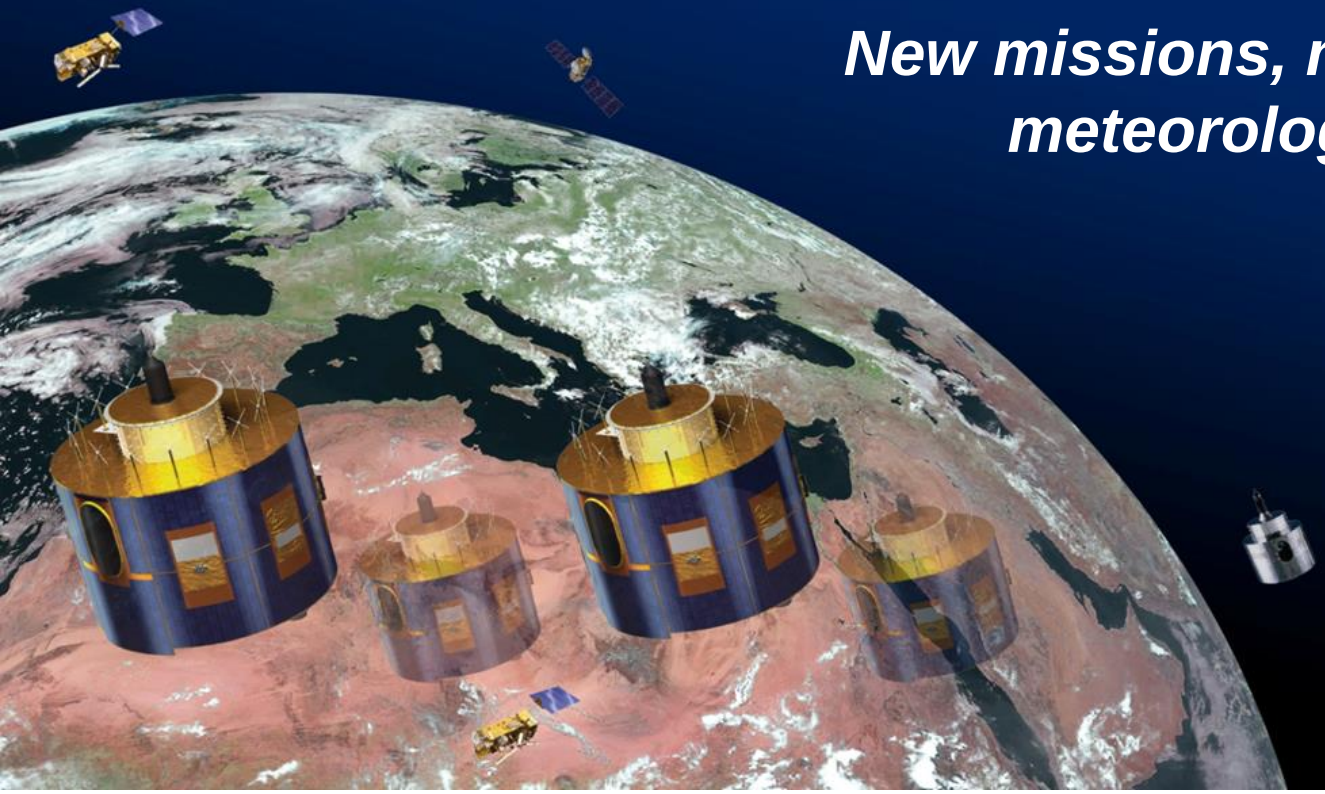
EUMETSAT products and services for monitoring storms

-

New missions, more data and more meteorological products

Jochen Grandell



Outline

- Overview of EUMETSAT missions
  - Current
  - ...and future
- Main EUMETSAT products for storm applications
  - Forecasting
  - Monitoring
- Other collaboration activities

EUMETSAT's mission

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

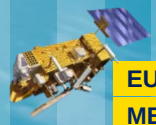
A further objective is to contribute to **operational climate monitoring** and detection of **global climatic changes**

By fulfilling these objectives, contribute to **environmental monitoring**, where **interactions** with the **ocean** and the **atmosphere** are involved

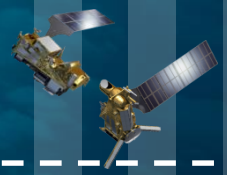
EUMETSAT Mission Planning

METEOSAT SECOND GENERATION
METEOSAT-8
METEOSAT-9
METEOSAT-10
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



EUMETSAT POLAR SYSTEM (EPS)
METOP-A
METOP-B
METOP-C



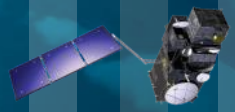
EUMETSAT POLAR SYSTEM SECOND GENERATION (EPS-SG)
METOP-SG A: SOUNDING AND IMAGERY
METOP-SG B: MICROWAVE IMAGERY

Mandatory Programmes

JASON (HIGH PRECISION OCEAN ALTIMETRY)
JASON-2
JASON-3

SENTINEL-6 (JASON-CS)

Optional Programmes



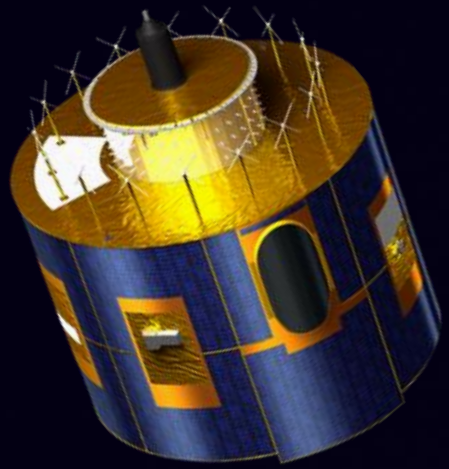
COPERNICUS
SENTINEL-3 A/B/C/D
SENTINEL-4 ON MTG-S
SENTINEL-5 ON METOP-SG A

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

The need for two types of meteorological satellites

Geostationary orbit
Vital for forecasts up to a few hours



Polar orbit
Critical for forecasts up to 10 days

Current EUMETSAT satellites

METOP-A & -B (98.7° incl.)

LOW EARTH, SUN-SYNCHRONOUS ORBIT

EUMETSAT POLAR SYSTEM (EPS) / INITIAL JOINT POLAR SYSTEM

JASON-2 & -3 (63° incl.)

LOW EARTH, NON-SYNCHRONOUS ORBIT

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

METEOSAT-8 (41.5° E)

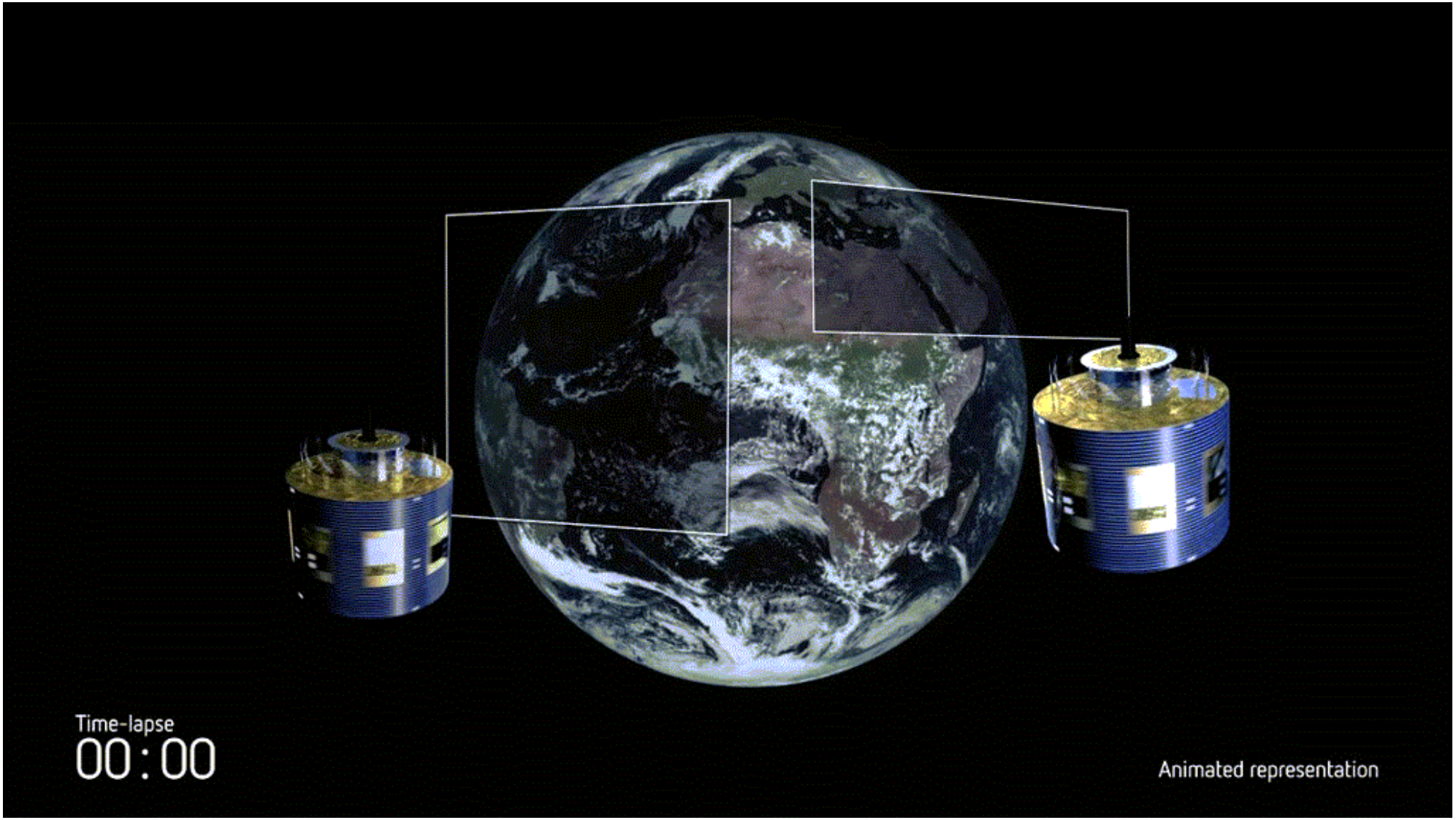
GEOSTATIONARY ORBIT

METEOSAT 2ND GENERATION PROVIDING IODC FROM FEBRUARY 2017 – MID-2020

METEOSAT-9, -10, -11

GEOSTATIONARY ORBIT	TWO-SATELLITE SYSTEM
METEOSAT 2ND GENERATION	FULL DISC IMAGERY MISSION (15 MINS) (METEOSAT-10 (0°)) RAPID SCAN SERVICE OVER EUROPE (5 MINS) (METEOSAT-9 (9.5° E)) *METEOSAT-11 STORED IN ORBIT (UNTIL MID-2018)*

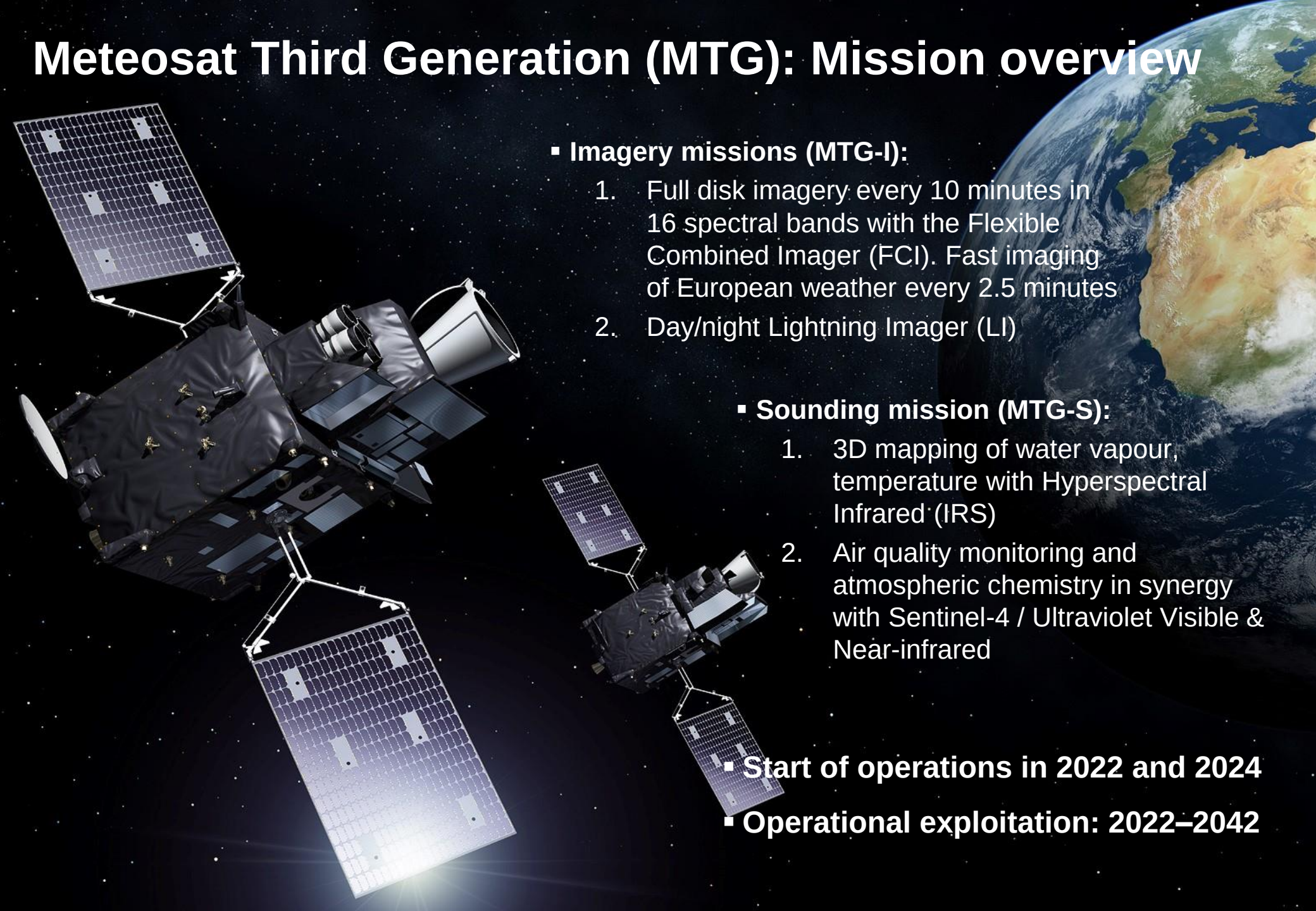
Meteosat Second Generation: a two-satellite operational system



Outline

- Overview of EUMETSAT missions
  - Current
  - ...and future
- Main EUMETSAT products for storm applications
  - Forecasting
  - Monitoring
- Other collaboration activities

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

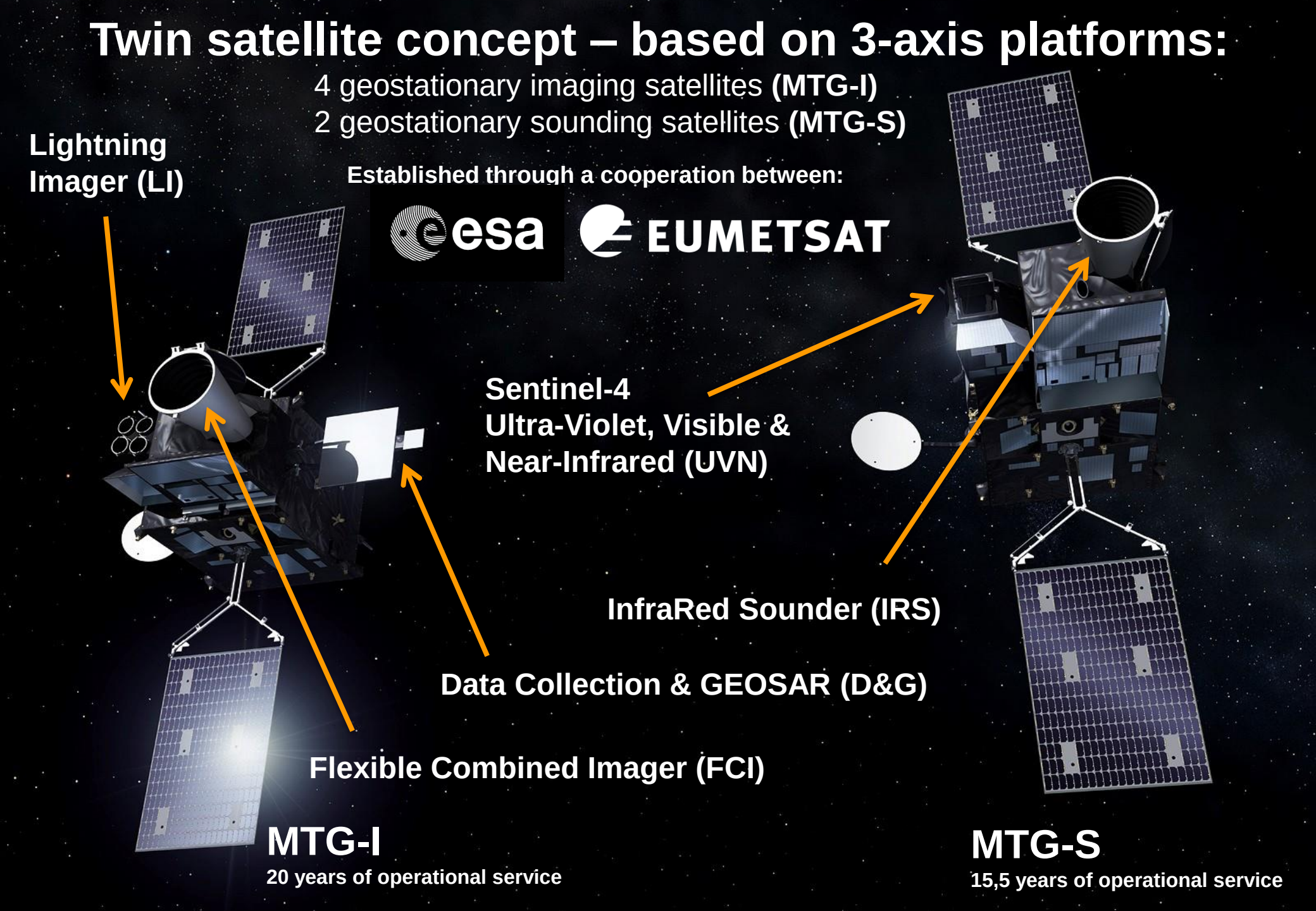
- **Start of operations in 2022 and 2024**
- **Operational exploitation: 2022–2042**

Twin satellite concept – based on 3-axis platforms:

4 geostationary imaging satellites **(MTG-I)**
2 geostationary sounding satellites **(MTG-S)**

Established through a cooperation between:

esa EUMETSAT



MTG-I

20 years of operational service

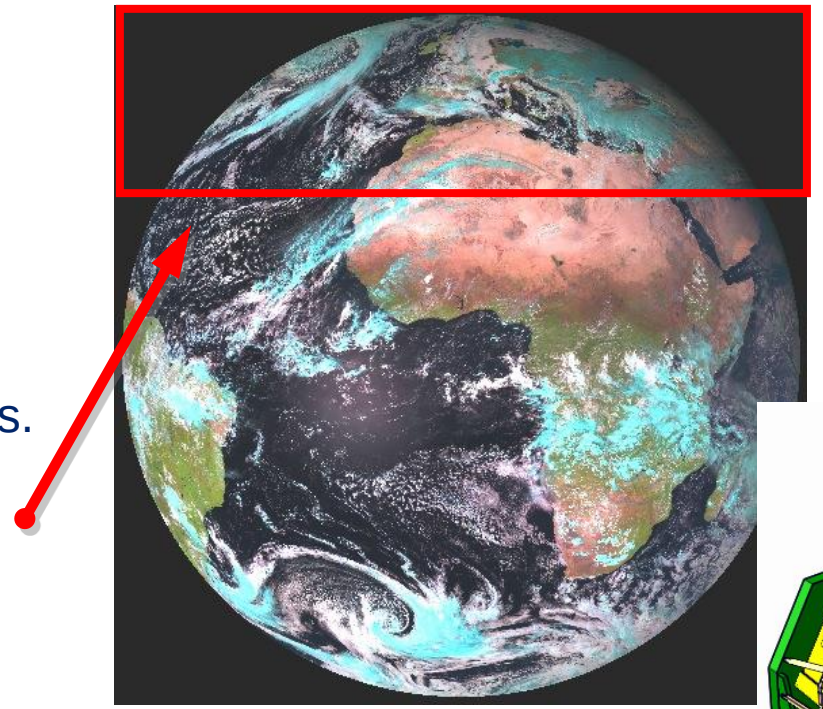
MTG-S

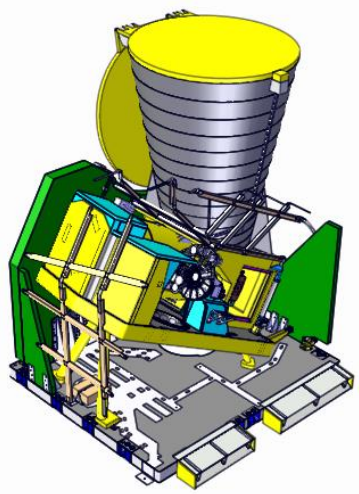
15,5 years of operational service

The Flexible Combined Imager (FCI) on MTG-I

- FCI will continue the **Full Disc Scanning Service** (FDSS) and **Rapid Scanning Service** (RSS) currently provided by the MSG SEVIRI instruments.
- **Full Disc High Spectral resolution Imagery** (FDHSI) **and High Resolution Fast Imagery** (HRFI) mission requirements are established for FDSS and RSS respectively.

- **Full Disk Scan Service (FCI-FDSS):**
  - global scales: Full Disk; @ 10 min Repeat Cycle
  - 16 channels at spatial resolution:
    - 1.0 km for the 8 solar channels;
    - 2.0 km for the 8 thermal channels.
- **Rapid Scan Service (FCI-RSS):**
  - local scales: 1/4th of Full Disk; @ 2.5 min Repeat Cycle
  - 4 channels at high spatial resolution:
    - 0.5 km for the 2 solar channels;
    - 1.0 km for the 2 thermal channels.



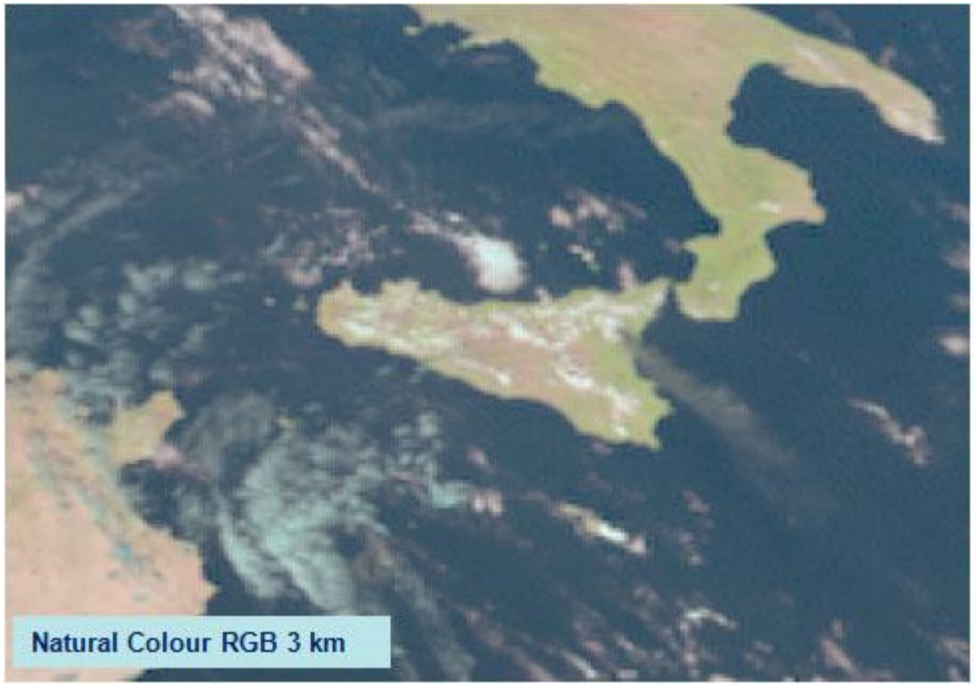


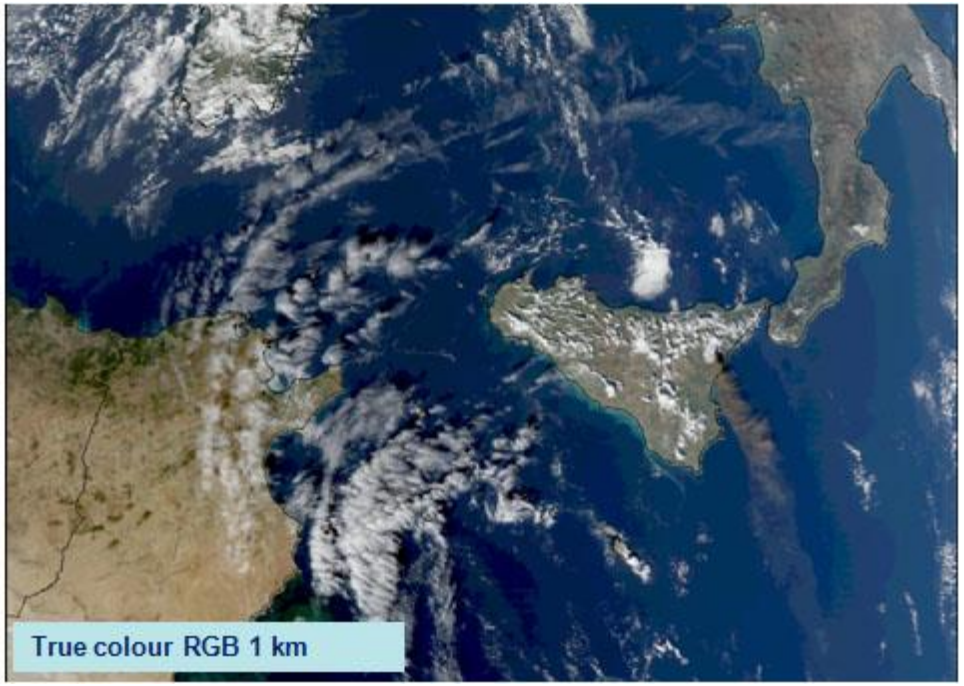
The MTG Flexible Combined Imager

	Meteosat 1st Generation			Meteosat 2nd Generation			Meteosat 3rd Generation		
'Core' channels	Central wavelength (µm)	Width (FWHM) (µm)	Spatial Sampling (km)	Central wavelength (µm)	Width (FWHM) (µm)	Spatial Sampling (km)	Central wavelength (µm)	Width (FWHM) (µm)	Spatial Sampling (km)
FC-VIS 0.4							0.444	0.06	1.0
FC-VIS 0.5							0.510	0.05	1.0
FC-VIS 0.6	0.7	0.35	2.5	0.635	0.08	3.0	0.645	0.08	0.5
FC-VIS 0.8				0.81	0.07	3.0	0.86	0.07	1.0
FC-NIR 0.9							0.96	0.06	1.0
FC-NIR 1.3							1.375	0.03	1.0
FC-NIR 1.6				1.64	0.14	3.0	1.61	0.06	1.0
FC-NIR 2.2							2.26	0.05	0.5
FC-IR 3.8 *				3.9	0.44	3.0	3.8	0.40	1.0
FC-IR 6.2	6.1	1.3	5.0	6.2	1.0	3.0	6.2	1.00	2.0
FC-IR 7.3				7.35	0.5	3.0	7.35	0.50	2.0
FC-IR 8.7 *				8.7	0.4	3.0	8.7	0.40	2.0
FC-IR 9.7				9.66	0.3	3.0	9.66	0.30	2.0
FC-IR 10.8	11.5	1.9	5.0	10.8	1.0	3.0	10.5	0.7	1.0
FC-IR 12.0				12.0	1.0	3.0	12.3	0.5	2.0
FC-IR 13.3				13.4	1.0	3.0	13.3	0.60	2.0
Repeat Cycle :	30 min			15 min			10 min		

* Dynamical range of FC-IR 3.8 channel extended to serve the fire community

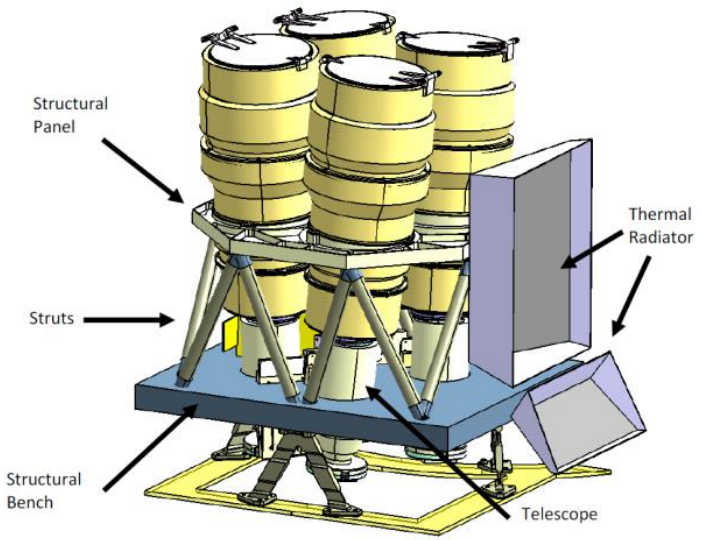
MTG – Higher resolution imagery





Example of ash detection, SEVIRI Natural Colour RGB, 12:15 UTC, 26 November 2006 (left), MODIS True Colour RGB, 12:20 UTC, 26 November 2006

Lightning Imager (LI) Instrument on MTG-I

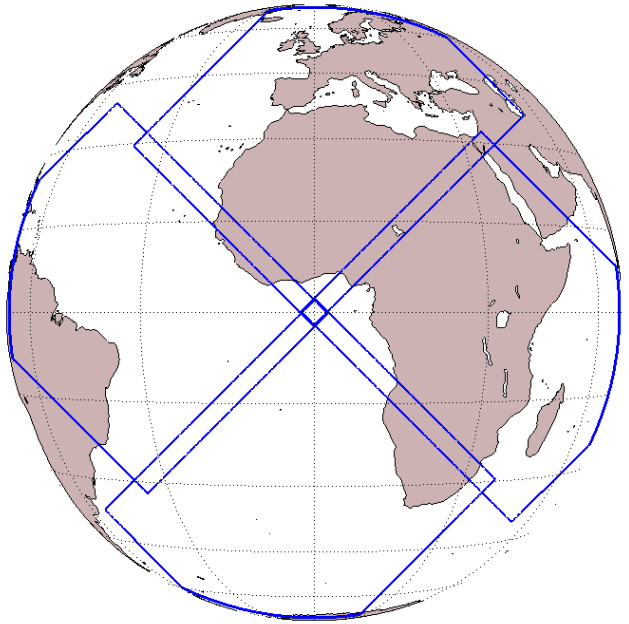


The baseline for the LI is a 4-Optical Chain solution:

- 4 identical optical channels with CMOS back-thinned backside illuminated detectors
- 1170 x 1000 pixels per camera

LI Main characteristics:

- Measurements at 777.4 nm
- Coverage close to “visible disc”
- Continuous measurements of (lightning) triggered events
- Spatial resolution ~ 4.5 km at SSP
- Integration time per frame 1 ms
- Background subtraction & event detection in on-board electronics

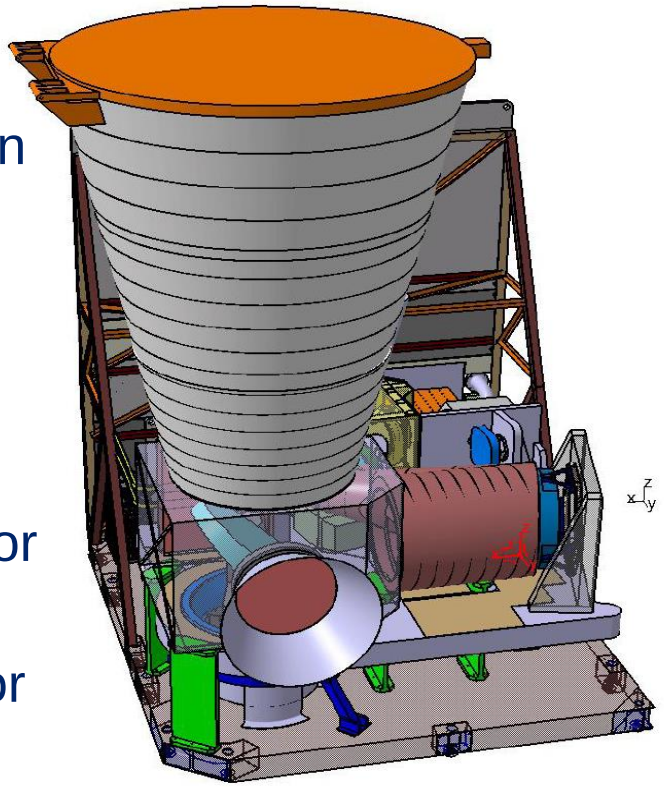


End-users (Level 2) will not see the “detector structure”

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 x 160 detectors
- Is taking measurements in two bands:
  - the Mid-Wave InfraRed (MWIR, 1600–2175 cm^{-1} or 6.25–4.6 µm) with 900 spectral channels
  - the Long-Wave InfraRed (LWIR, 700–1210 cm^{-1} or 14.3–8.3 µm) with 800 spectral channels
- Has a spatial resolution of 4 km at nadir and ~10 km at the edges (~7km over Europe)

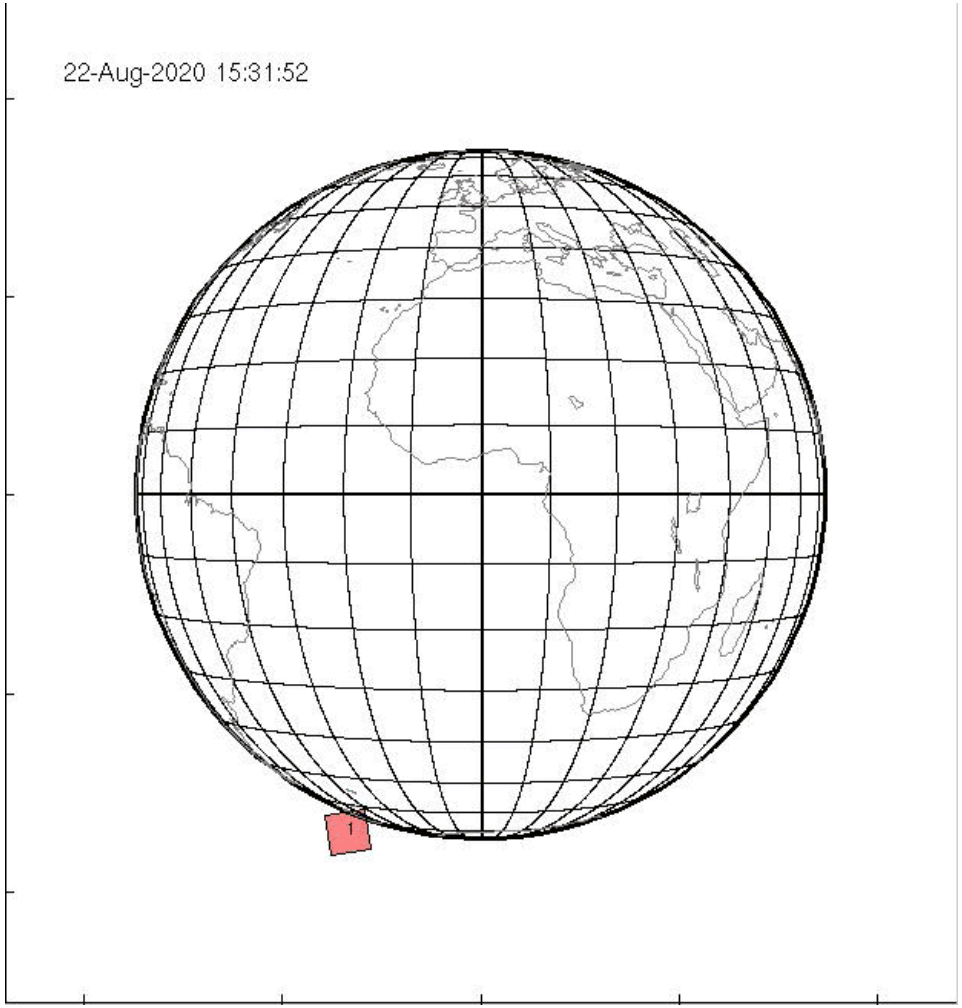


Volume: 1.4 x 1.6 x 2.2 m^3

Mass: 400 kg

Power: 750 W

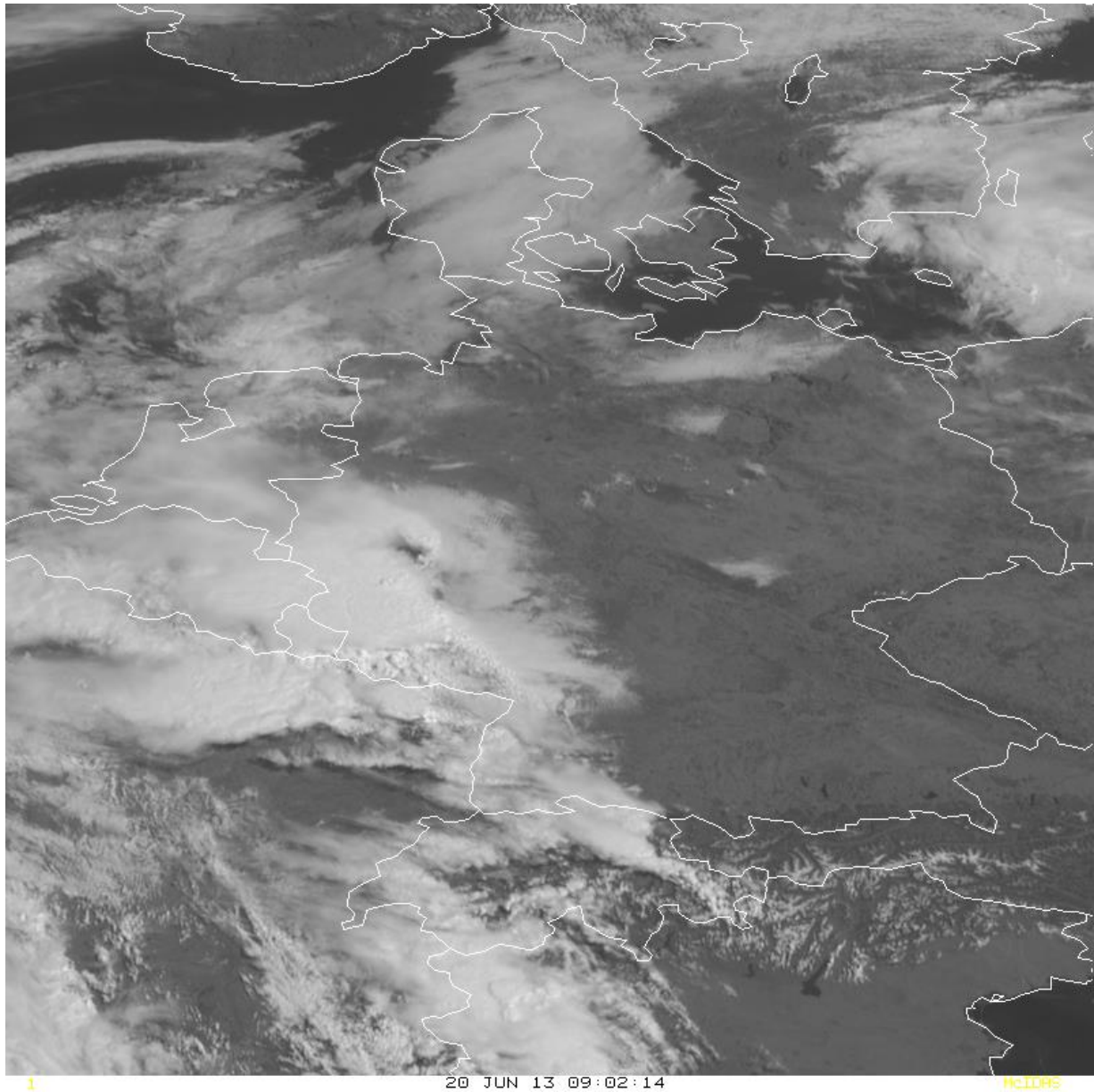
MTG sounding mission covering Europe every 30 minutes



- Coverage LAC-4 (Europe) every 30 minutes

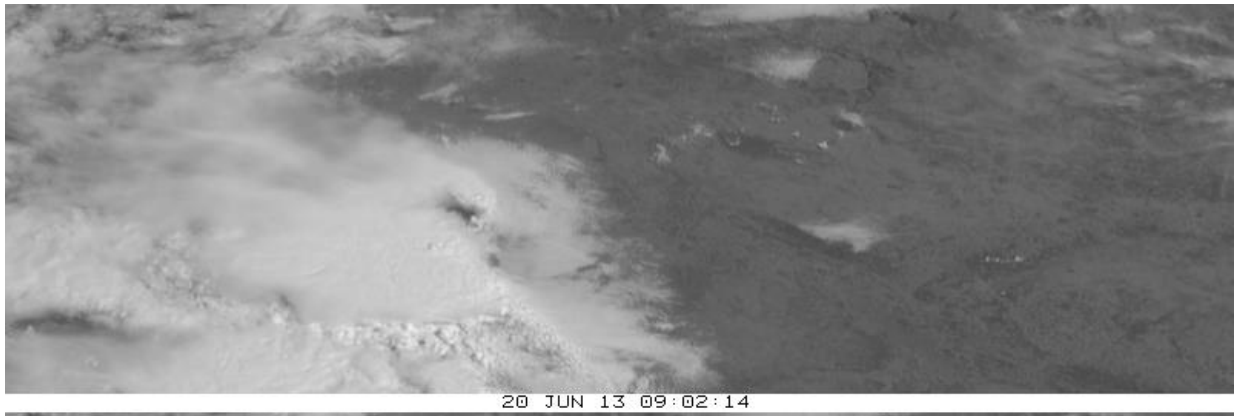
Specific MTG Imager Benefits: Better Temporal Resolution

- Rapid image updates are important when we have “interesting” weather situations, i.e. rapid changes
- Severe thunderstorms are an example:

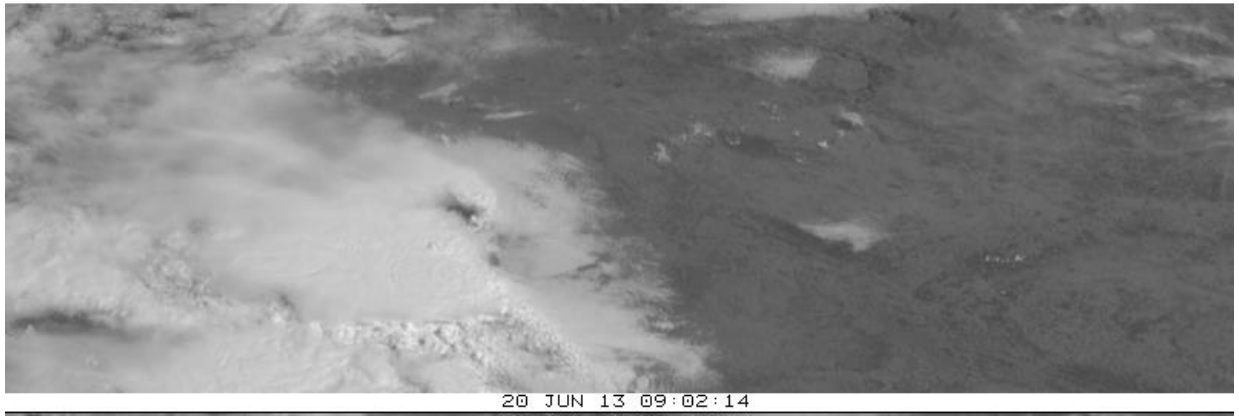


2.5 min Scans

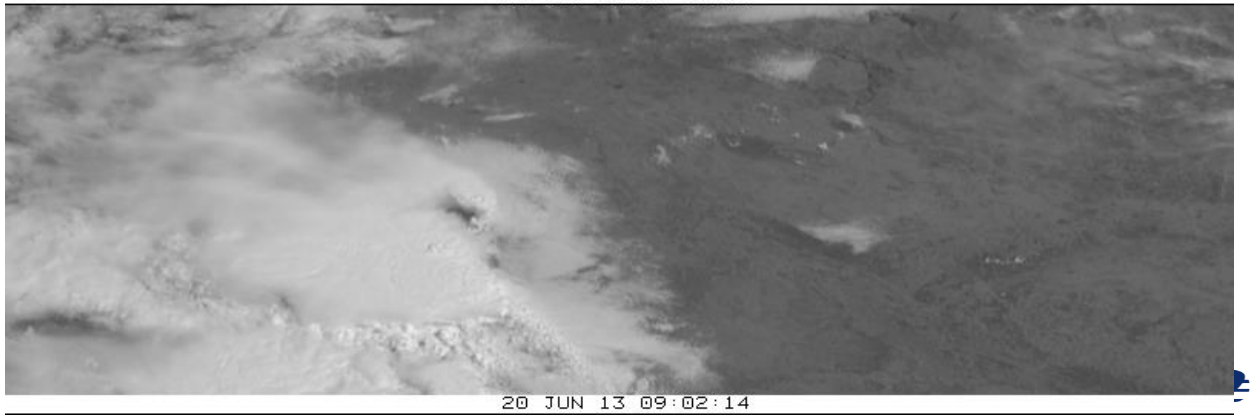
2.5 min



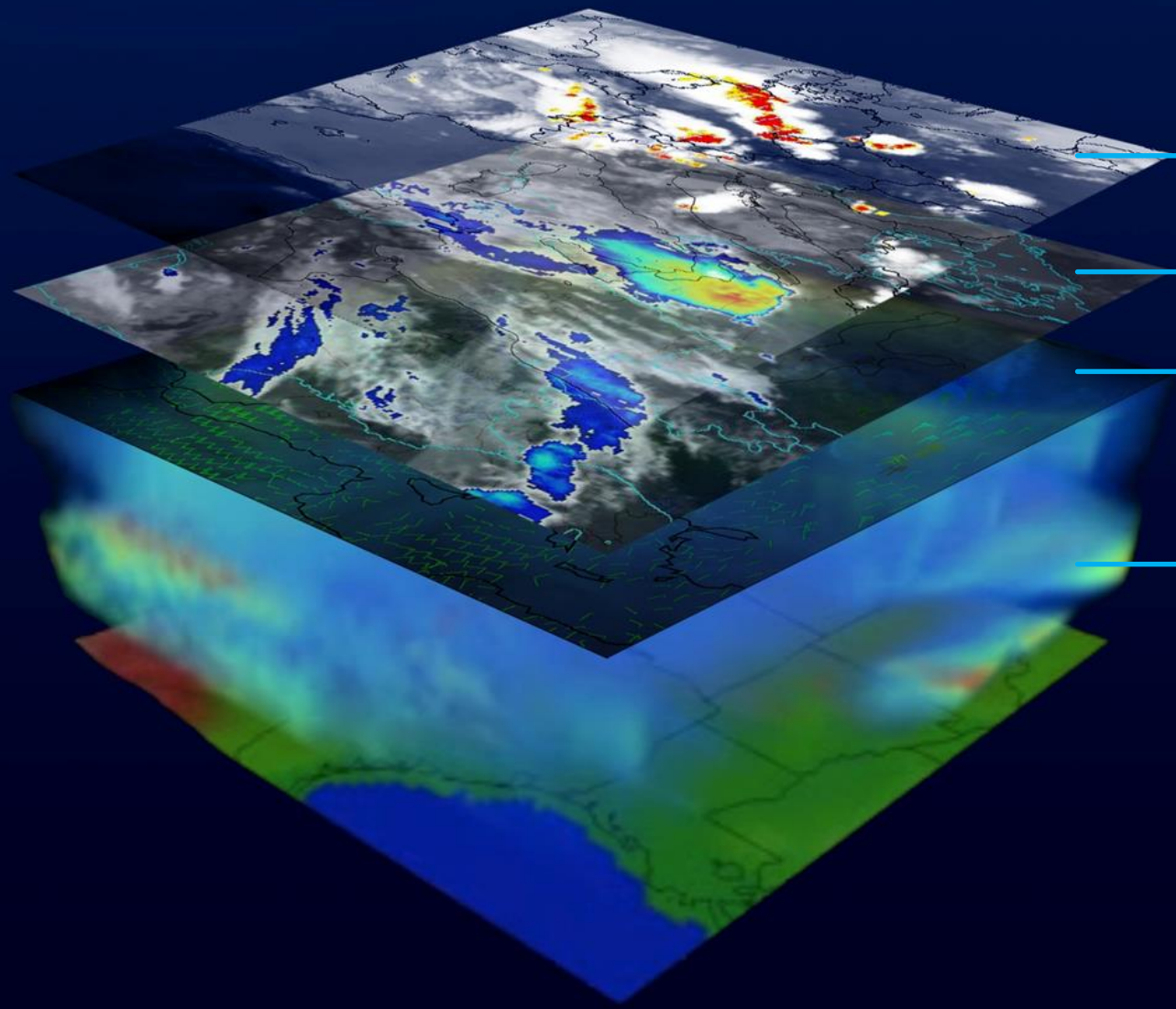
5 min



15 min



4D weather cube with MTG-I and MTG-S

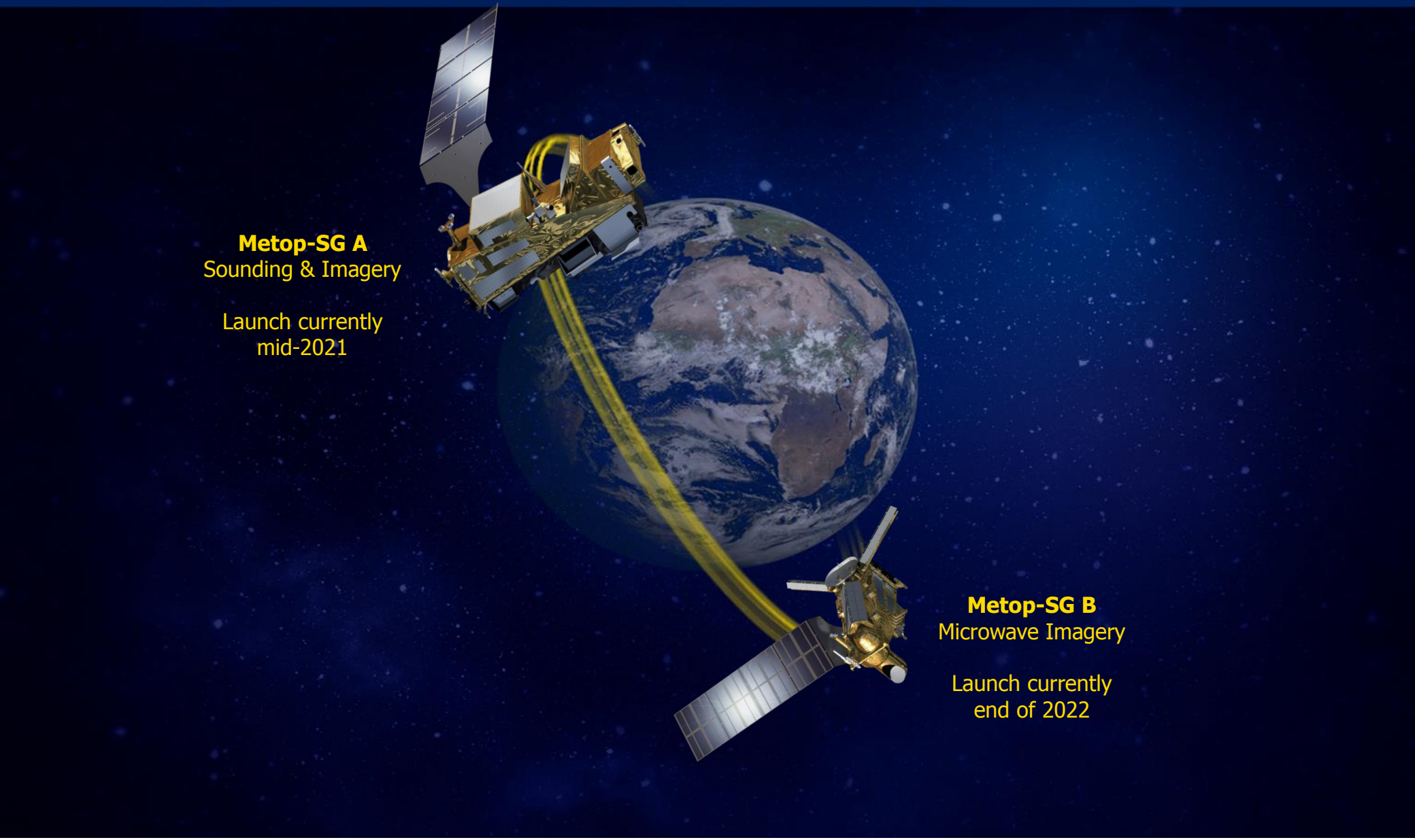


- Lightning
- Convection
- Winds
- Atmosphere

Eumetsat Polar System – Second Generation (EPS-SG)

- Will provide continuity of observations and respond to the needs of the users in the 2022 => time frame.
- EPS-SG represents Europe's contribution to the future Joint Polar System (JPS), which is planned to be established together with the National Oceanic and Atmospheric Administration (NOAA) of the United States, following on from the Initial Joint Polar System (IJPS).
- Polar orbiting satellites, due to their global coverage and of the variety of passive and active sensors have the most significant positive impact on Numerical Weather Prediction (NWP).
- Polar orbiting satellites also deliver unique infrared and microwave imagery inputs to critical nowcasting of high impact weather at high latitudes.
- The European Space Agency will develop the Metop-SG satellites and a number of instruments, with CNES and DLR developing some of the key instruments.
- EUMETSAT will provide the launch and LEOP services and operate the satellites for a nominal duration of 21 years.

EPS-SG full operational configuration



EPS-SG A sounding and imagery mission

1. **IASI-NG**
   Infrared Atmospheric Sounding
2. **MWS**
   Microwave Sounding
3. **METImage**
   Visible-Infrared Imaging
4. **RO**
   Radio Occultation
5. **3MI**
   Multi-viewing, -channel, -polarisation Imaging
6. **Copernicus Sentinel-5**
   UN/VIS/NIR/SWIR Sounding

EPS-SG B microwave imagery mission

1. **SCA**
   Scatterometer
2. **RO**
   Radio Occultation
3. **MWI**
   Microwave Imaging for Precipitation
4. **ICI**
   Ice Cloud Imager
5. **ARGOS-4**
   Advanced Data Collection System

EPS-SG mission capabilities

- Major improvements to all EPS observation missions
  - Infrared and microwave sounding
  - Optical imagery (METImage, developed by DLR)
  - Scatterometer
  - Radio occultation

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

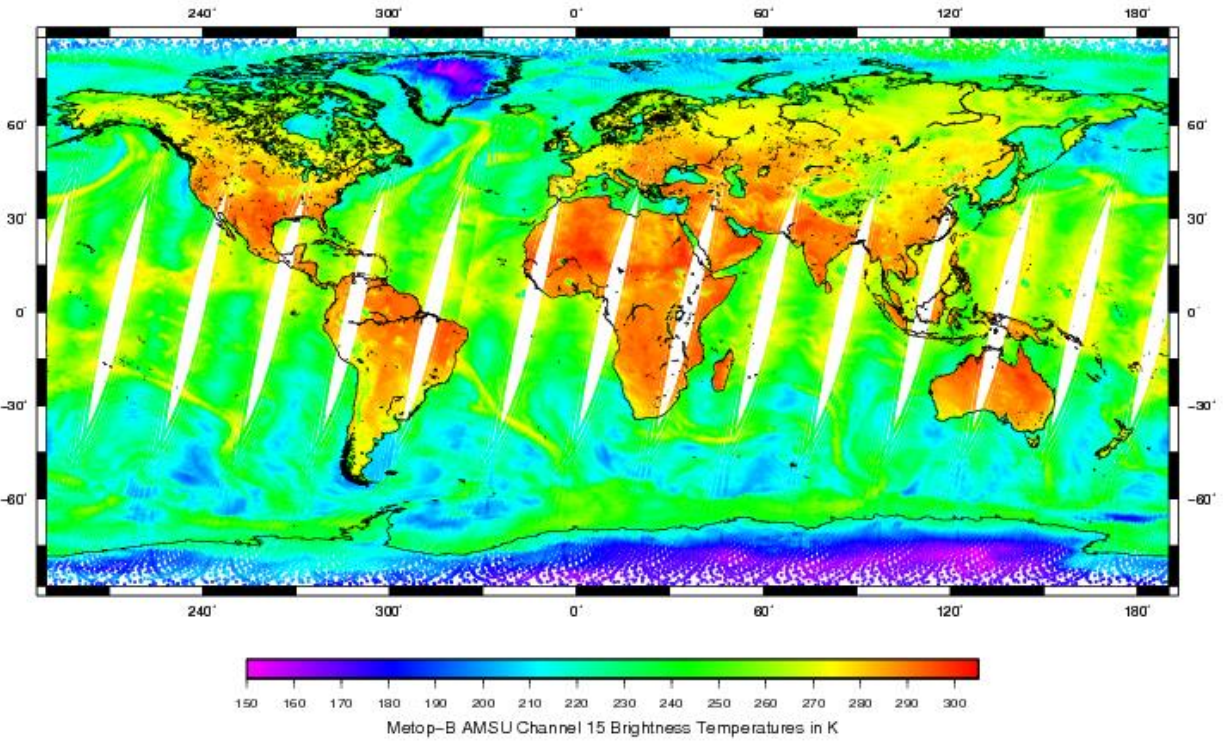
Outline

- Overview of EUMETSAT missions
  - Current
  - ...and future
- Main EUMETSAT products for storm applications
  - Forecasting
  - Monitoring
- Other collaboration activities

EUMETSAT Level 1 (& Level 2) data - assimilation into NWP models

- NWP models assimilate observations from polar-orbiting (LEO) and geostationary satellites (GEO). Of these, LEO observations are used most extensively and have the greatest impact.

- Satellites provide observations in otherwise data sparse areas (oceans, most of the Southern Hemisphere).



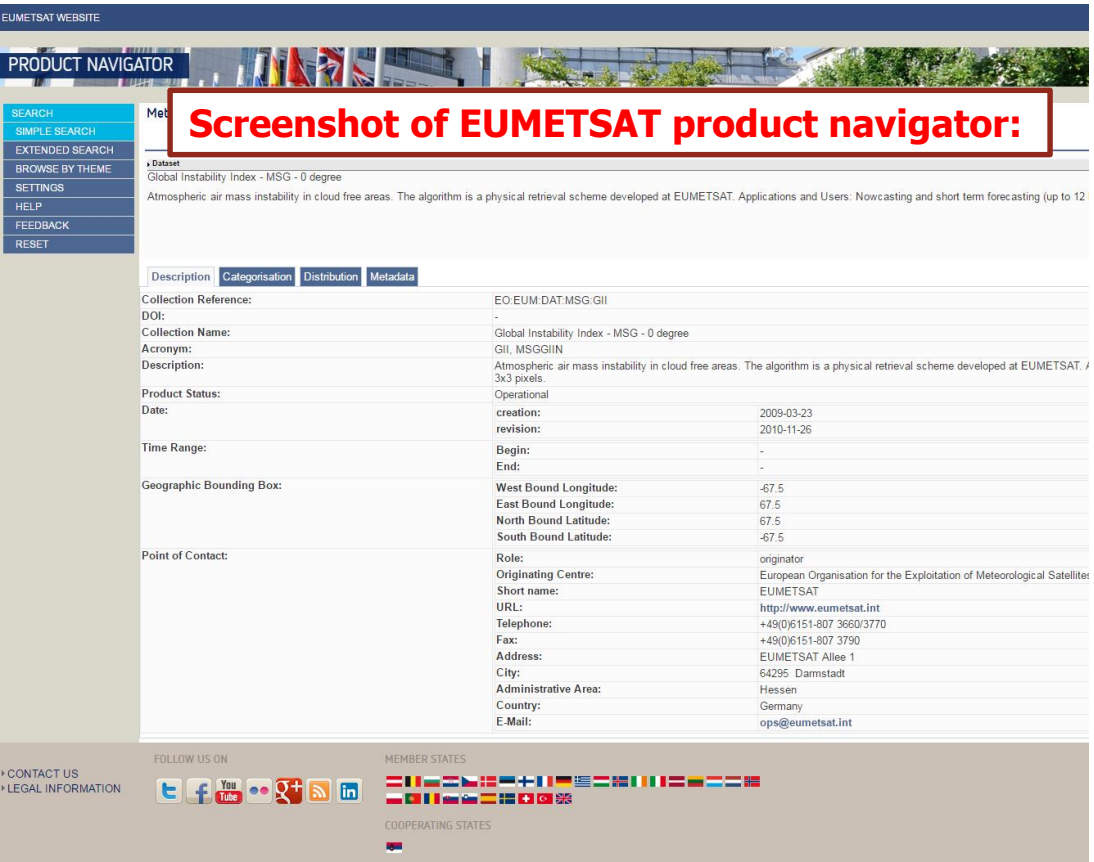
- Limitations in NWP models and computing resources prevent 95% of all satellite observations from being assimilated.

Level 2 product example: Geostationary Instability index (GII) – (1)

- The operational atmospheric instability product for MSG SEVIRI, the GII (geostationary instability index), comprises of a number of so-called instability indices.
- Convective systems can develop in a thermodynamically unstable atmosphere. Such systems may quickly reach high altitudes and can cause severe storms. Meteorologists are thus especially interested in identifying such storm potentials while the system is still in a pre-convective state.
- A number of instability indices have been defined to describe such situations. Traditionally, these indices are taken from temperature and humidity soundings by radiosondes.
- As a radiosonde sounding is effectively only a point measurement done only a few times a day, indices derived from geostationary satellite data offer a superior temporal and spatial resolution and coverage.

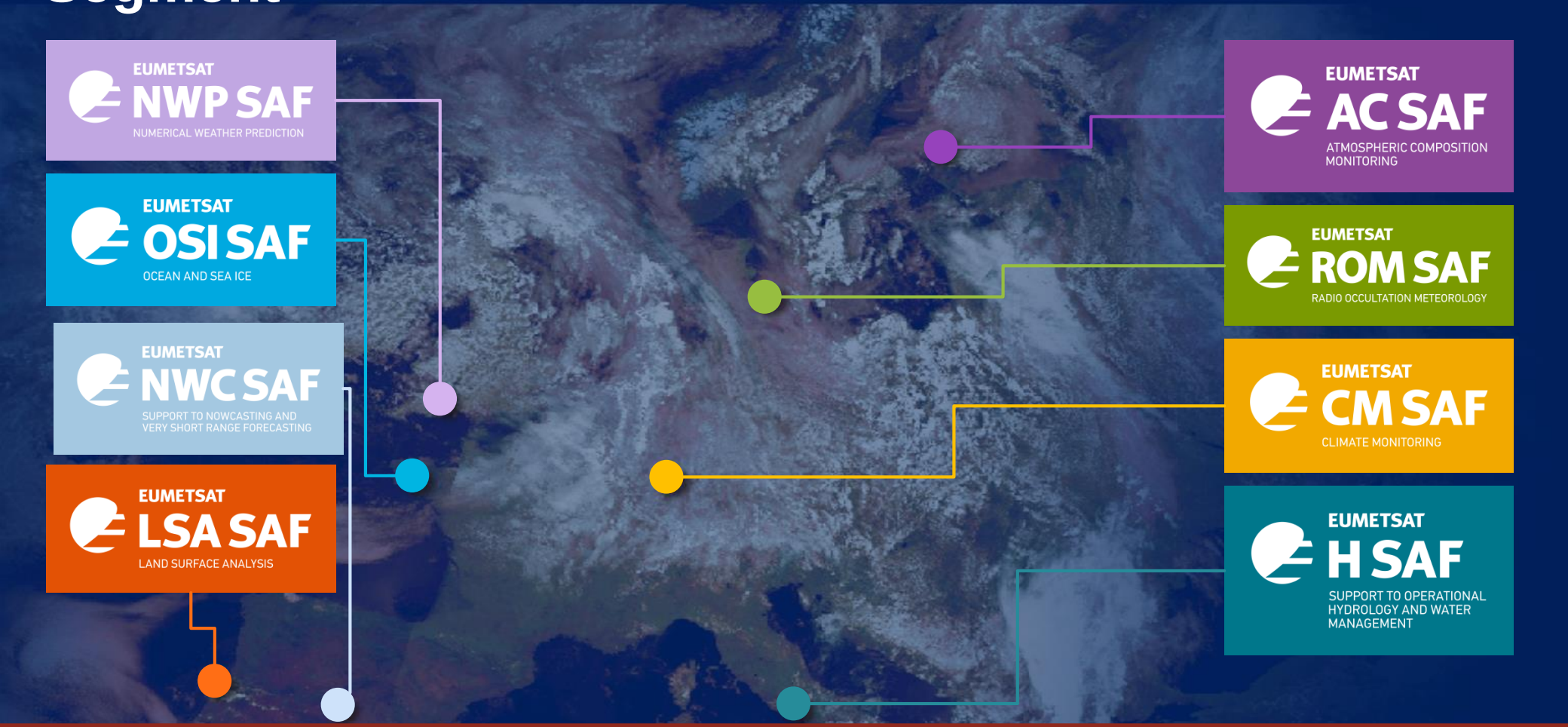
Level 2 product example: Geostationary Instability index (GII) – (2)

- The instability indices are defined such that it describes a potentially unstable layering if it exceeds a certain threshold. Therefore, such indices describe the potential of convection as a single number, usually defined as T/q differences at different atmospheric levels.



- The MSG GII product is derived over cloud-free areas through a combination of the MSG measurements and NWP forecast fields. The retrieval algorithm adjusts the atmospheric profile (T, q, O_3) according to a combination of the MSG measurements and NWP fields weighted according to their respective errors.

The distributed EUMETSAT Application Ground Segment

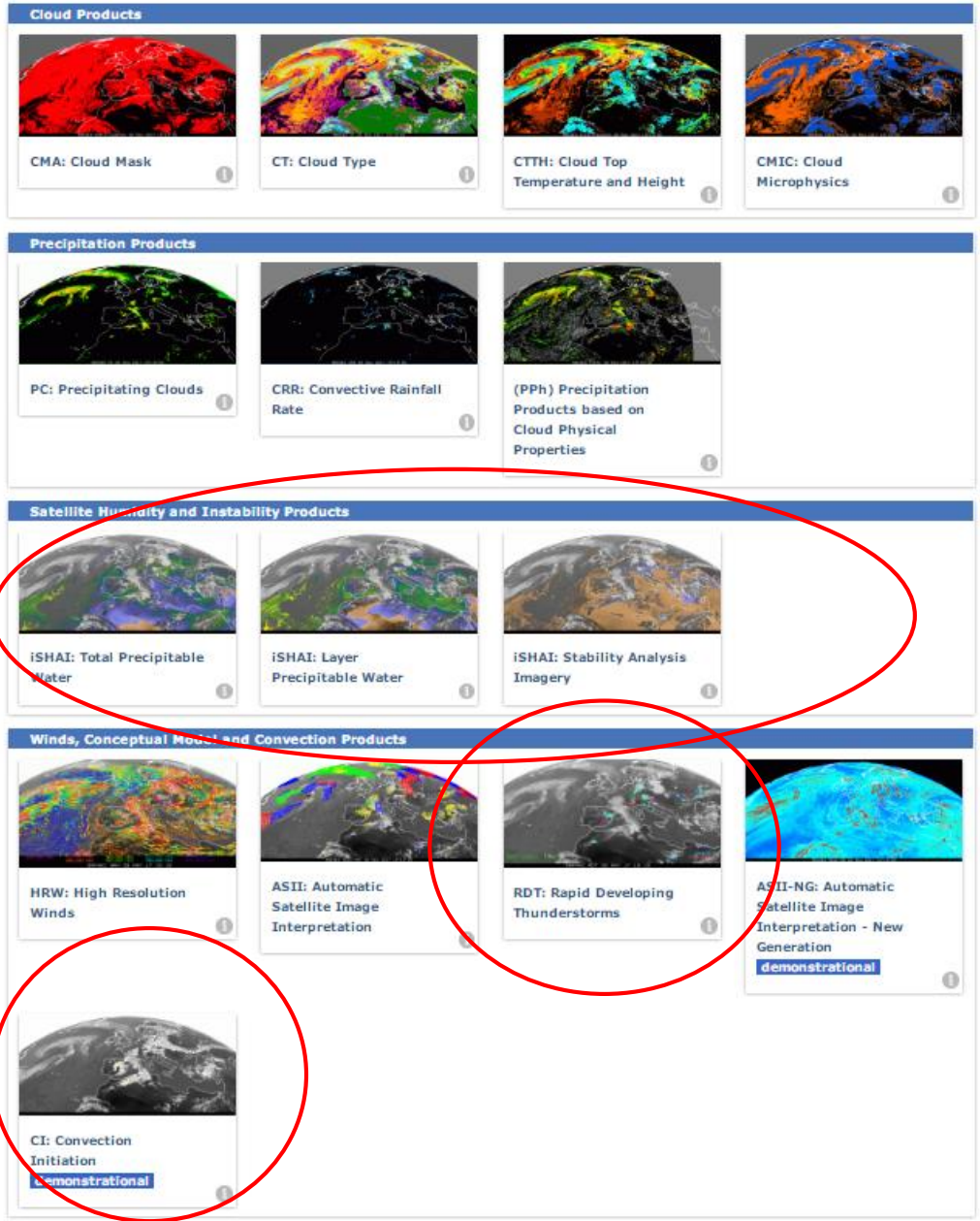


Utilising specialist expertise from the Member States, Satellite Application Facilities (SAFs) are dedicated centres of excellence for processing satellite data. They form an integral part of the distributed EUMETSAT Application Ground Segment.

The eight EUMETSAT SAFs provide users with operational data and software products, each one for a dedicated user community and application area.

NWC SAF (SAF for support to nowcasting and very short range forecasting)

EUMETSAT NWC SAF
SUPPORT TO NOWCASTING AND VERY SHORT RANGE FORECASTING



The key objective of the NWC SAF is the production and provision of a software application for the near real time generation of a set of meteorological products to support Nowcasting activities

Several storm monitoring related products in the portfolio currently

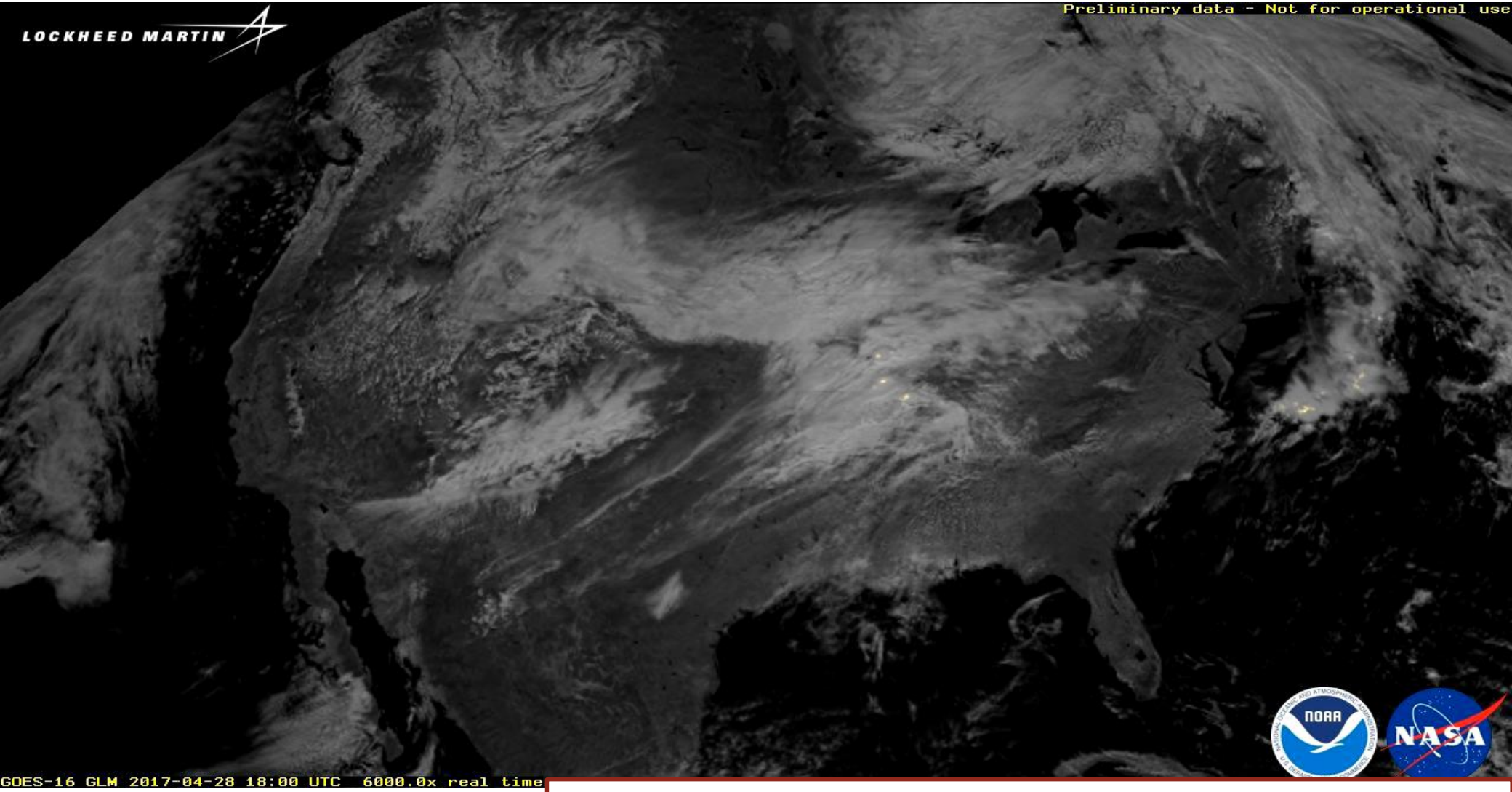
More to come with the preparation for the future missions (e.g. Lightning Imager based products).

A dedicated talk on NWC SAF products on Tuesday 13 June!

More information:
http://www.nwcsaf.org/

EUMETSAT

Future capabilities: Lightning monitoring for NWC / VSRF



April 28-30, 2017

GOES-16 GLM lightning superimposed on GLM background

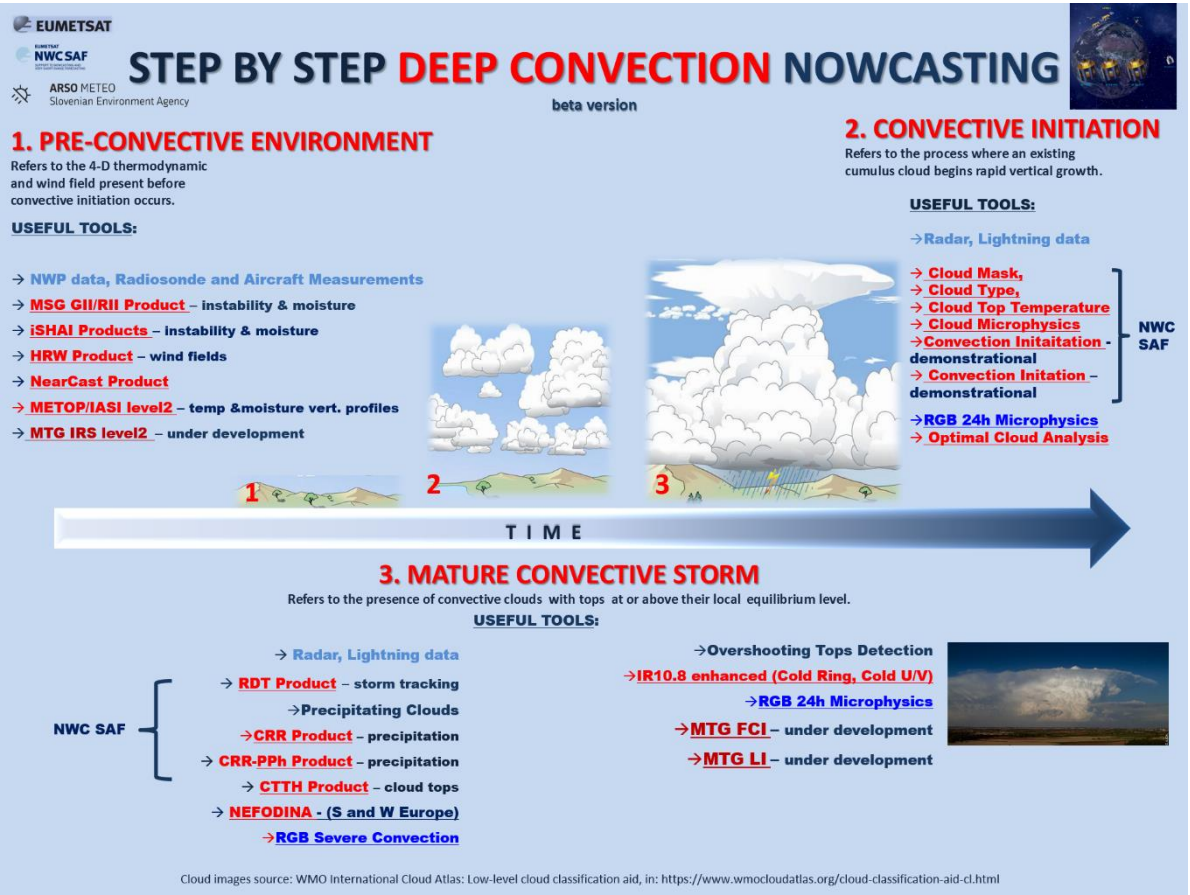
Outline

- Overview of EUMETSAT missions
  - Current
  - ...and future
- Main EUMETSAT products for storm applications
  - Forecasting
  - Monitoring
- Other collaboration activities

EUMETSAT Convection Working Group (CWG)

The main purpose of the Convection Working Group is to stimulate efficient utilization of satellite data in operational meteorology for detection, analysis and prediction of deep moist convection and associated phenomena

The group, which started small, has met for a full workshop every 2 years since 2007



Cloud images source: WMO International Cloud Atlas: Low-level cloud classification aid, in: https://www.wmocloudatlas.org/cloud-classification-aid-cl.html

Last meeting on 4 – 8 April 2016, Florence, Italy

47 participants from 20 countries

15 EUMETSAT Member states, NOAA, NASA, JMA, KMA, CMA,...

Next meeting in April 2018, Ljubljana, Slovenia

EUMETSAT

Summary

- EUMETSAT has provided satellite data for decades, to be either assimilated in NWP models or used in NWC applications – both serving the “storm” community
- Product development distributed between SAFs and HQ activities
- Future observational capabilities will significantly add data interesting for storm prediction & monitoring, while also providing continuity to existing missions

Backup

Online access to data

	eoportal.eumetsat.int	create and manage your user account, subscribe to our services
	navigator.eumetsat.int	explore our catalogue, what and where, supporting documentation
	eumetcast.com	learn more about our push delivery service
	coda.eumetsat.int	download Sentinel-3 marine and atmosphere data
	archive.eumetsat.int	order past data
	eumetview.eumetsat.int	visualise and explore, create layers in GIS applications