

# European Weather Satellites

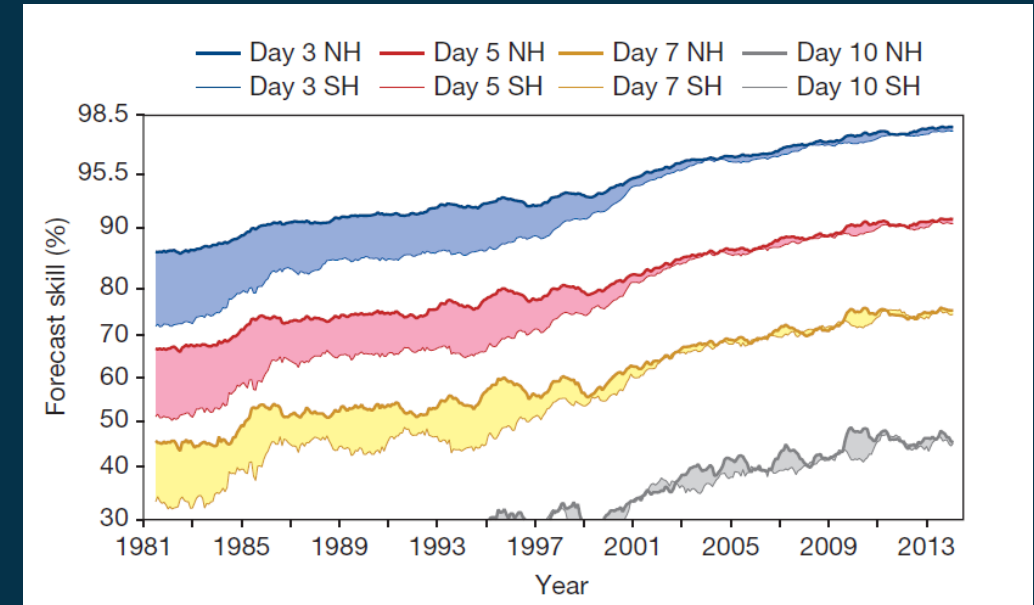
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Pieter Van den Braembussche

BELSPO Space Talks, 17 April 2023

# Relevance of meteorological satellites

- Over **95%** of the 40 million observations processed every day for weather forecasting are provided by satellites.
- Difference between Southern and Northern hemisphere forecast almost disappeared thanks to satellite data.
- Around **1/3** of European economy is weather-sensitive, e.g. agriculture, energy, transport, tourism, infrastructure, ...
- The socio-economic benefits of weather forecasting in the EU are estimated to be up to **61 billion/year**.



*The quiet revolution of numerical weather prediction*  
Peter Bauer, Alan Thorpe, Gilbert Brunet

# European meteorological satellites



ESA launched the first Meteosat satellite in November 1977 as its first Earth Observation satellite



Today, ESA - EUMETSAT cooperation :

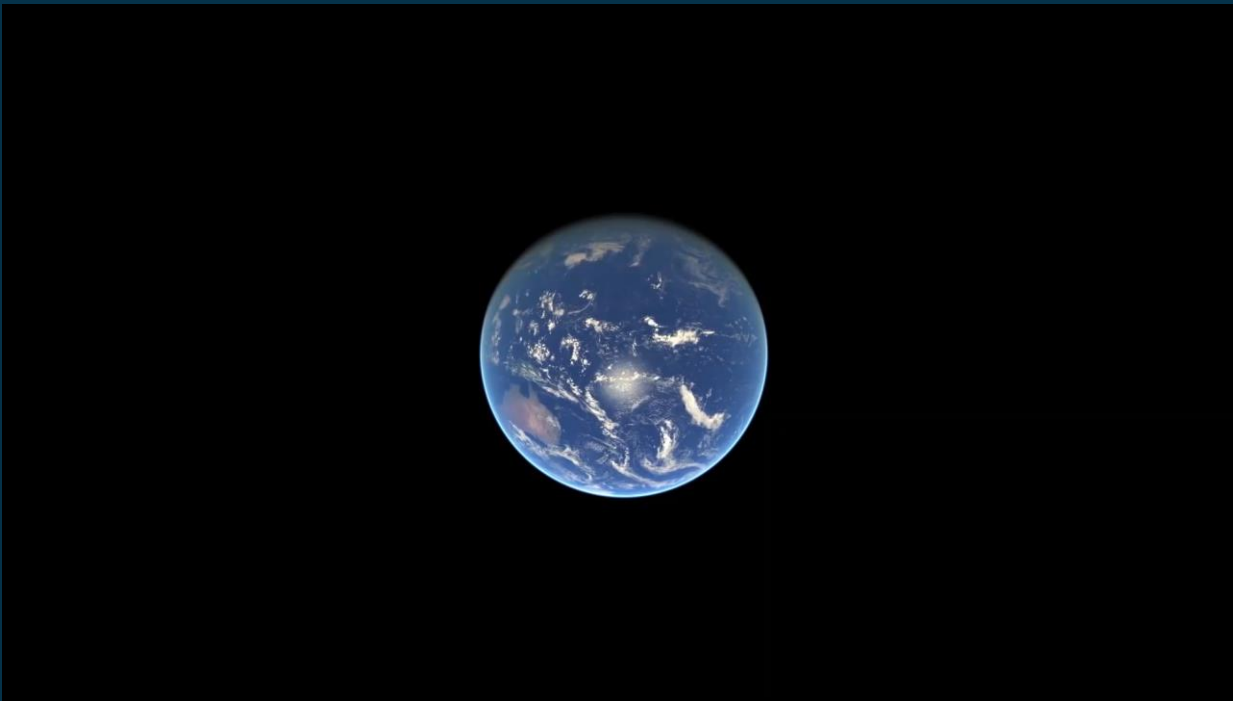
- ESA develops the Proto-Flight Model satellites and procures the recurrent satellites
- EUMETSAT establishes the end-user requirements, develops the ground segment, procures the launch services, funds the recurrent satellites and operates the full system

EUMETSAT is also responsible for operating the Copernicus Sentinel-3 and Sentinel-6 ocean monitoring satellites, developed by ESA for the EU.



Currently, 2 types of ESA-EUMETSAT operational satellites are in orbit and used for meteorology:

- MSG in geostationary orbit
- METOP in polar orbit at 800 km altitude



EUMETSAT animation

## ***Geostationary orbit***

- regular images (Europe every 2.5 min)
- detection of developing weather, such as severe storms and fog over the coming hours
- issue weather alerts
- feed climate models
- lightning data for air traffic management

## ***Low Earth polar orbit***

- High resolution images
- more instruments
- feed the computer models that predict weather up to 10 days ahead



# European meteorological satellites



4 meteorological missions are currently developed :

## 1. Meteosat Third Generation (MTG)

- 6 satellites

## 2. METOP Second Generation (METOP-SG)

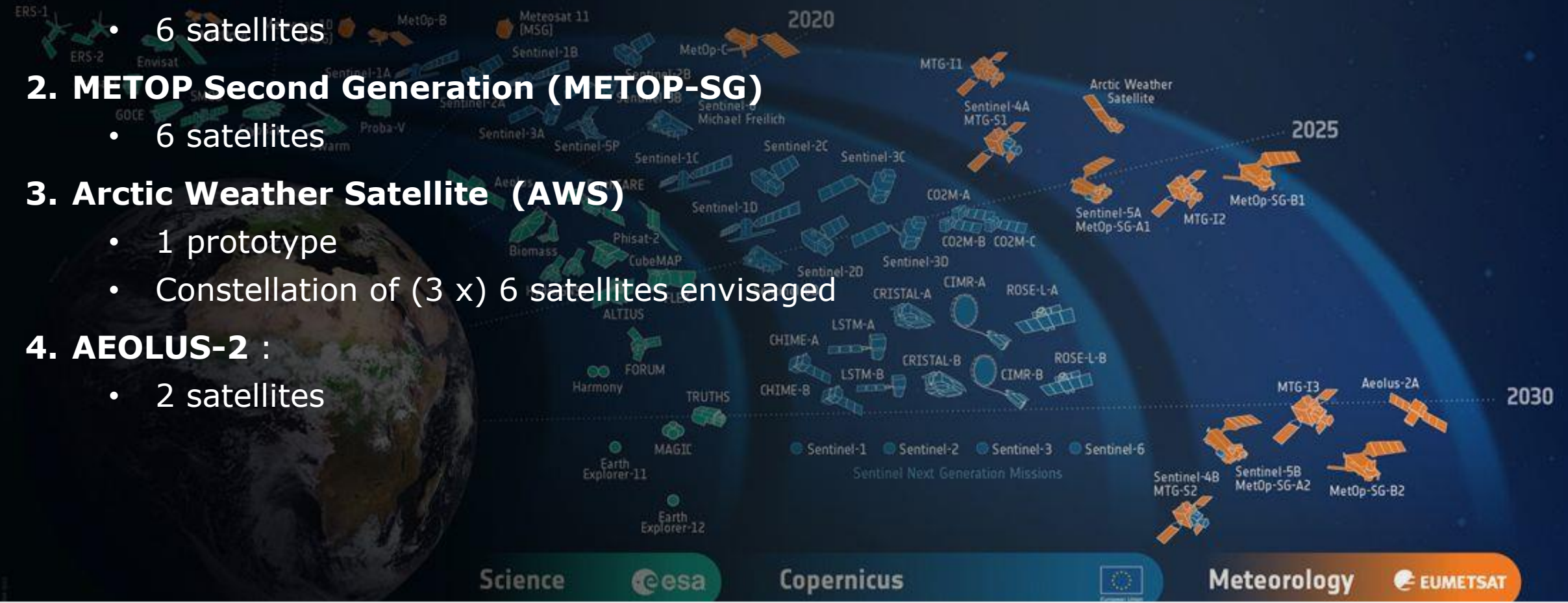
- 6 satellites

## 3. Arctic Weather Satellite (AWS)

- 1 prototype
- Constellation of (3 x) 6 satellites envisaged

## 4. AEOLUS-2 :

- 2 satellites



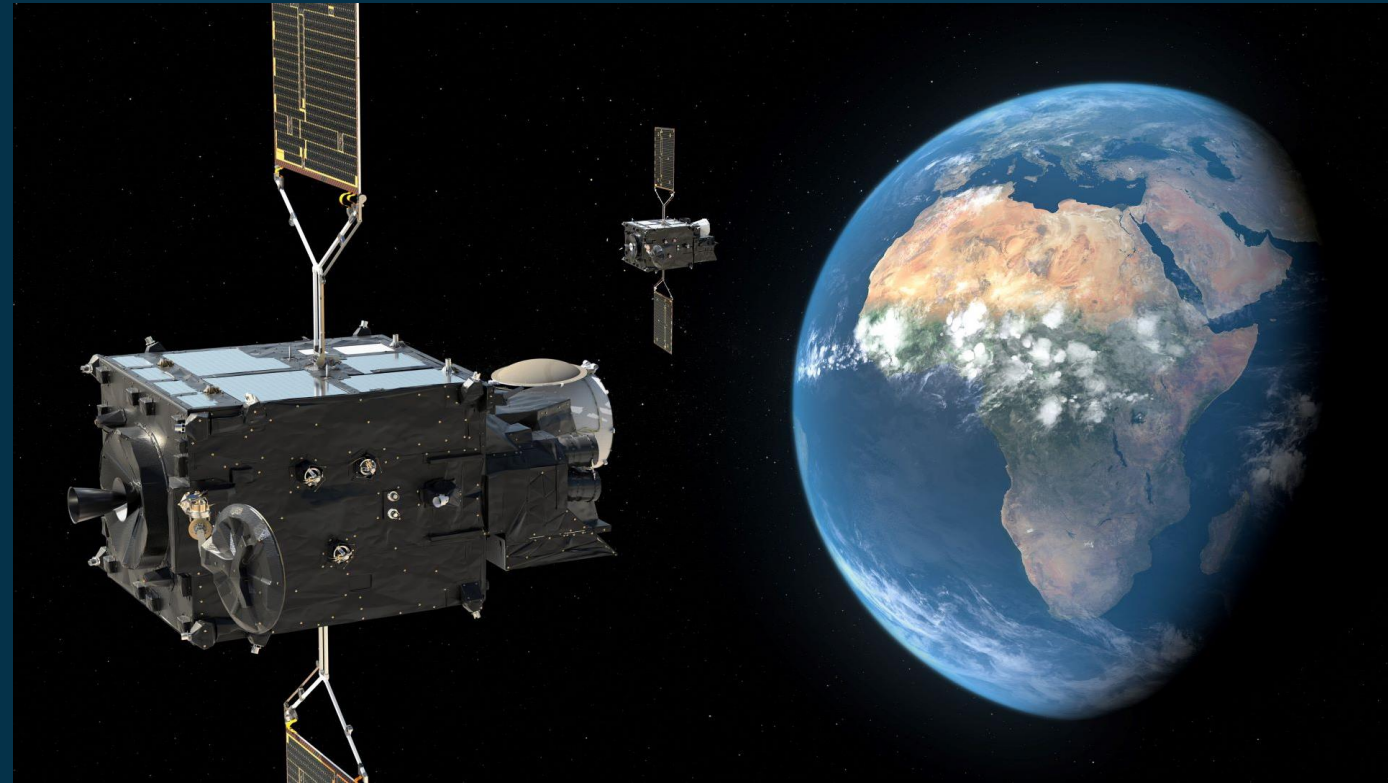
# MTG – Meteosat Third generation

## MTG-I - “Imager”

- **FCI:** Flexible Combined Imager
- **LI:** Lightning Imager
- MTG-I1 was launched on 13/12/2022

## MTG-S – “Sounder”

- **IRS:** Infra-Red Sounder
  - Fourier Transform IR spectrometer
  - Full Earth covered in 1 hour
  - IRS PFM currently tested in CSL, Liège
- **UVN - Sentinel-4**
  - UV-Vis-NIR (UVN) imaging spectrometer
  - Coverage of Europe and North Africa in 1 hour, delivering HR measurements of trace gases (nitrogen dioxide, ozone, sulphur dioxide, ...) for air quality monitoring
  - Qualification test campaign completed, PFM delivered to MTG
- Target launch date for MTG-S1: Q4 2024 (with Ariane 64)





1977

↓ MOP/MTP



2002

↓ MSG

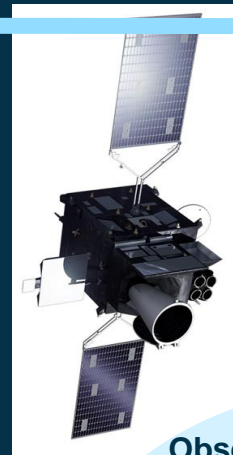


2022

and

2024

↓



MTG-I

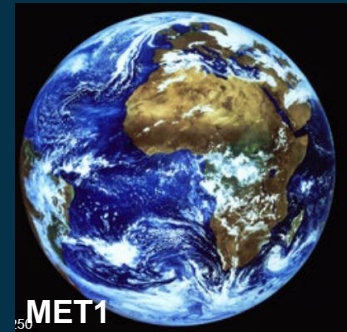
MTG-S



Observation mission:  
 • **MVIRI:** 3 channels  
 30 mins scan  
**Spinning** satellite  
 Class 800 kg  
 Data rate ~850 Kb/s

Observation missions:  
 • **SEVIRI:** 12 channels  
 15 mins scan  
 • **GERB**  
**Spinning** satellite  
 Class 2 tonnes  
 Data rate ~2 Mb/s

Observation missions:  
 • **FCI:** 16 channels  
 10 mins scan  
 • **IRS:** >1700 channels  
 • **LI:** 1 channel at 777.4 nm  
 • **Sentinel-4** (via Copernicus)  
**3-axis stabilised** satellites  
 Twin Satellite configuration  
 Class 3.6 – 3.8 tonnes  
 Data rate up to 200 Mb/s



**MET1**  
 1<sup>st</sup> image: 09/12/1977



**MSG-4 (MET11)**  
 1<sup>st</sup> image: 04/08/2015



1<sup>st</sup> image: 02/05/2023



# MTG – Meteosat Third generation

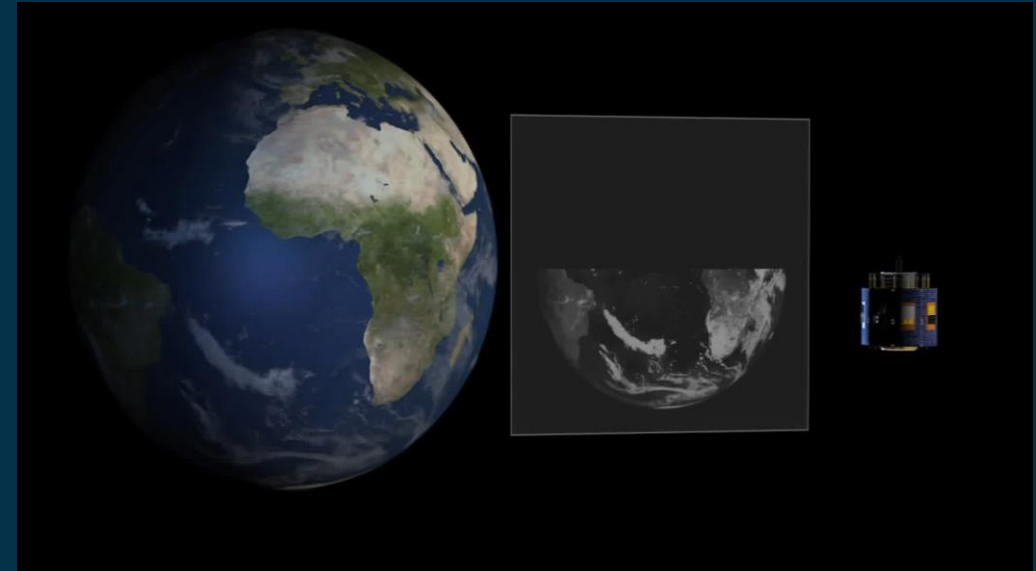


## FCI - Flexible Combined Imager

- MSG = spinning satellite (100 rpm)
- MTG = 3-axis stabilized

## MTG pointing stability challenge :

- MTG misses the gyroscopic stability of the spinning satellite
- Resolution decreased from 1 km to 500m (14 microrad)
- Perturbation torques from scanner and reaction wheels



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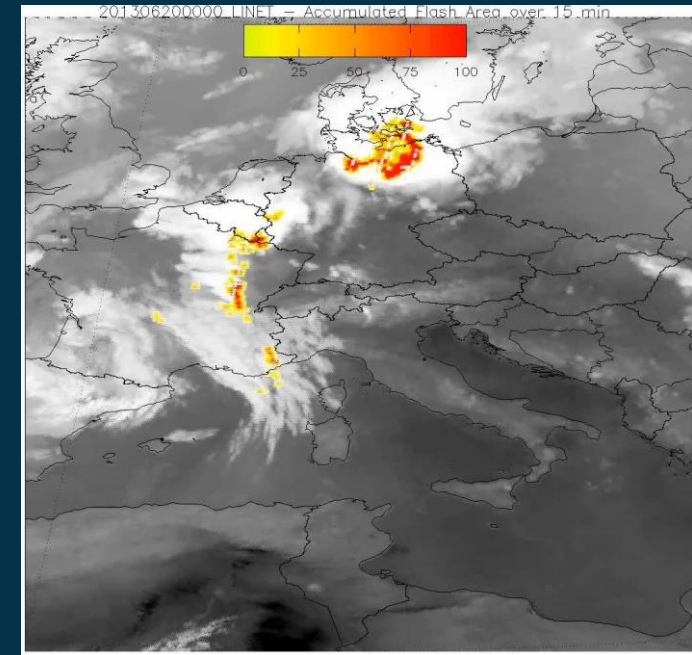
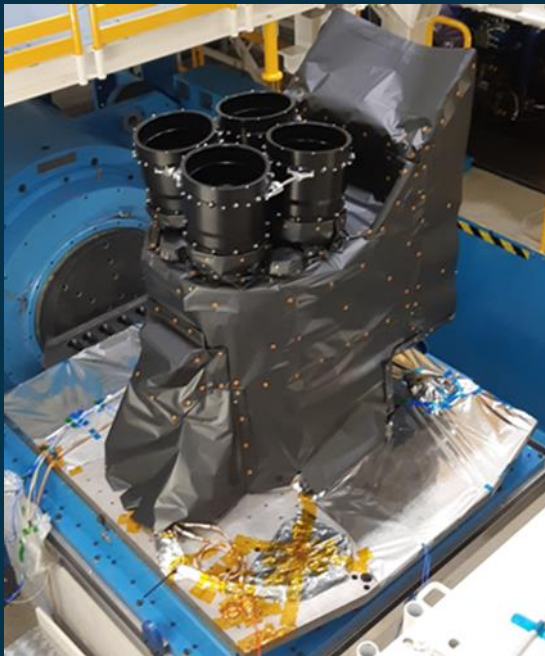




# MTG – Meteosat Third generation

## LI - Lightning Imager

- Acquisition every 1 ms
- FOV = 84% of the visible disk from GEO
- Pixel size = 4.5 km at sub-satellite point



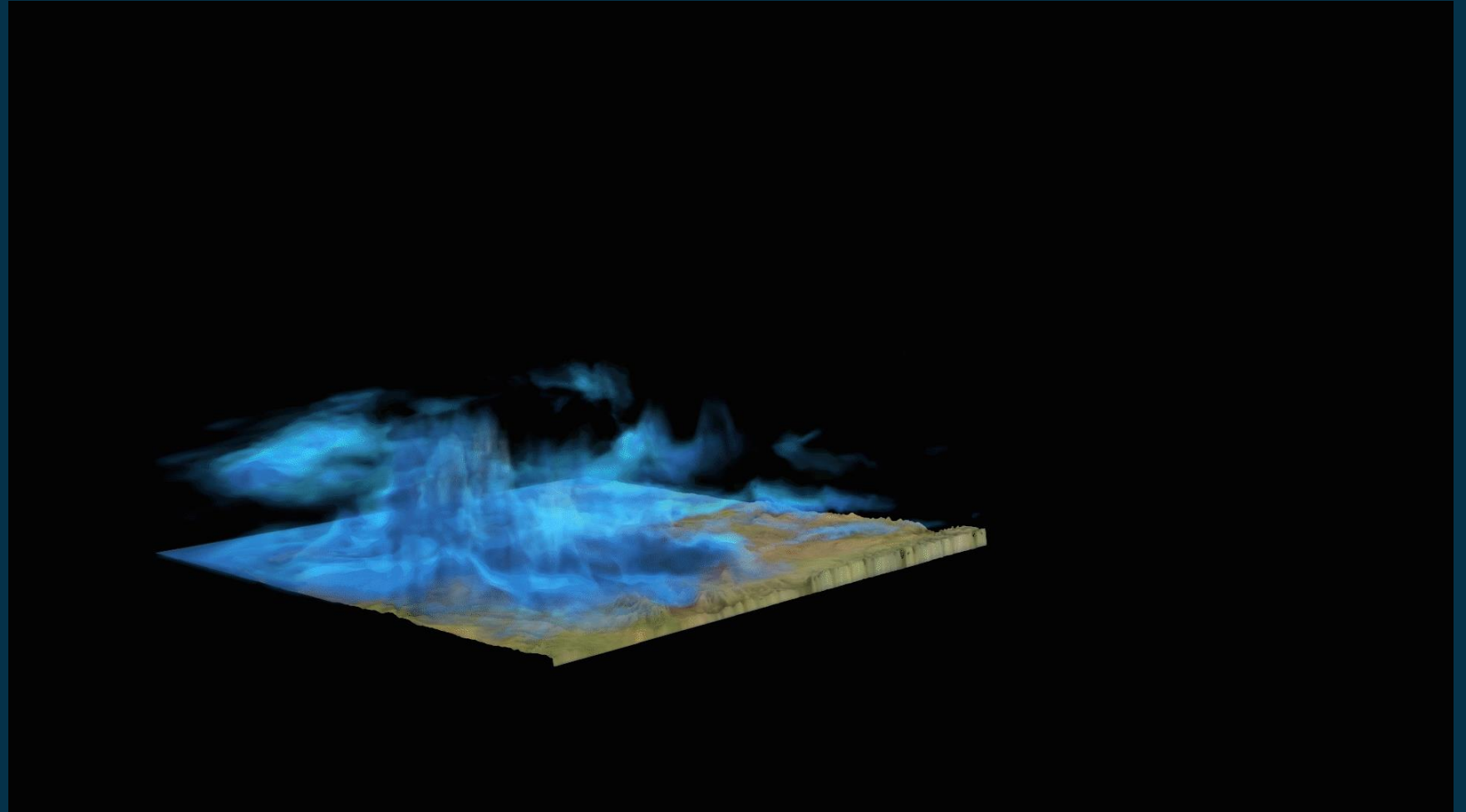
# MTG – Meteosat Third generation



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The “4D weather cube”, enabled by MTG instruments, will for the first time enable forecasters to simultaneously track meteorological phenomena, such as convection, winds and lightning.

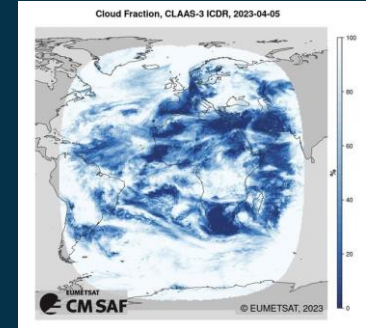
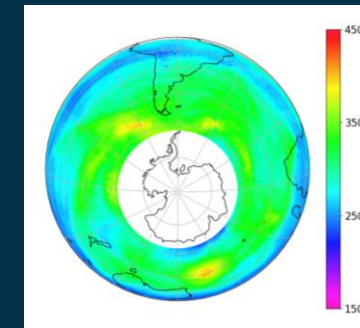
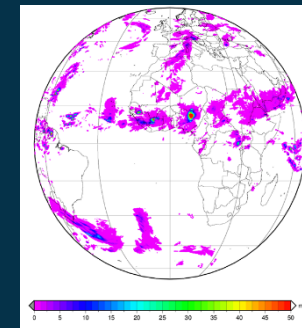
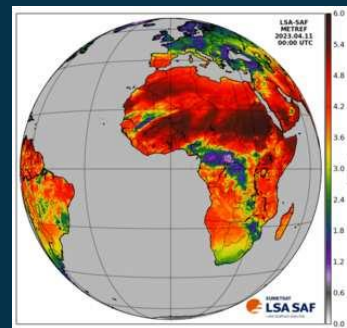


EUMETSAT animation





- RMI has a leading role in the data processing of the Geostationary Earth Radiation Budget (GERB) instrument on MSG and intends to continue this activity in combination with MTG data.
- RMI is a partner in 4 of the Eumetsat Satellite Application Facilities (SAFs) :
  - Climate Monitoring
  - Atmospheric Composition Monitoring
  - Land Surface Analysis
  - Hydrology and Water Management

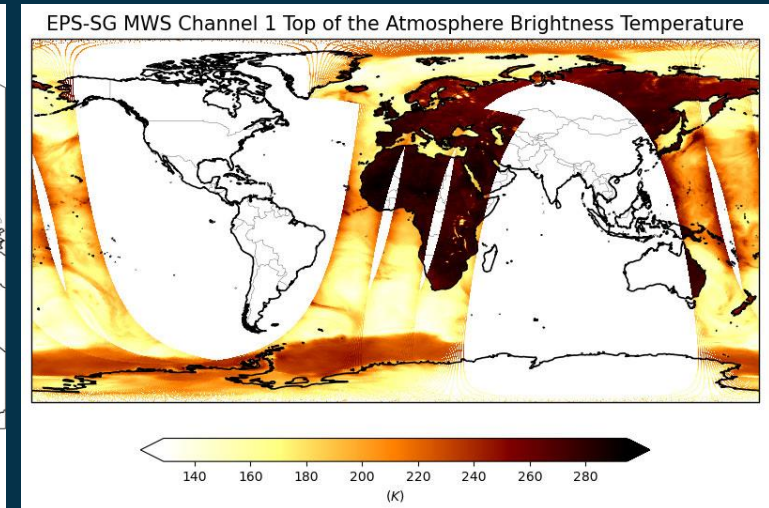
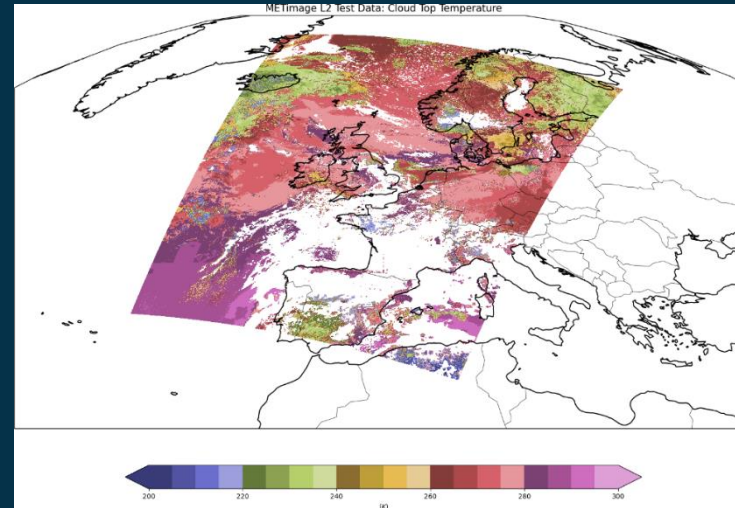
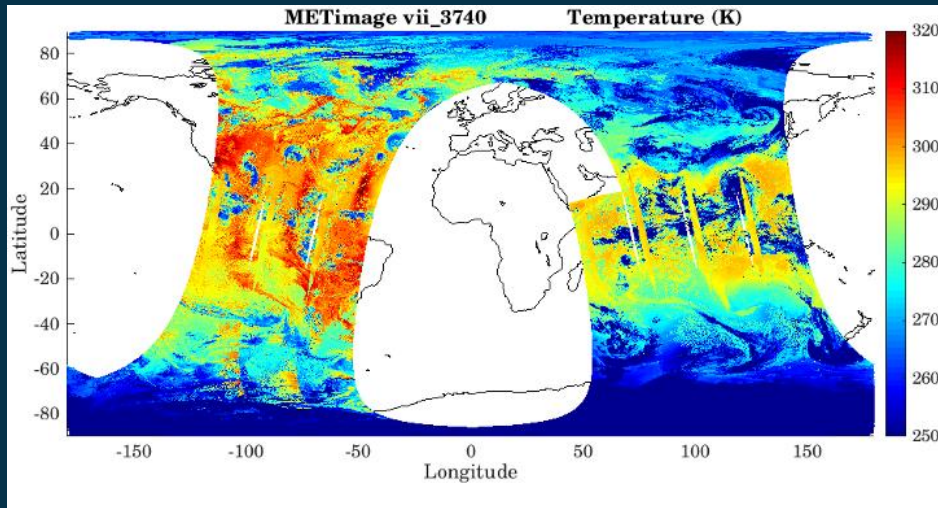


# Metop-SG – Metop – Second Generation

- MetOp-SG represents the European component of the space segment of the Joint Polar System, which is a collaboration between EUMETSAT and NOAA.
- MetOp-SG consists of two series of satellites (Sat-A and Sat-B), with three satellites in each series in polar orbit at 832 km

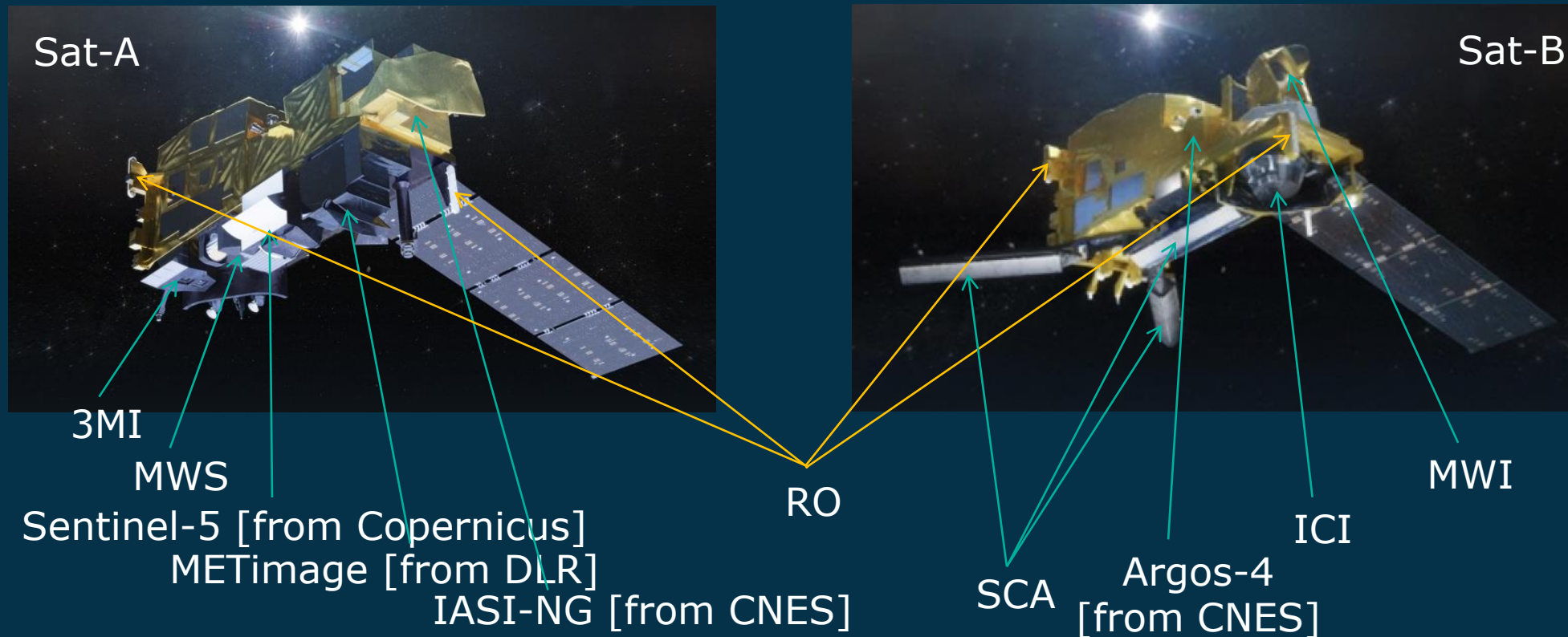


EUMETSAT animation



# Metop-SG – Metop – Second Generation

- Sat-A1 build and Sat-B1 build completed
- Sat-A1 : mechanical testing completed, thermal testing will start at the end of April 2023
- Sat-B1 : environmental testing will start in Q4 2023
- Target launch date: Q1 2025 for Sat-A1, Q4 2025 for Sat-B1





# AWS – Arctic Weather Satellite

- Proto-type satellite developed for a possible future constellation of passive, microwave sounders to complement the MetOp-SG satellites.
- Development based on a “new space” approach
- Single satellite design to be configured for different orbital planes (03:30, 07:30, 11:30) at 595 km
- Mass: 120 – 135 kg
- Baseline constellation = 3 orbital planes with 2 satellites in each plane, to be replaced after 5 and 10 years.
- EUMETSAT will present the constellation (called ‘EPS-Sterna’) to the Delegate Bodies in Spring 2024.



# AEOLUS-2

- Aeolus was launched in August 2018 as ESA's 5<sup>th</sup> Earth Explorer mission to demonstrate the benefits of an ultra-violet (355 nm) Doppler Lidar instrument to measure vertical wind profiles
- Aeolus-2 is conceived as an operational follow-on to Aeolus in collaboration with EUMETSAT
- Aeolus-2 program was approved by ESA council in November 2022
- Polar 'dawn-dusk' orbit at 370km altitude
- First launch planned at the end of 2031, with two satellites providing over 10 years of operations



## MTG

- Total value of contracts to Belgian companies = 40 M€
- Main contracts to Belgian companies: AMOS, CSL, EHP, Antwerp Space, TAS-Belgium, Spacebel, AMS

## MetOp-SG

- Total value of contracts to Belgian companies = 35.5 M€
- Main contracts to Belgian companies: TAS-Belgium, Redwire, Sonaca, Spacebel, Vitrociset, Antwerp Space, Rhea, M3 systems

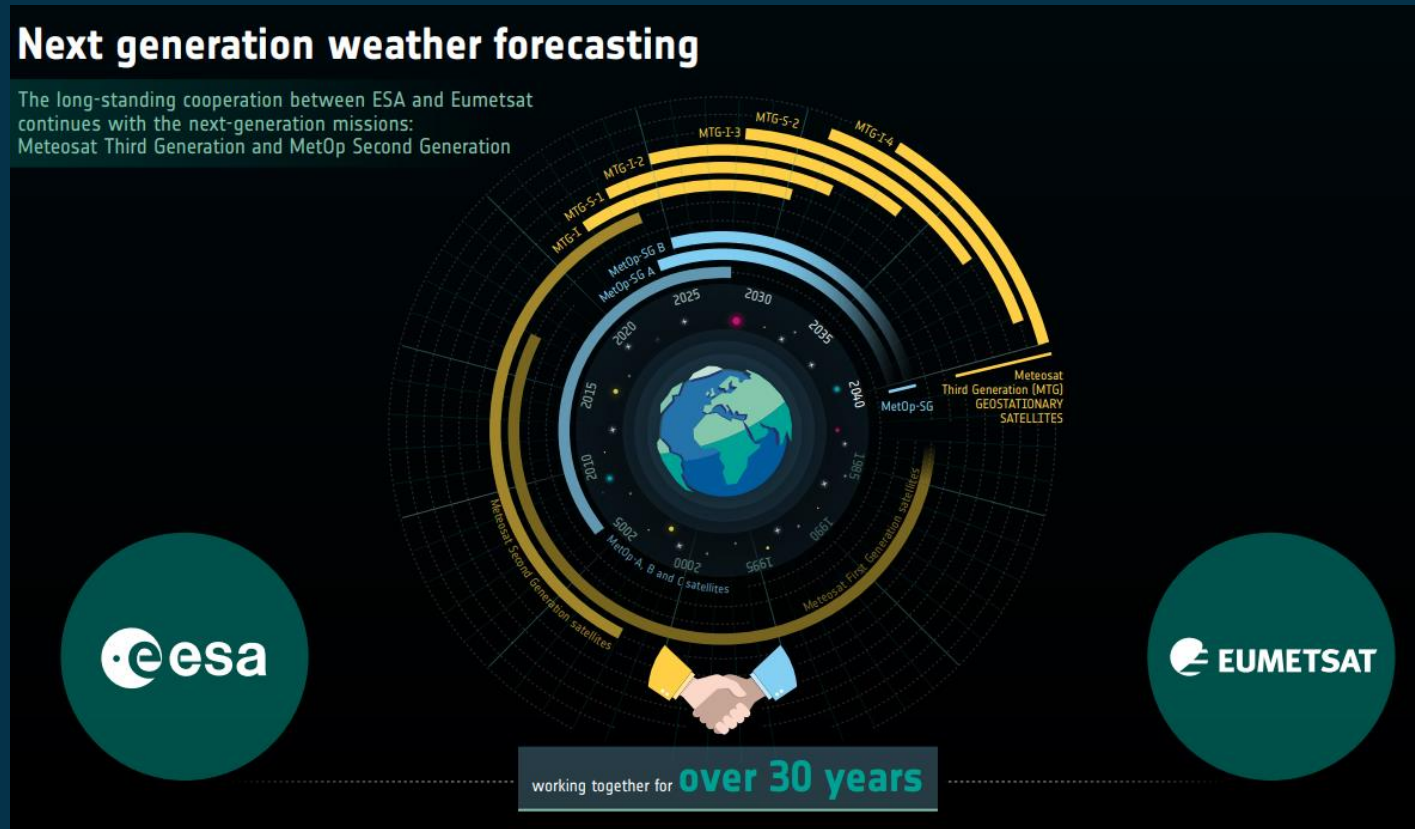
## AEOLUS-2

- Belgian contribution = 2.17% of 413.8 M€



# Conclusion

→ Continuation of generation of meteorological data from GEO and LEO guaranteed until 2040



→ Data from several new instruments and missions expected in the coming years: AWS, AEOLUS-2, IR sounder on MTG, UV spectrometer, ...