

An Introduction to EUMETSAT Polar System – Second Generation (EPS-SG)

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EPS-SG User Preparation Manager

*17th Satellite Application Course: Earth Observation by Low Orbiting Satellite
Muscat, 20-24 March 2022*

- Introduction
- EPS-SG Observation Missions
- Preparing users for EPS-SG



Current EUMETSAT operations in space: 10 satellites

METOP-B & -C (Local Equator Crossing Time - 9:30 AM)

LOW EARTH, SUN-SYNCHRONOUS ORBIT

EUMETSAT POLAR SYSTEM (EPS) /
INITIAL JOINT POLAR SYSTEM

SENTINEL-3A & -3B (98.65° incl.)

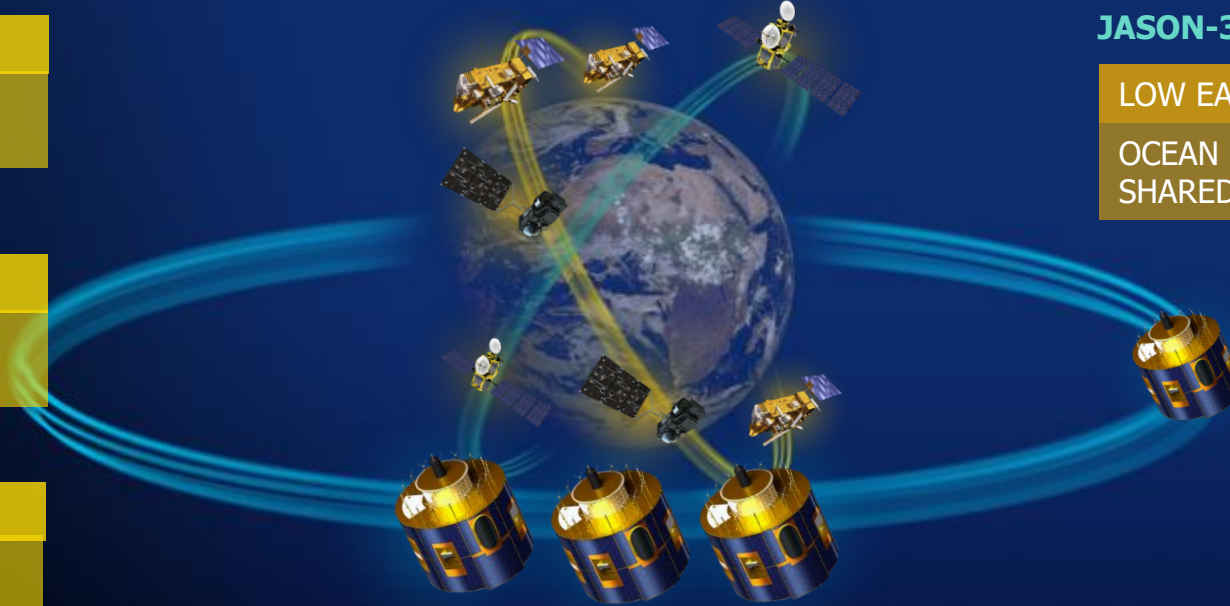
LOW EARTH, SUN-SYNCHRONOUS ORBIT

COPERNICUS SATELLITES DELIVERING
MARINE AND LAND OBSERVATIONS

SENTINEL-6 Micheal Freilich (66° incl.)

LOW EARTH, DRIFTING ORBIT

COPERNICUS OCEAN SURFACE
TOPOGRAPHY MISSION SHARED WITH
CNES/NOAA/NASA/EU



JASON-3 (63° incl.)

LOW EARTH, NON-SYNCHRONOUS ORBIT

OCEAN SURFACE TOPOGRAPHY MISSION,
SHARED WITH CNES/NOAA/EU

METEOSAT-9, -10, -11

GEOSTATIONARY ORBIT

TWO-SATELLITE SYSTEM

METEOSAT 2ND GENERATION

FULL DISC IMAGERY MISSION (15 MINS) (METEOSAT-11 (0°))
RAPID SCAN SERVICE OVER EUROPE (5 MINS) (METEOSAT-10 (9.5°
E))

METEOSAT-9 STORED IN ORBIT (BACKUP)

METEOSAT-8 (41.5° E)

GEOSTATIONARY ORBIT

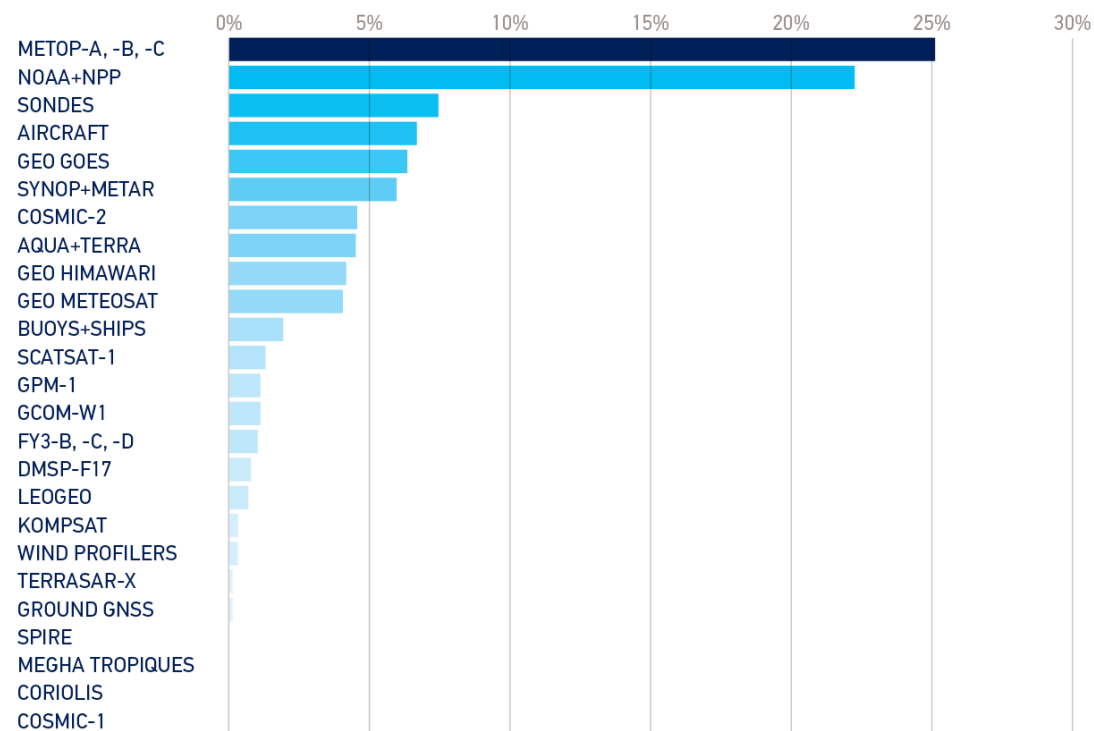
METEOSAT 2ND
GENERATION PROVIDING
INDIAN OCEAN DATA
COVERAGE SERVICE (IODC)



Relative impact on NWP: satellite obs vs other obs



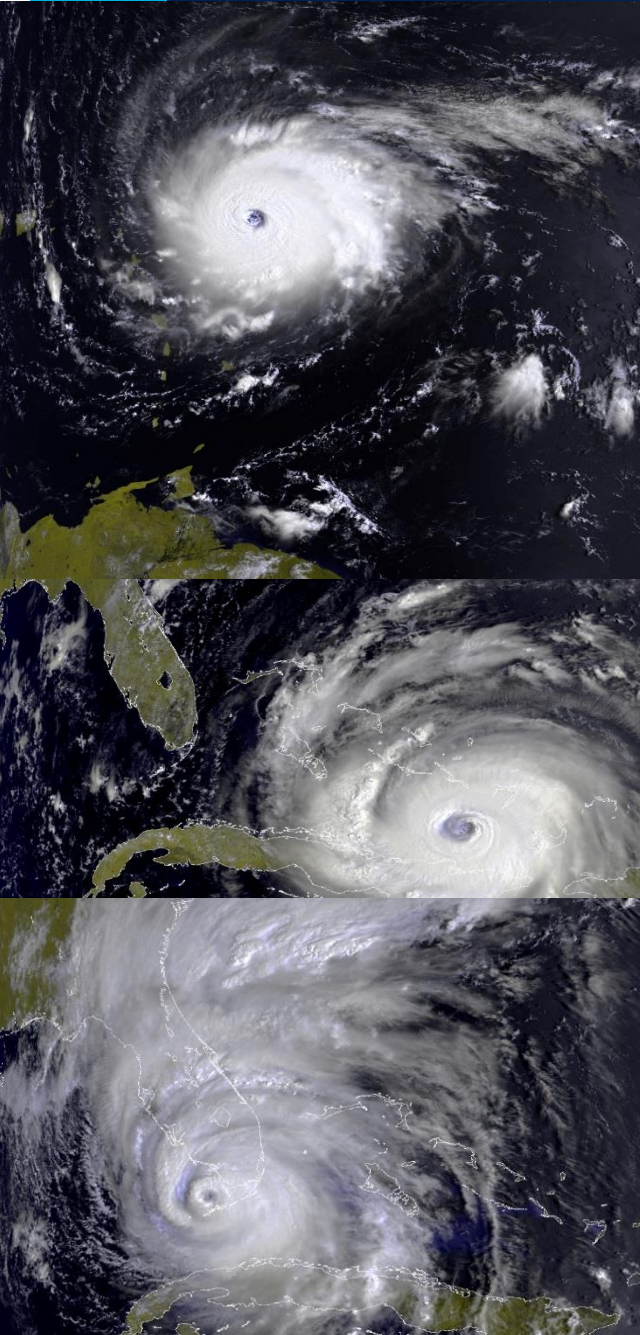
- Metop-A, -B, -C - 25%
- NOAA JPSS/S-NPP - 22%
- GEO satellite observations - 15%
- Other LEO satellite observations - 11%
- Other Radio Occultation observations - 5%
- In-Situ/Conventional observations - 22%



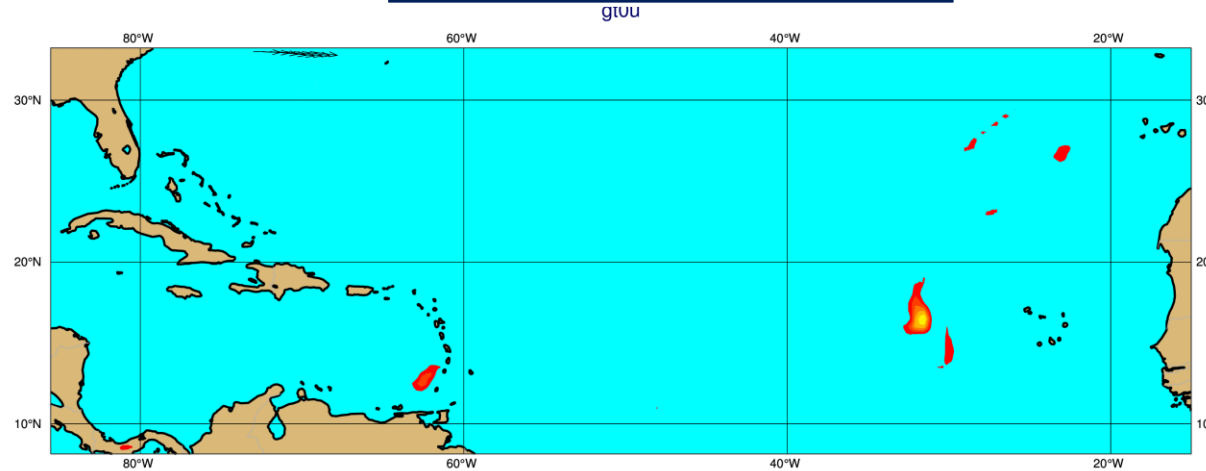
Source: Met Office, UK



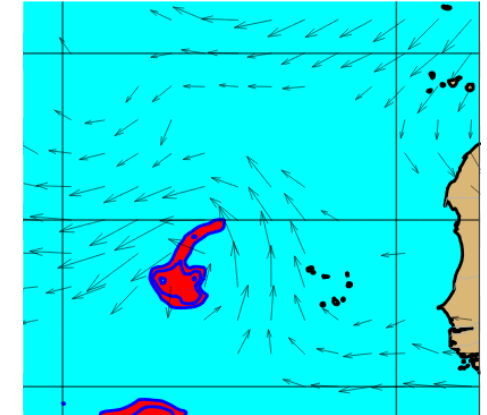
Hurricane Forecasting and Tracking: Hurricane Irma



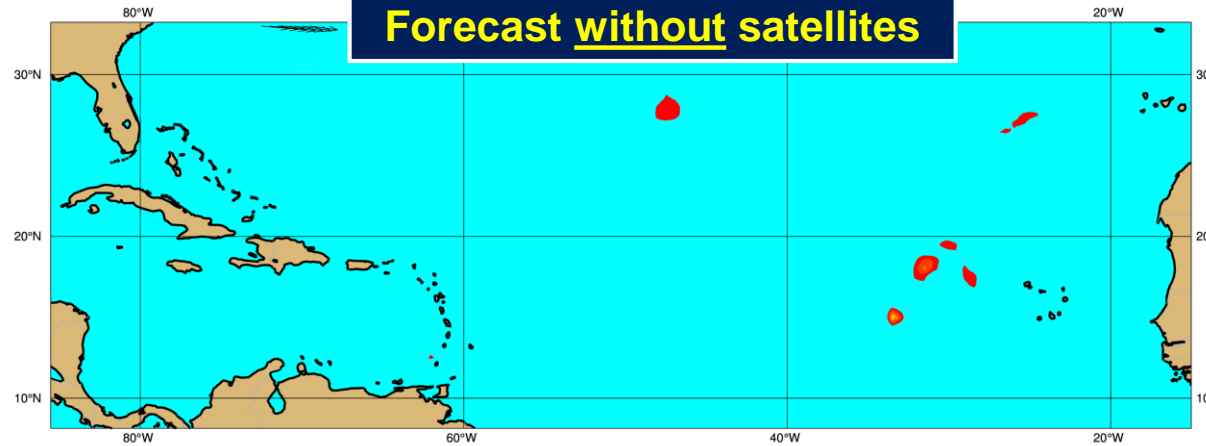
Forecast with satellites



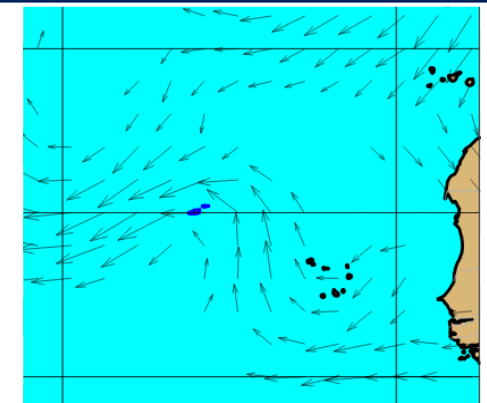
700hPa humidity and wind initial conditions with satellites



Forecast without satellites



700hPa humidity and wind initial conditions without satellites



Red shading humidity > 95%

Source: ECMWF (2018)

EUMETSAT FUTURE: TWO HIGHLY INNOVATIVE PROGRAMMES

METEOSAT THIRD GENERATION (MTG)

EUMETSAT POLAR SYSTEM – SECOND GENERATION (EPS-SG)

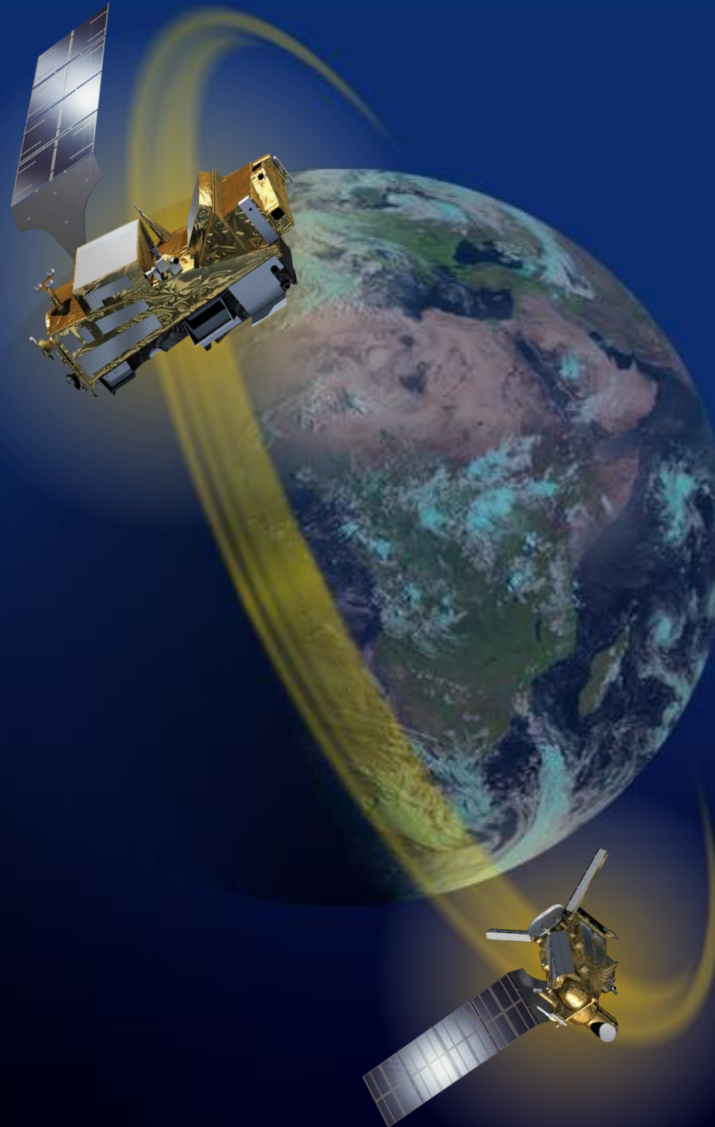


EPS-SG full operational configuration

Metop-SG A

Sounding & Optical Imaging

Launch of Metop-SG A1 – Q2 2024



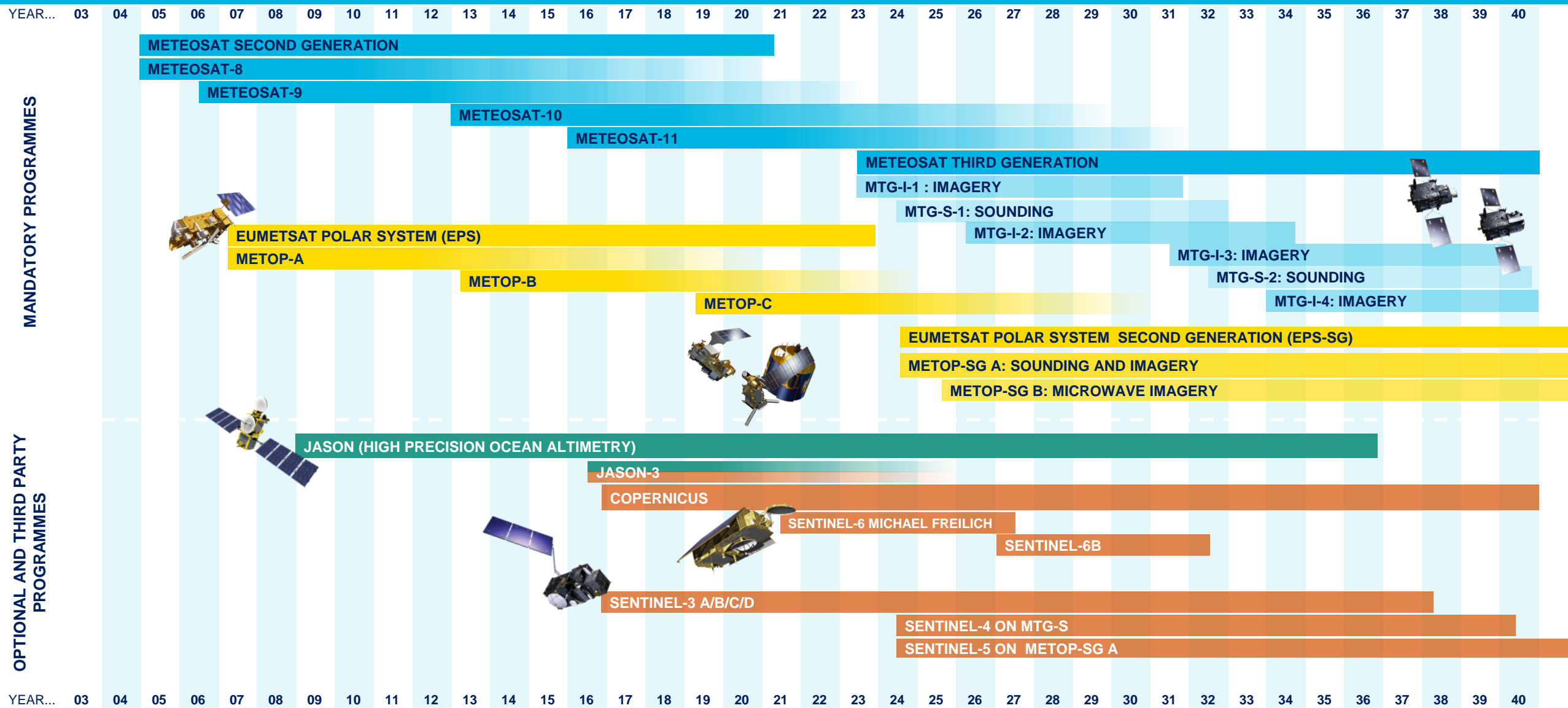
- Same orbit as Metop
 - sun-synchronous,
 - 832 km mean altitude
 - 09:30 local equator crossing time

Metop-SG B

Microwave Imaging and Sounding

Launch of Metop-SG B1 – Q1 2025

EUMETSAT MISSION PLANNING





- Primary mission: further improve observational inputs to Numerical Weather Prediction models.
- Continuation and enhancement of service from mid morning polar orbit in 2024 – 2043.
- 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 (first generation).



- Major improvements to all EPS observation missions

- Infrared and microwave sounding
- Optical imagery
- Scatterometer
- Radio occultation

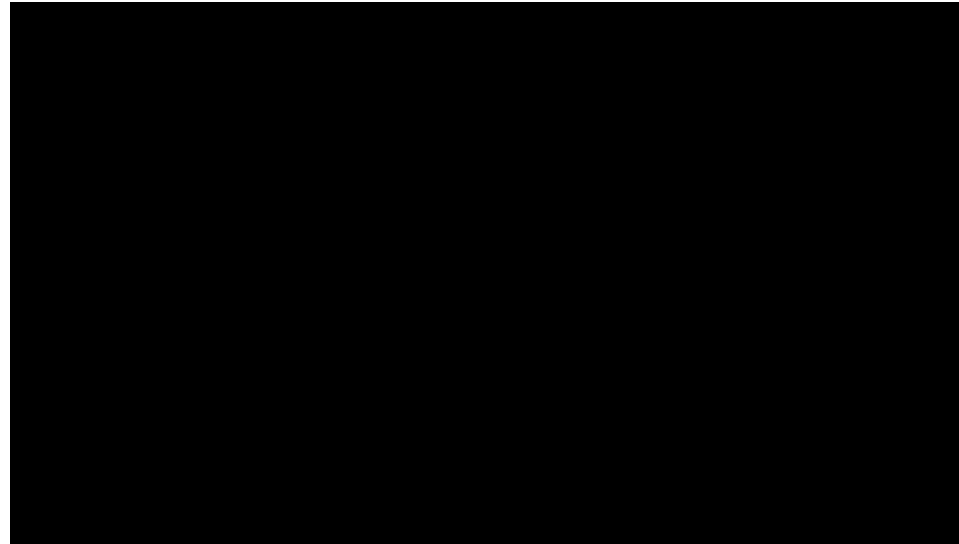
- New imagery missions:

- 3MI: first operational imaging polarimeter
- MWI: microwave imagery of precipitation
- ICI: Ice Cloud imagery

Metop-SG payload	Metop-SG satellite
Infrared Atmospheric Sounding Interferometer – New Generation (IASI-NG)	A
Micro-Wave Sounder (MWS)	A
Visible-Infrared Imager (METImage)	A
Scatterometer (SCA)	B
Radio Occultation (RO)	A and B
UV-VIS-NIR-SWIR Sounder (Sentinel-5)	A
Multi-viewing, -channel, -polarisation Imager (3MI)	A
Micro-Wave Imager (MWI)	B
Sub-mm wave Ice Cloud Imager (ICI)	B



EPS-SG overview video:

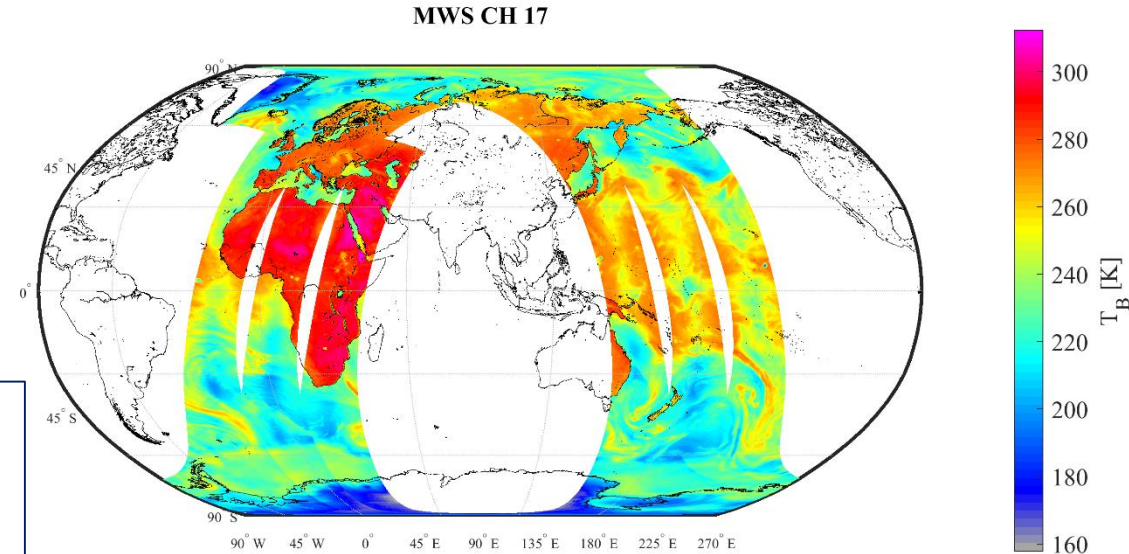
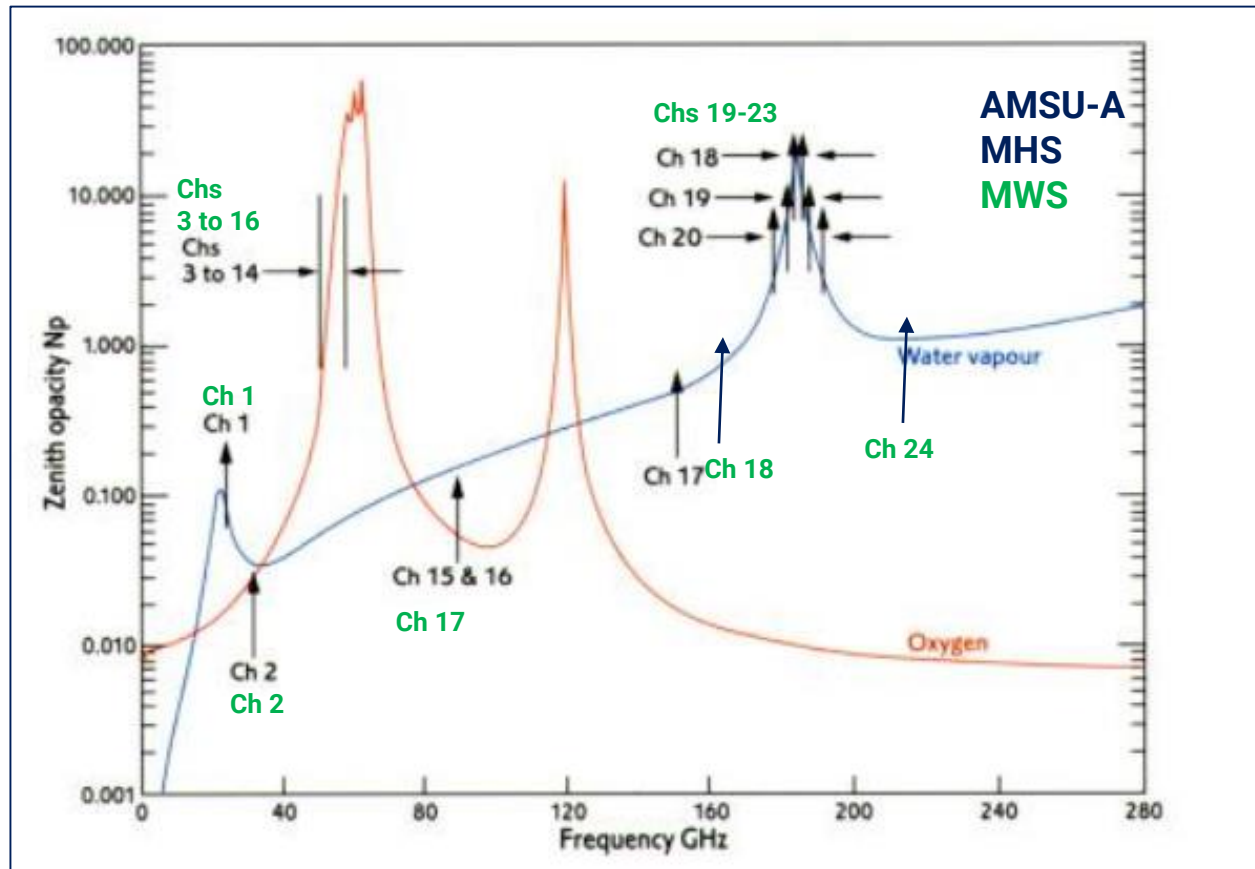




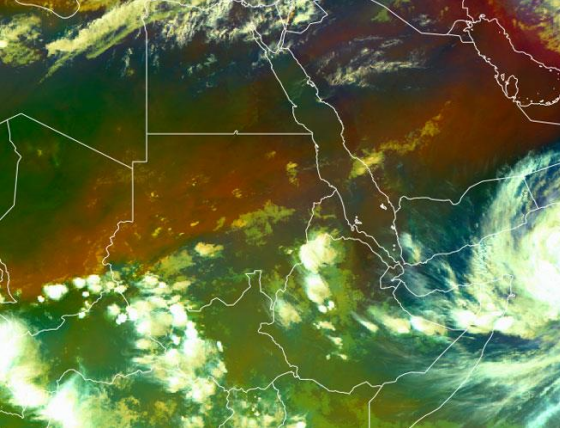
Microwave Sounder (MWS)

Objectives / products

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



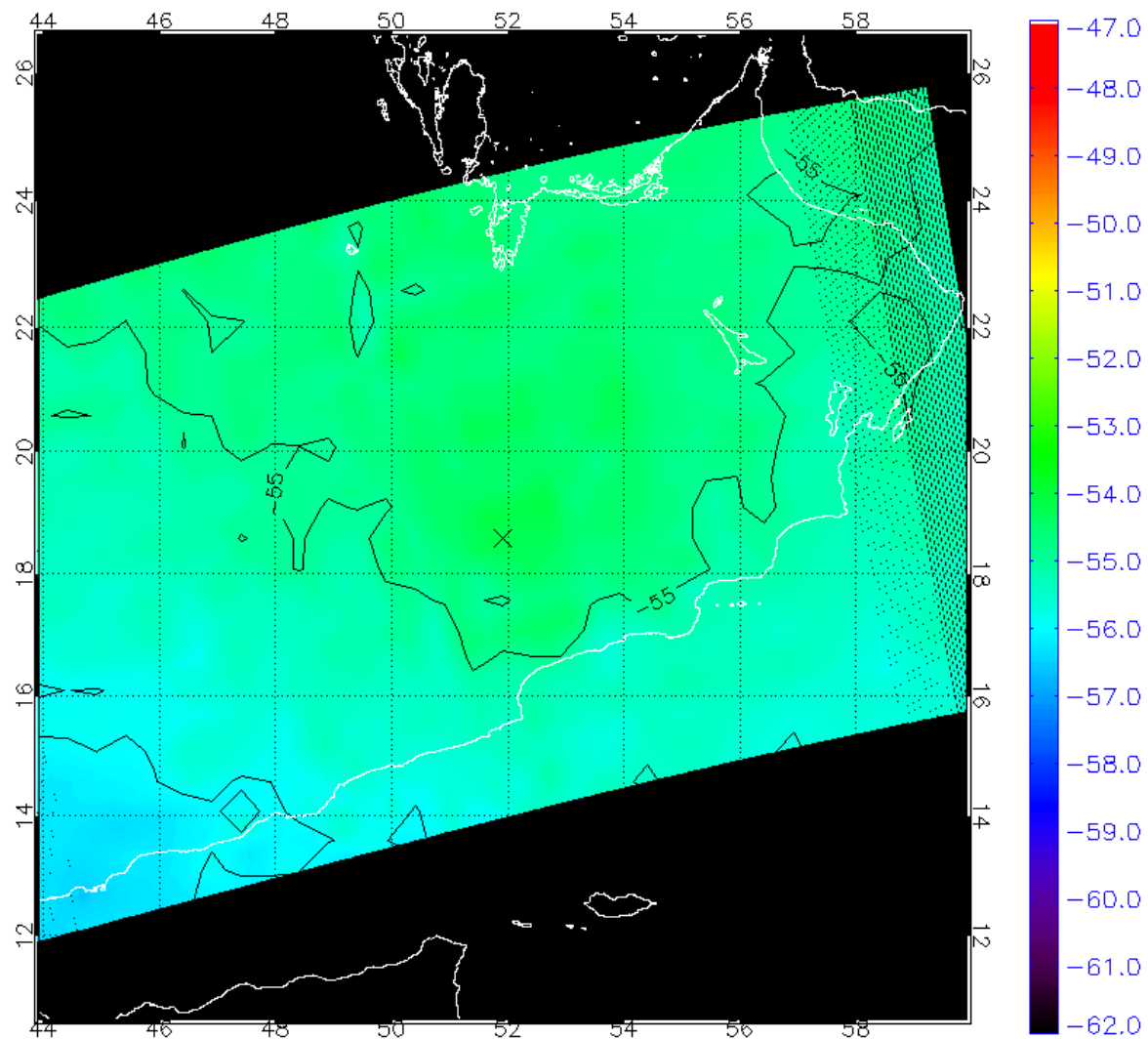
Obs Freq. (GHz)	AMSU-A/MHS	MWS
23.8	48 km	40 km
31.4	48 km	40 km
50-58	48 km	20 km
89	48 km/ 16 km	17 km
157-167	16 km	17 km
183-191	16 km	17 km
229	N/A	17 km



201802A 2018
AMSU-A Channel 8 (55.5GHz) Brightness Temperature (C)
0526 Time: 1752 UTC
Metop-B

Tropical Cyclone Mekunu

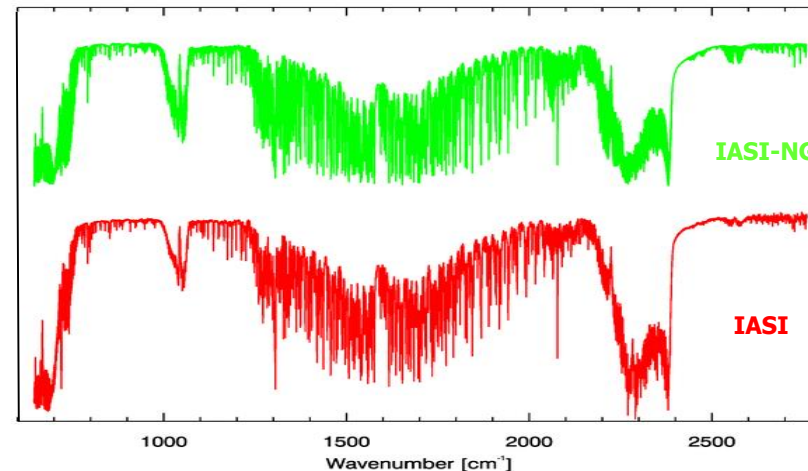
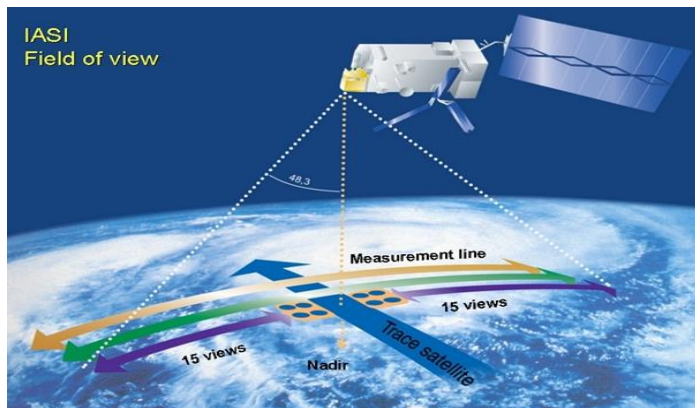
Microwave Warm Core



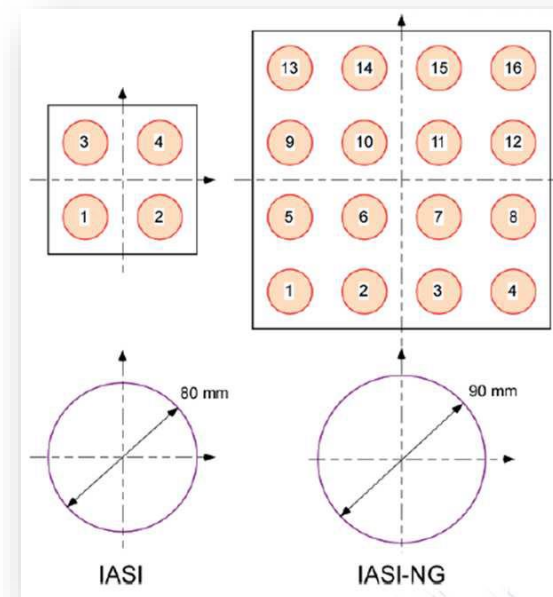
Storm position x
Max Tb: -54.1 C Contour Interval = 1C



IASI-NG is a continuation of the IASI mission: Michelson **interferometer**



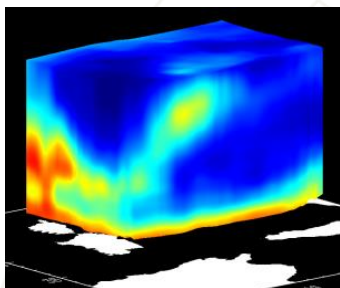
- ✓ Spectral coverage: 645 - 2760 cm^{-1}
- ✓ Spectral sampling (0.125 cm^{-1}) and resolution of 0.25 cm^{-1}
 → Better than IASI (0.25 cm^{-1} and 0.5 cm^{-1} respectively)
- ✓ Swath of 2200 km and pixel size is 12km at nadir
- ✓ Detector: 4x4 pixels (100x100 km)
- ✓ Half of the IASI radiometric noise (0.25K)





IASI-NG Products

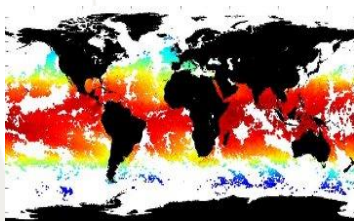
Temperature, Humidity profiles



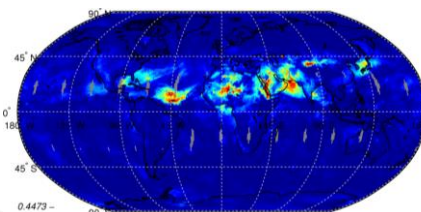
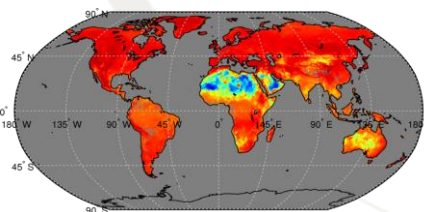
Cloud mask, fraction, top height



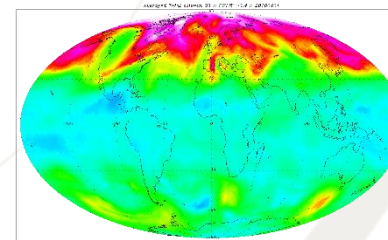
Sea surface temperature



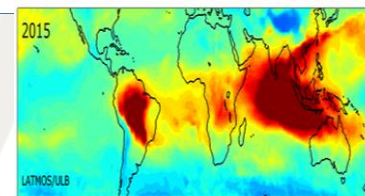
Land surface temperature and emissivity



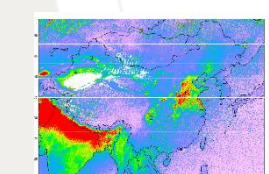
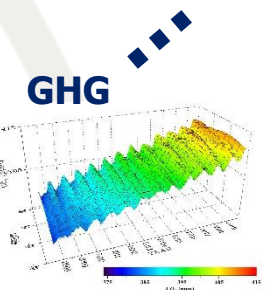
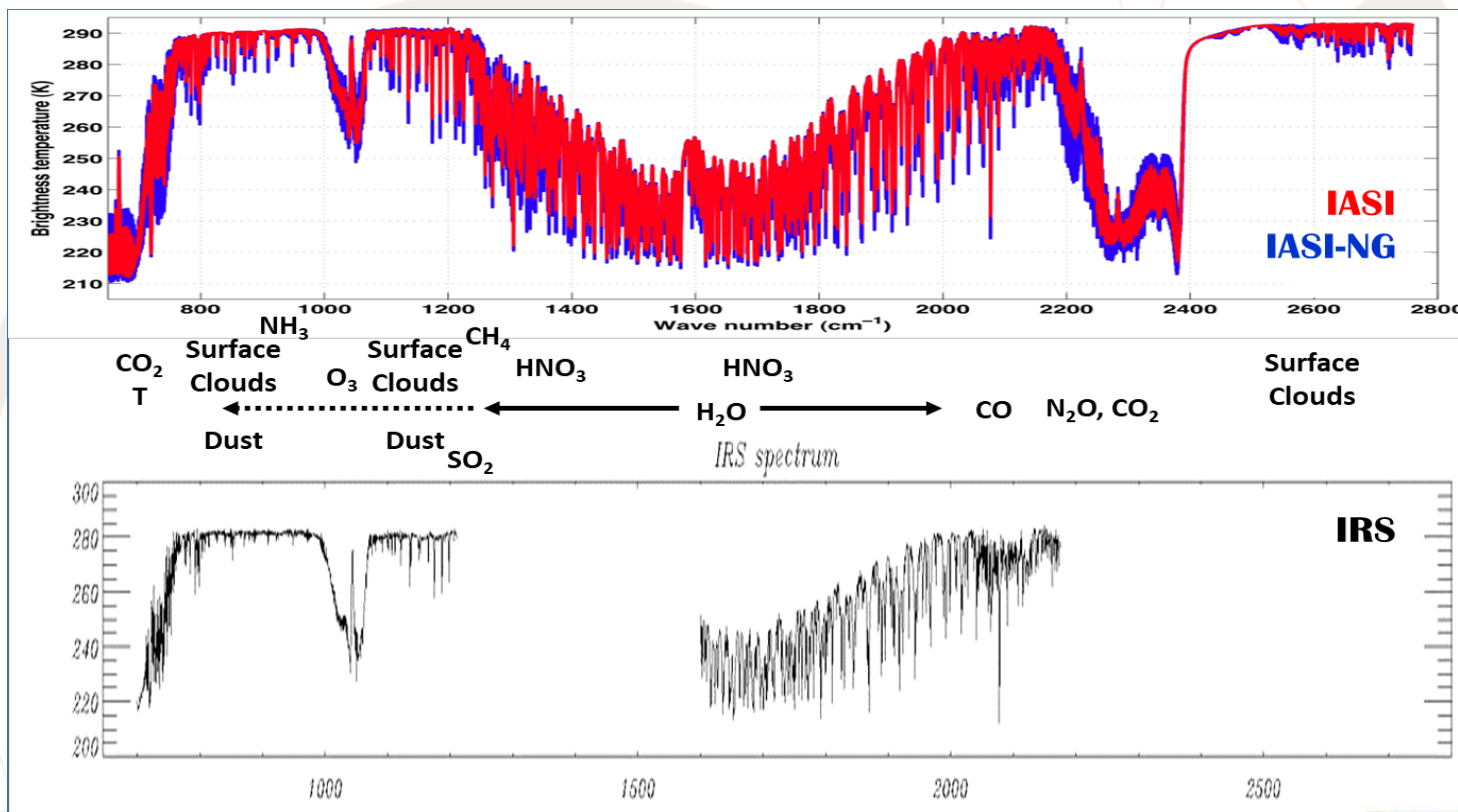
Dust index



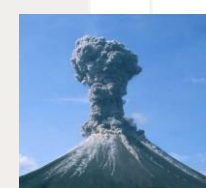
Ozone



Carbon monoxide



NH₃

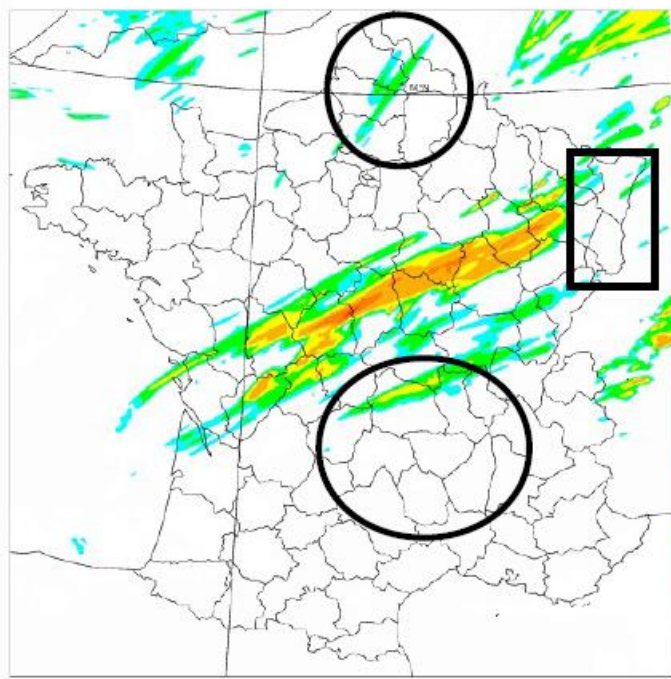


SO₂

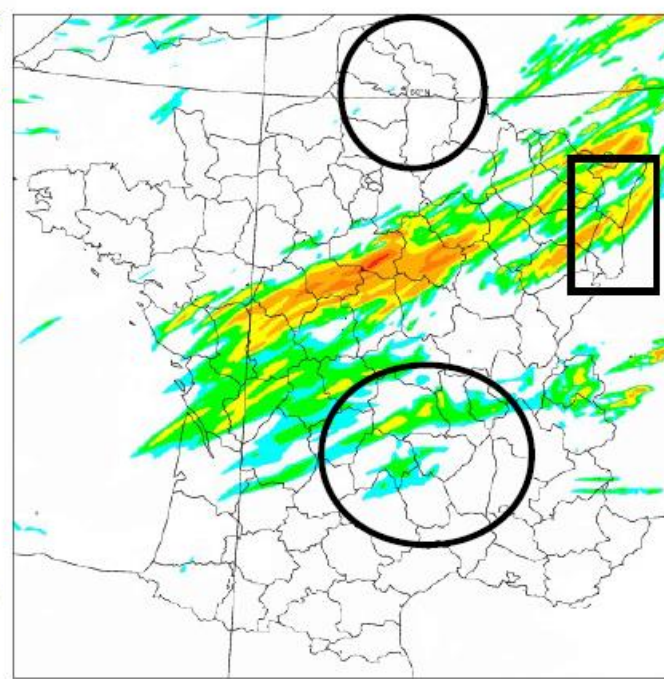


Impact on precipitation prediction example of 12h precipitation between 00 and 12UTC on 21 May 2009

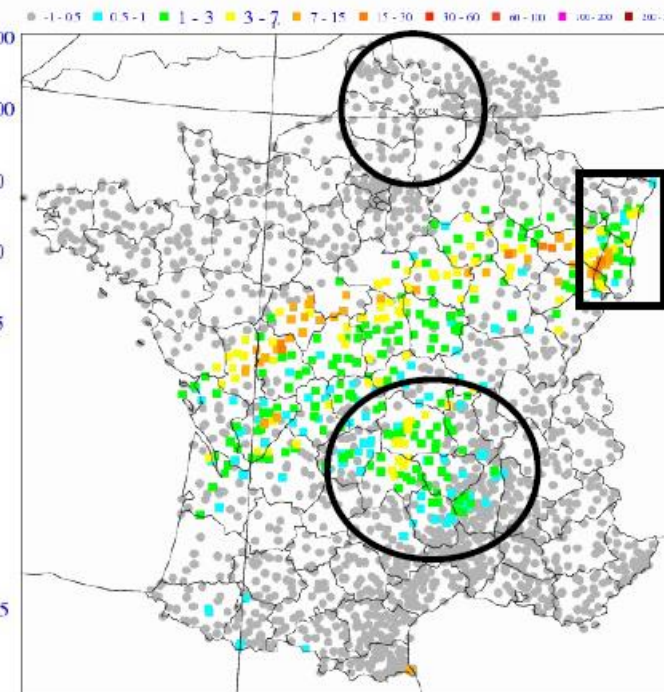
12h forecast range



Reference: no IASI



Experiment: with IASI



Verif.: Rain gauges

Guidard et.al, QJRMS, 2011



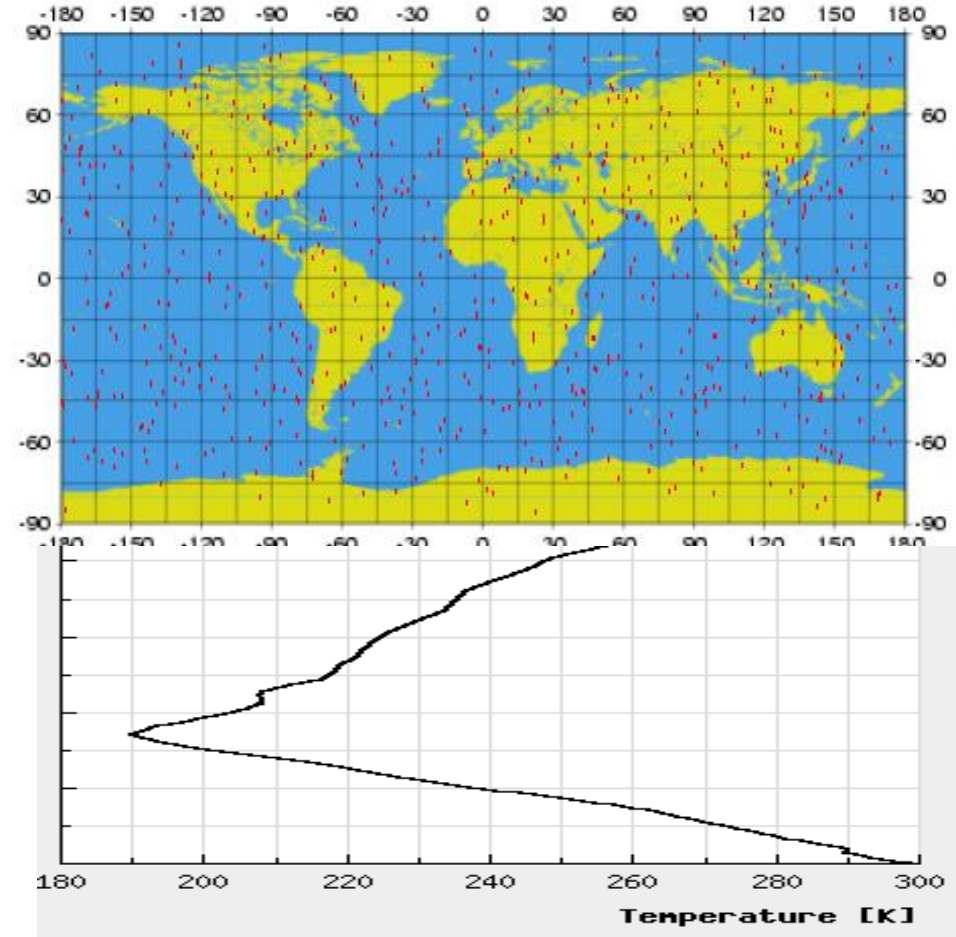
Radio occultation sounding (RO)

Objectives / products

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

Breakthrough

- Tracking of GPS and Galileo satellites to double the number of occultation measurements
- RO mission on board Metop-SG A and B satellites.





METImage on board EPS-SG will:

- Provides continuity to
 - AVHRR (Advanced Very High Resolution Radiometer) series on board the EPS and NOAA satellites and
 - VIIRS on board NOAA satellites.
- Great improvement with respect to AVHRR and comparable performance with respect to VIIRS

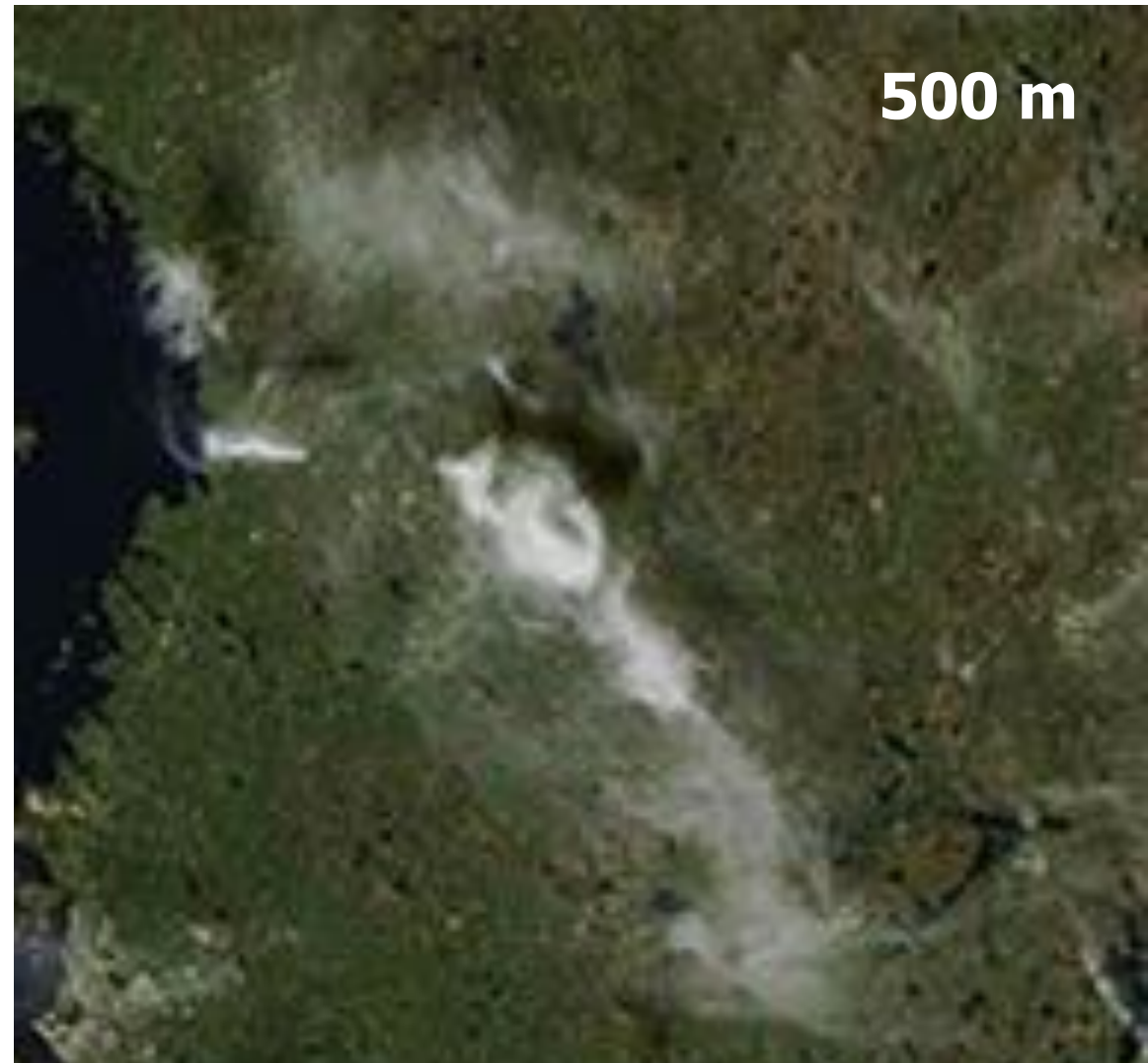
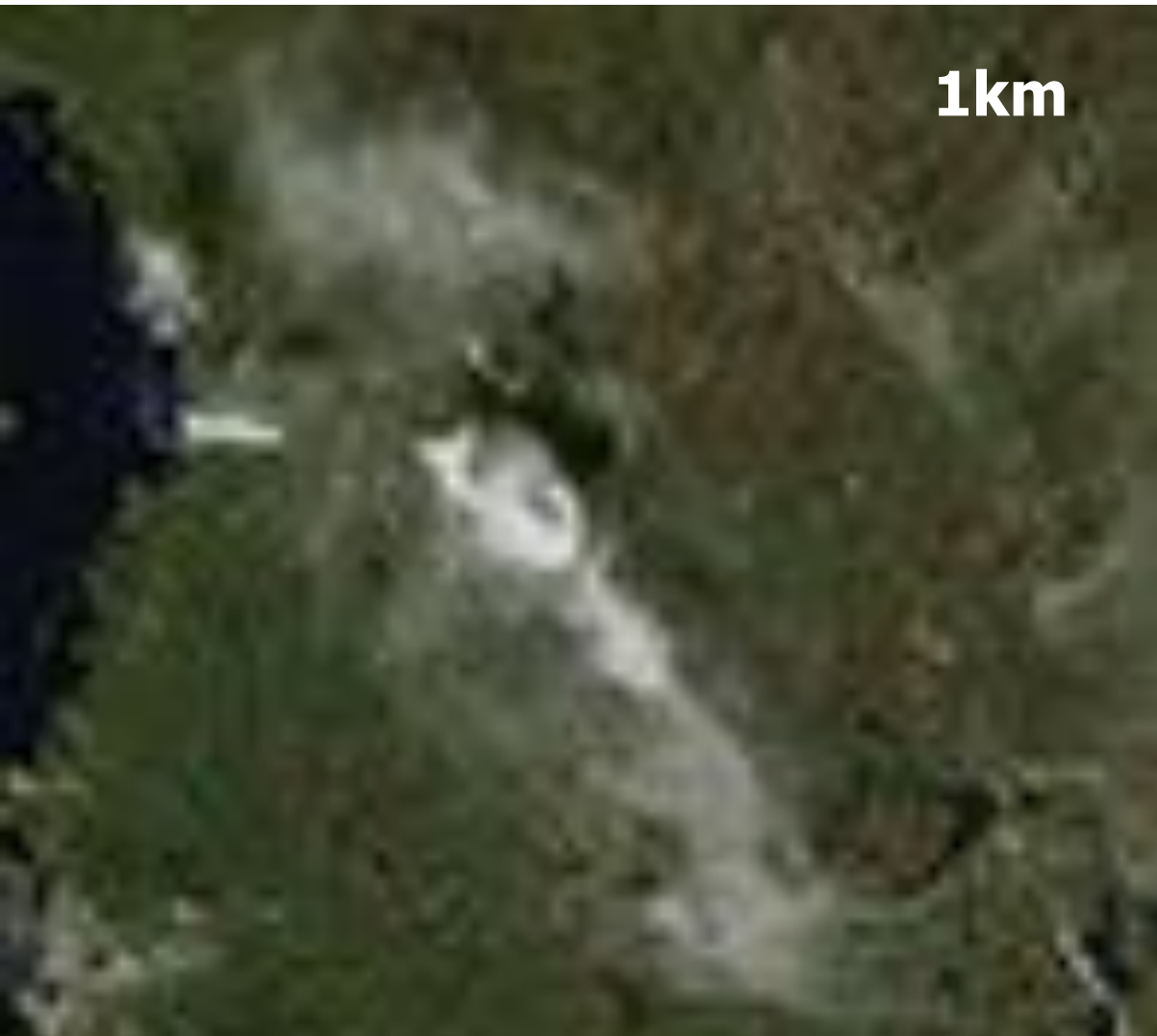
METImage

- Number of channels: **20** (from $\sim 0.44\mu\text{m}$ to $\sim 13.3\mu\text{m}$)
- Spatial resolution: **500m**
- Swath: 2800 km
- Dynamic surface auxiliary data (albedo, surface emissivity)
- Dynamic snow/ice auxiliary map
- Auxiliary forecast with every 1h step

AVHRR

- Number of channels: **5** (from $\sim 0.6\mu\text{m}$ to $\sim 12\mu\text{m}$)
- Spatial resolution: **1km**
- Swath: 2900 km
- Static surface auxiliary data (climatology)
- No snow/ice map
- Auxiliary forecast with every 6h step

Wavelength Region	Metop AVHRR	Metop-SG METimage	Information from additional channels
Visible (μm)	0.63, 0.865	0.443, 0.555, 0.668, 0.752, 0.763, 0.865	Aerosols, Clouds (cloud top height)
Near Infrared (μm)	1.61	0.914, 1.24, 1.375, 1.63, 2.25	Water vapour Imagery, Total water vapour column, cloud
Infrared (μm)	3.74, 10.8, 12	3.74, 3.959, 4.05, 6.725, 7.325, 8.54, 10.69, 12.02, 13.345	clouds (cirrus clouds, cloud microphysics), temperature profile information

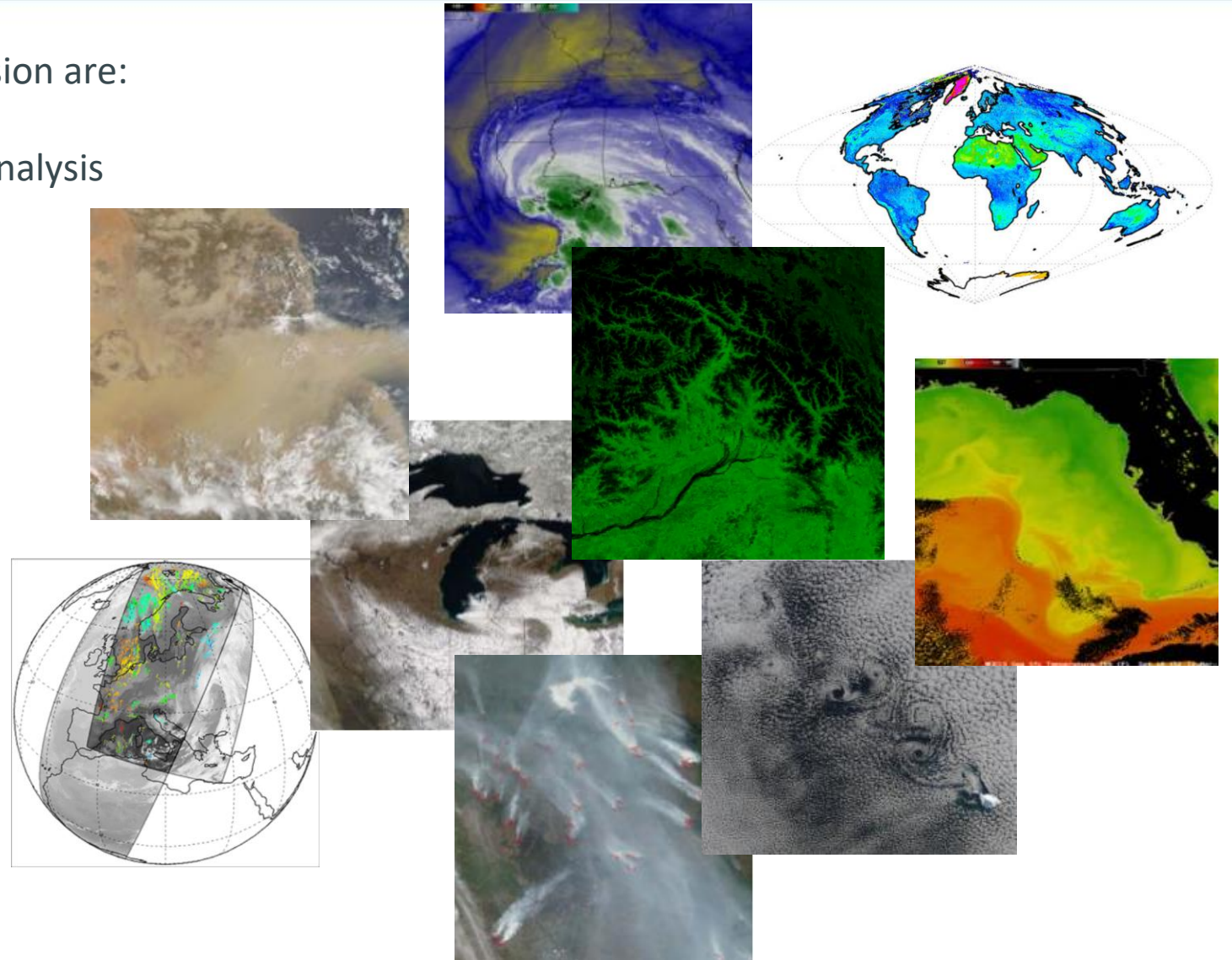


03 June 2021, 10:45 UTC Aqua MODIS, over Finland

METImage primary products

Primary products to be derived from the VII mission are:

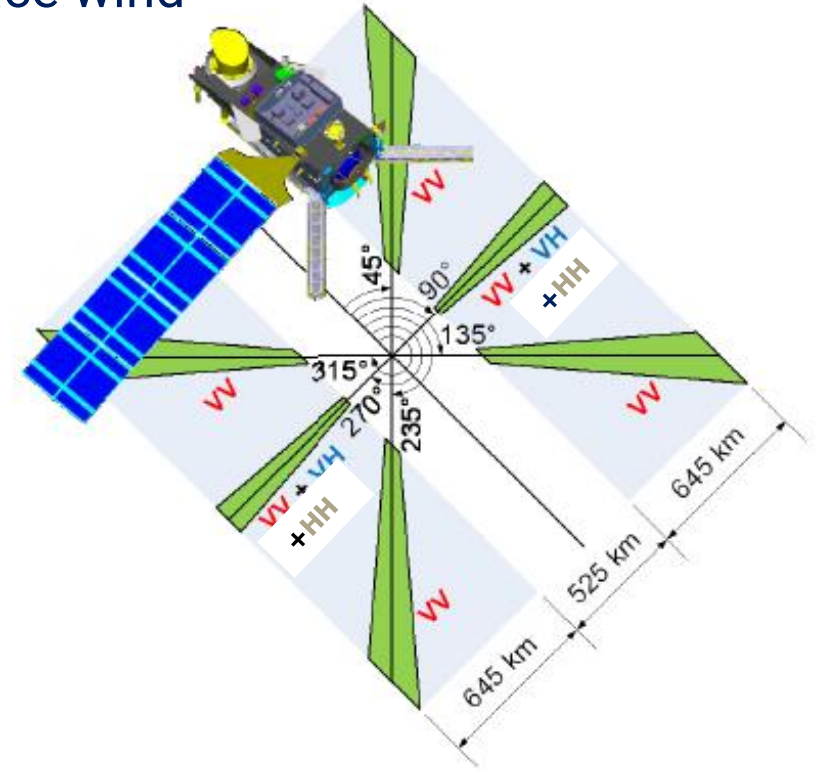
-
- Cloud observations including microphysical analysis
- Water-vapour imagery
- Aerosol observations
- Polar Atmospheric Motion Vectors (AMVs)
- Earth surface albedo
- Vegetation
- Cryosphere (snow, sea and land ice imagery)
- Fire detection
- Surface temperature (land and sea)





EPS-SG Scatterometer

- Provide information on the intensity and direction of ocean surface wind
- Soil moisture
- Snow equivalent water
- Sea-ice type



• Metop – ASCAT

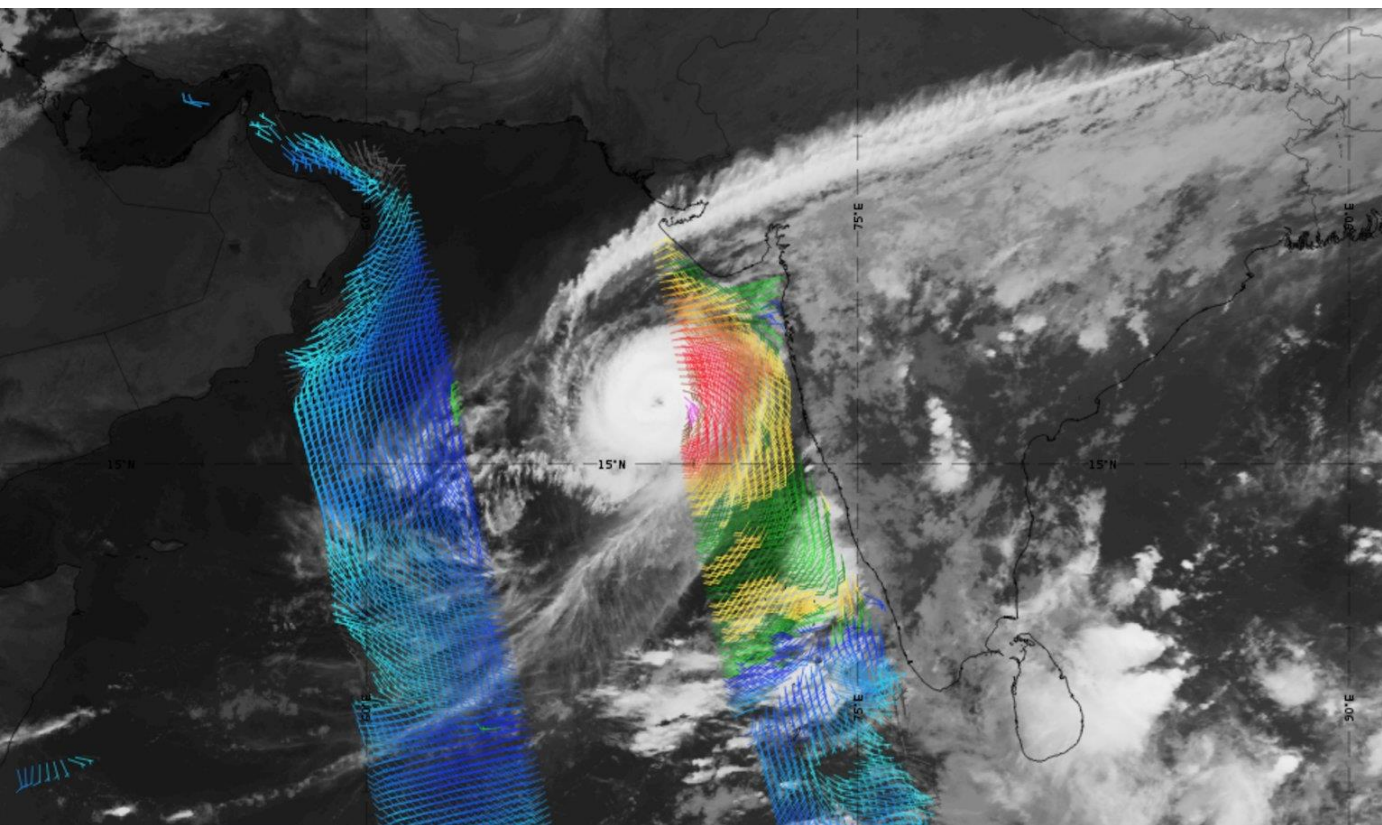
- Frequency 5.255 GHz (C-band)
- Swath width 550 km
- Spatial resolution 50 km
- Incidence angles
 - 25° to 53° (mid beams)
 - 34° to 65° (side beams)
- Polarisation: VV

• Metop SG – SCA

- Frequency 5.355 GHz (C-band)
- Swath width ~650 km
- Spatial resolution 25 km
- Incidence angles
 - 20° to 53.7° (mid beams)
 - 28.4° to 65° (side beams)
- Polarisations: VV plus HH + HV + VH on mid-beams for improved high winds retrieval



Tropical cyclone Kyarr: Wind Speed and Direction

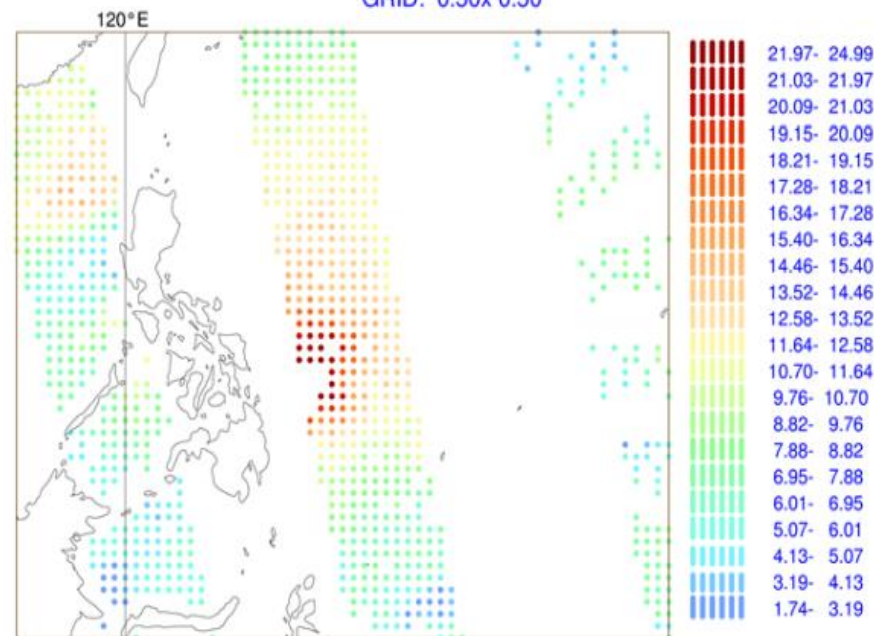


Metosat-8 IR10.8 channel with Metop-A ASCAT winds overlaid, 27 Oct 00:00 UTC.

<https://www.eumetsat.int/active-indian-ocean-tropical-cyclone-season>

Typhoon Haiyan: Assimilation of Scatterometer data

STATISTICS FOR 10MWINDSPEED FROM FROM METOP-A/ASCAT (GLOBAL)
 MEAN OBSERVATION (USED)
 DATA PERIOD = 2013-11-07 09 - 2013-11-07 21
 EXP = G0QE, BEST AMBIGUOUS WIND
 Min: 1.740 Max: 24.990 Mean: 9.566
 GRID: 0.50x 0.50



De Chiara et.al, ECMWF Technical Notes, 2016



MicroWave Imager (MWI)

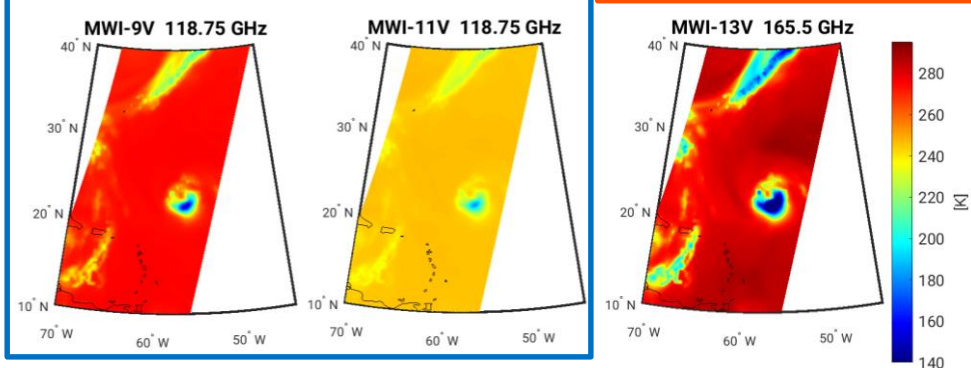
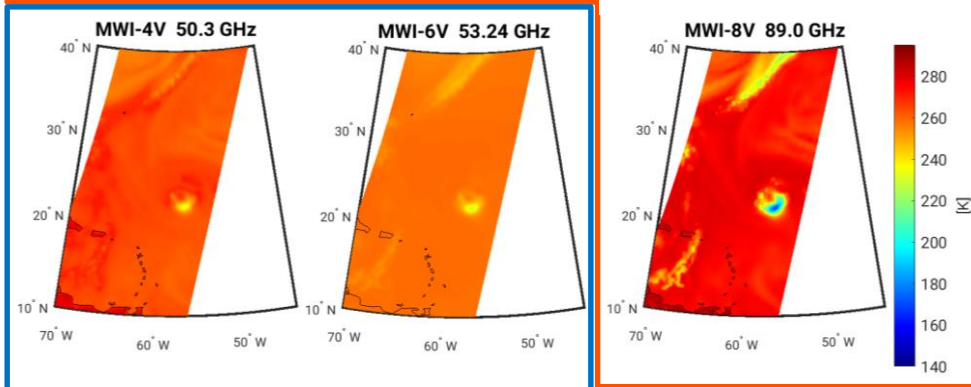
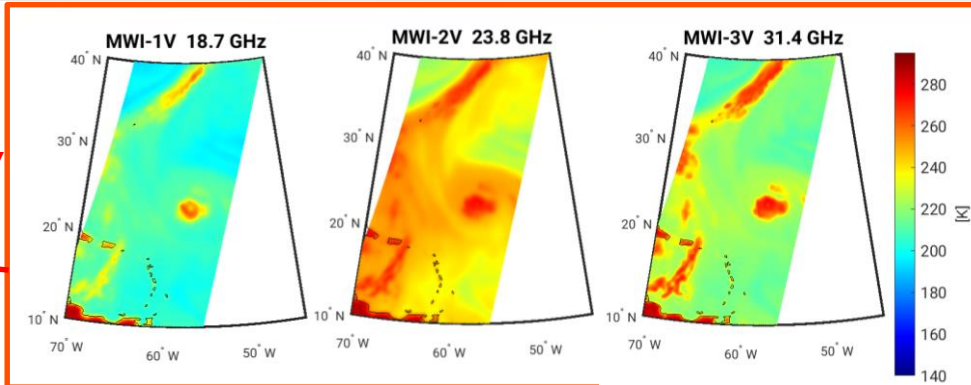
- Provision of cloud and precipitation products
- Support Numerical Weather Prediction at regional and global scales
- Nowcasting and very short-range forecasting at regional scales
- Support observations of sea ice parameters and snow cover, snow water equivalent, sea surface wind.
- Continuity of measurements of key microwave imager channels as observed by SSM/I, TMI, SSMIS, AMSR-E, GMI, in support of long-term climate records

Ice Cloud Imager (ICI)

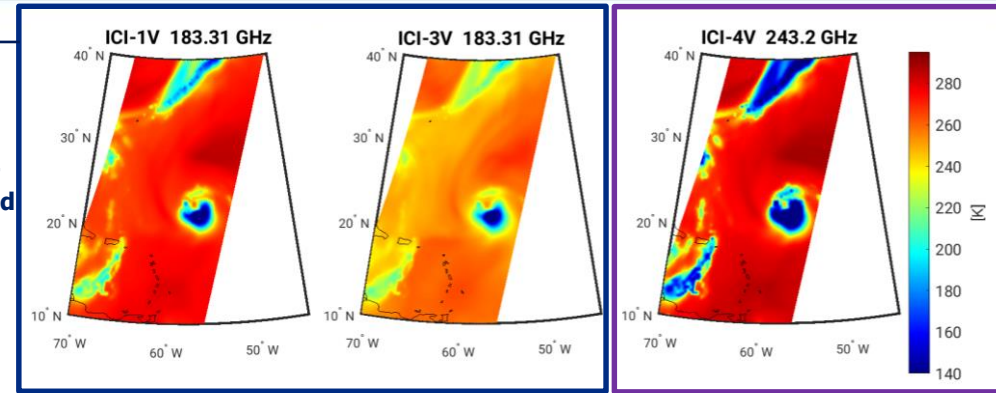
- Provision of ice cloud products for climate monitoring
- Support the validation of ice clouds models and the parameterisation of ice clouds in weather and climate models
- Fill observational gap: provide information on non-precipitating ice that are not covered either in the optical/thermal IR or in the mm-wave range

MWI and ICI TB simulations (hurricane "IKE", 06/2008)

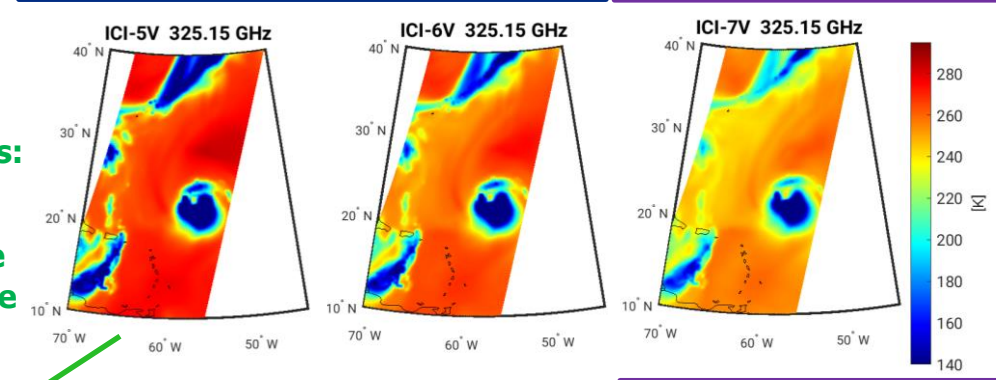
Total Column Water Vapour, liquid and frozen hydrometeors, sea ice, snow cover, wind speed, surface emissivity



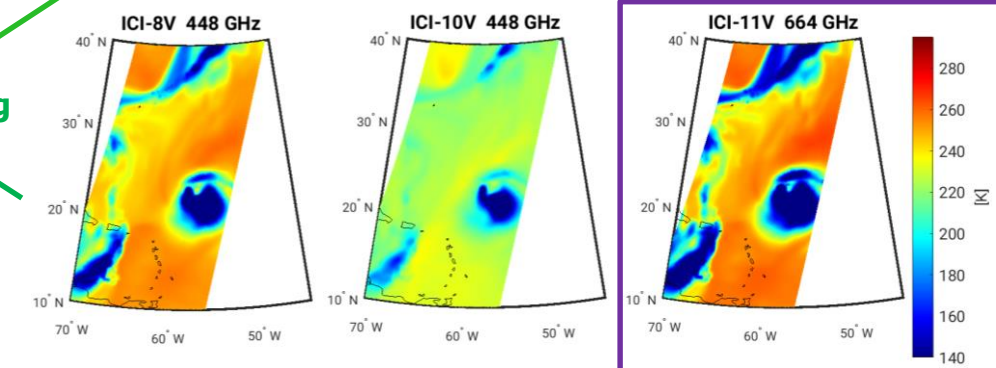
183.31 GHz water vapour profiles and snowfall. Cloud slicing



ICI channels: Ice Water Path and ice particles size



Cloud slicing

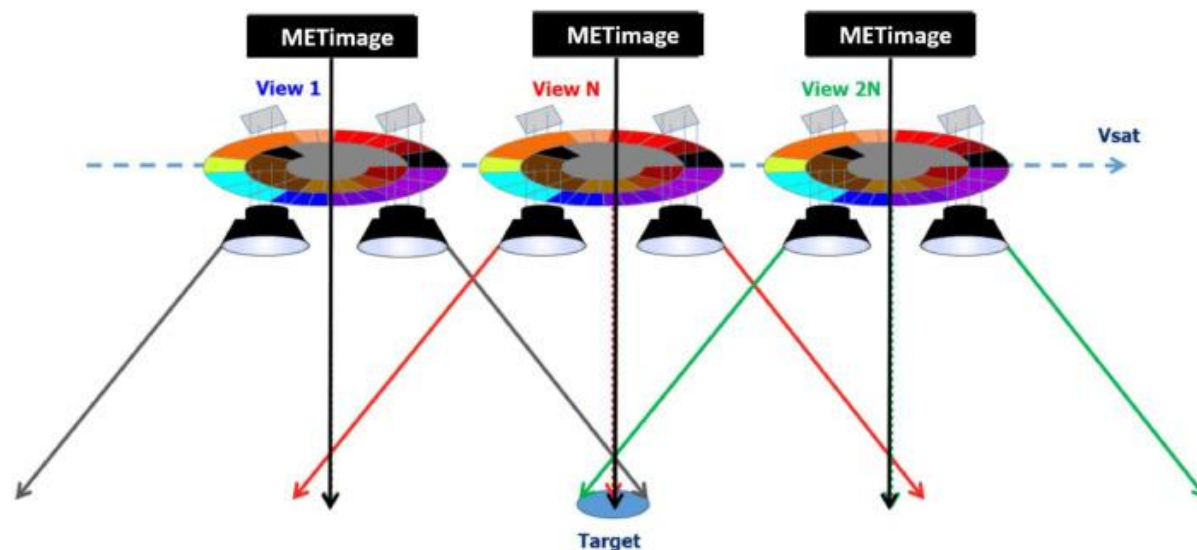


243.2 and 668 GHz V and H polarisation for ice habits and orientation



Objectives / products

- Aerosol – optical thickness, particle size, type, height, absorption
- Volcanic Ash
- Cloud phase, height, optical depth
- Surface albedo

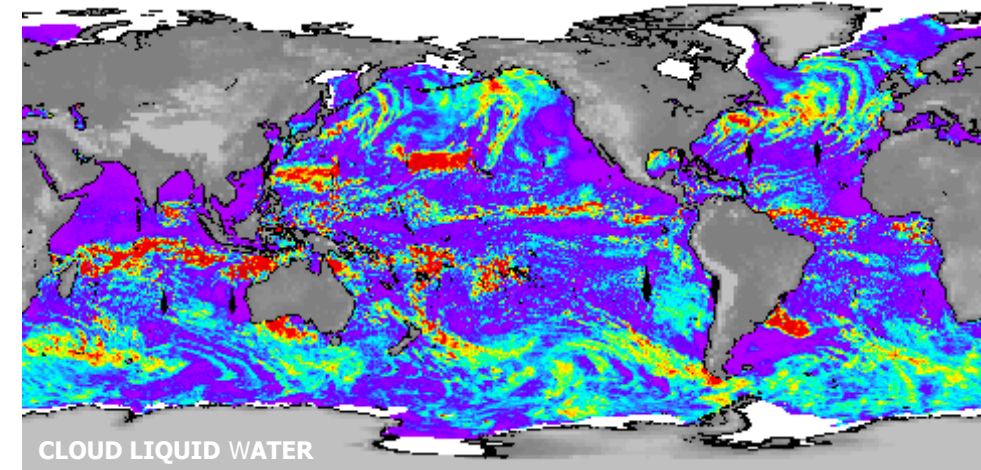
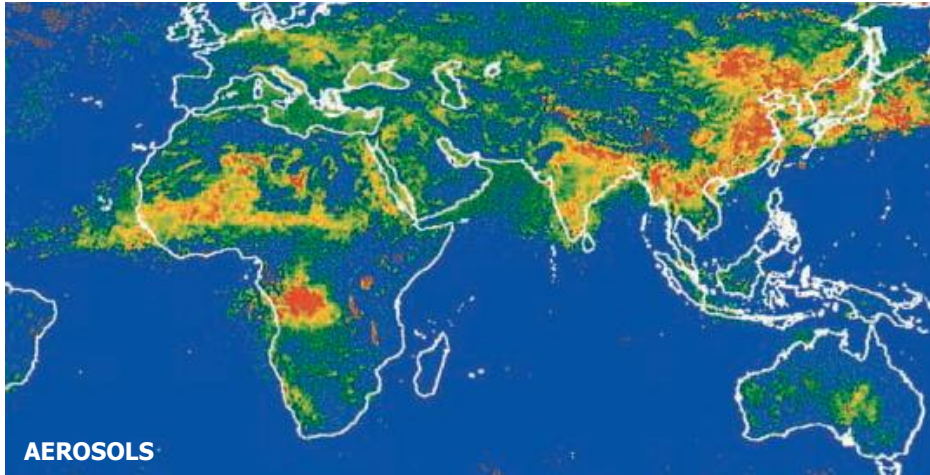


Multi-view: 1 ground target is seen 14 times

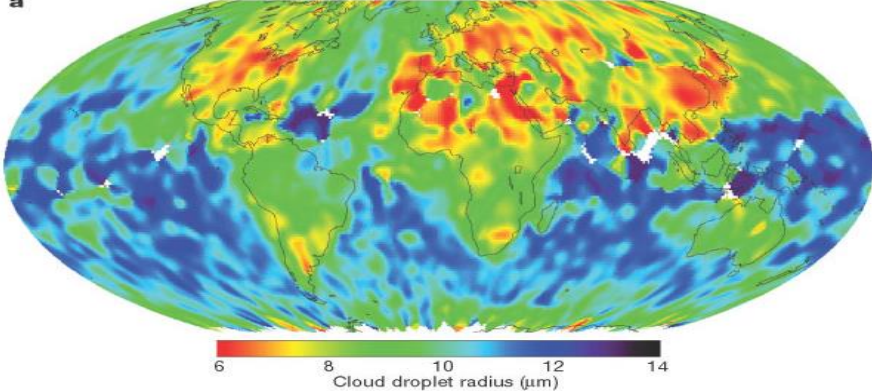
Multi-channel (12 channels from 410 to 2130 nm)

Multi-polarisation (9 channels with -60° , 0° , $+60^\circ$ polarisers)

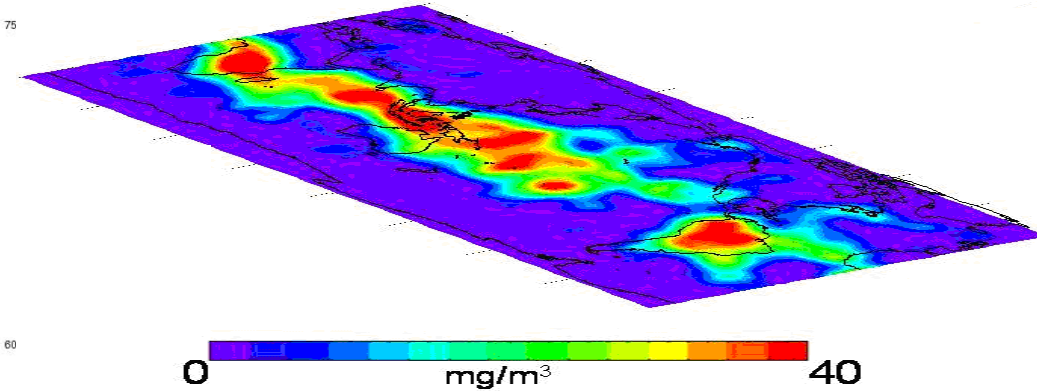
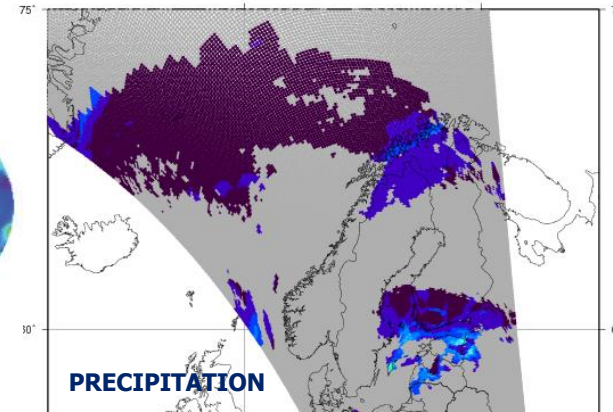
NEW MEASUREMENTS FROM EPS-SG



CLOUD DROPLET RADIUS



EUMETSAT H-SAF PR-OBS-1 Instantaneous Rain Rate from Conical MW Scan



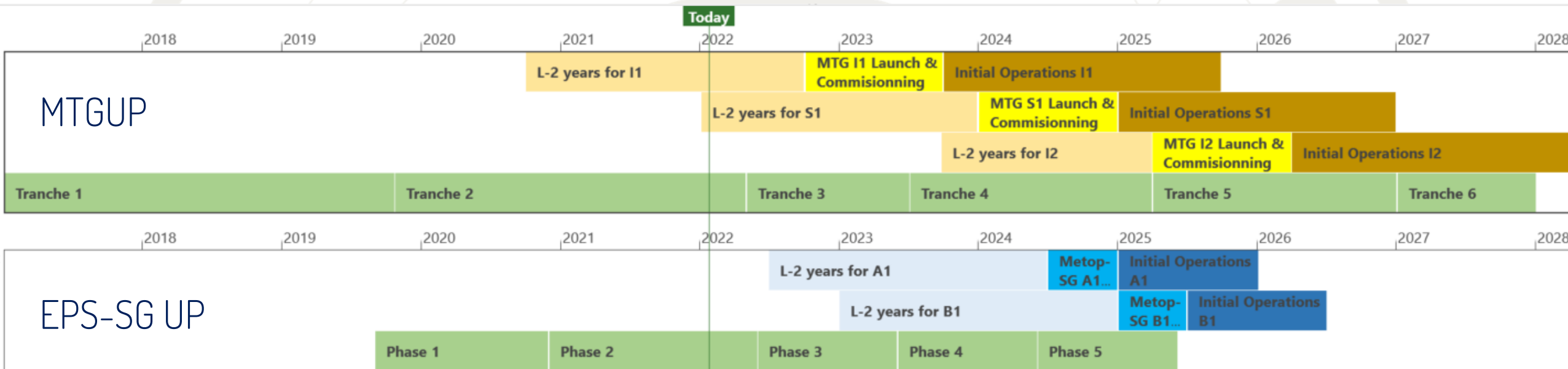
ICE CLOUDS

Preparing Users for EPS-SG





MTG UP and EPS-SG UP: High Level Schedule



Core Themes

- Test Data and Format Support
- Science support
- User Information and Communication
- Training
- Data Access

MTGUP: Tranche 2 - Entered L-1 years phase for MTG-I1
Entered L-2 years for MTG-S1

EPS-SG UP: Phase 2



EPS-SG Test Data and Format Support – Test Data schedule

www.eumetsat.int

	Product Generation Function	Test data v1	Test Data v2
SAT-A	MWS L1-L2	Delivered (December 2019)	Delivered (December 2022)
	RO	Delivered (December 2019)	Delivered (January 2022)
	METimage L1	Delivered (February 2020)	Delivered (January 2022)
	METimage L2 + CM	Delivered (June 2020)	Delivered (January 2022)
	3MI L1b	Delivered (February 2020)	Delivered (March 2022)
	3MI L1c	Delivered (April 2020)	Delivered (March 2022)
	3MI L2 + MAP		Q2 2022
	S5 L1		Q3 2022
	S5 L2		Q2 2023
	IASI-NG L1D	Delivered (February 2020)	Delivered (March 2022)
	IASI-NG L2	Delivered (April 2021)	Q1 2022
	IASI-NG L1C	Delivered (February 2021)	Q1 2022
SAT-B	MWI – ICI L1	Delivered (February 2021)	Q4 2022
	MWI – ICI L2	Delivered (February 2021)	Q4 2022
	SCA	Delivered (June 2020)	Q4 2022

- Test Data V2:
 - updated instrument design and processing algorithms
 - updated format specifications
 - three orbits of data
- Test Data V1 and V2:

[EPS-SG Test Data](#)



• In 2020-2021, online User Preparation Webinars on all next-generation Observation Missions and key Applications

- Overview of measurement principles
- L1 and L2 product generation
- Formats, test data and dissemination
- Application perspectives
- Open participation
- Collaboration with SAFs, external experts

Observation Mission	Dates	Participants	Countries	Q&A
IRS and IASI-NG	13-14 Oct 2020	153	32	38
LI	16-17 Feb 2021	217	49	64
SCA	20-21 May 2021	144	40	31
FCI and METimage	8-10 Jun 2021	174	33	103
3MI	14-15 Jun 2021	130	33	46
MWI/ICI/MWS	12-13 Oct 2021	122	30	45
RO	27-28 Oct 2021	70	26	38
UVN/UVNS	Q2 2022			

Recordings, presentations, Q&A available online:

[MTG resources](#) | [EUMETSAT Website](#)

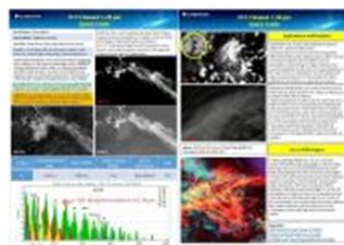
[EPS-SG resources](#) | [EUMETSAT Website](#)



- EUMETSAT Training team

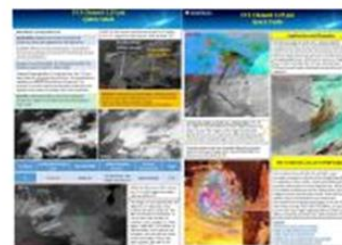
- Application guides
- Case studies
- Jupyter notebooks
- Simulators

Quick Guide - 1.37 μm Channel



[Download Quick Guide](#)

Quick Guide - 2.25 μm Channel



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RGB Quick Guide - Cloud Type



[Download Quick Guide](#)

- EUMeTrain – EUMETSAT training project

- Product guides
- RGB quick guides

RGB Quick Guide - Cloud Phase



[Download Quick Guide](#)

RGB Quick Guide - True Colour



[Download Quick Guide](#)

RGB Quick Guide - Fire Temperature



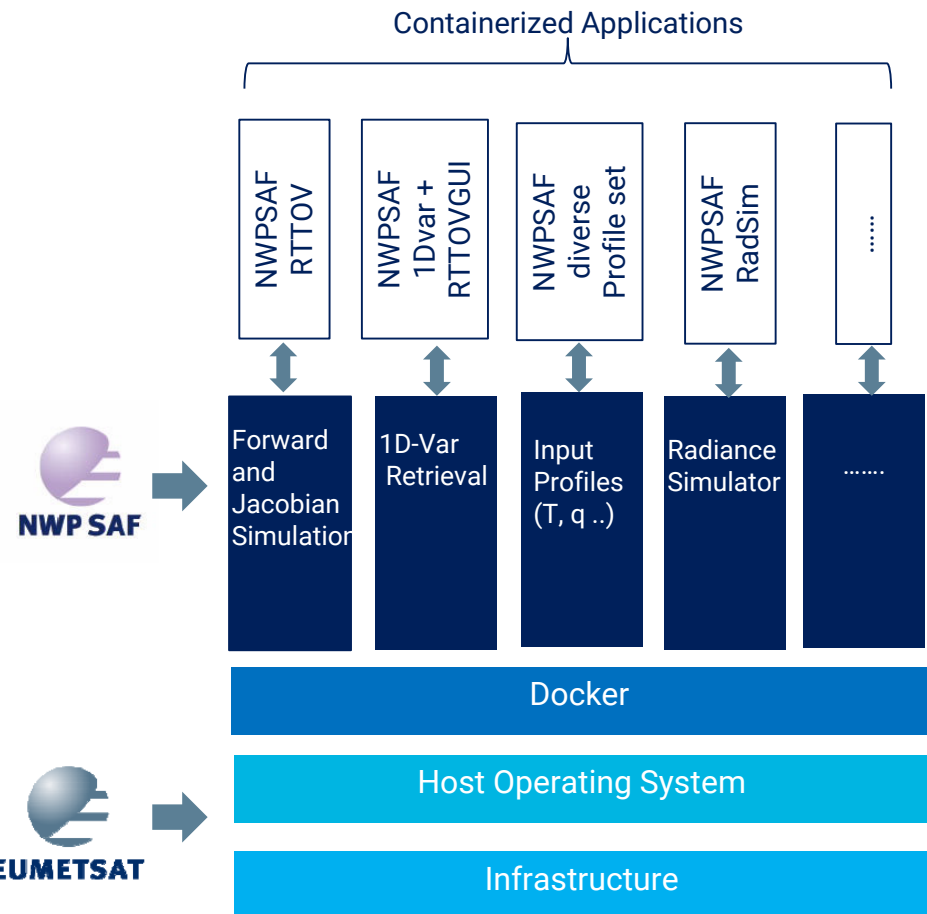
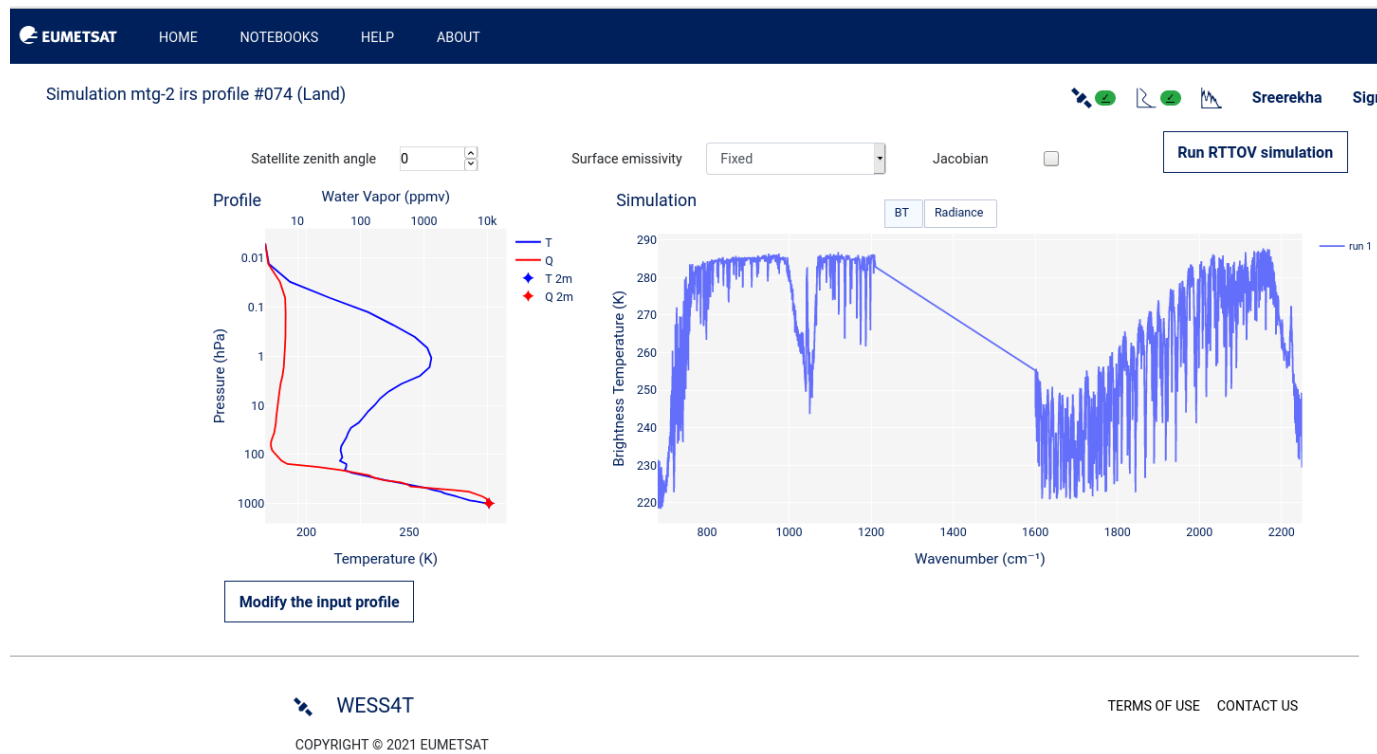
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Prototype Web-based Satellite Sounding Training Application

- An easy web interface to
 - Simulate radiances and jacobians from satellite sounders
 - Perform retrievals of temperature, humidity and other parameters

<https://sounding.trainhub.eumetsat.int/>





- One animation per instrument
 - Spectral and geometrical characteristics
 - Visualisation of L1 and L2 products
- Links to completed MTG videos
 - FCI → <https://youtu.be/dSghwvFt8U8>
 - LI → <https://youtu.be/EQJVo-0Vvi4>
 - Sentinel-4 UVN → <https://youtu.be/Mj9szNkmu7c>
 - IRS nearing completion
- EPS-SG Videos
 - Kicked off IASI-NG
 - Aiming to complete by Q3 2022



EUMETSAT MONITORING WEATHER AND CLIMATE FROM SPACE

HOME IMAGES ABOUT US SATELLITES DATA NEWS QUICK LINKS

EPS-SG DATA AND PRODUCTS

SATELLITES

- CURRENT SATELLITES
- FUTURE SATELLITES**
- METEOSAT THIRD GENERATION
- EUMETSAT POLAR SYSTEM - SECOND GENERATION
- IASI-NG
- MWS
- METIMAGE
- 3MI
- SENTINEL-5
- ICI
- MWI
- SCA
- RO
- EPS-SG DATA**
- EPS-SG USER TEST DATA
- EPS-SG DATA AND PRODUCTS**
- EPS-SG GROUND SEGMENT
- EPS-SG RESOURCES

The future ESP-SG products are listed in this section.

All EPS-SG global and Regional Level 1 and L2 products generated at EUMETSAT headquarters are shown in this table. While all the products in this table will be generated centrally at EUMETSAT, some of them will be developed and validated within the SAF Network or by ESA.

For EPS-SG products generated by SAFs, see [EPS-SG higher-level online products to be generated within the EUMETSAT SAF Network](#) and [EPS-SG higher-level offline products to be generated within the EUMETSAT SAF Network](#).

	PRODUCT	PROD LEVEL	COVERAGE	RESOLUTION	NRT
IASI-NG	Radiances	L1C	global regional	Pixel	YES
	Spectra Principal Component Scores	L1D	global regional	Pixel	YES
	Temperature profile	2	global regional	Pixel	YES
	Water vapour profile	2	global regional	Pixel	YES
	Cloud detection and fractional coverage from VII and IAS	1C/2	global regional	IAS Pixel	YES
	Water vapour total column from IAS and MWS	2	global regional	MWS Pixel	YES
	Cloud top phase	2	global regional	Cloudy pixel	YES

Ref.:

Products by EUMETSAT

- Central facility
- Satellite Application Facility

Click this link on EUMETSAT Webpage:

[EPS-SG Data and Products](#)



Summary of EPS-SG Mission

www.eumetsat.int

- EPS-SG will continue to be a key provider of information to improve Numerical Weather Prediction (NWP) in Europe and worldwide
- EPS-SG also supports operational oceanography by providing ocean surface wind vectors, sea surface temperatures, and sea ice cover
- Atmospheric composition applications particularly monitoring and forecasting of air quality, ozone, aerosols and volcanic ash, and surface ultra-violet radiation, will be served with high spectral and spatial resolution
- All EPS-SG observation missions will support climate monitoring, based on the production of relevant Climate Data Records involving also heritage observations from the EPS Programme.
- More Information available at: <https://www.eumetsat.int/metop-sg>



Thank you!

Questions are welcome.