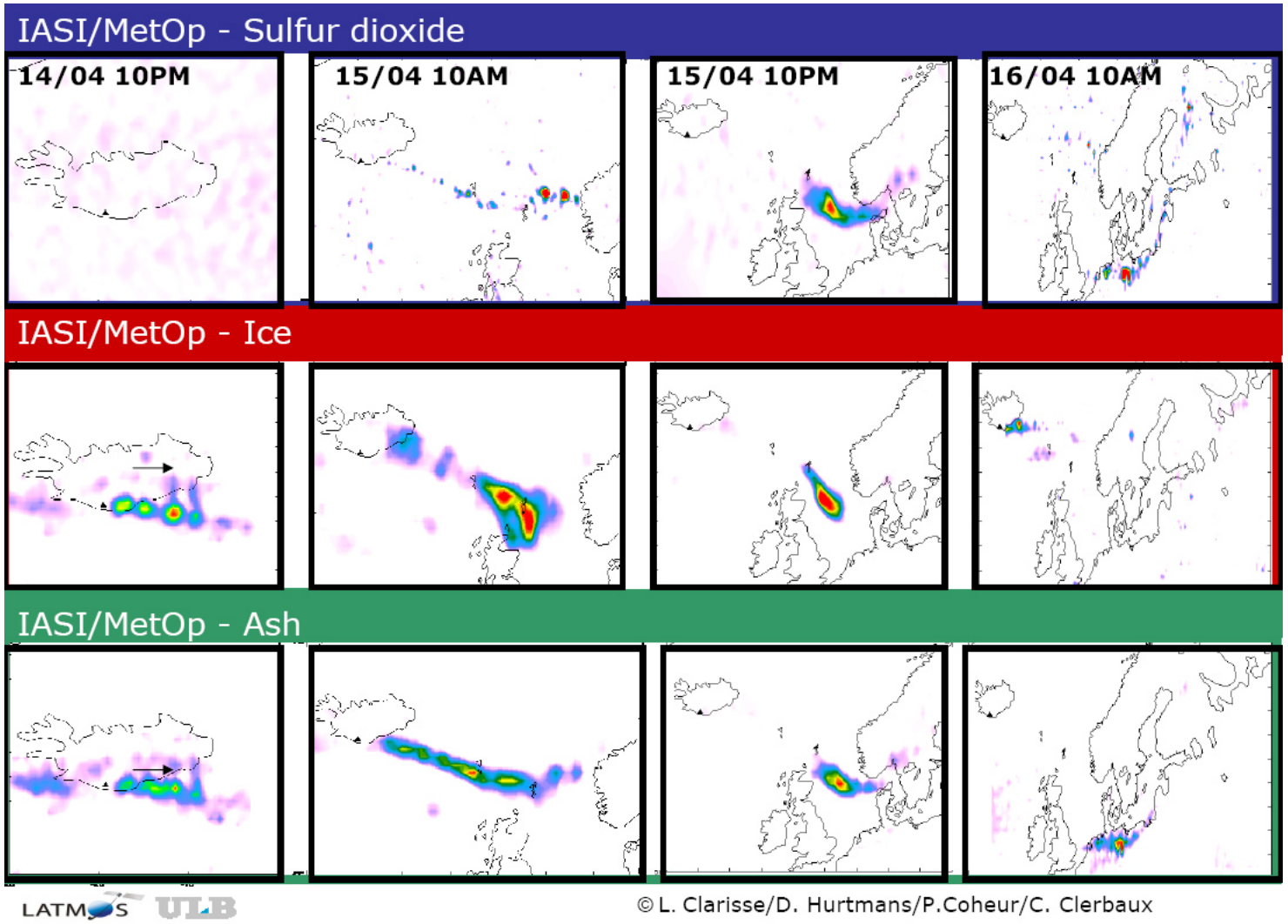




The IASI L2 processor v6 implements the FORLI-CO algorithm developed at ULB/LATMOS (O3M-SAF CDOP-2)

Atmospheric Composition

Trace Gas Products –IASI SO2 from ULB / LATMOS / O3M SAF



O3M SAF

SO2 total column
Credits ULB/LATMOS

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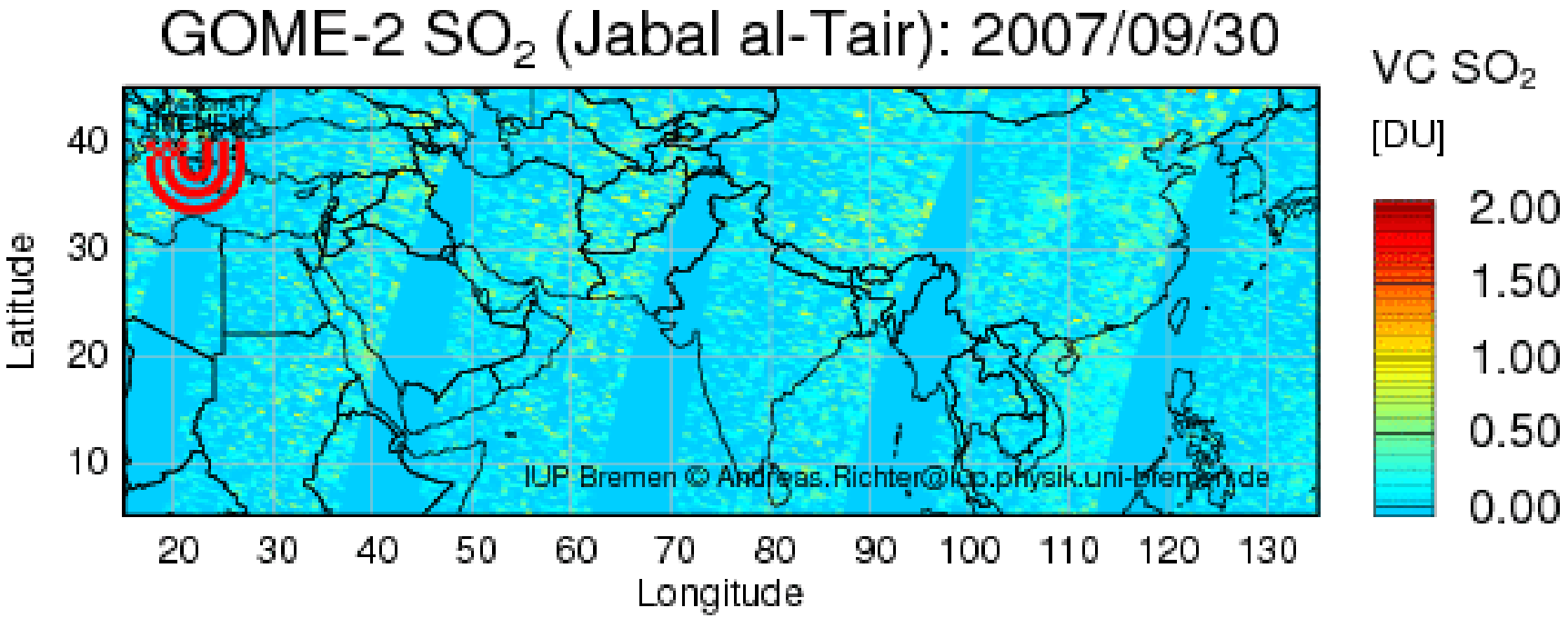
GOME-2 SO_2 courtesy of University of Bremen (Andreas Richter & colleagues)



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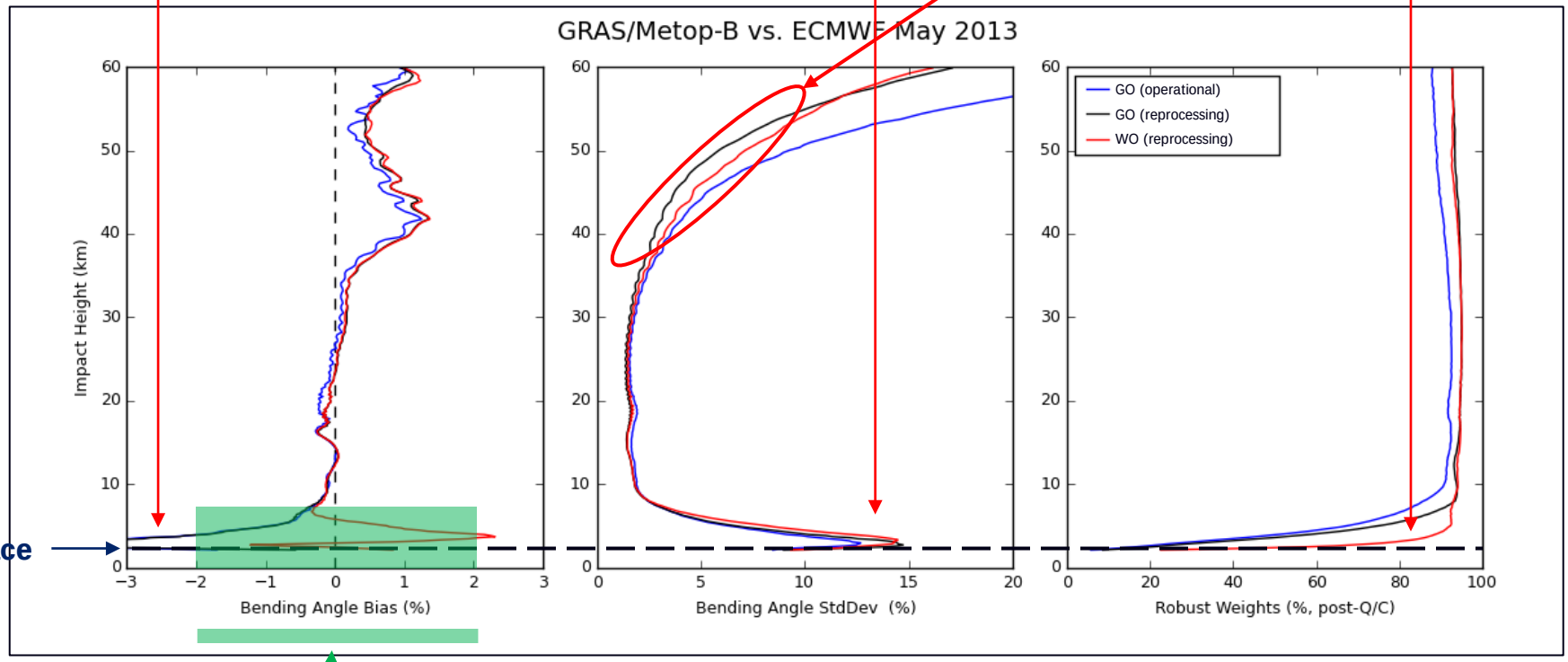
Scientific development for future / enhanced products
Wave optics for retrieval of GRAS profiles

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

Under investigation; can be improved



Surface

Uncertainty in NWP reference data

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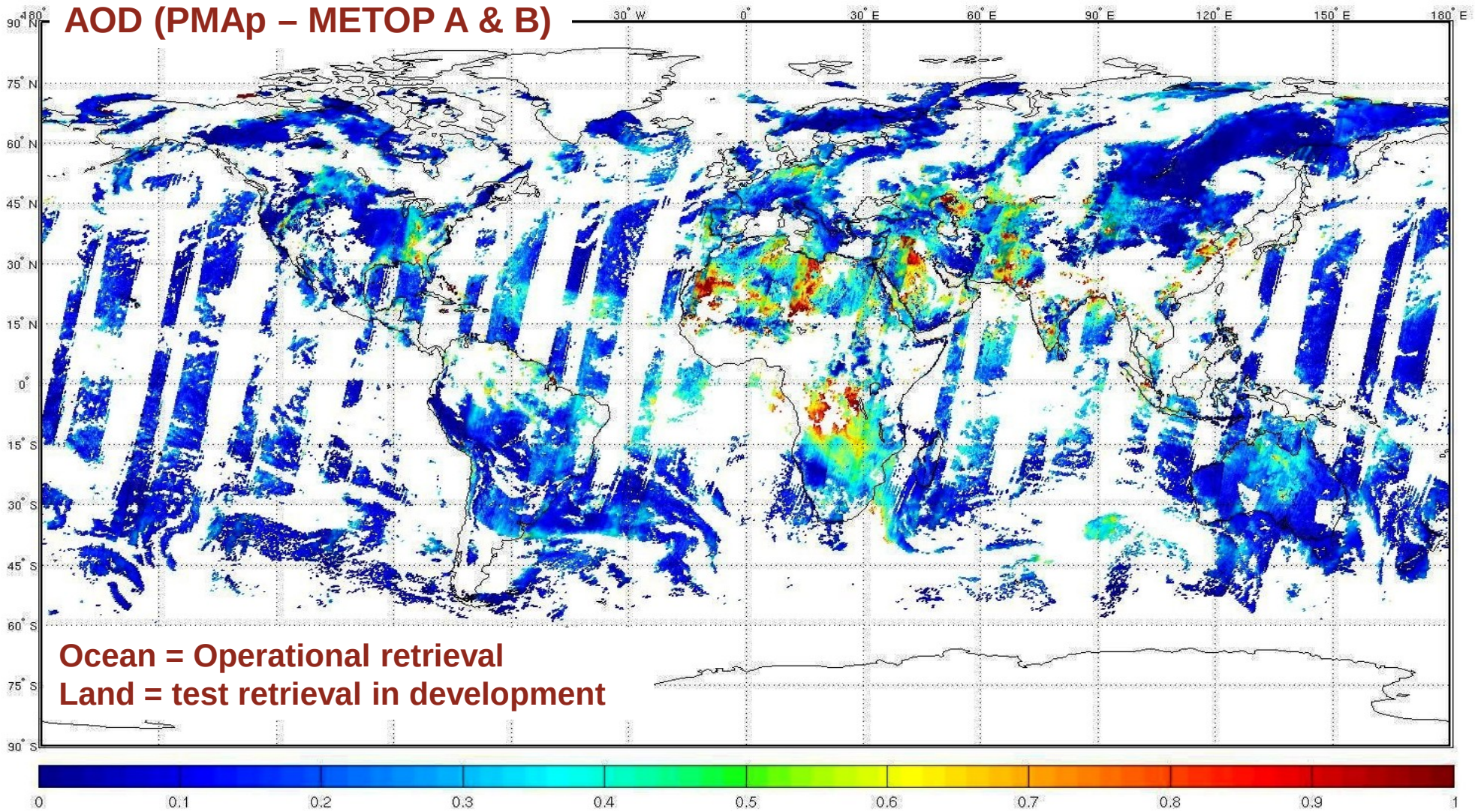
Aerosol: PMAp (GOME-2 + AVHRR) Metop A & B combined



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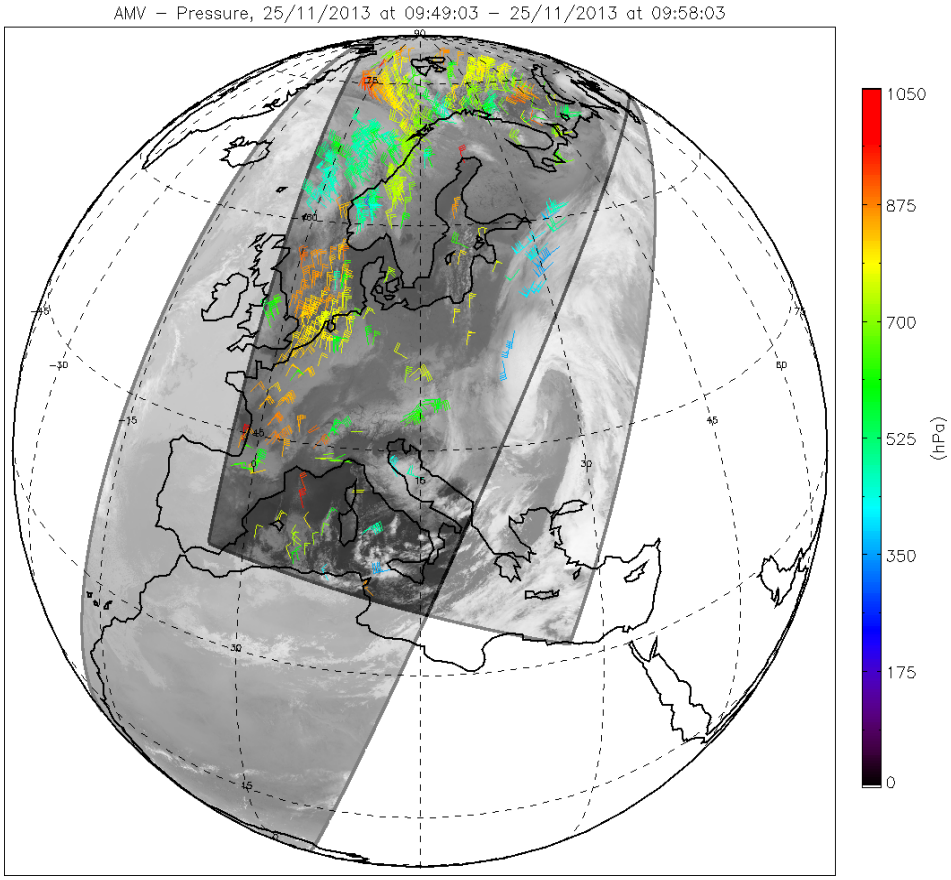
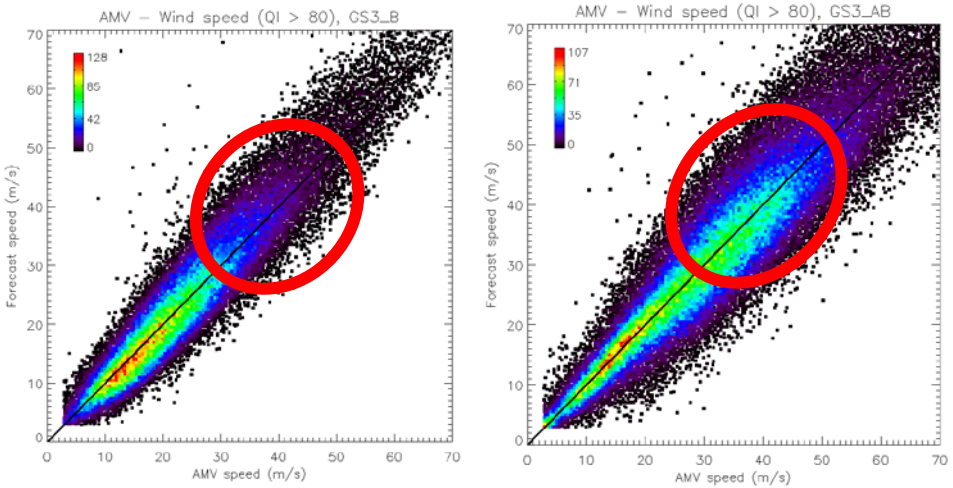
Dual Metop winds:
Global coverage and quality improvement in polar regions

Global dual Metop winds



Metop winds over South Pole (QI>80)



One Metop

Dual Metop

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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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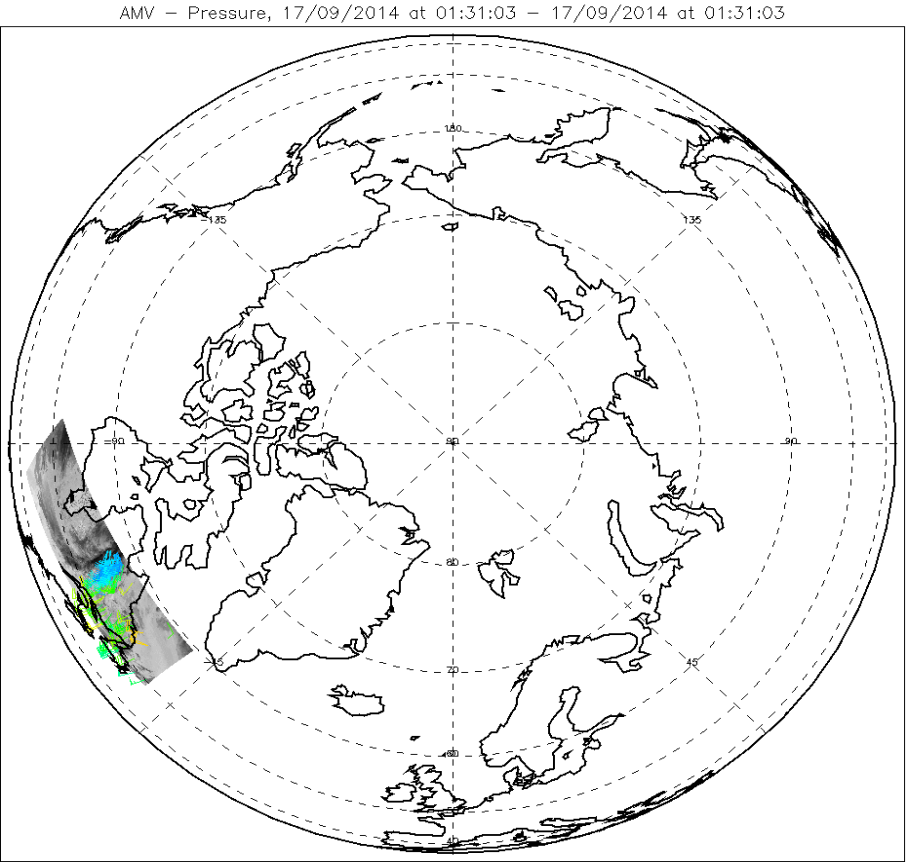
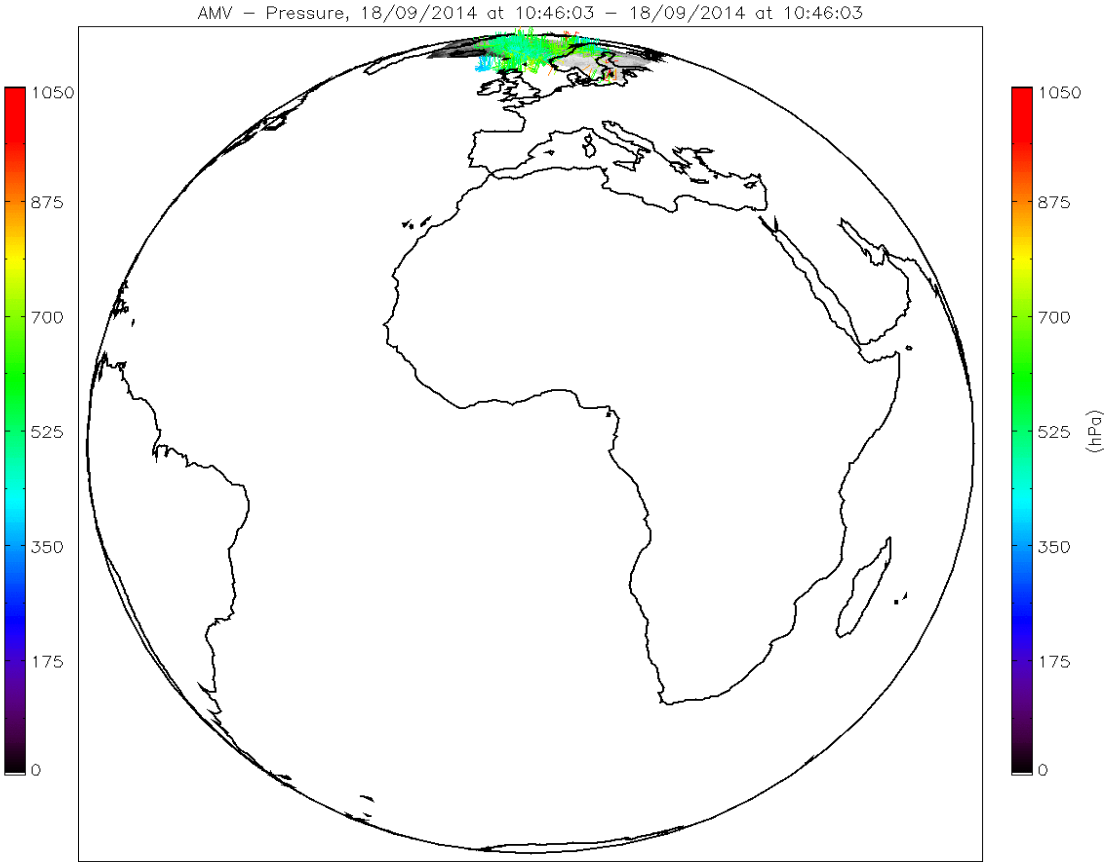
AVHRR winds

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



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



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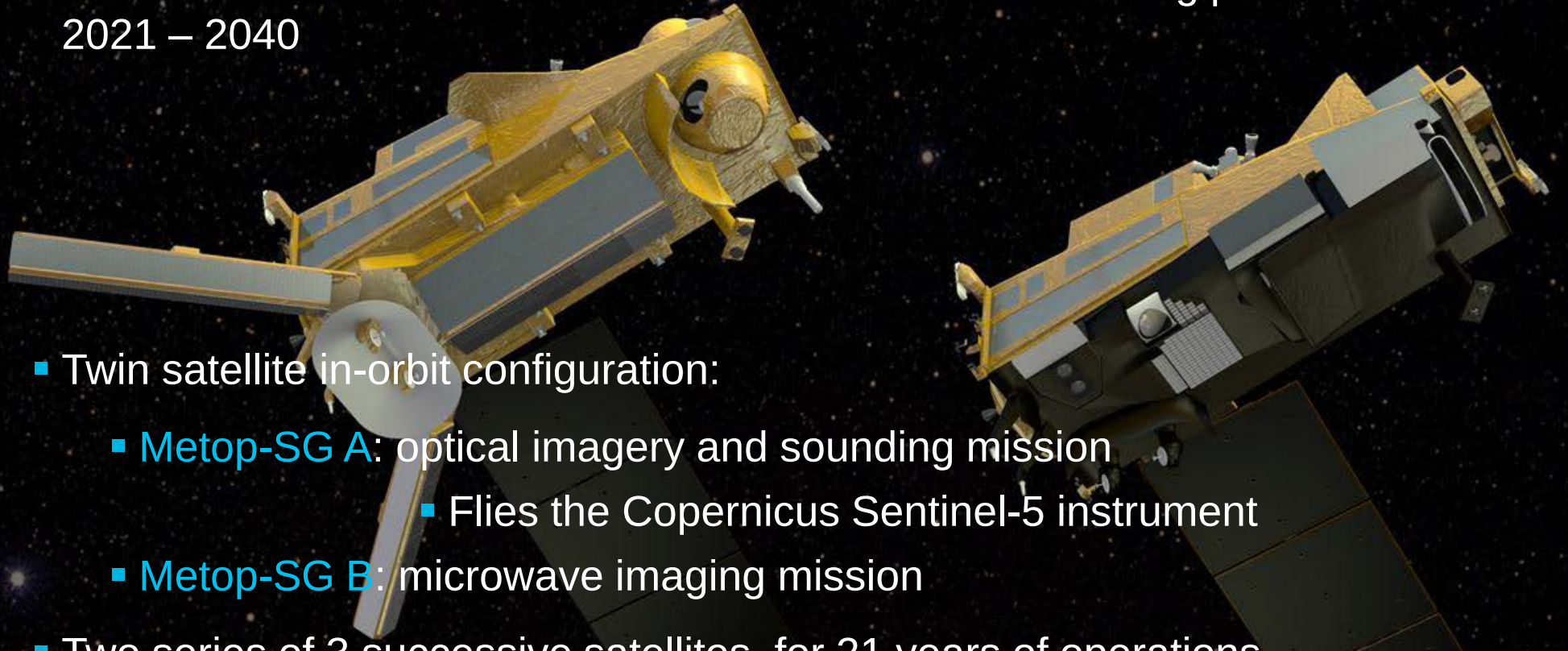
But Metop-A is growing old: Options (LTAN evolution)

Last OOP	2015			2016			Comment
LTAN Drift (mins)	Fixed GT	GT Hops	Drifting GT	Fixed GT	GT Hops	Drifting GT	
2	Dec 2016	Dec 2016	Dec 2016	May 2017	May 2017	May 2017	Limited impact on GOME on winter 2017 (none if 2016 OOP executed)
5	May 2017	May 2017	May 2017	Nov 2017	Nov 2017	Nov 2017	Very large impact on GOME on winter 2018 (mitigation by yaw slew? TBC)
30	Jan 2019	Jan 2019	Jan 2019	Jul 2019	Jul 2019	Jul 2019	Assumed preference for nominal fixed GT
40		Jun 2019	Jun 2019		Dec 2019	Dec 2019	2016 + hop marginal on fuel 2015 + 2 hops as well
60		Feb 2020	Feb 2020			Sep 2020	>40 minutes LTAN drift feasibility to be confirmed by ESA study
90			Jan 2021			Jul 2021	
120			Sep 2021			Apr 2022	180 minutes LTAN drift not likely to be feasible due to power constraints.
180			Dec 2022			Jun 2023	

EPS Second Generation

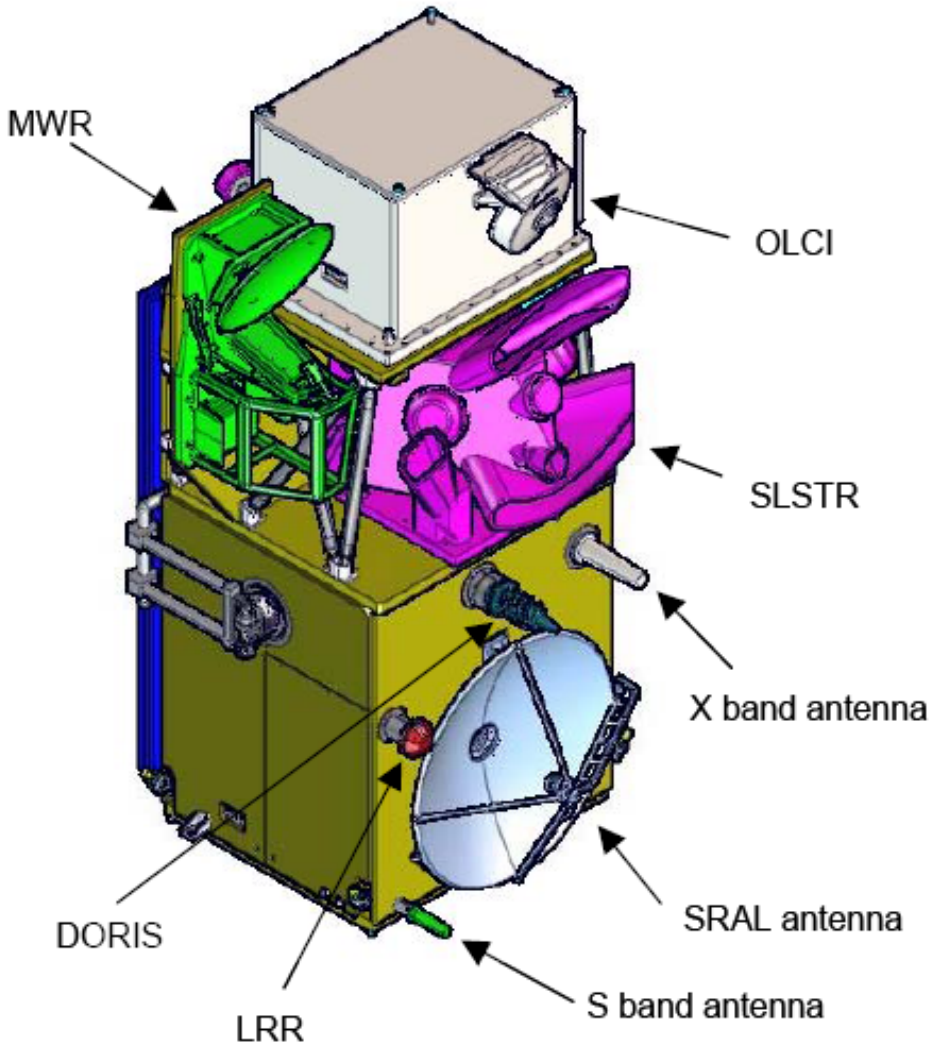
- Continuation and enhancement of service from mid morning polar orbit in 2021 – 2040



- 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

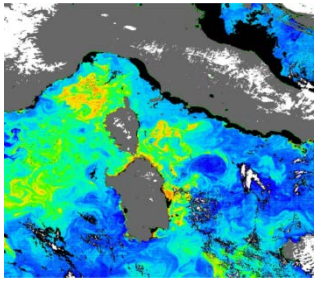


- SLSTR: Sea and Land Surface Temperature Radiometer
- SRAL: Synthetic Aperture Radar Altimeter
- OLCI: Ocean and Land Colour Instrument
- MWR: Micro-Wave Radiometer
- LRR: Laser Retro-Reflector
- DORIS: Doppler Orbitography and Radiopositionning Integrated by Satellite
- STM: Surface Topography Mission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

Sentinel-3 Marine product contents

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

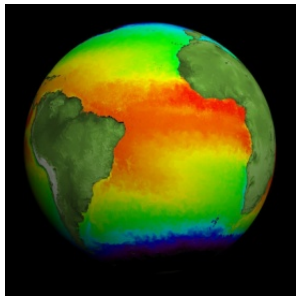
(ESA and EUMETSAT)



Level 2 SLTSR:

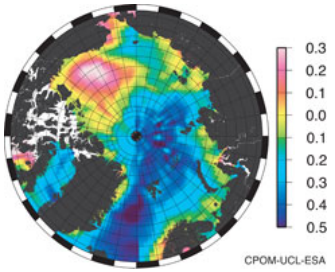
- Sea surface temperature

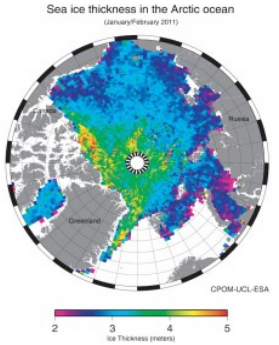
(L2P GHRSST standard)



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)

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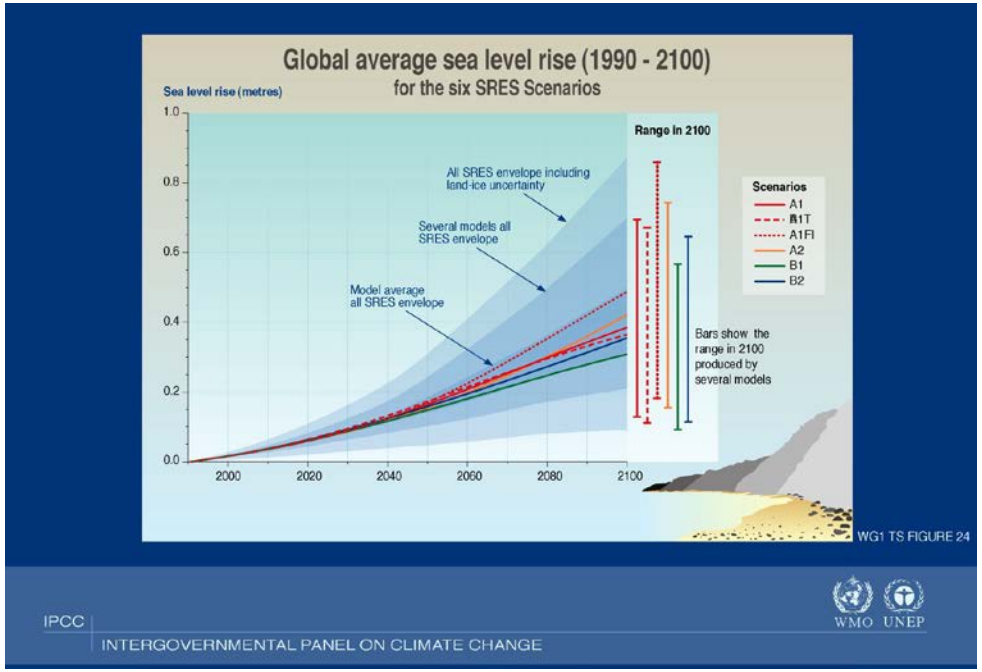
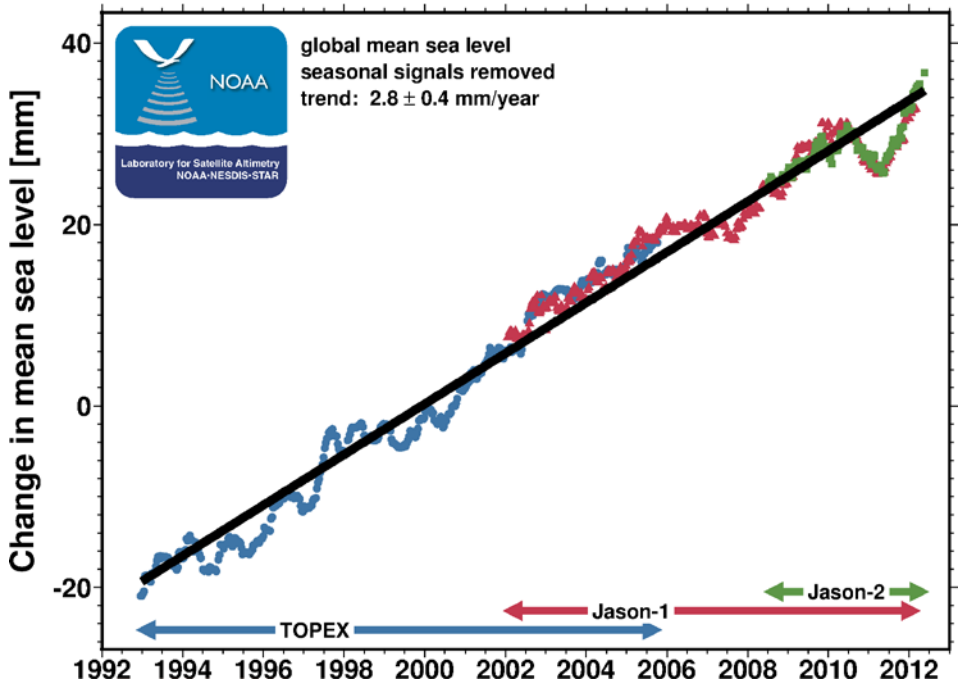
From Jason-2 to Jason-3 (launch 17 Jan 2016)
Global sea level rise

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.

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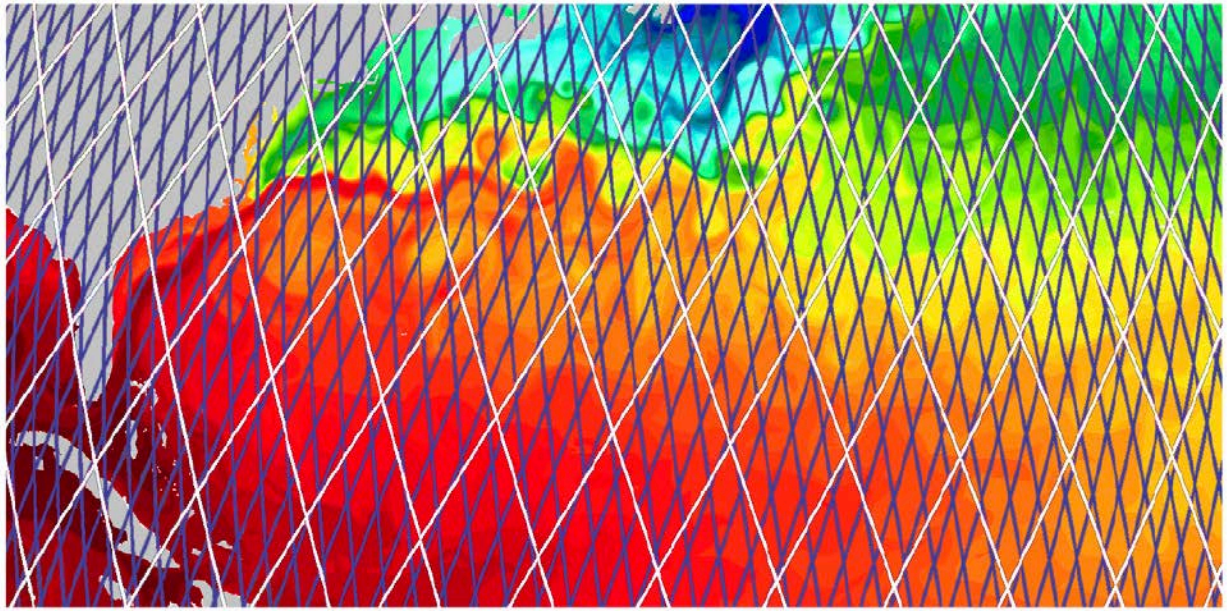
Combining Sentinel-3 & Jason altimetry for operational oceanography and climate change monitoring



(Courtesy CNES/CLS/ESA)

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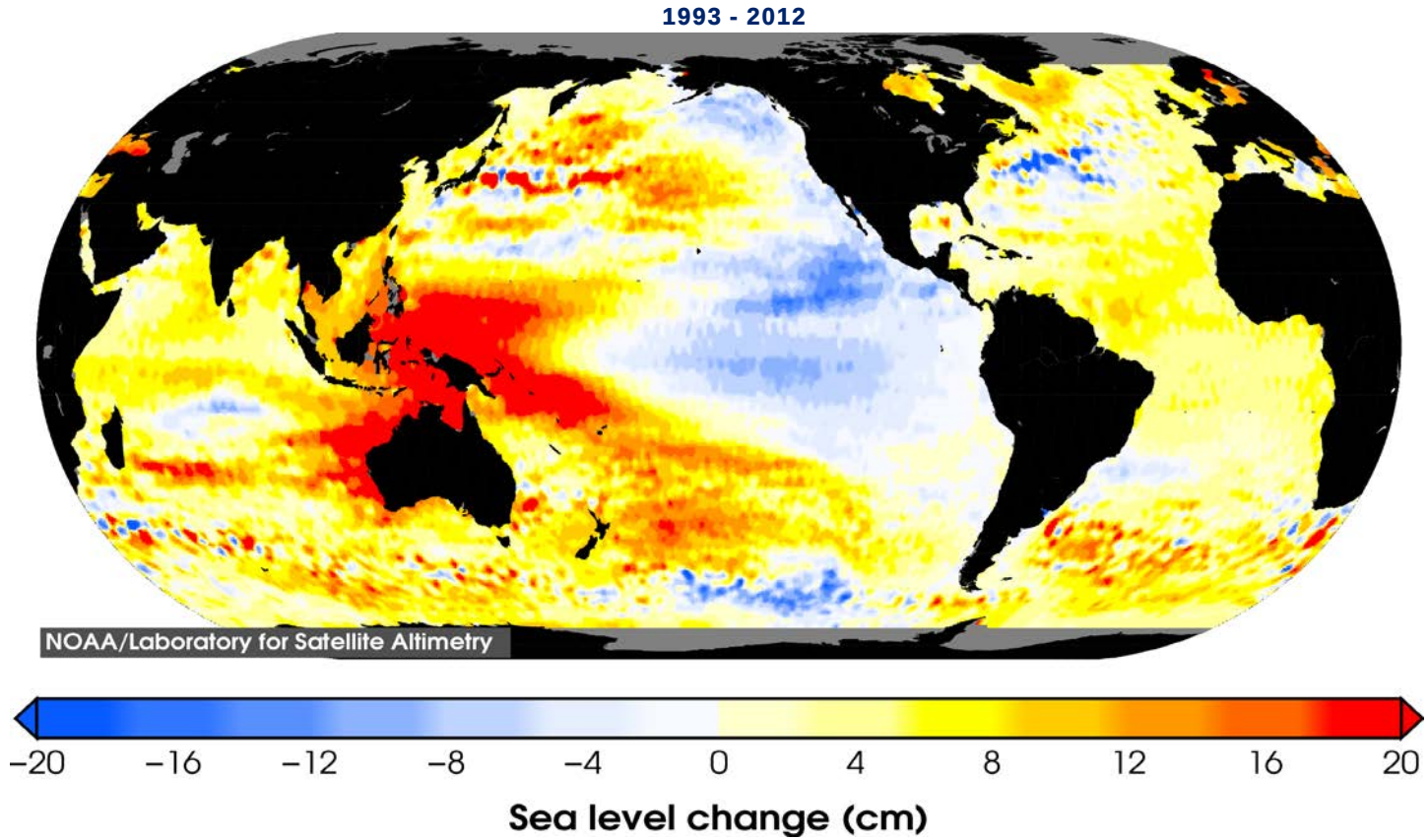
Mean sea level trends : regional differences



- 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?