

Product plans and science applications for MTG-IRS

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- Overview of EUMETSAT Missions
- MTG and the IRS instrument
- IRS product plans and science applications
- Summary

EUMETSAT's mission

To **establish, maintain** and **exploit** European **operational** meteorological satellite systems, while considering the recommendations of **WMO** as much as possible

A further objective is to contribute to **operational climate monitoring** and detection of **global climatic changes**

By 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

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)

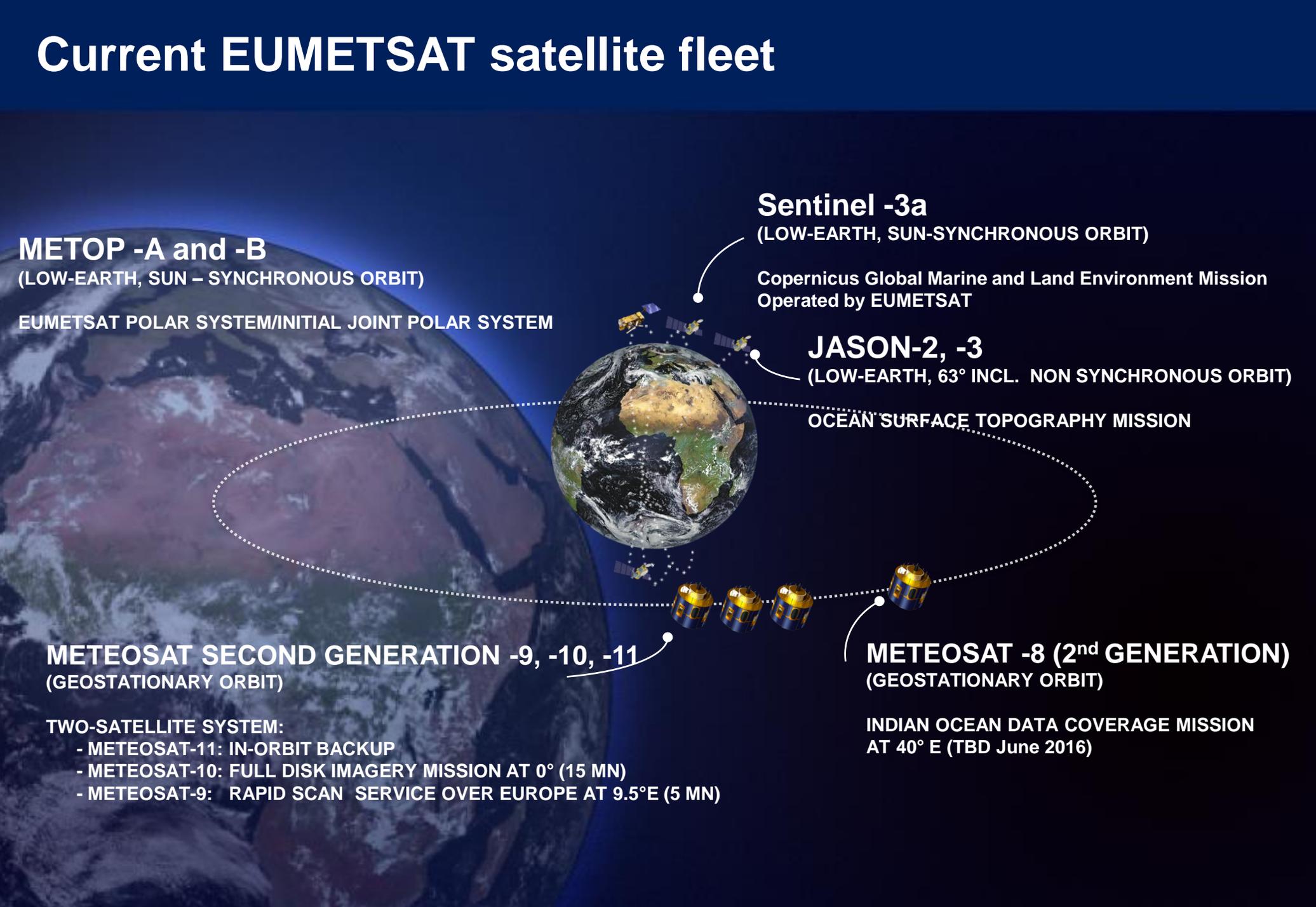
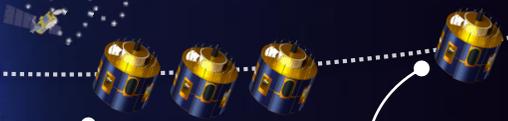
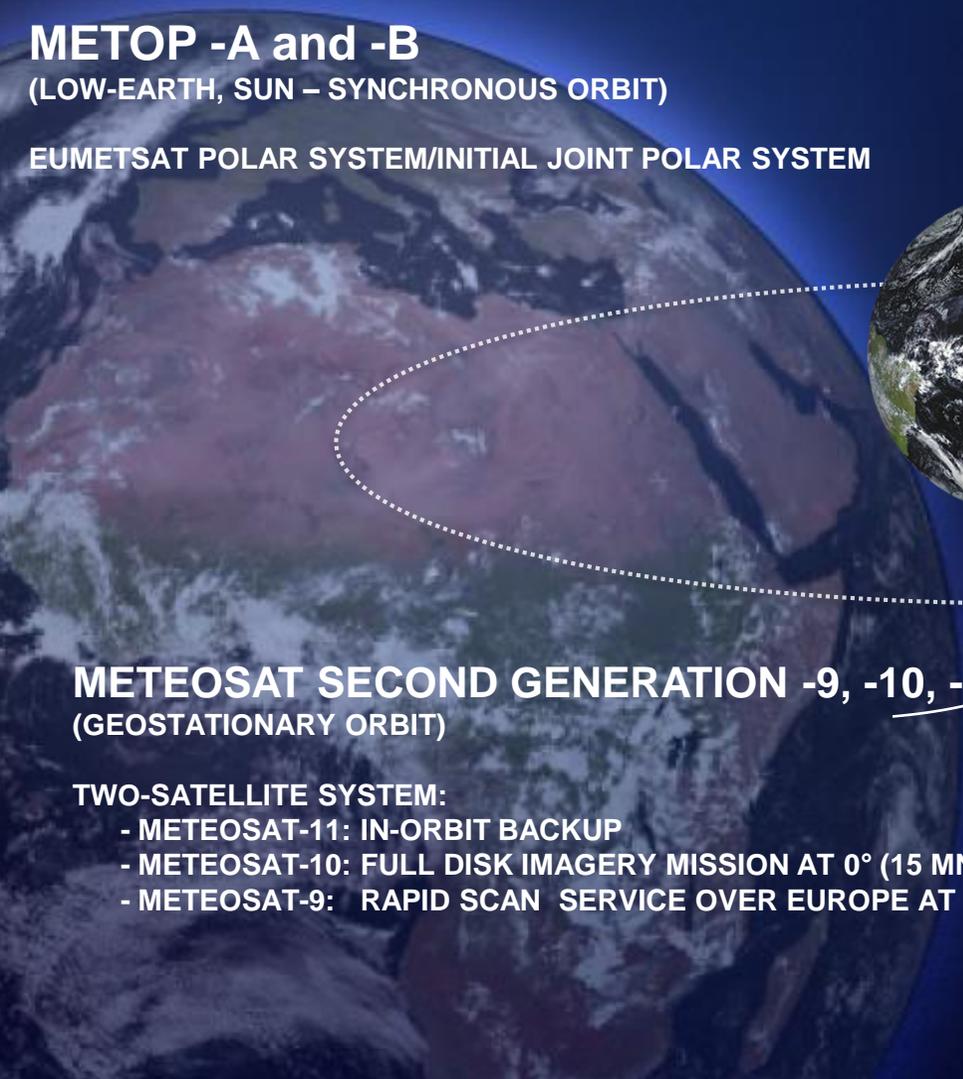
TWO-SATELLITE SYSTEM:

- 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 future 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

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

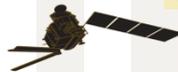
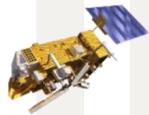
**First Launch
year 2023**

METOP-SG-A2

METOP-SG-B2

METOP-SG-A3

METOP-SG-B3



Operational Development

Optional and Third Party Programmes

JASON

JASON-2

JASON-3

JASON CONTINUITY OF SERVICE (JASON-CS)

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

Meteosat Third Generation (MTG): Mission overview

- **Imagery missions (MTG-I):**

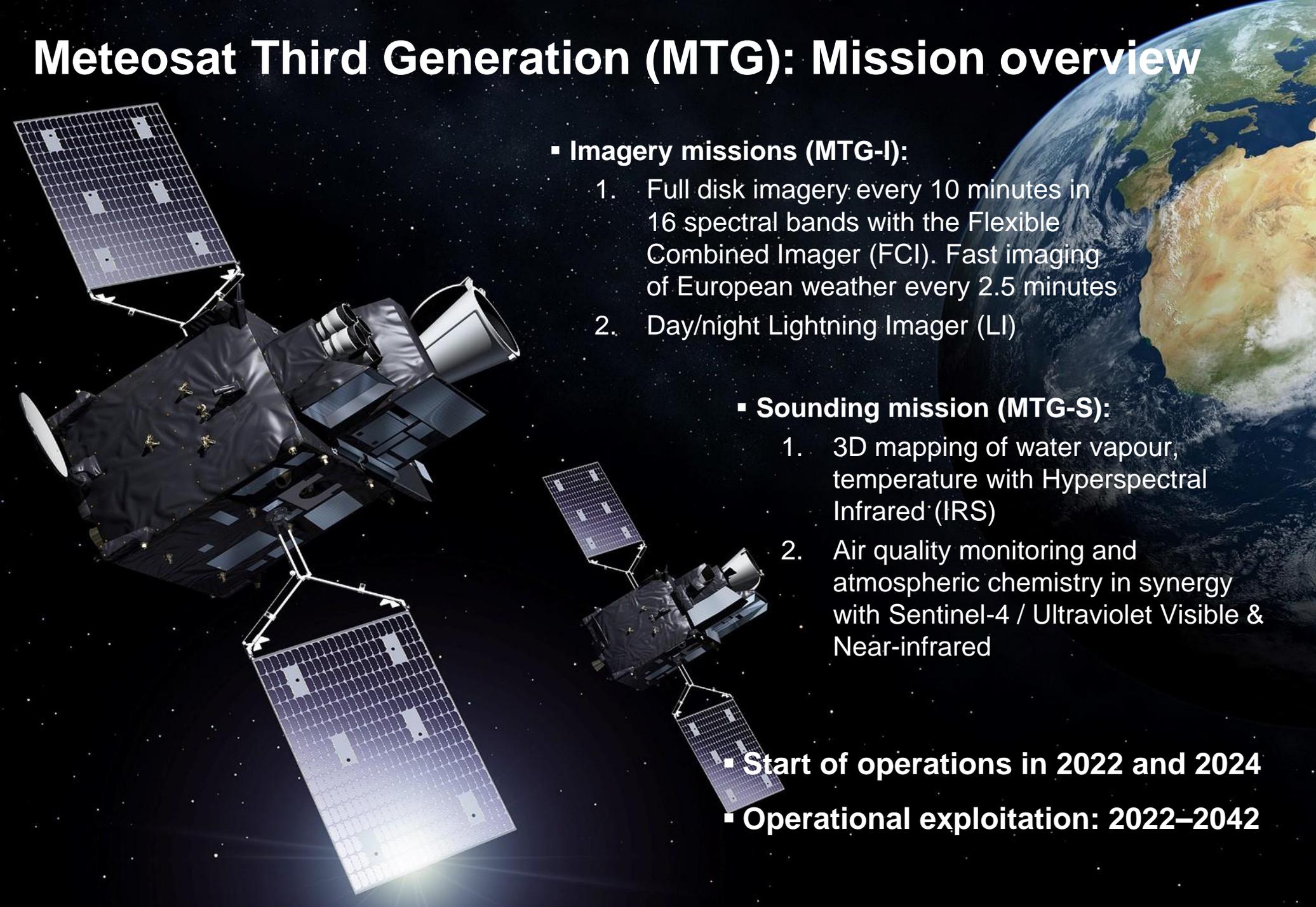
1. Full disk imagery every 10 minutes in 16 spectral bands with the Flexible Combined Imager (FCI). Fast imaging of European weather every 2.5 minutes
2. Day/night Lightning Imager (LI)

- **Sounding mission (MTG-S):**

1. 3D mapping of water vapour, temperature with Hyperspectral Infrared (IRS)
2. Air quality monitoring and atmospheric chemistry in synergy with Sentinel-4 / Ultraviolet Visible & Near-infrared

- **Start of operations in 2022 and 2024**

- **Operational exploitation: 2022–2042**



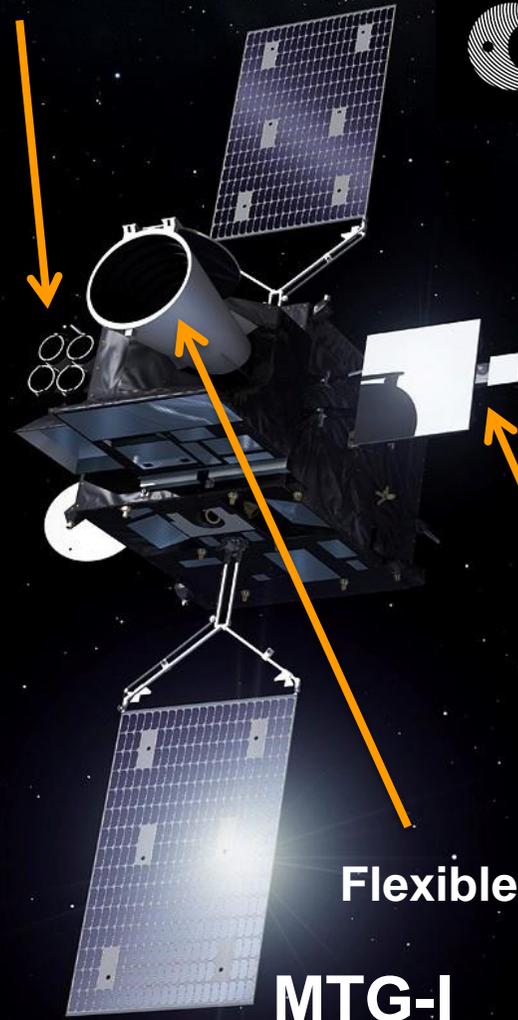
Twin satellite concept – based on 3-axis platforms:

4 geostationary imaging satellites (MTG-I)

2 geostationary sounding satellites (MTG-S)

Lightning
Imager (LI)

Established through a cooperation between:



Sentinel-4
Ultra-Violet, Visible &
Near-Infrared (UVN)

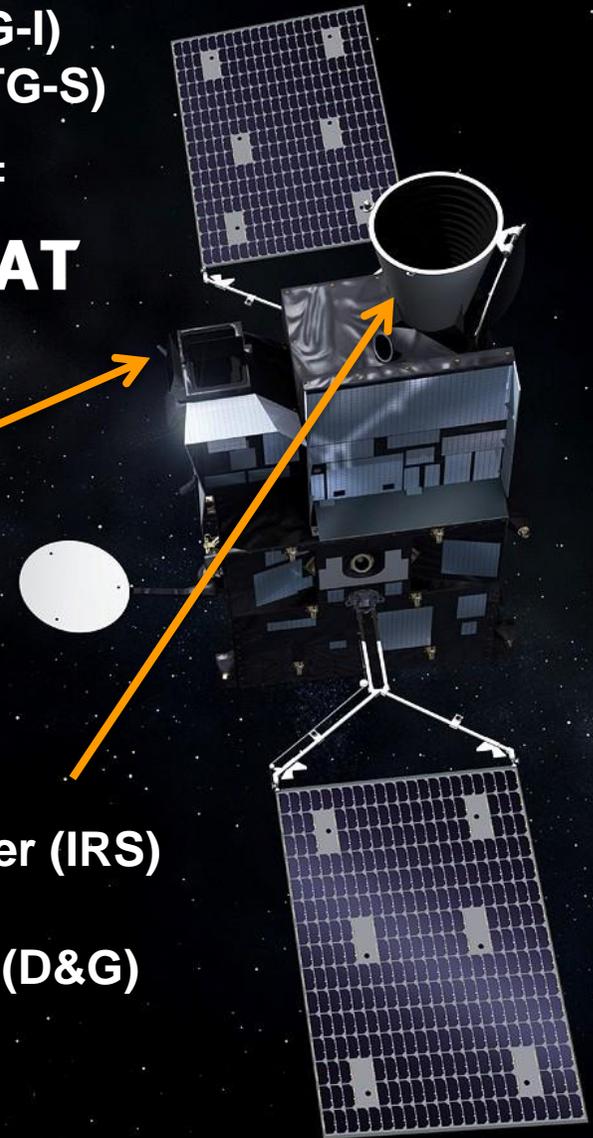
InfraRed Sounder (IRS)

Data Collection & GEOSAR (D&G)

Flexible Combined Imager (FCI)

MTG-I

20 years of operational service



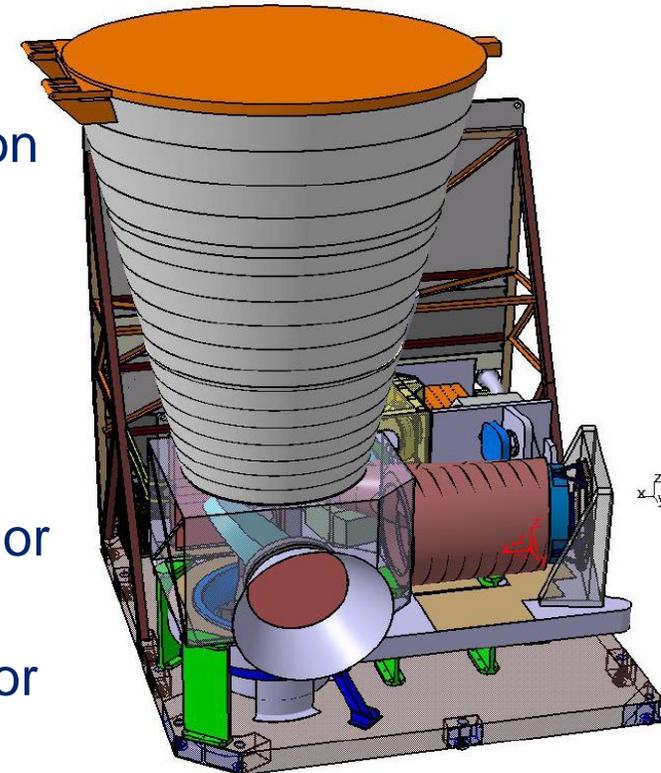
MTG-S

15,5 years of operational service

MTG-IRS: Instrument Characteristics

The InfraRed Sounder (IRS):

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



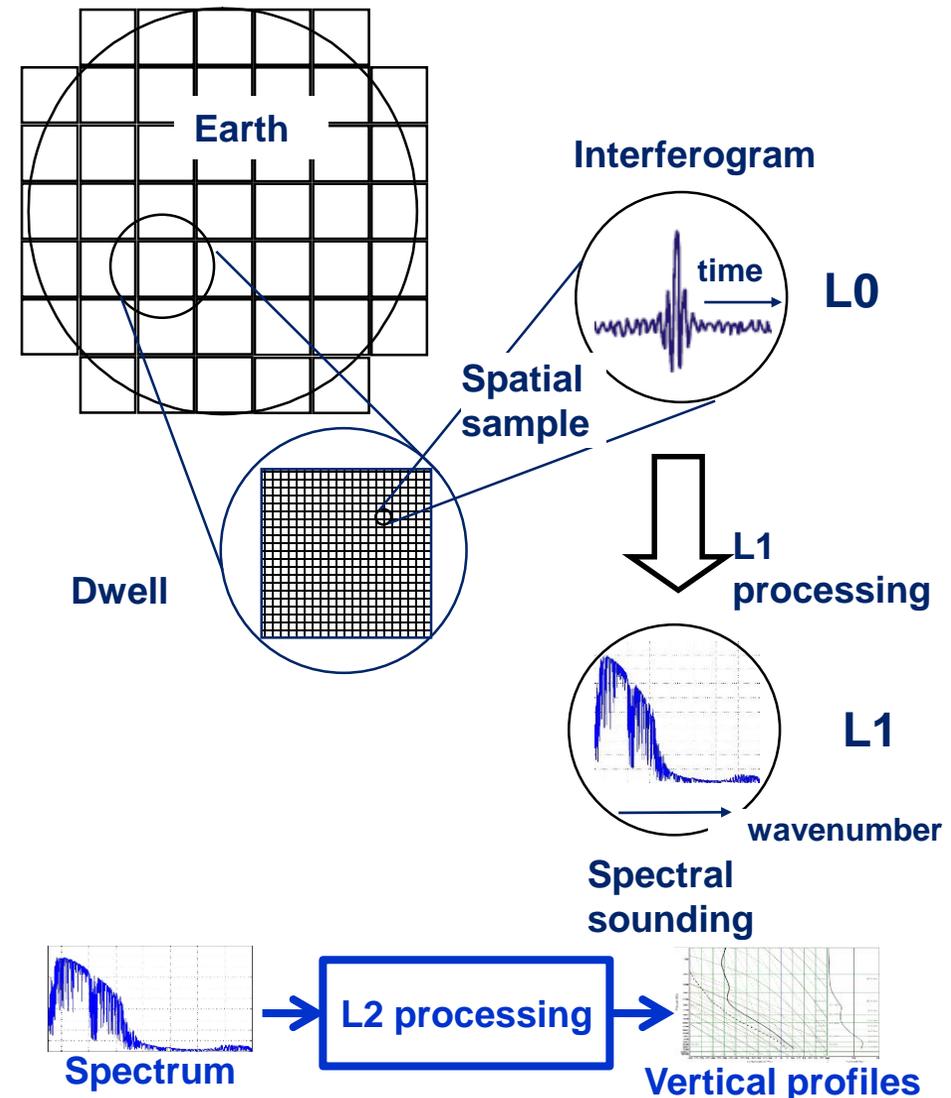
Volume: $1.4 \times 1.6 \times 2.2 \text{ m}^3$

Mass: 400 kg

Power: 750 W

MTG-IRS: Working Principle

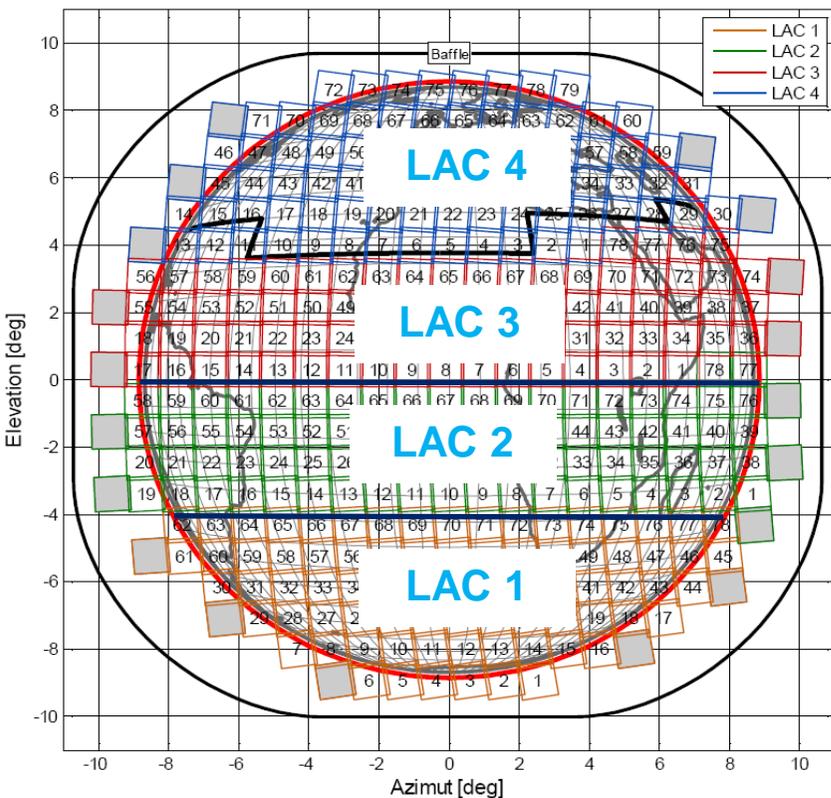
- The instrument works in **step-and-stare mode**, with the Earth disc covered through a sequence of contiguous square sub-images called **dwells**
- With the current design, each **dwells** is taken in 10s and covers about **640 x 640 km²** (at nadir) with 160 x 160 spatial samples
- Within a single dwell, a set of **interferograms**, one per spectral sample, is produced
- A **spectral sounding** is the result of the **Fourier transformation of an interferogram** from a single spatial sample
- L2 processing generates IRS L2 products



MTG-IRS: Measurement Schedule

Measurement schedule: 4 Local Area Coverage (LAC) zones, South to North, with LAC4 covering Europe every 30 minutes

78 LAC1 + 78 LAC2 + 78 LAC3 + 79 LAC4 = 313 Dwells

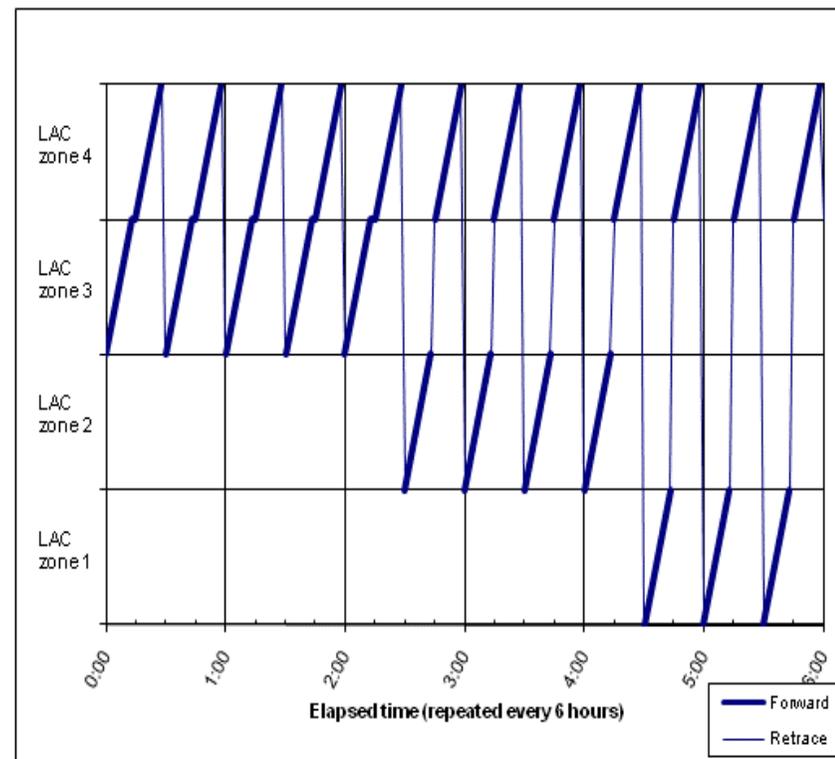


LAC 4: every 30 min

LAC 3: every 4h:00 min
5 times every 30 min

LAC 2: every 4h:30 min
4 times every 30 min

LAC 1: every 5h:00 min
3 times every 30 min



MTG IRS: Product Context

The **IRS** is a new mission for **EUMETSAT**: *a hyperspectral sounder in a geostationary orbit*

Extended experiences on processing of hyperspectral data, as measured by the **IASI instrument** on Metop-A/-B, **exists within EUMETSAT**, and also within the EUMETSAT SAF network and the Member States

The **development of the IRS Level 2** product generation processing chain will **capitalise on this valuable IASI heritage**, to produce high-quality, interoperable datasets for users across missions

IRS product dissemination

Level-1: fully calibrated and traceable spectra distributed as Principle Components (and/or full spectra through EUMETCAST terrestrial, tbc) for LAC-1 through LAC-4

→ *detailed talk on Level-1 by D. Coppens later today*

Level-2 products:

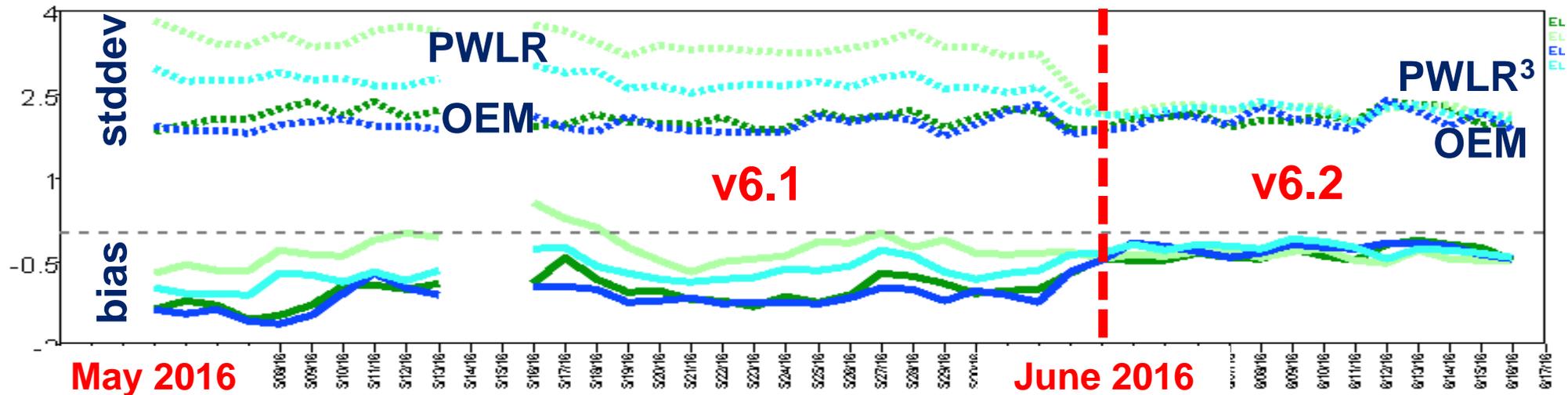
Committed	Non-committed or aspirational
T, q, Ts for LAC-4 (Europe) <i>Note: layers and cloud-free thresholds tbd</i>	T, q, Ts for LAC-1, 2, 3
	AMV profiles, horizontal components
	O3 profiles, CO total column
	<i>Cloud and Aerosol Detection (NWP-SAF)</i>

Timeliness (from dwell to user): 15 min. for level-1, 15-30 min. for level-2, tbc

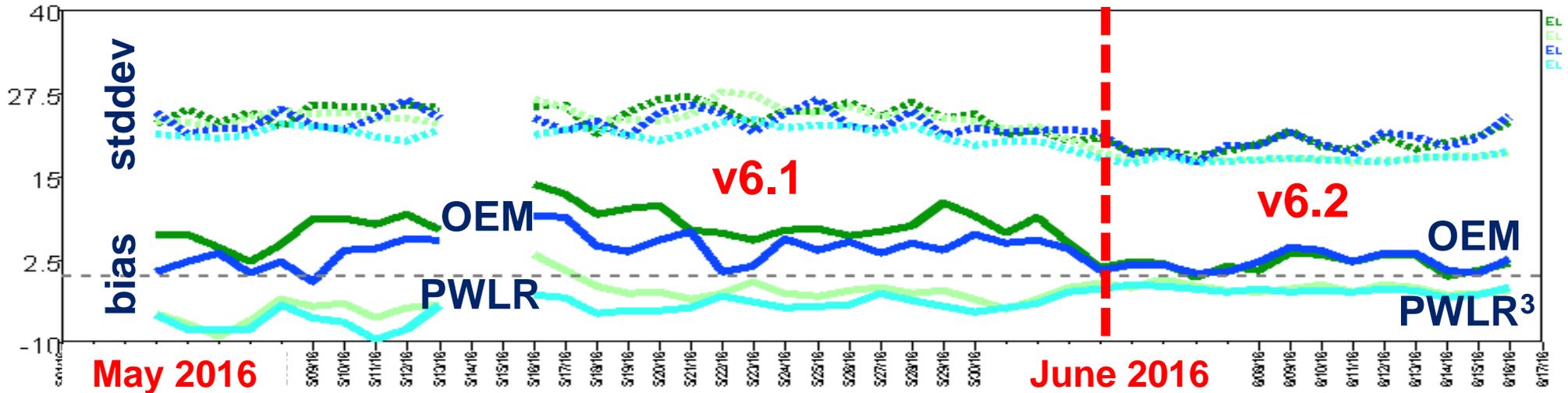
IASI L2 v6 performances

Monitoring with *in situ* data

T@940 hPa :: IASI-A & -B L2 vs radiosondes :: maritime



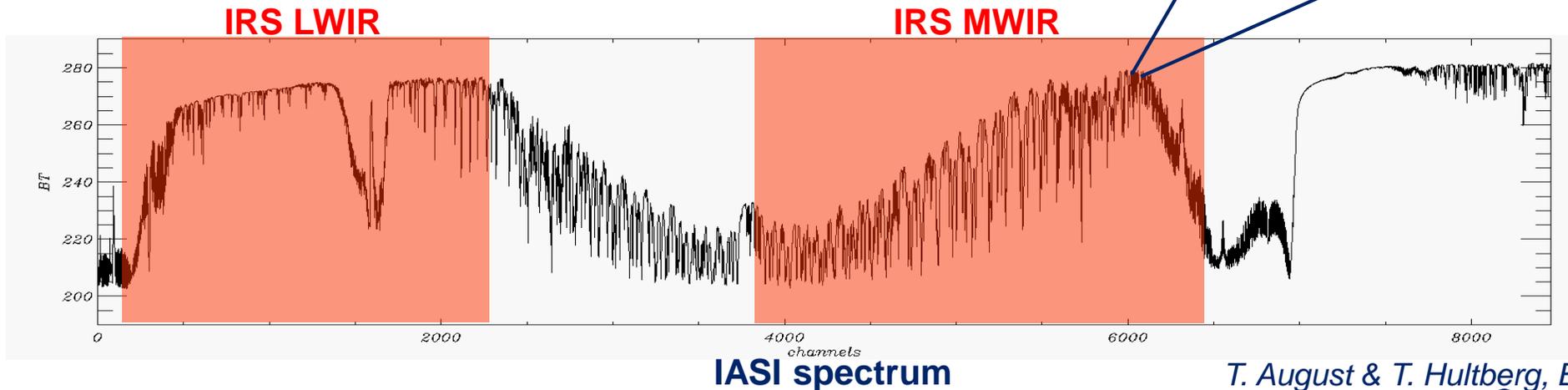
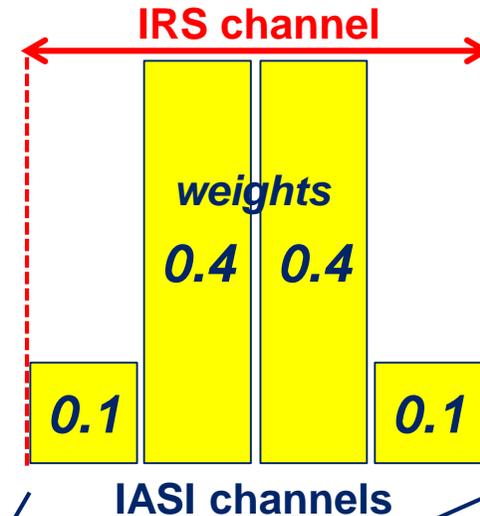
WV@800 hPa :: IASI-A & -B L2 vs radiosondes :: maritime



Monitoring credits T. Reale & B. Sun, NPROVS, NOAA

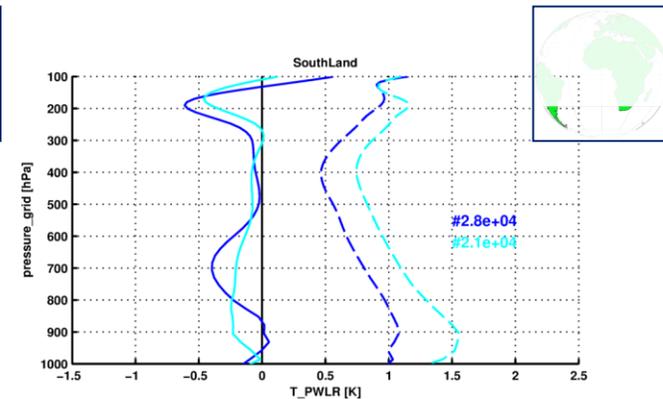
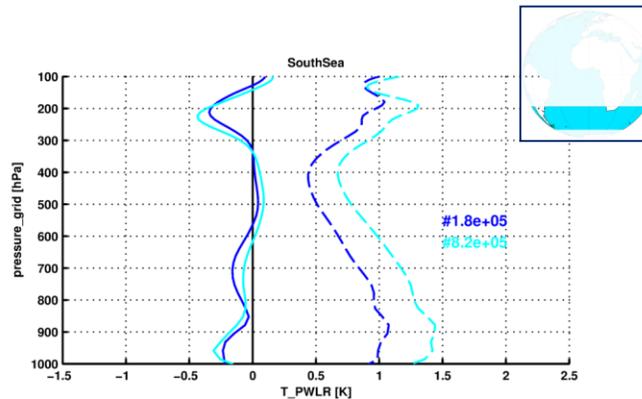
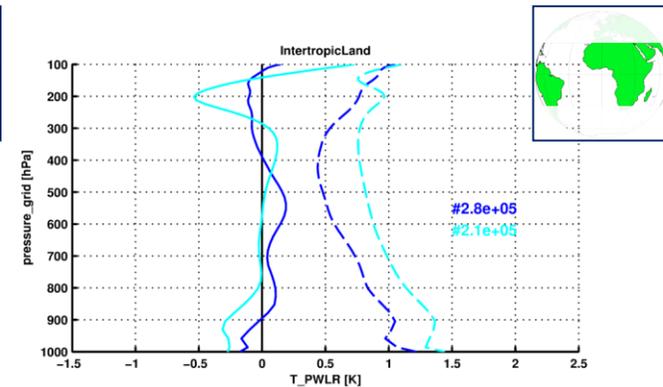
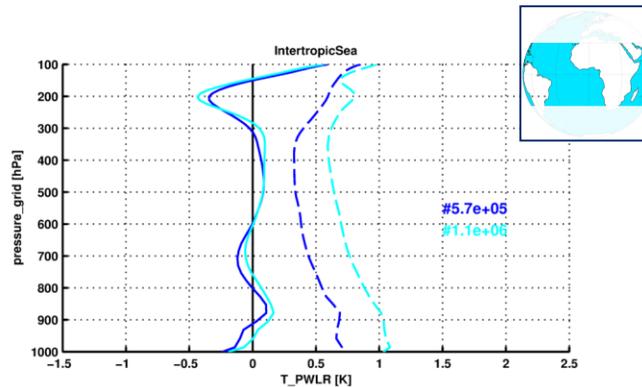
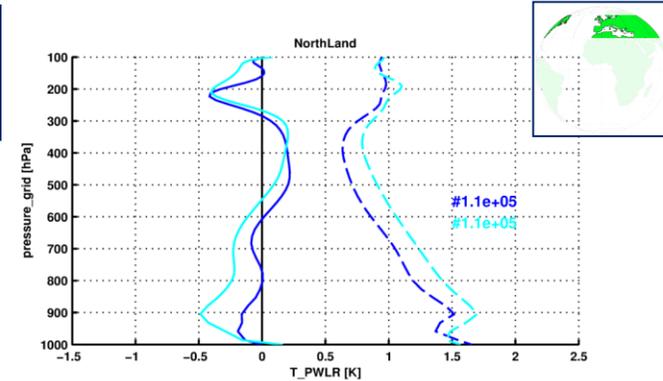
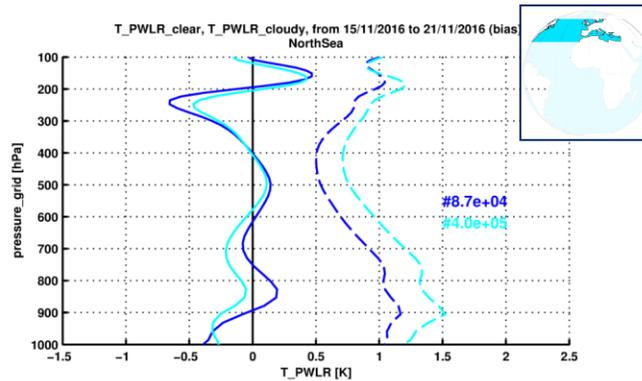
IRS-PWLR³ - IASI L2 v6.2 applied to IRS

- IRS measurements emulated from IASI spectra
- IRS spectral coverage
- Simple convolution function IASI → IRS
- IRS eigenvectors ← convolved IASI covariance
- IRS-PWLR³ trained (*k-mean clustering and regression*) with IRS-ified same training base as IASI-PWLR³ (IR-only).
- IRS-retrievals from IASI convolved measurements



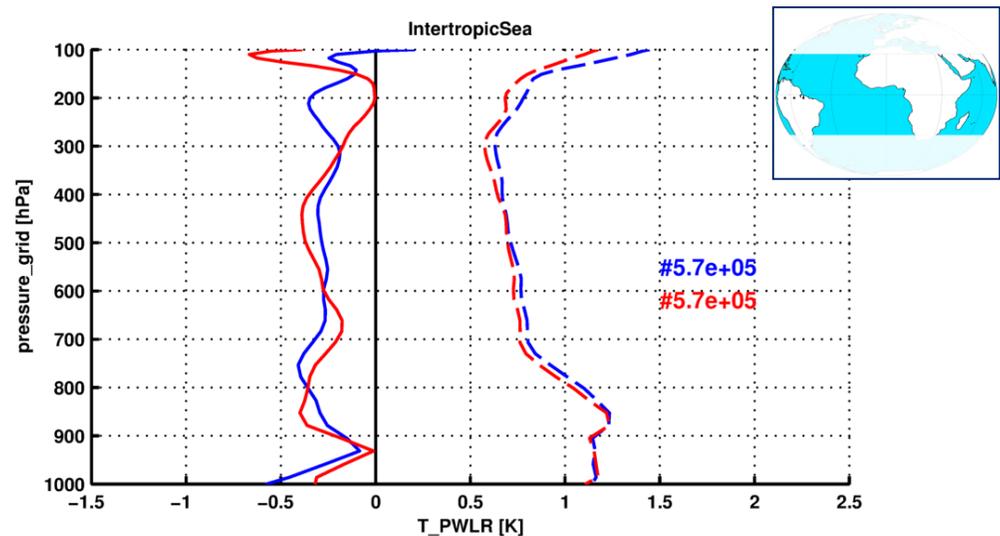
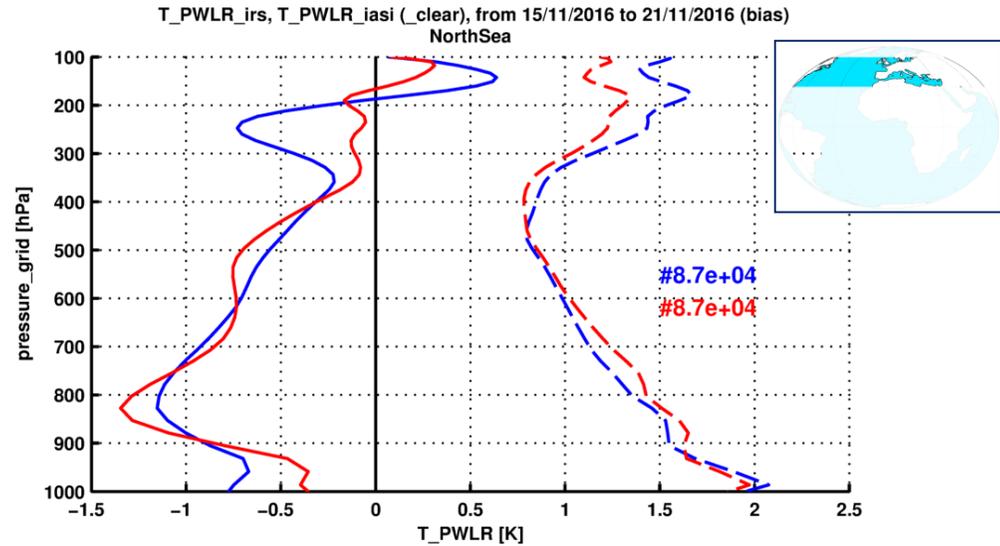
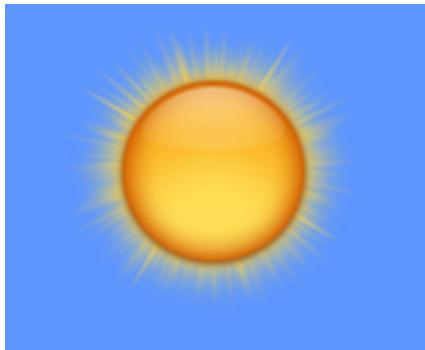
IASI- vs. IRS- Temperature 15-21/11/2016

- Clear-sky
- Cloudy pixels



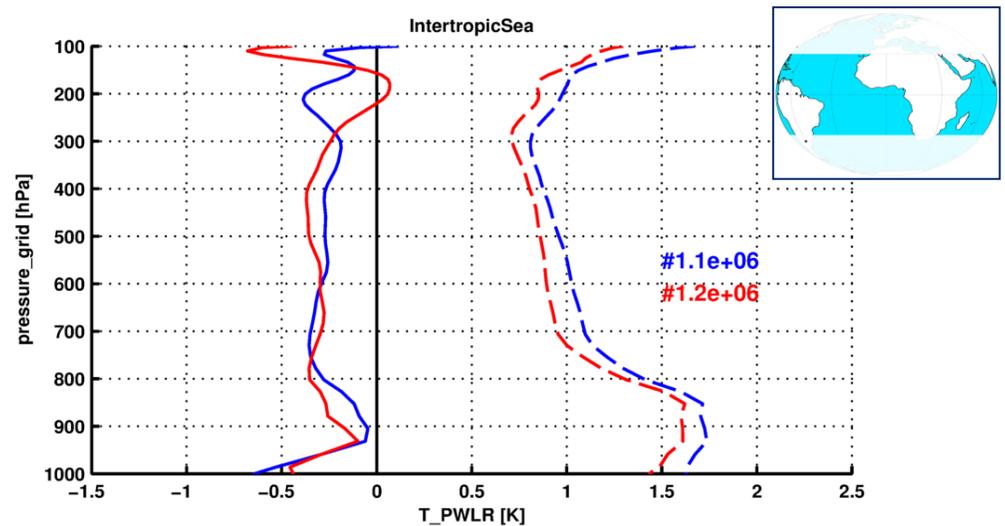
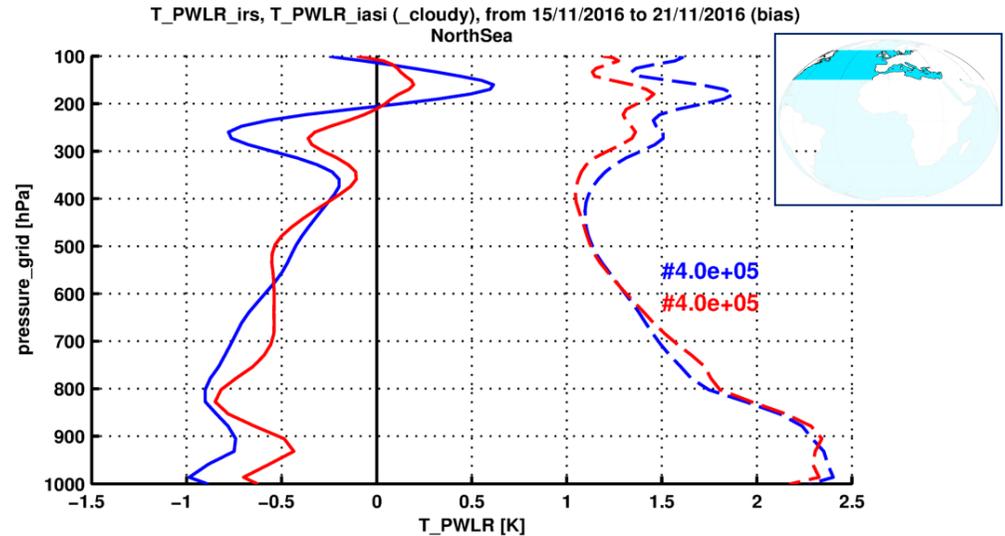
Temperature retrieval vs. ECMWF analyses 15-21/11/2016 Clear-sky

- IRS-PWLR³
- IASI-PWLR³



Temperature retrieval
vs.
ECMWF analyses
15-21/11/2016
Cloudy pixels

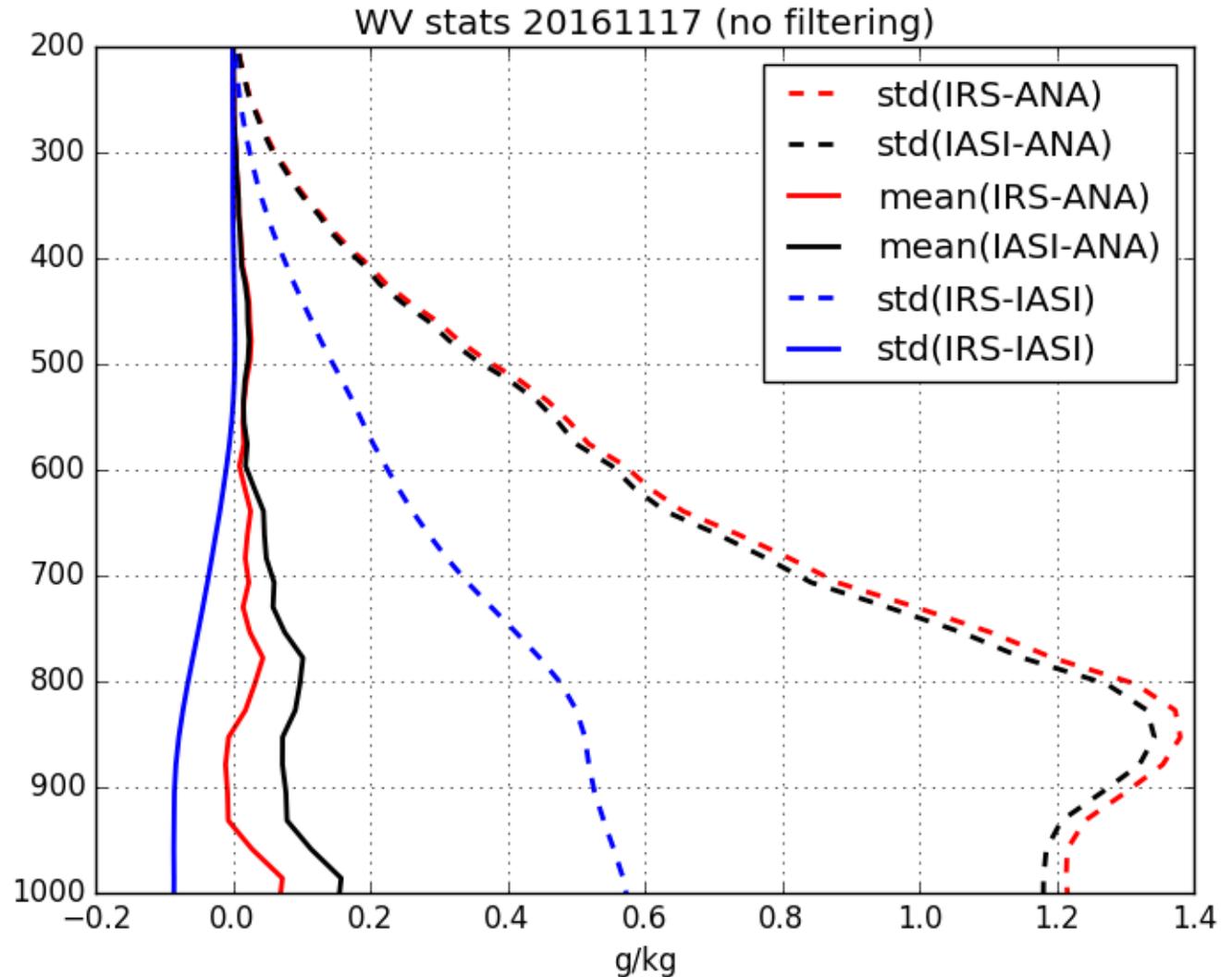
- IRS-PWLR³
- IASI-PWLR³



20161117
Global statistics

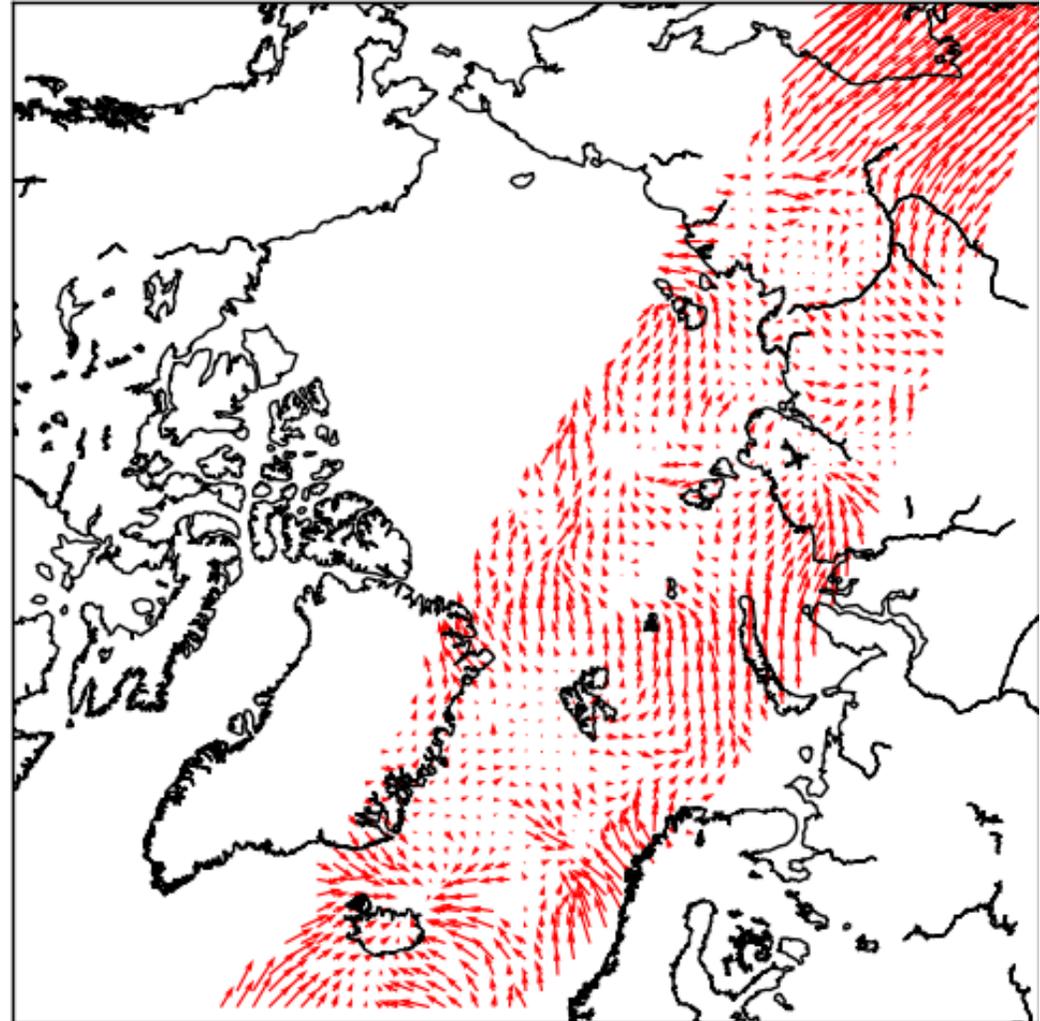
No QC selection
All-sky

L2 - ECMWF ANA hPa



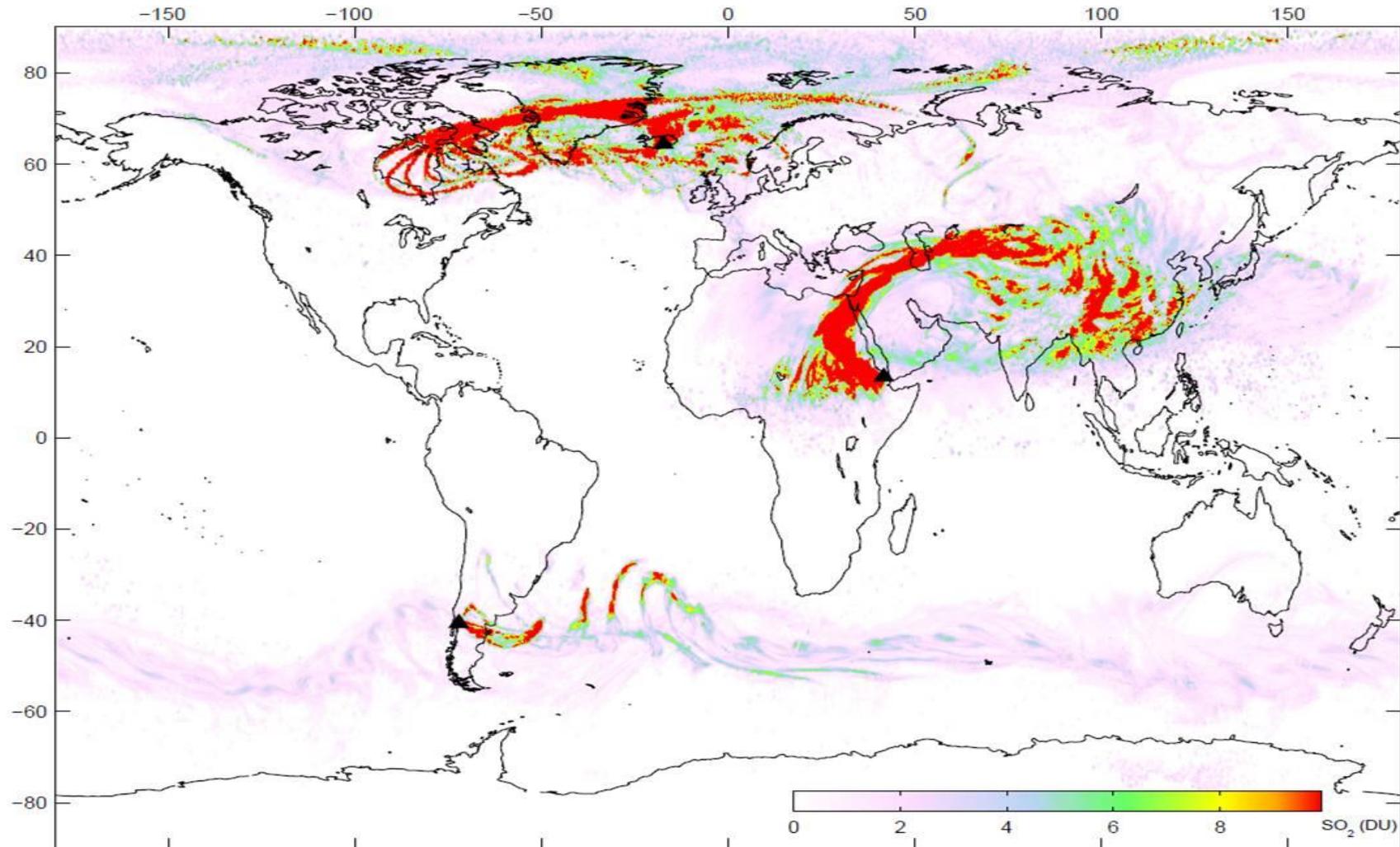
3D winds fields – *aspirational MTG-IRS product*

- Development of a 3-D wind product from IASI L2 temperature and humidity fields in preparation of IASI-NG and IRS:
 - Collaboration with P. Héas from INRIA (Rennes in France)
 - Use of 3-D optical flow software – **no model a priori data used**
 - Proof of concept tested on forecast fields and then applied to IASI L2 products (700hPa example right)



→ *Detailed talk on AMVs by R. Borde tomorrow*

SO₂ from infrared sounding (to be oper. in IASI v6.3)



Cumulative SO₂ from volcanic eruptions (20 May and 30 June 2011)

Courtesy: Clarisse, et al., doi: 10.5194/amt-5-581-2012

Retrieval under development for IRS: IASI-L2VDP

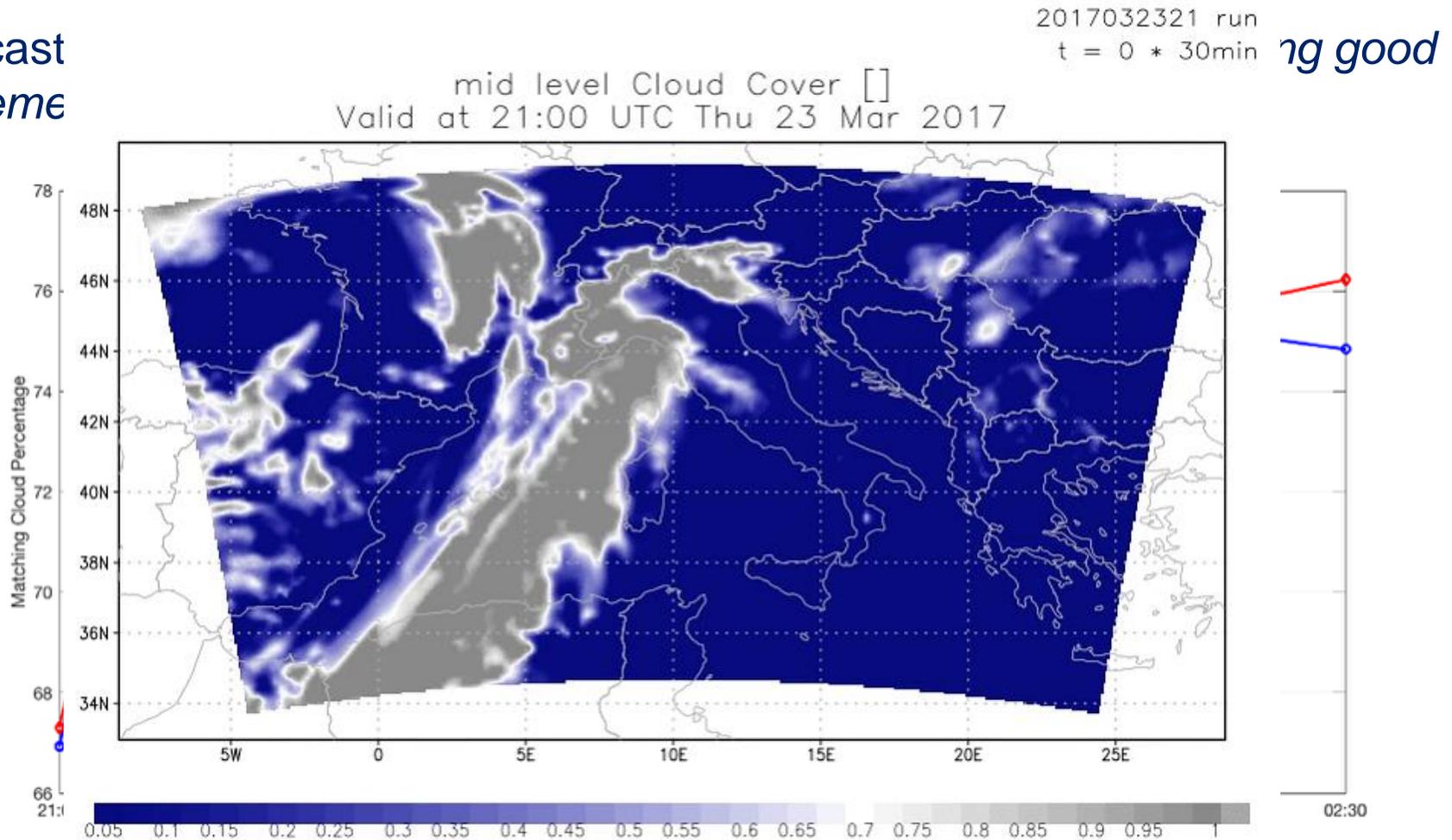
- Full spectra research retrieval of T, q, using OE being developed at EUMETSAT in cooperation with P. Antonelli (SSEC)
- Similar performances to IASI operational algorithm, but with a strong dependence on the forecast for the a priori
- Innovation of the L2VDP is the implementation of the Scaled Projected States (SPS) transformation of Migliorini (2012)
 - Linear and does **not** require detailed knowledge of the observational system (like radiosonde assimilation)
 - Its transparent (like assimilation of observations from hundreds of different RS stations)
 - Provides information from the surface to the top of DA system
- SPS from L2VDP currently under evaluation by ECMWF, KNMI and CETEMPS

→ Related talk by S. Migliorini tomorrow

IASI-L2VDP: SPS example

- Testing of SPS assimilation for cloud cover in CETEMPS (L'Aquila, IT) severe weather regional model by P. Antonelli (SSEC)

- Forecast
agreement



Summary

- MTG programme and MTG-IRS currently on track for launch in early 2023
- Products development based on IASI heritage, with the aim to provide high-quality, interoperable level-1 and level-2 datasets to users
- New level-2 product developments and applications on-going at EUMETSAT and within the SAF Network

Thank you for your attention!

MTG-IRS Earth view (measurement schedule)

**Current
baseline**

LAC

every 30 min

4

every 4h00 min
5 times every 30 min

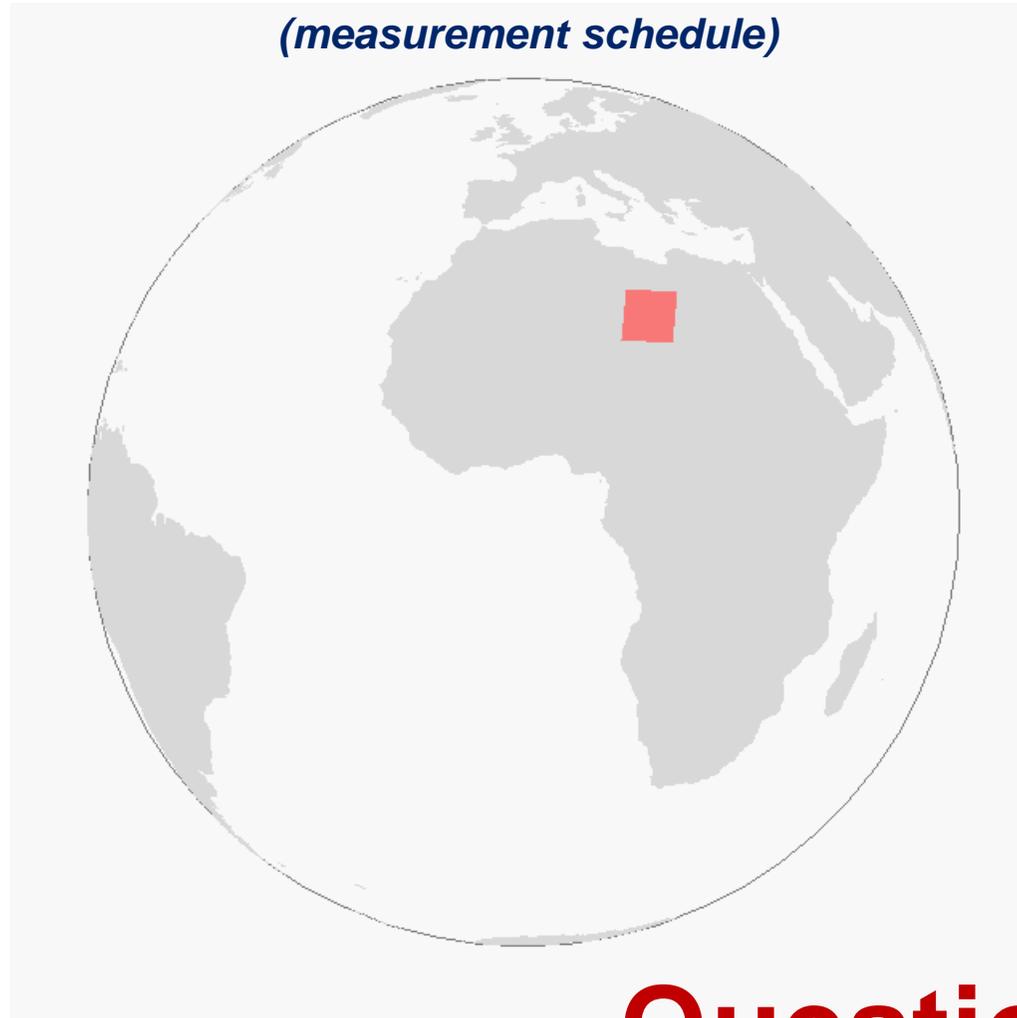
3

every 4h30 min
4 times every 30 min

2

every 5h00 min
3 times every 30 min

1



Questions?