The Meteosat Third Generation satellite mission and its future contribution to the monitoring of convective storms

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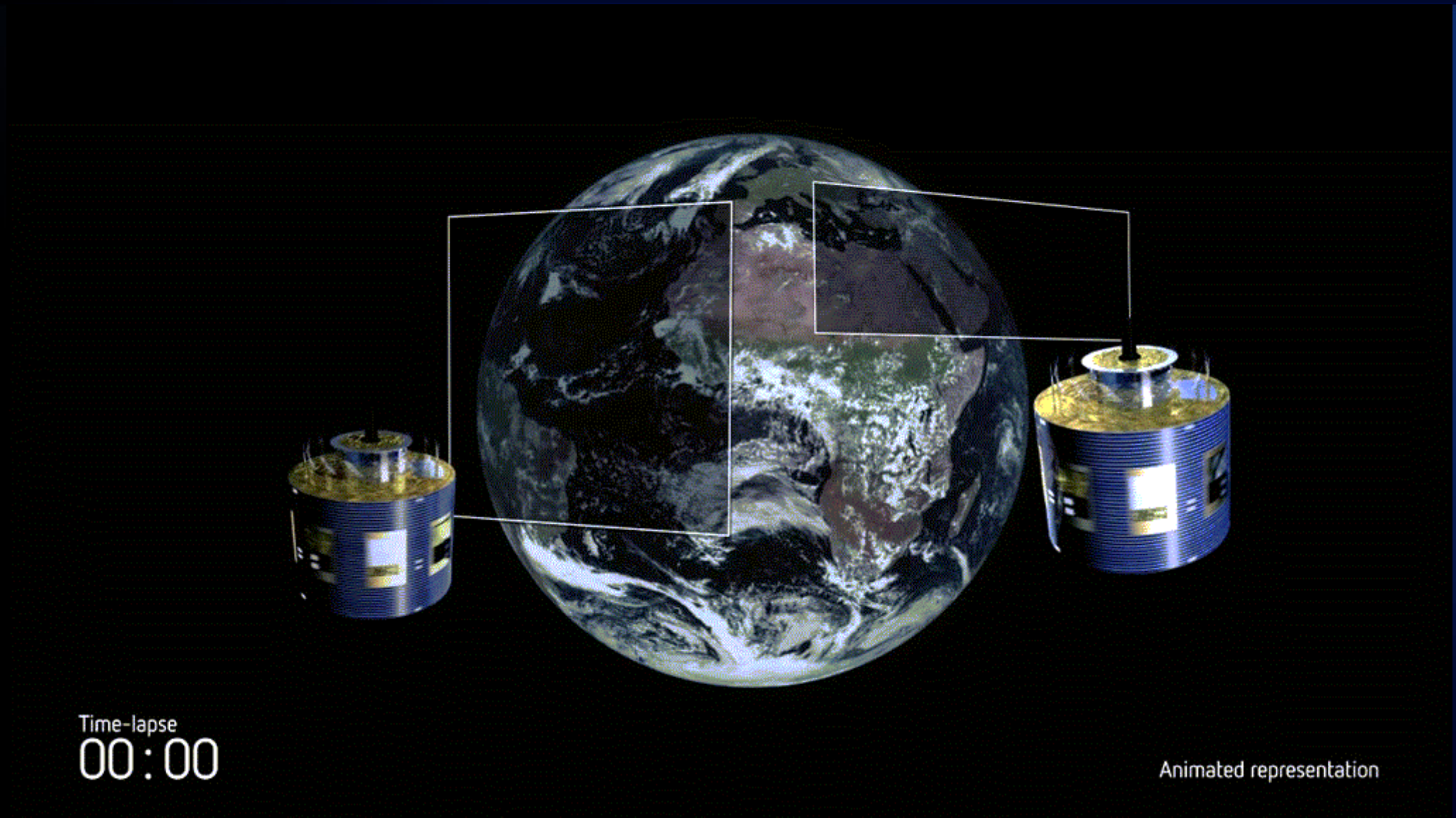
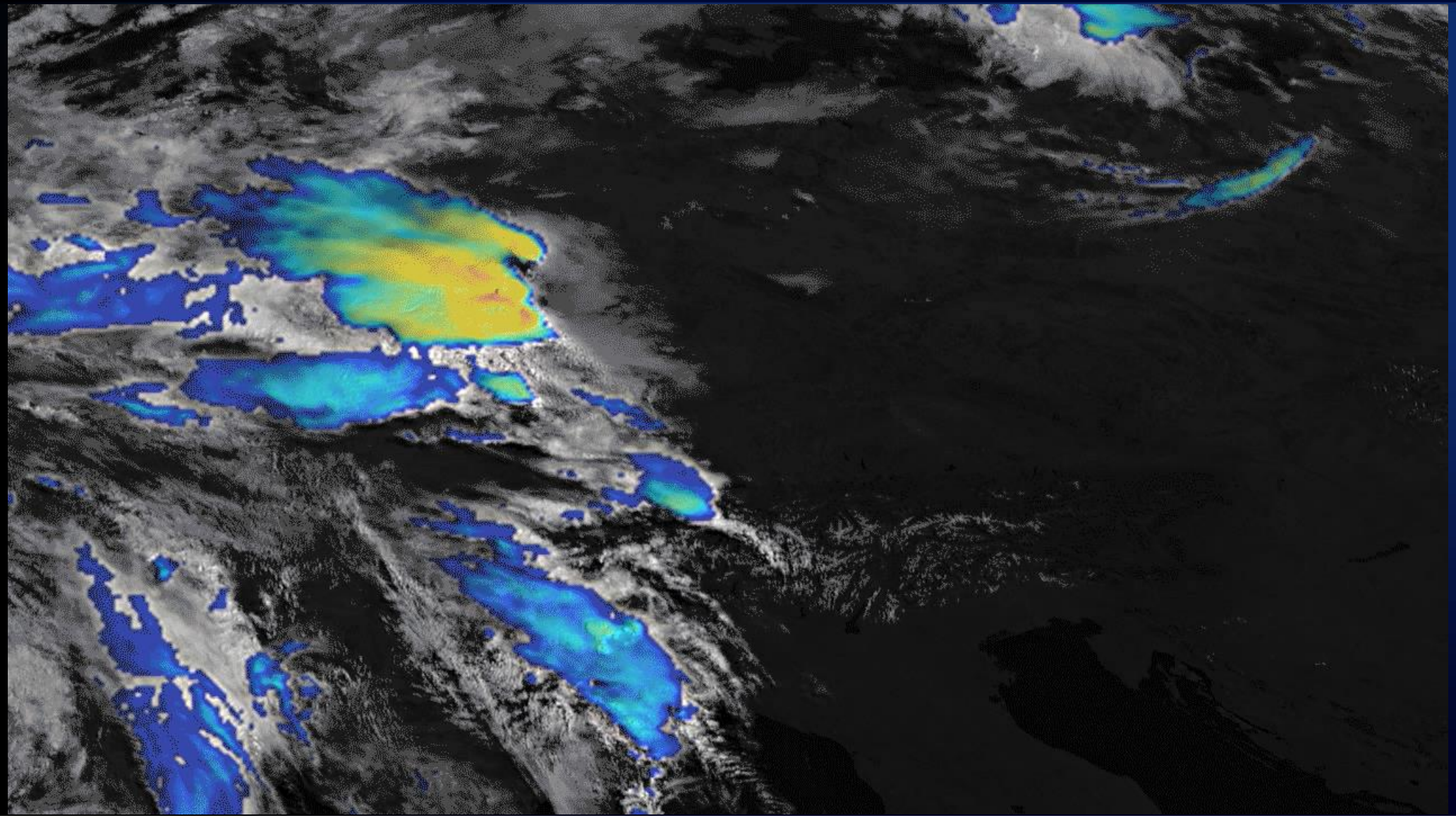
10th European Conference on Severe Storms (ECSS)

Kraków, Poland, 6 November 2019

Current situation:
Meteosat Second Generation: a two-satellite operational system for meteorology

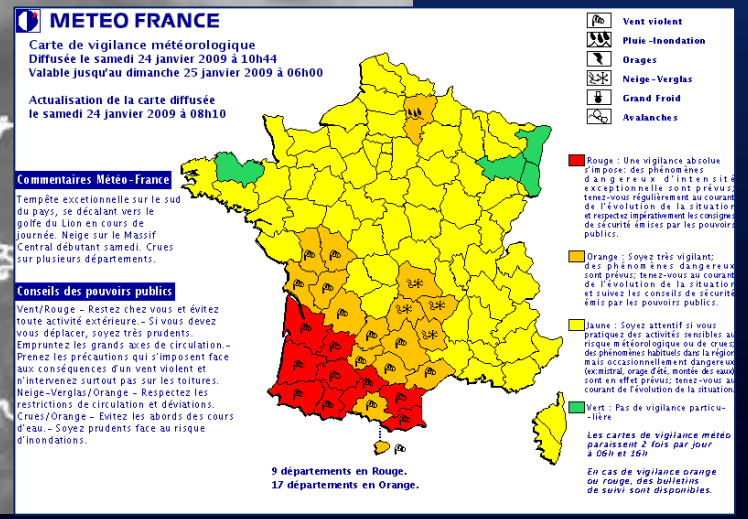


Meteosat for nowcasting of severe weather: thunderstorms

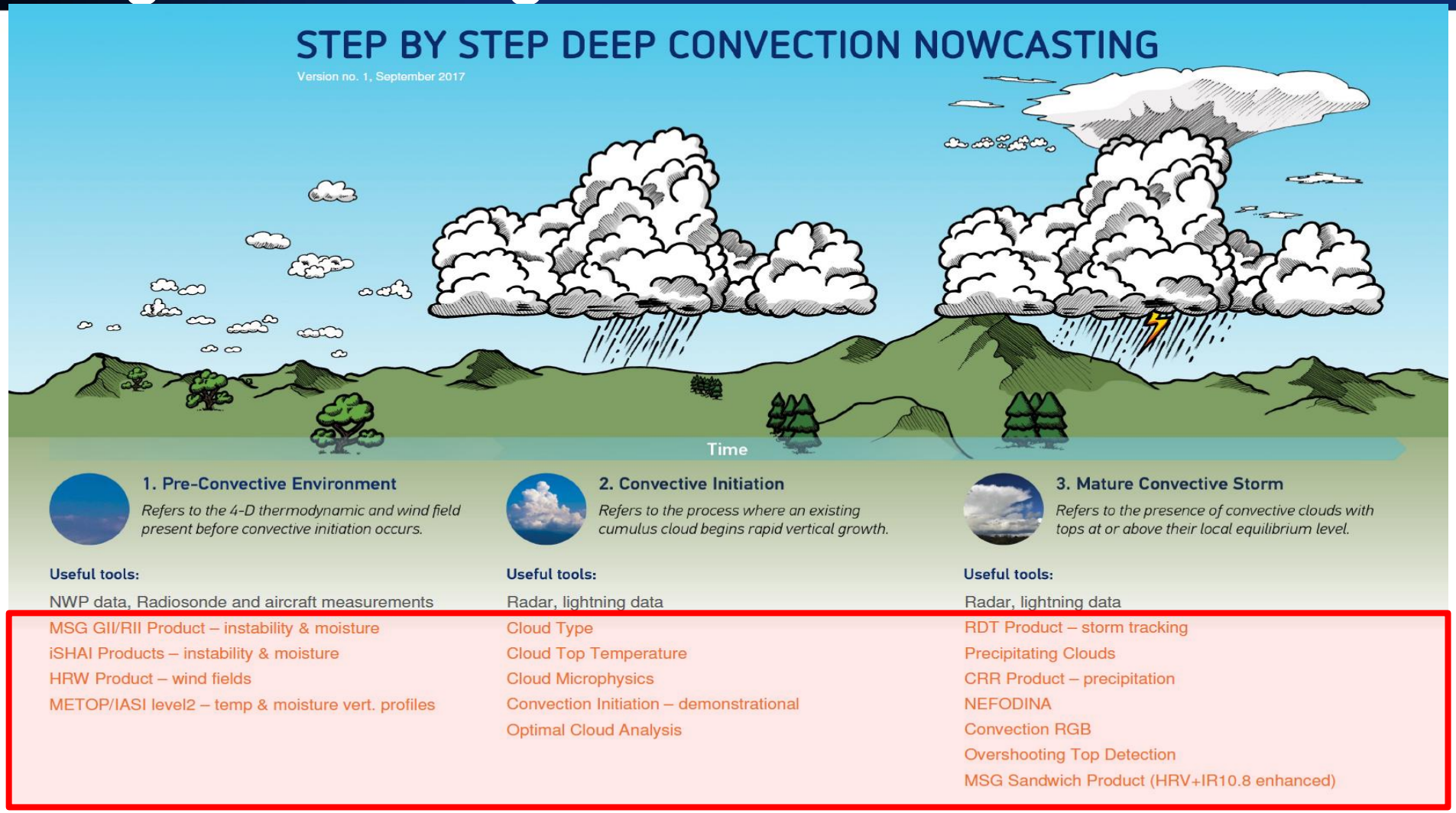


Meteosat for confirmation of forecasts

Winter storm "Klaus" 2009
MSG Water Vapour Imagery

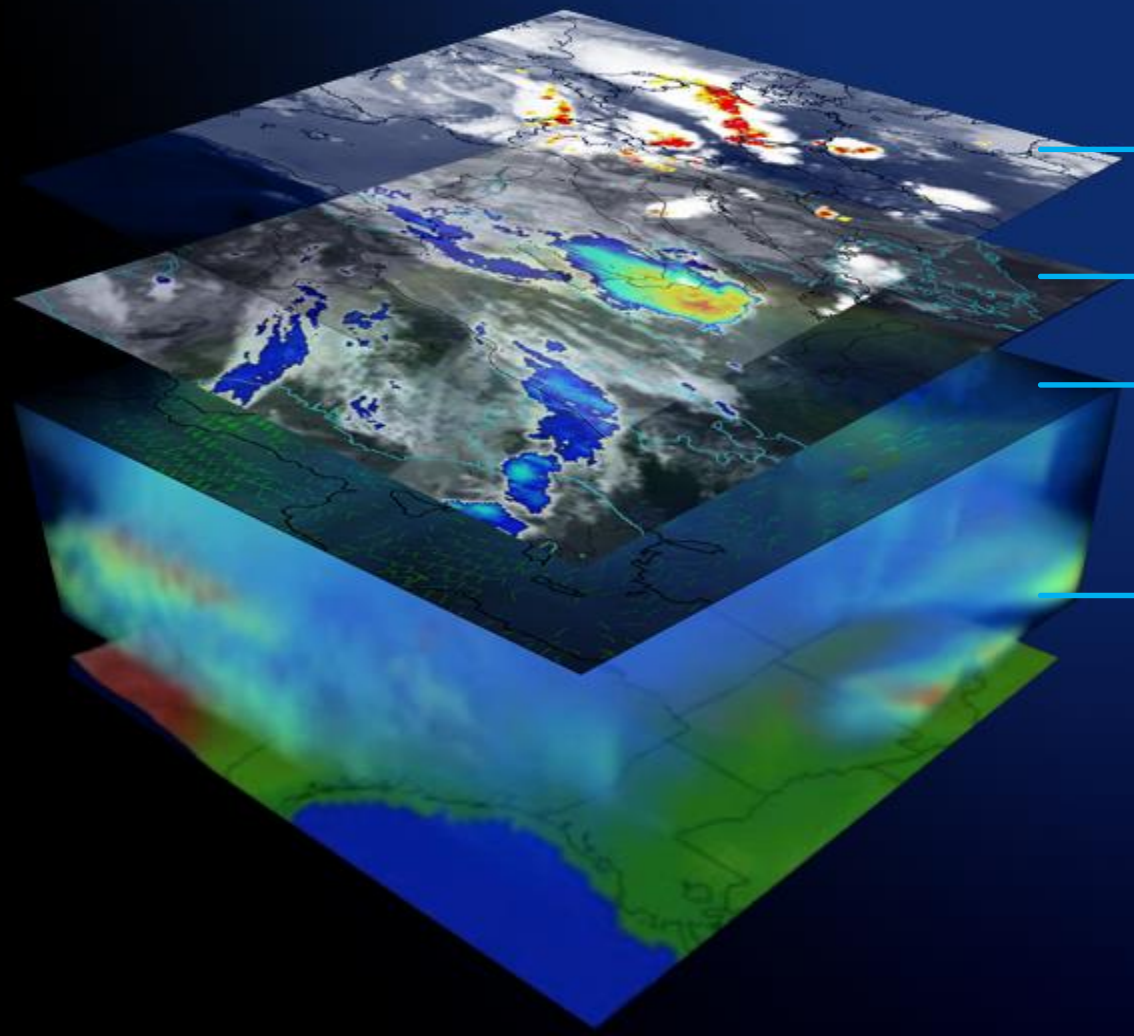


Key motivation for Meteosat Third Generation: Enhancing Nowcasting of Severe Storms



Existing satellite products

4D Weather Cube



- Lightning
- Convection
- Winds
- Atmosphere

Every 30 min over Europe

Meteosat Third Generation: Imaging mission (MTG-I)

- Imagery mission implemented by two MTG-I satellites
- Full disc imagery every 10 minutes in 16 bands
- Fast imagery of Europe every 2.5 minutes
- New Lightning Imager (LI)

- **Start of operations in 2022**
- **Operational exploitation: 2022-2042**

Meteosat Third Generation: Sounding mission (MTG-S)

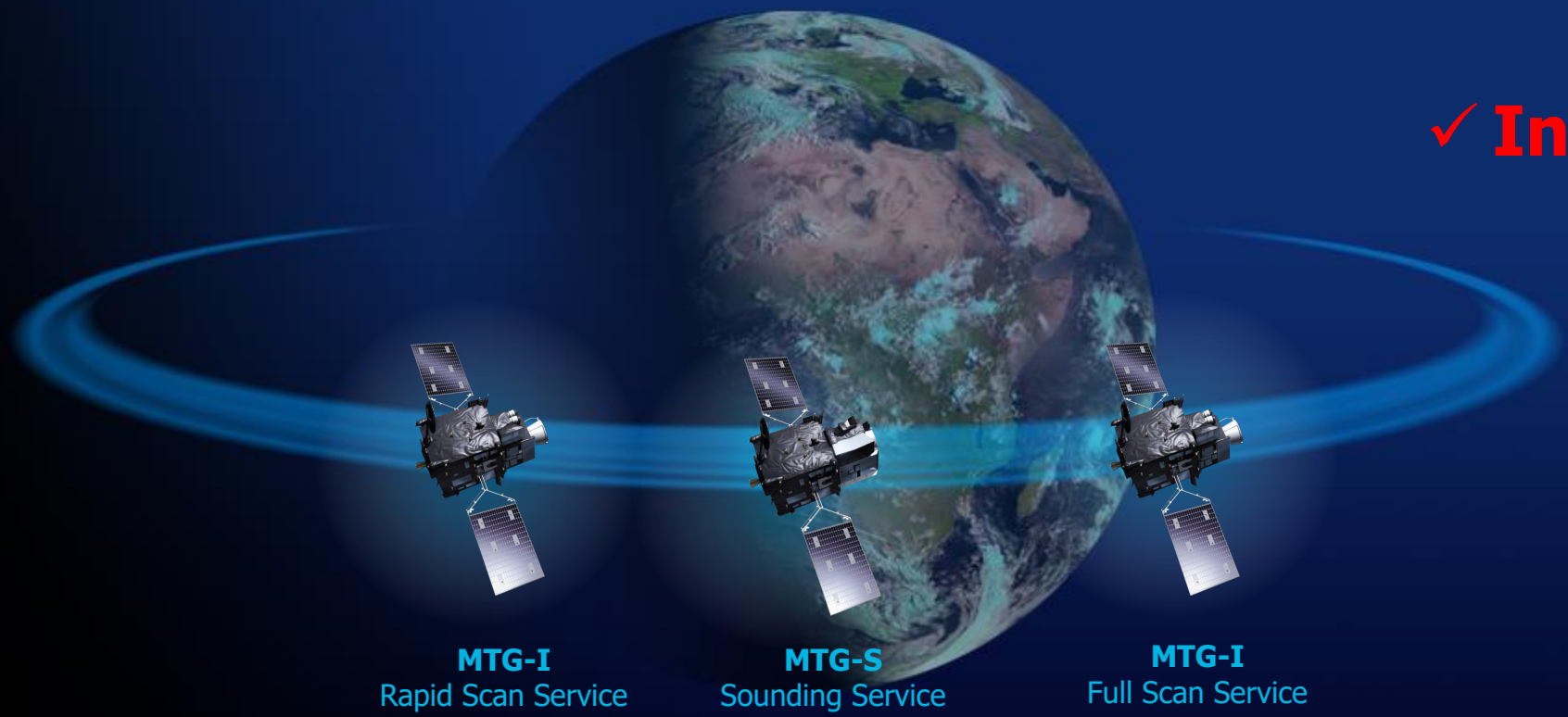
- Hyperspectral infrared sounding mission
- Temperature, water vapour, O3 profiles, every 30 minutes over Europe
- Air quality monitoring and atmospheric chemistry in synergy with Copernicus Sentinel-4 instrument

- **Start of operations in 2024**
- **Operational exploitation: 2024-2043**

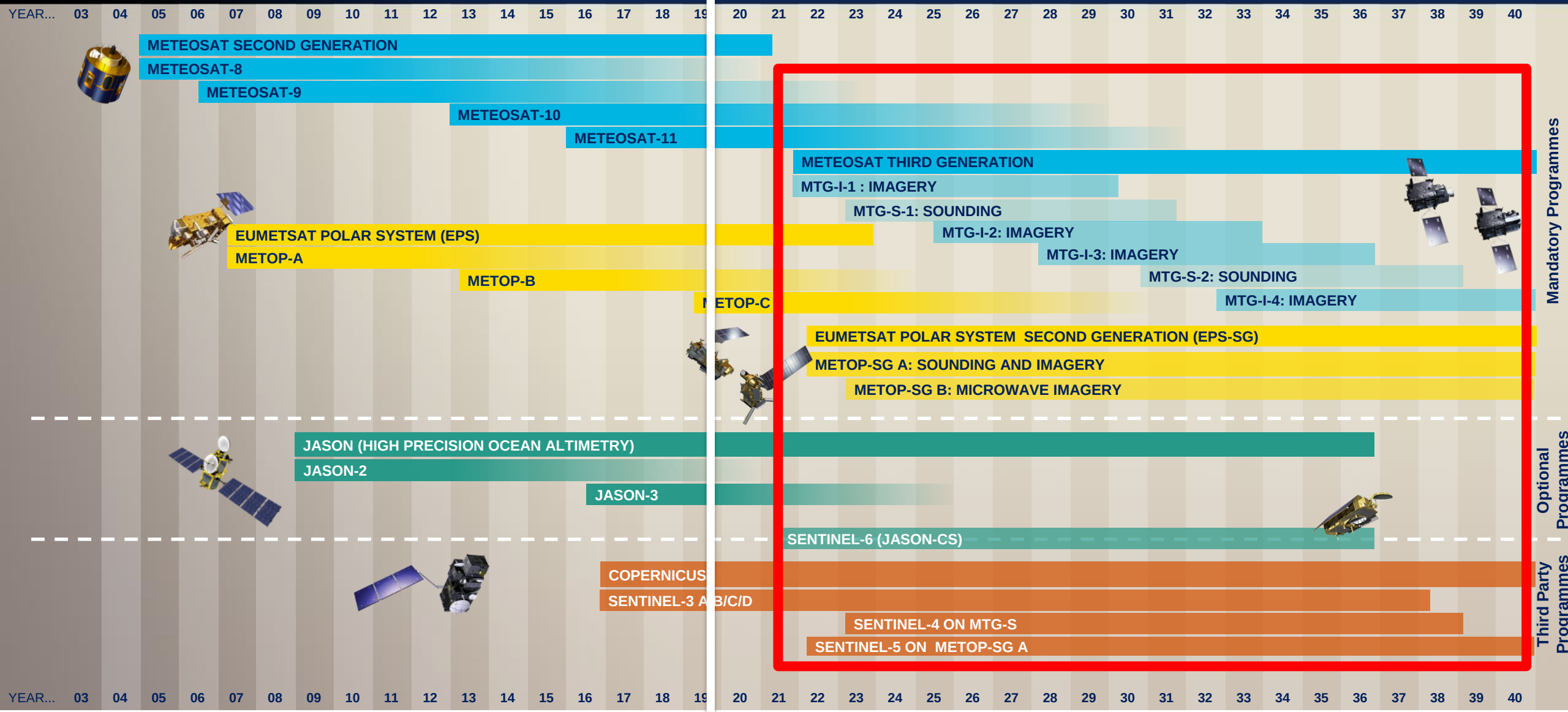
Full operational configuration (~ 2026)

✓ **Continuity**

✓ **Innovation**



EUMETSAT Next-generation Missions: European multi-satellite programmes for long-term commitments - until early 2040s



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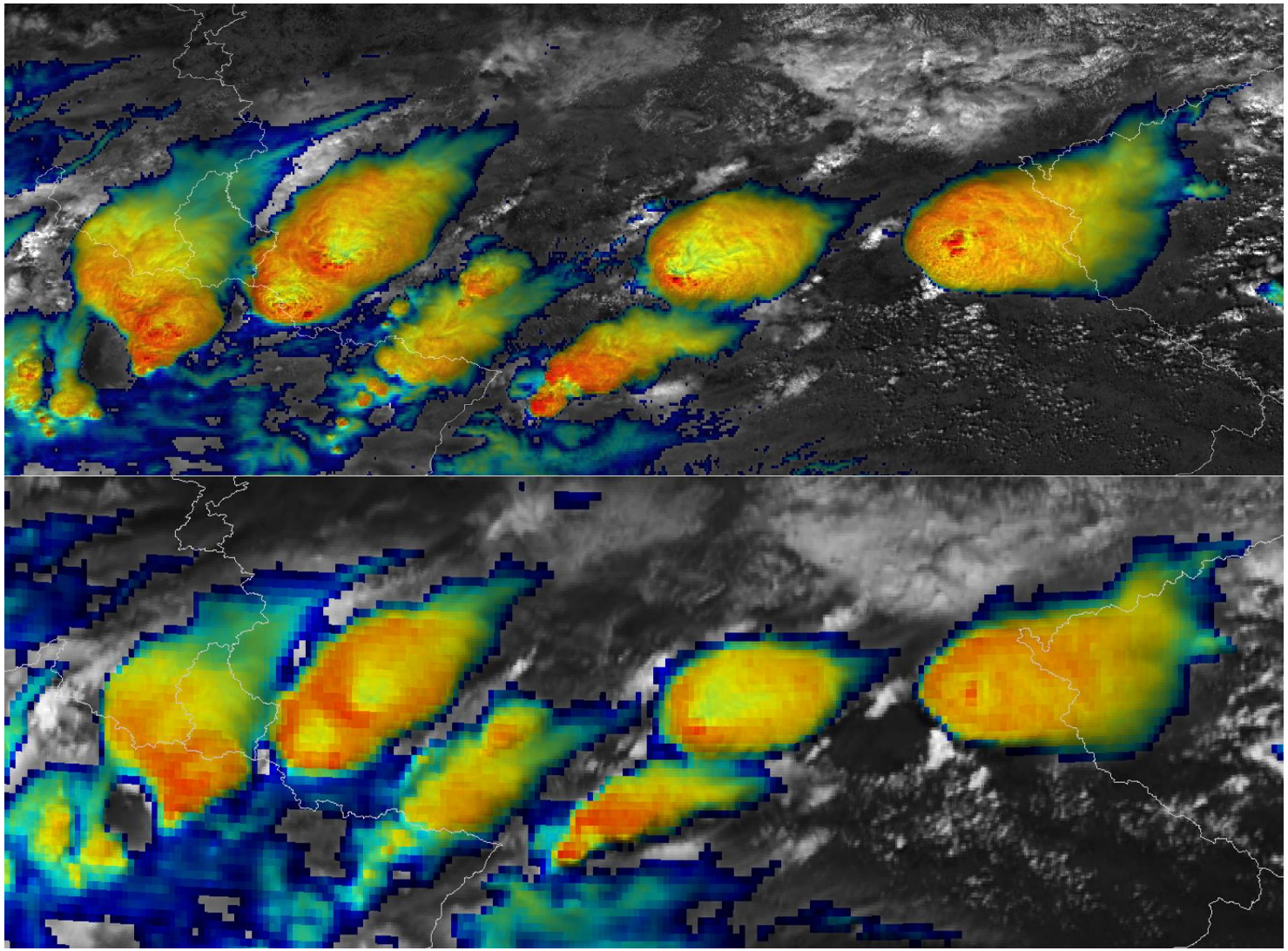
Some expected improvements from

Meteosat Third Generation (MTG) missions

MTG Imager (FCI): New insights into convective storms through higher spatial and temporal resolution imagery

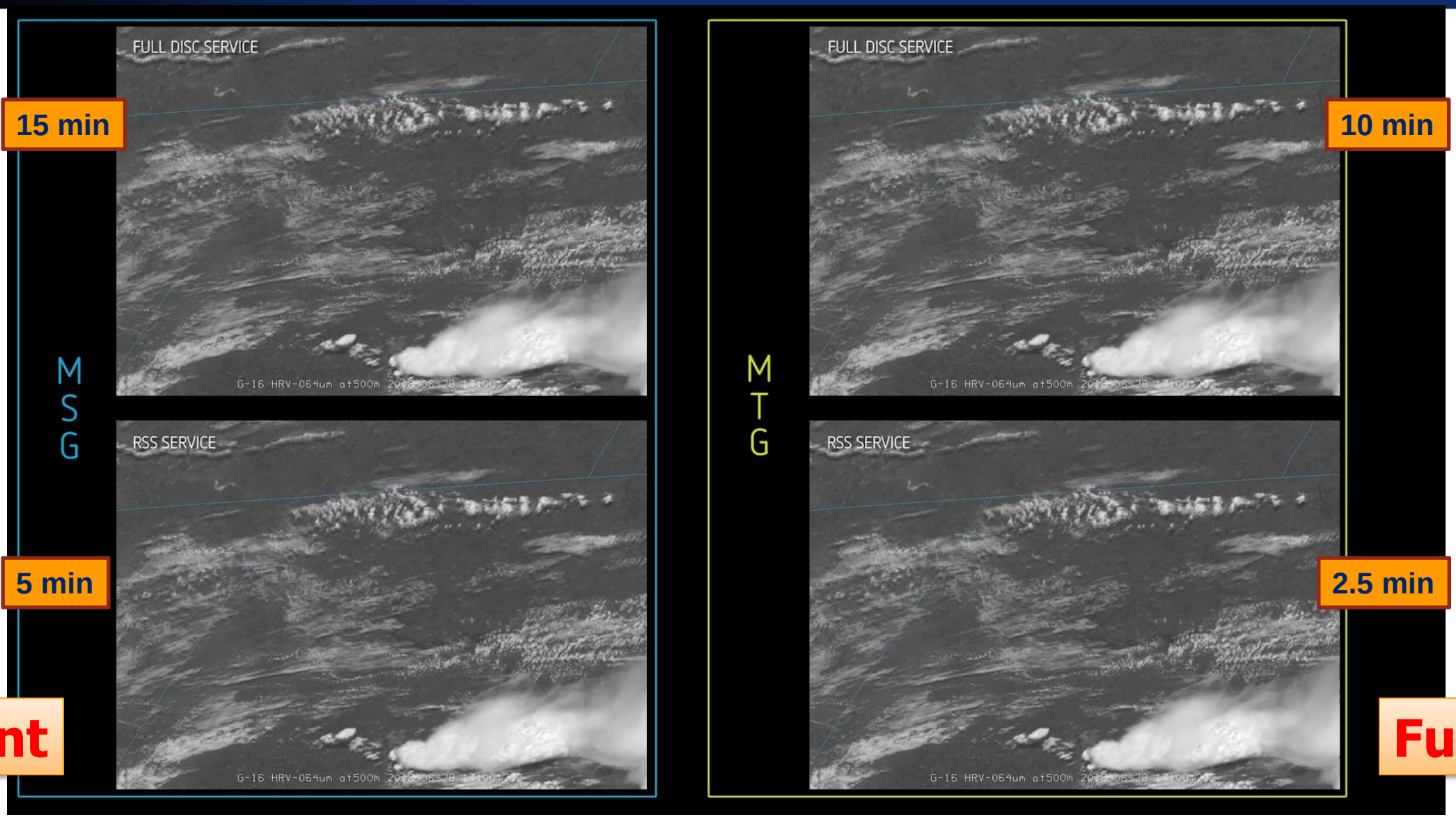
Future



Current

Source: M. Setvak; 11 June 2018, 11.37 UTC; SEVIRI data in lower panel, and upper panel with FCI imagery simulated over Central Europe based on data from the VIIRS instrument on the NOAA Suomi-NPP satellite; combining 0.865 µm imagery (background) and 11.45 µm (convective storms) to a 'sandwich' product.

MTG Imager (FCI): New insights through higher temporal resolution



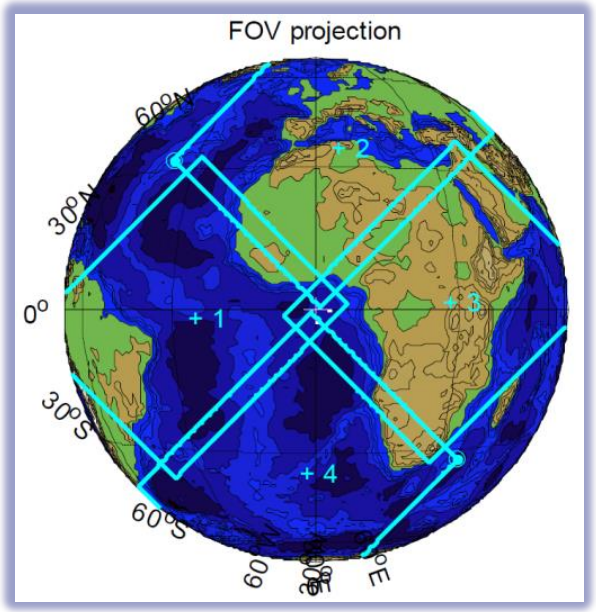
Improvements through the MTG Imager (FCI)

- **New spectral channels (vs current Meteosat):**
  - 0.444 µm and 0.51 µm: for **true colour images** and improved **aerosol retrievals**
  - 0.91 µm: **daytime total column precipitable water** (esp low-level, over land)
  - 1.375 µm: improved detection of **very thin cirrus clouds**
  - 2.26 µm: **improved retrieval of cloud microphysics.**
- Higher spatial resolution (1 km and 2 km) of the 3.8 µm channel: **improved fire detection** and the quality of products.
- **Improved convection detection** through the shorter repeat cycle and better spatial resolution.

MTG lightning imager (LI) mission

- Lightning is a precursor of severe weather, with a lead time of tens of minutes
- Most ground-based lightning location systems are mainly sensitive to cloud-to-ground lightning (CG)
- Often, no increase in CG observed due to “weather intensification” → **Total lightning is the parameter of interest**

Total lightning =
cloud-to-ground
+ cloud-to-cloud lightning

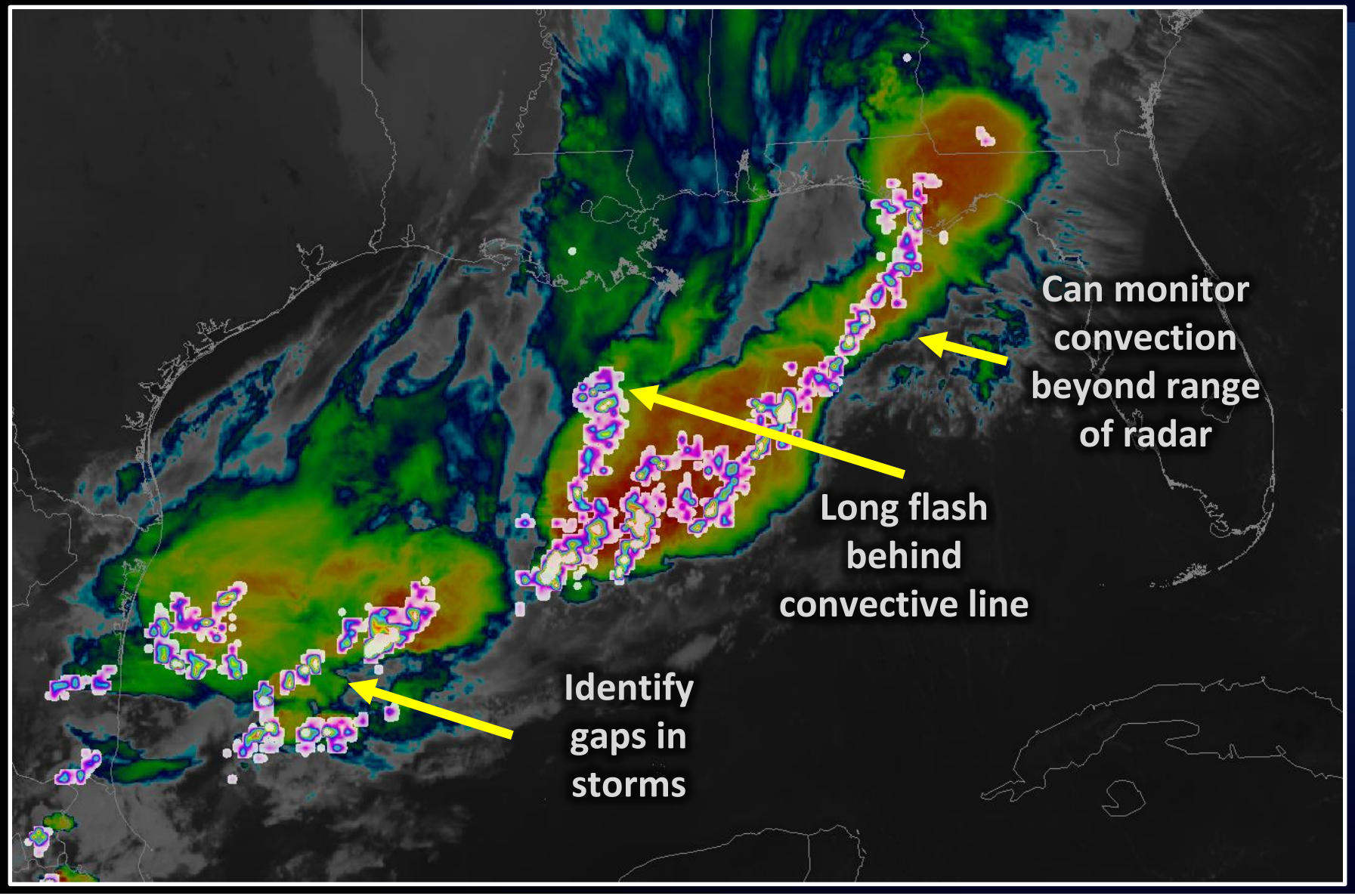


MTG Lightning Imager features:

Spatial resolution:
~ 4.5 km at sub-satellite nadir

Update cycle of accumulated product:
30 seconds

MTG Lightning Imager (LI): U.S. Proxy Data

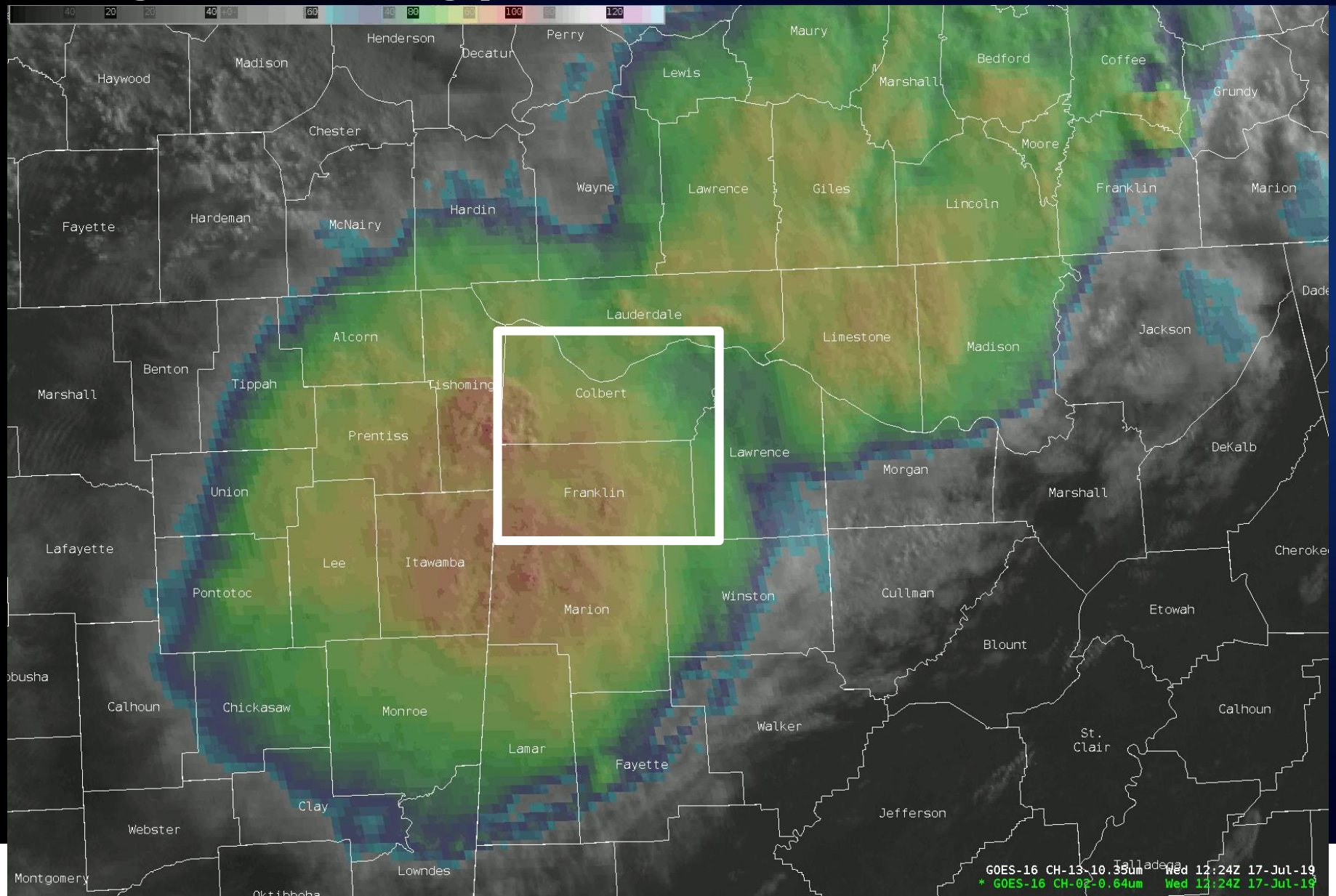


- GOES Lightning Mapper (GLM) Group Density
- Repeat cycle: 1 min
- Horizontal resolution: 8 km

- GOES ABI 11.2 IR
- 4 May 2017

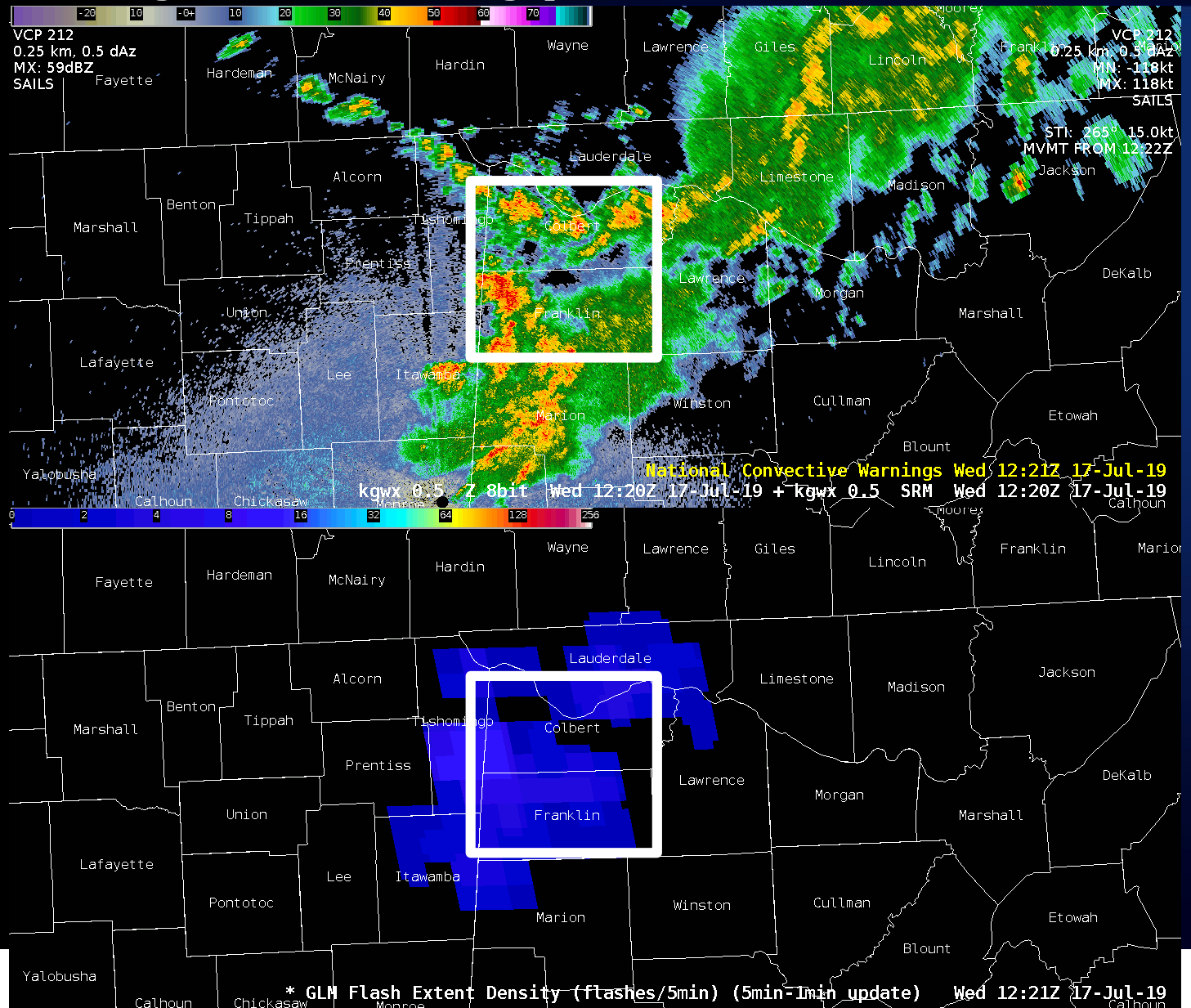
- Source: G. Stano, NASA SPoRT

Example from Chris White (U.S. National Weather Service) - 17 July 2019: A typical Summertime Thunderstorm Event



Note the convection initiated further west and approaching the counties of Colbert and Franklin in northern Alabama, USA

Example from Chris White (U.S. National Weather Service) - 17 July 2019: A typical Summertime Thunderstorm Event



GLM Flash Extent Density product (FED)

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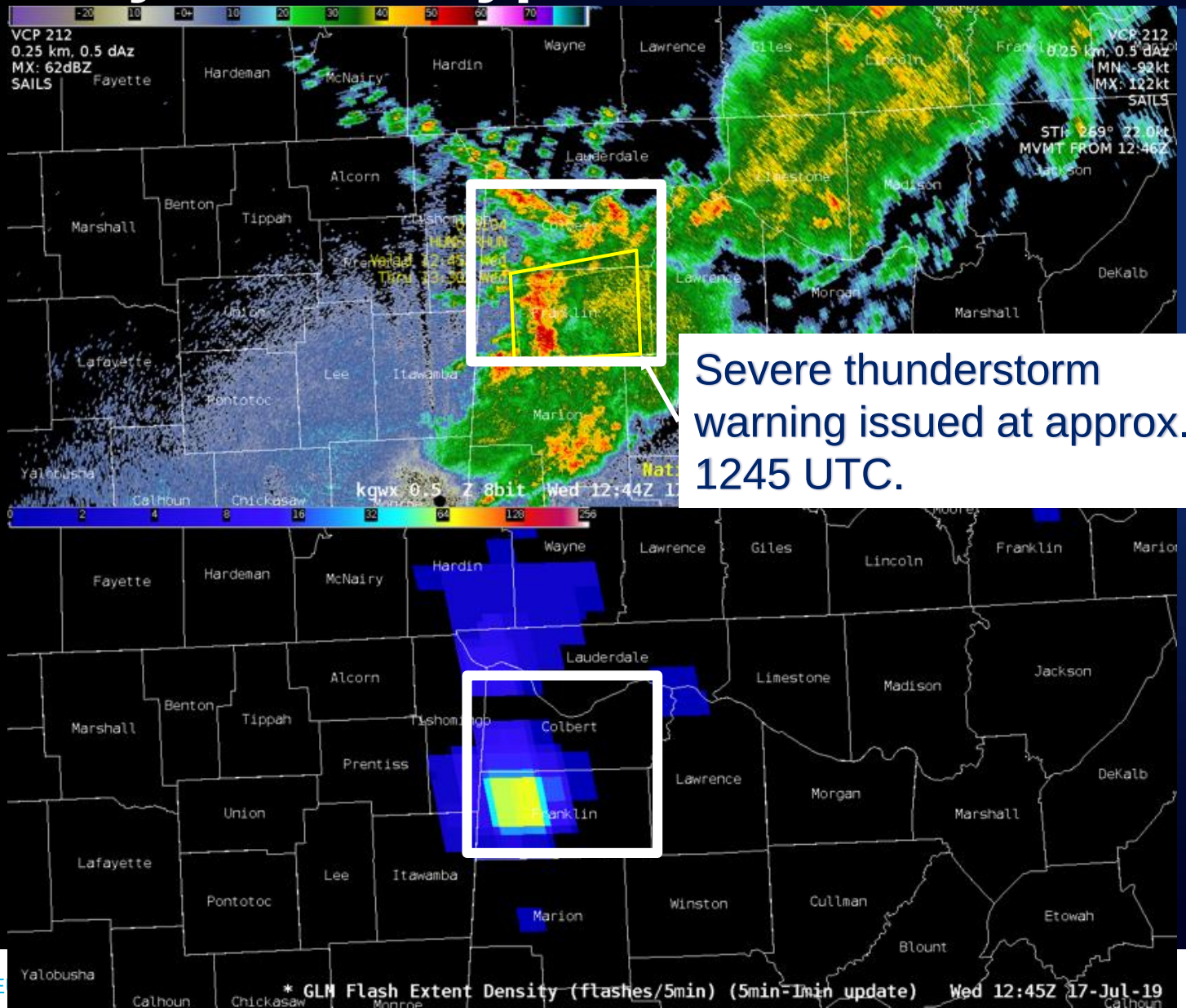
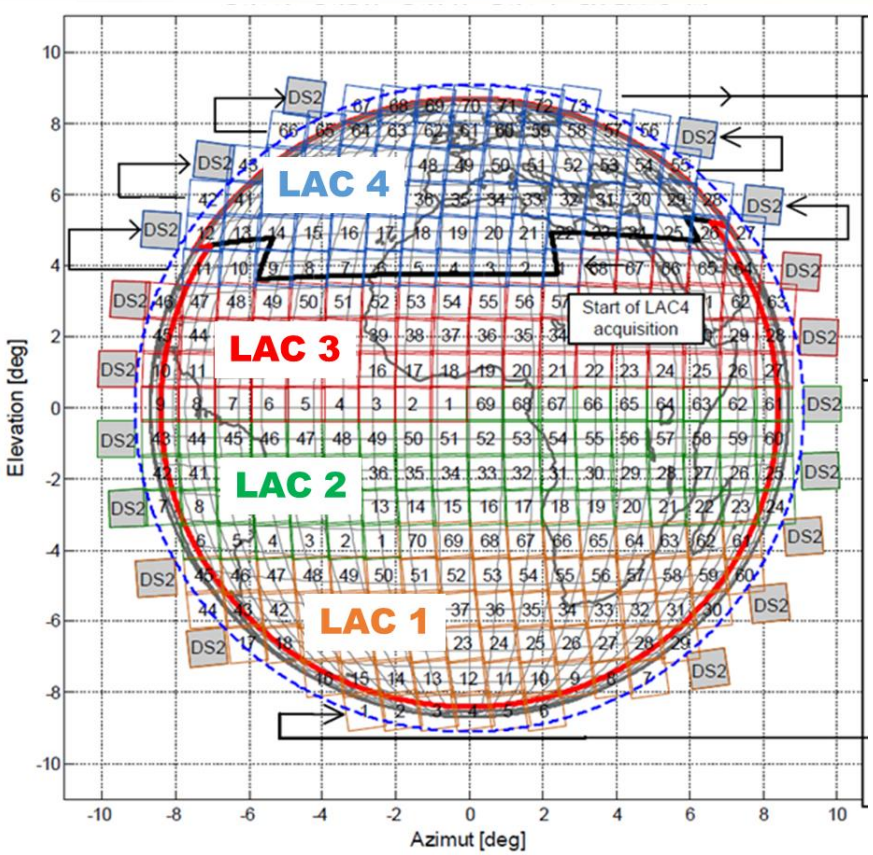
Example from Chris White (U.S. National Weather Service) - 17 July 2019: A typical Summertime Thunderstorm Event

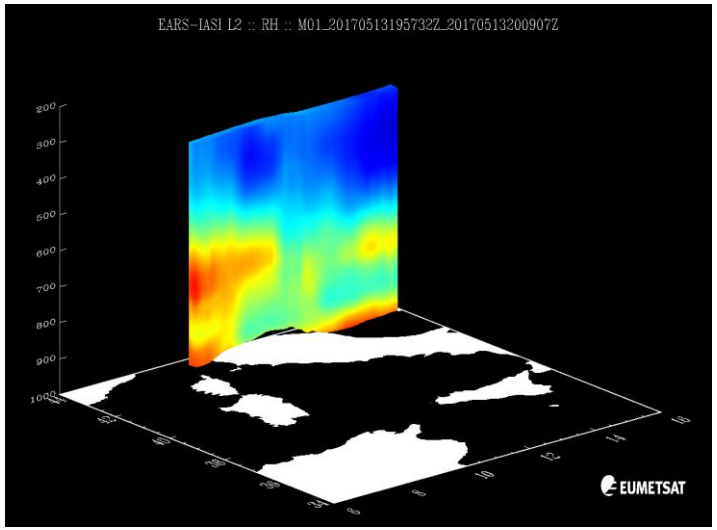


Chris White / NWS-Alabama:

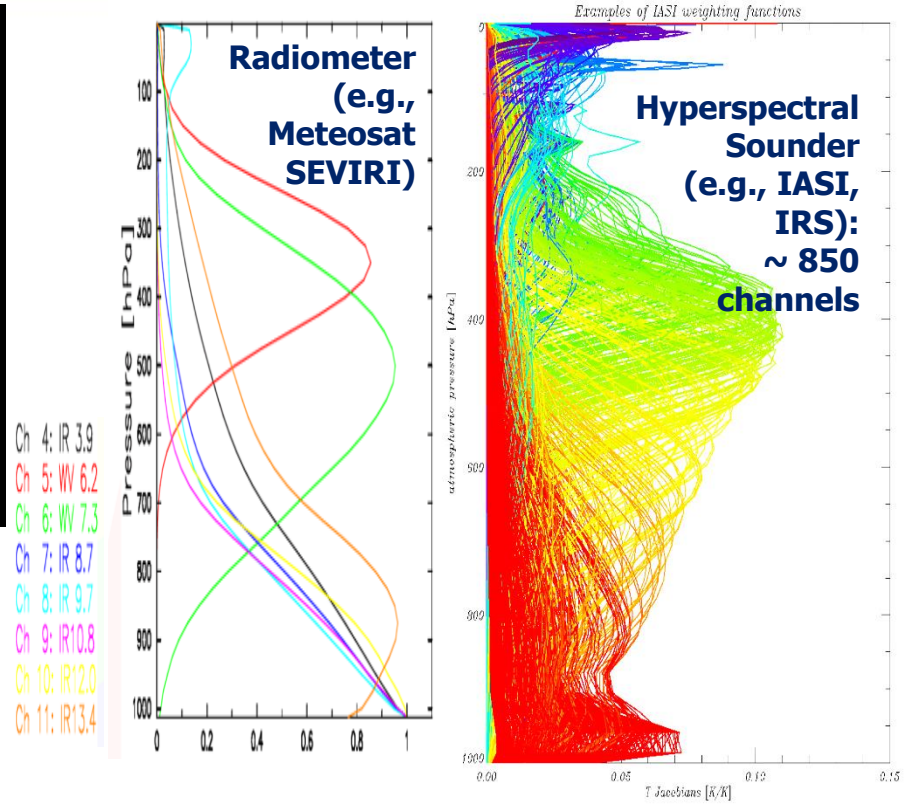
- Watching for jumps or increases in GLM to provide focus for strongest updraft
- GLM can provide evidence that a storm, which is considered “near severe”, may be about to produce severe weather, tipping the scales in favor of issuing a warning.
- **But GLM alone is not sufficient to determine thunderstorm severity**
- **It can provide higher confidence in warning decisions when lightning products match trends from other observational platforms**

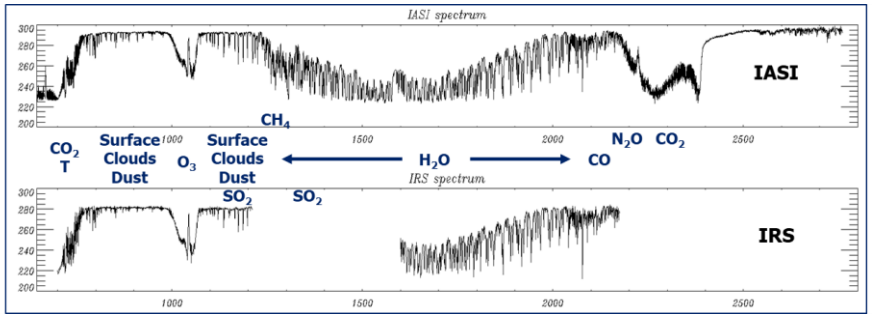
MTG InfraRed Sounder (IRS)





Major innovation: Operational spectro-imagery at high spectral, spatial & temporal resolution

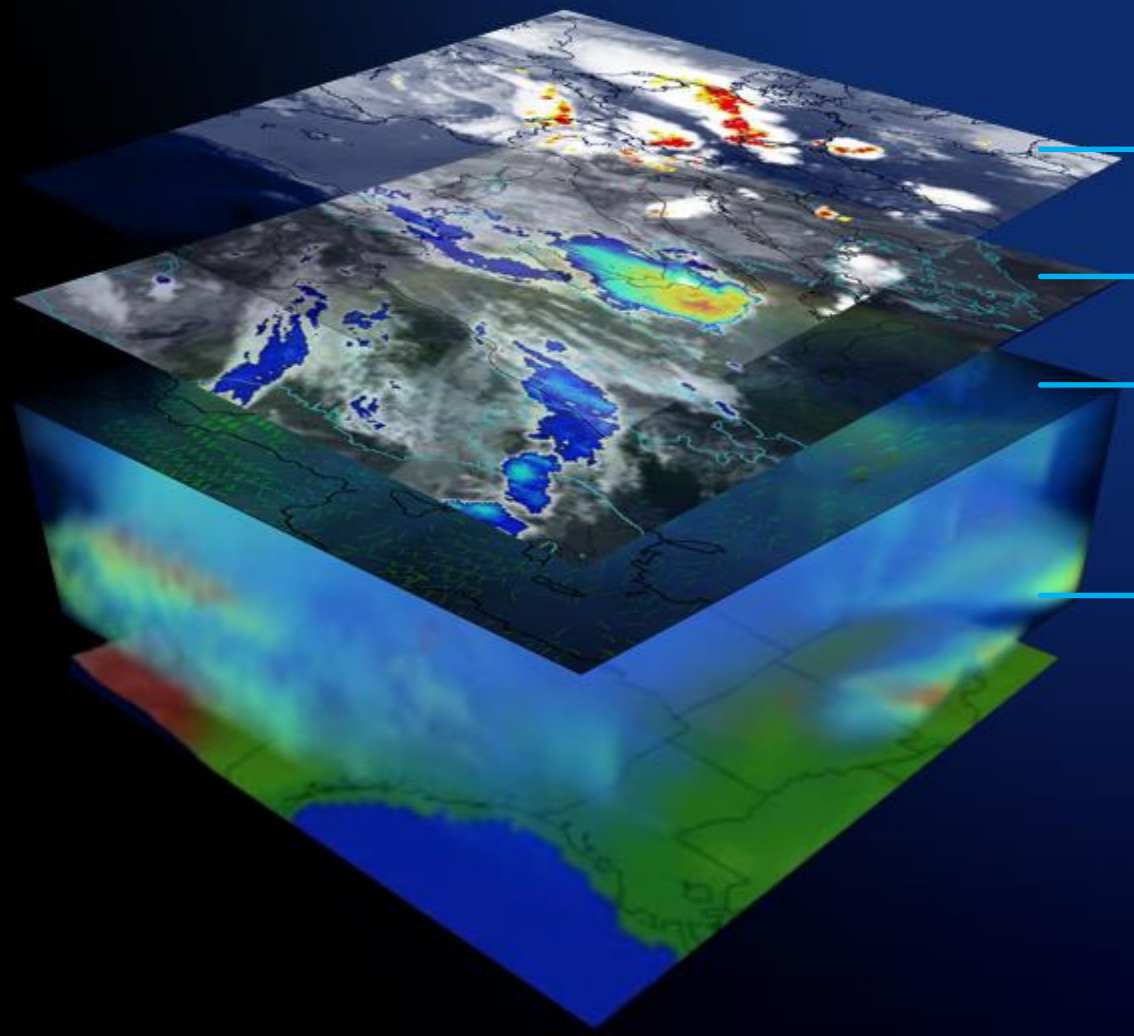




4 Local Area Coverage (LAC):

- One LAC acquired within 15’
- Overlapping step & stare dwells
- 160x160 pixels, ~4km at Nadir
- Europe (LAC 4) observed every 30’

Summary: 4D Weather Cube



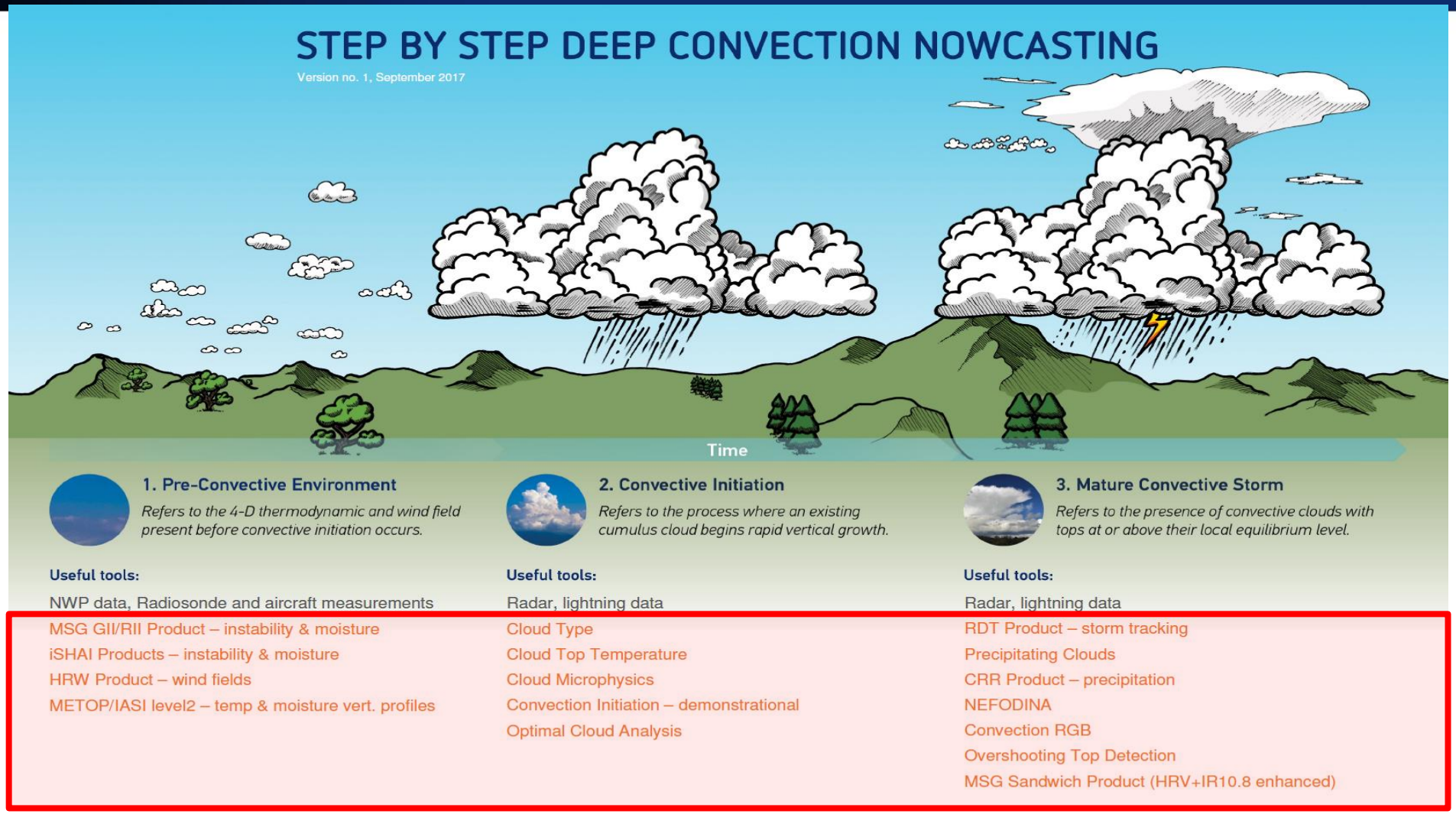
- Lightning
- Convection
- Winds
- Atmosphere

Every 30 min over Europe

MTG Imager and Sounder: Tools for Nowcasting

Existing satellite products

To be enhanced with MTG data



In Summary: Application scenarios for MTG data

- Monitoring and nowcasting severe convective storms
- Detecting convective initiation, a precursor of potentially severe storms
- Fog detection for transport safety
- Lightning monitoring for storm tracking over oceans
- Air quality monitoring
- Fire detection and monitoring
- Enhancing numerical weather prediction

MTG User Preparation: Training Workshop on Applications

- Overview of MTG Applications enabled by
  - Flexible Combined Imager
  - Lightning Imager
  - InfraRed Sounder
  - Ultraviolet, Visible and Near Infrared Sounder (Sentinel-4)
- 23-27 September 2019, EUMETSAT HQ, Darmstadt, Germany
- 21 participants from 17 countries

Information on Meteosat Third Generation Programme

- www.eumetsat.int : Satellites : Future Satellites : Meteosat Third Generation
  - Technical Details
  - Test Data Releases
  - Data Access
- MTG User Preparation Project (MTGUP)
- User Helpdesk: ops@eumetsat.int

MTG Data and Geophysical Products* *excluding products from EUMETSAT Satellite Application Facilities (SAF)

MTG Level-1 Data				
	FCI	LI	IRS	UVN
Disseminated in near-real time	Compressed using CharLS algorithm: 16 imager channels (Full Disc Scanning Service), 4 imager channels at high spatial resolution (Rapid Scanning Service)	None	Principal component scores	None
Available from data archive	Uncompressed: 16 imager channels (Full Disc Scanning Service), 4 imager channels at high spatial resolution (Rapid Scanning Service)	Lightning Triggered Events	Full spectral channels, Principal component scores	Daytime Earth radiances and solar irradiances in NIR and UV/VIS bands

FCI: Flexible Combined Imager
LI: Lightning Imager
IRS: InfraRed Sounder
UVN: Ultra-Violet, Visible and Near-Infrared Sounder

MTG Level-2 Geophysical Products*				
	FCI	LI	IRS	UVN
	Atmospheric Motion Vectors All Sky Radiance Clear/Cloud/Dust/Ashes Flag Clear Sky Reflectance Cloud Analysis Fire Detection Global Instability Indices Cloud Drop Effective Radius Outgoing Longwave Irradiance at Top of Atmosphere Ozone Total Column Volcanic Ash	Accumulated Flash Area Accumulated Flash Radiance Accumulated Flashes Lightning Flashes Lightning Groups	Temperature profile Humidity profile Instability indices Ozone profile Surface temperature (land and sea) Surface emissivity (land) Cloud products (detection, fraction, top pressure)	Ozone Total Column Ozone Tropospheric Column Nitrogen Dioxide Total Column Nitrogen Dioxide Tropospheric Column Sulphur Dioxide Formaldehyde Glyoxal Aerosol Index Aerosol Layer Height

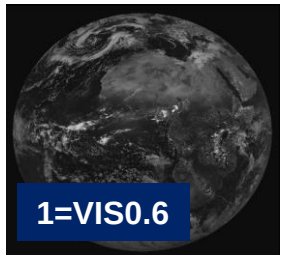
*Disseminated in near-real time, and available from data archive

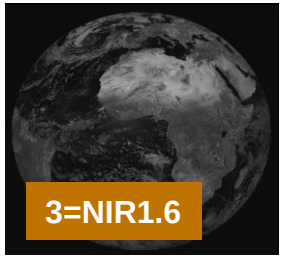
Thank you

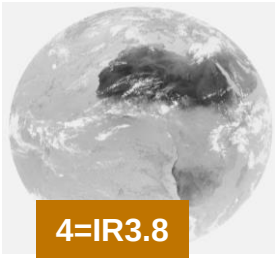
Questions?

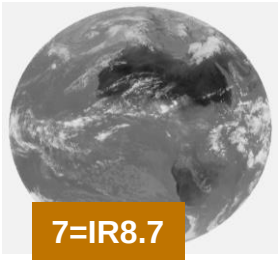
BACKUP

Current and future imagers channels: MSG SEVIRI and MTG FCI



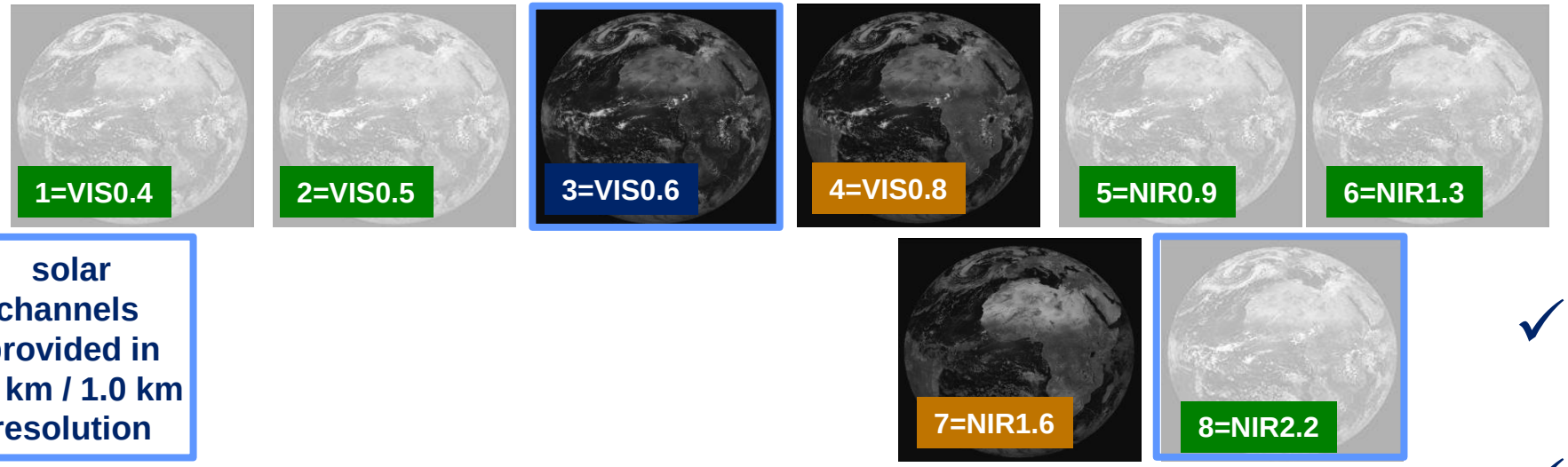






Current SEVIRI

Current and future imagers channels: MSG SEVIRI and MTG FCI



solar channels provided in 0.5 km / 1.0 km resolution

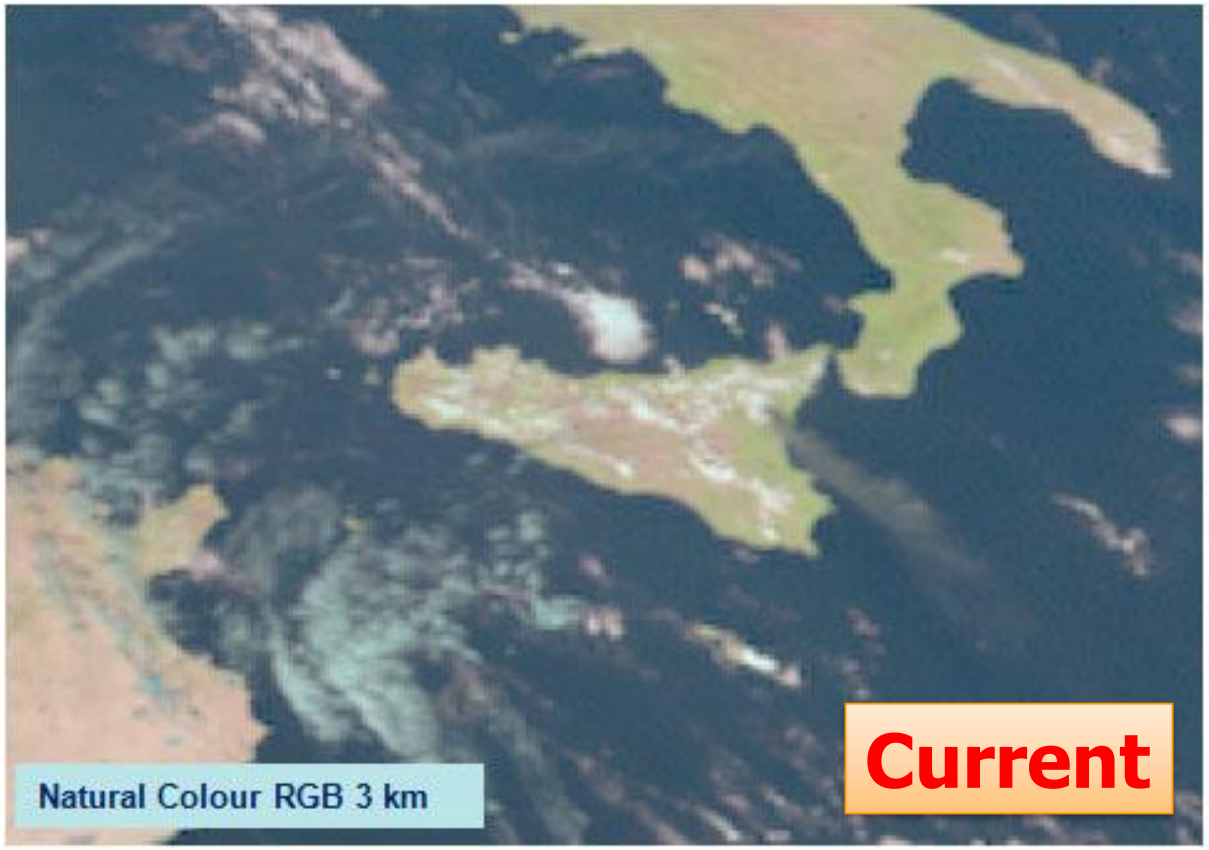
thermal channels provided in 1 km / 2 km resolution

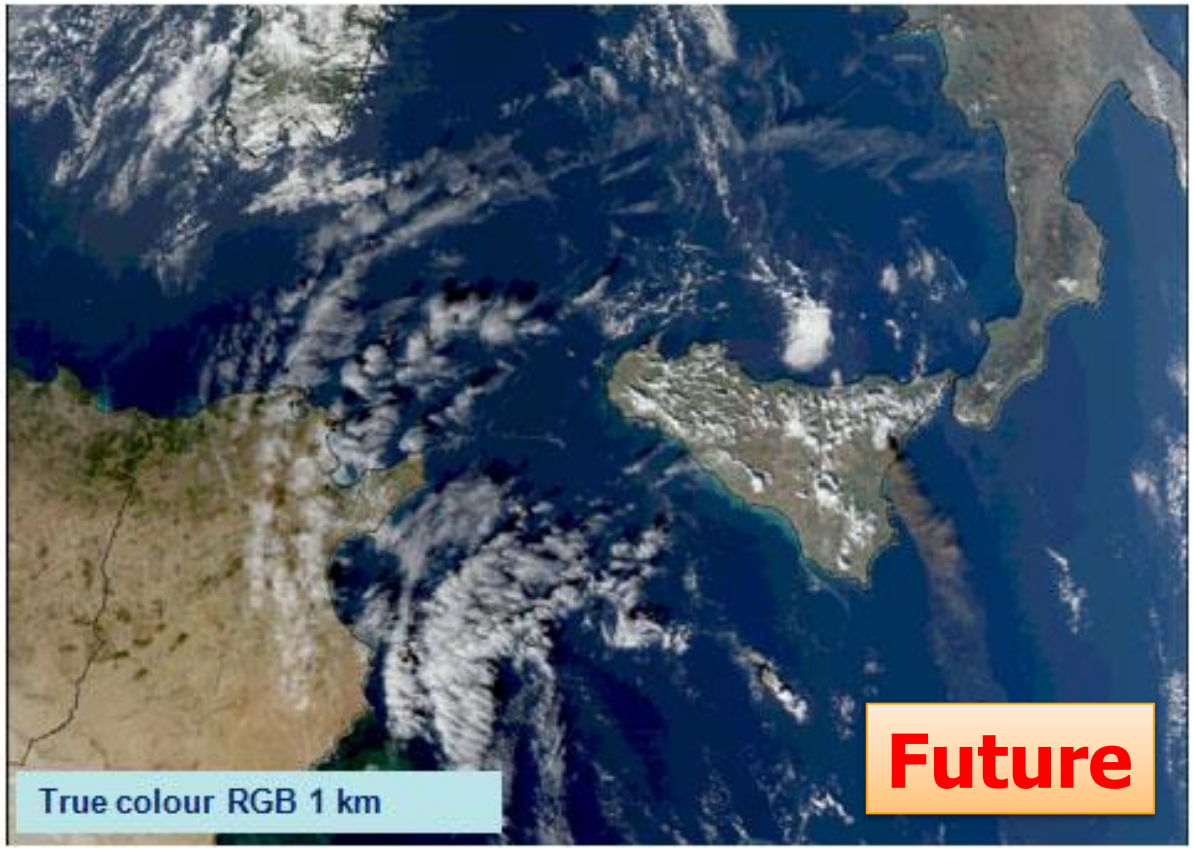
✓ **Continuity**

✓ **Innovation**

Future FCI

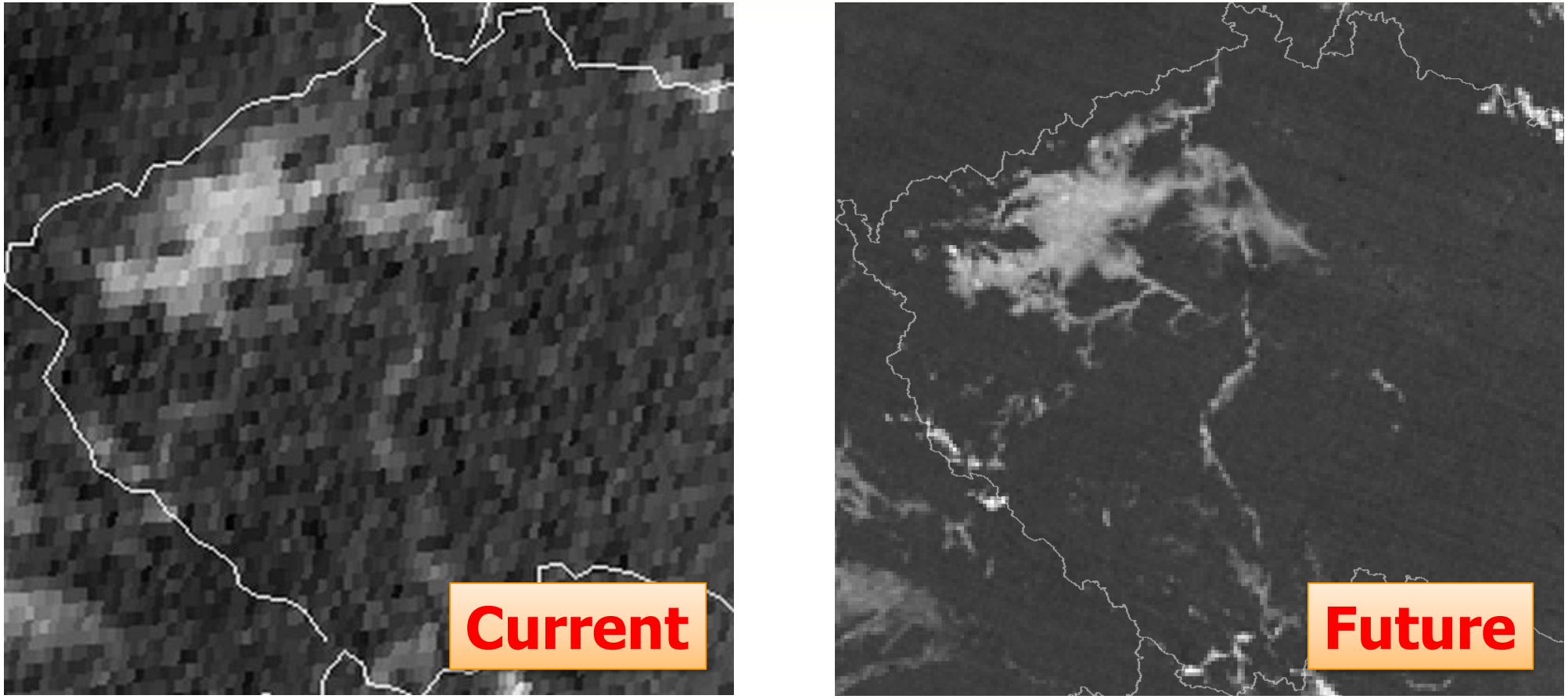
MTG Imager (FCI): higher spatial resolution imagery





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

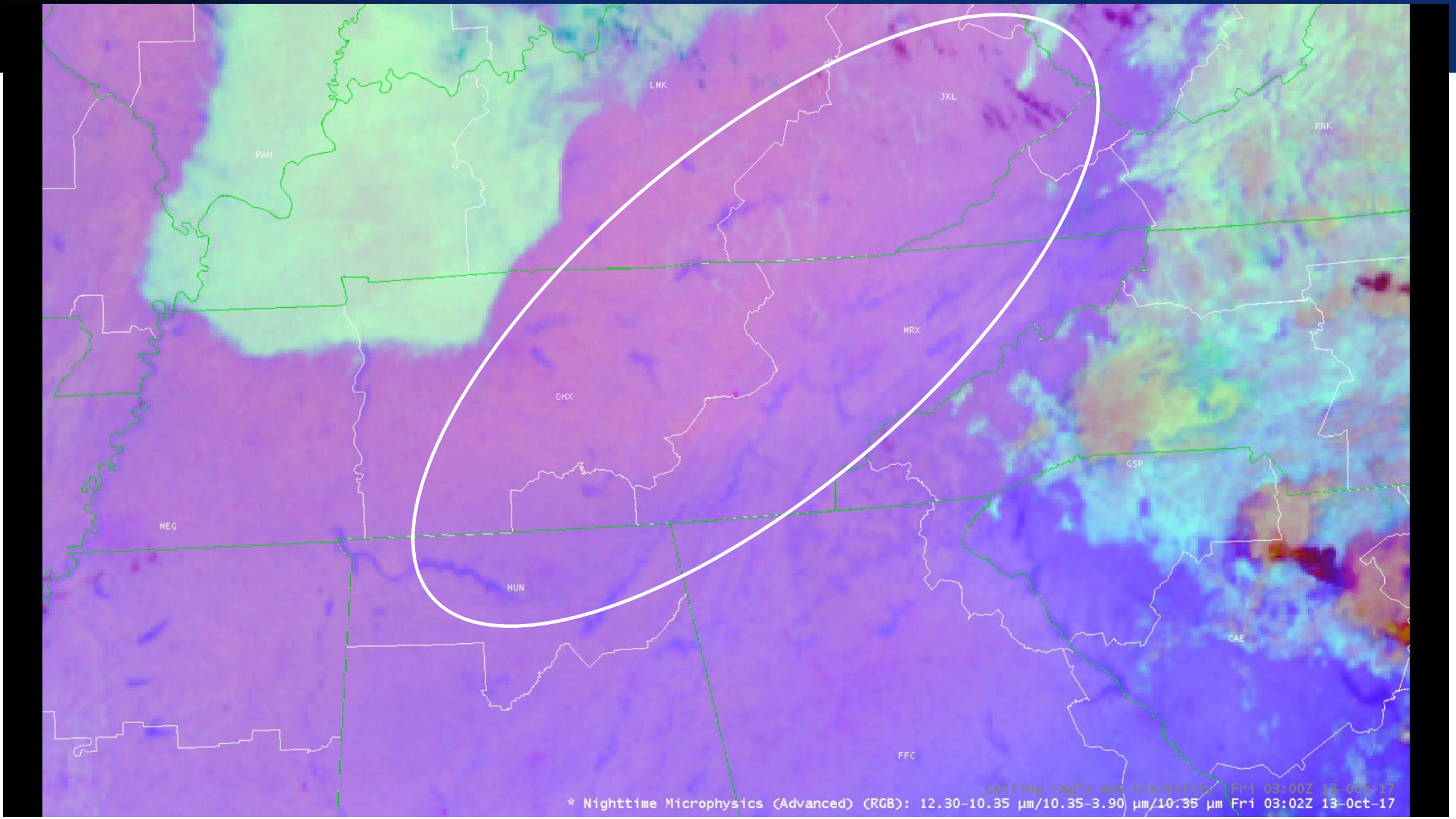
MTG Imager (FCI): higher spatial resolution imagery



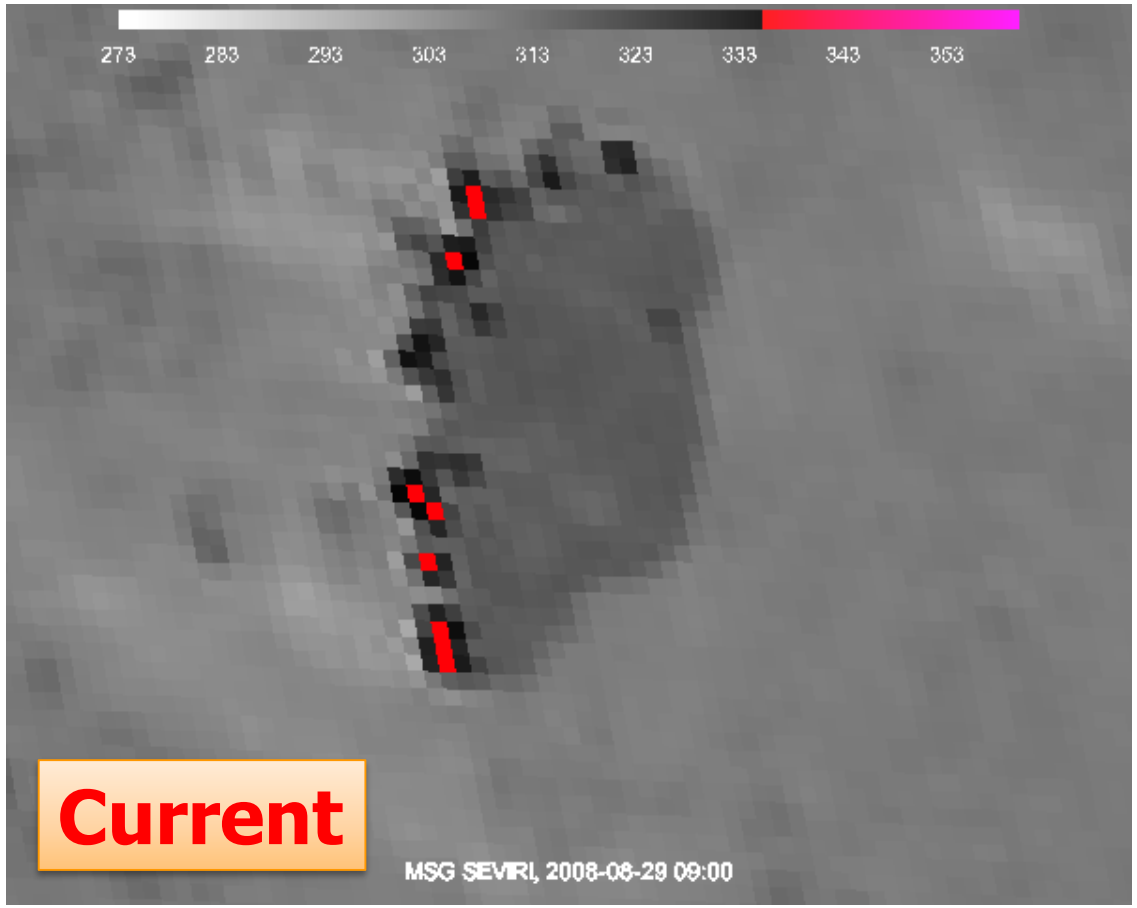
Example of fog detection over Czech Republic

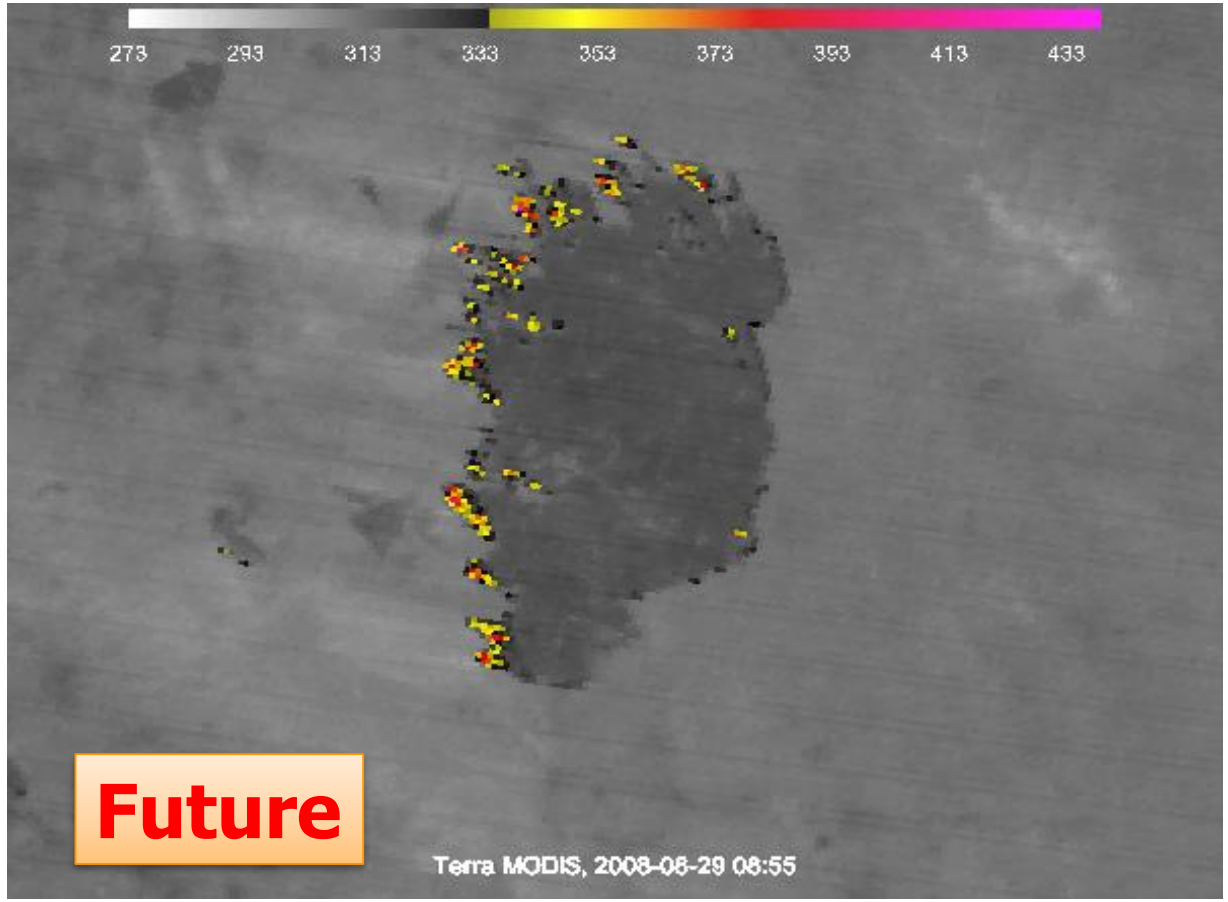
Source: M. Setvak, J. Kerkmann; 16 Nov 2018, 01.37 UTC
Right panel: simulated FCI imagery at ~2 km horizontal resolution (1 km at nadir), based on NOAA Suomi-NPP VIIRS data
Left panel: MSG SEVIRI imagery at 5 km horizontal resolution (3 km at nadir)

GOES-16 ABI: Early Detection of Fog Formation



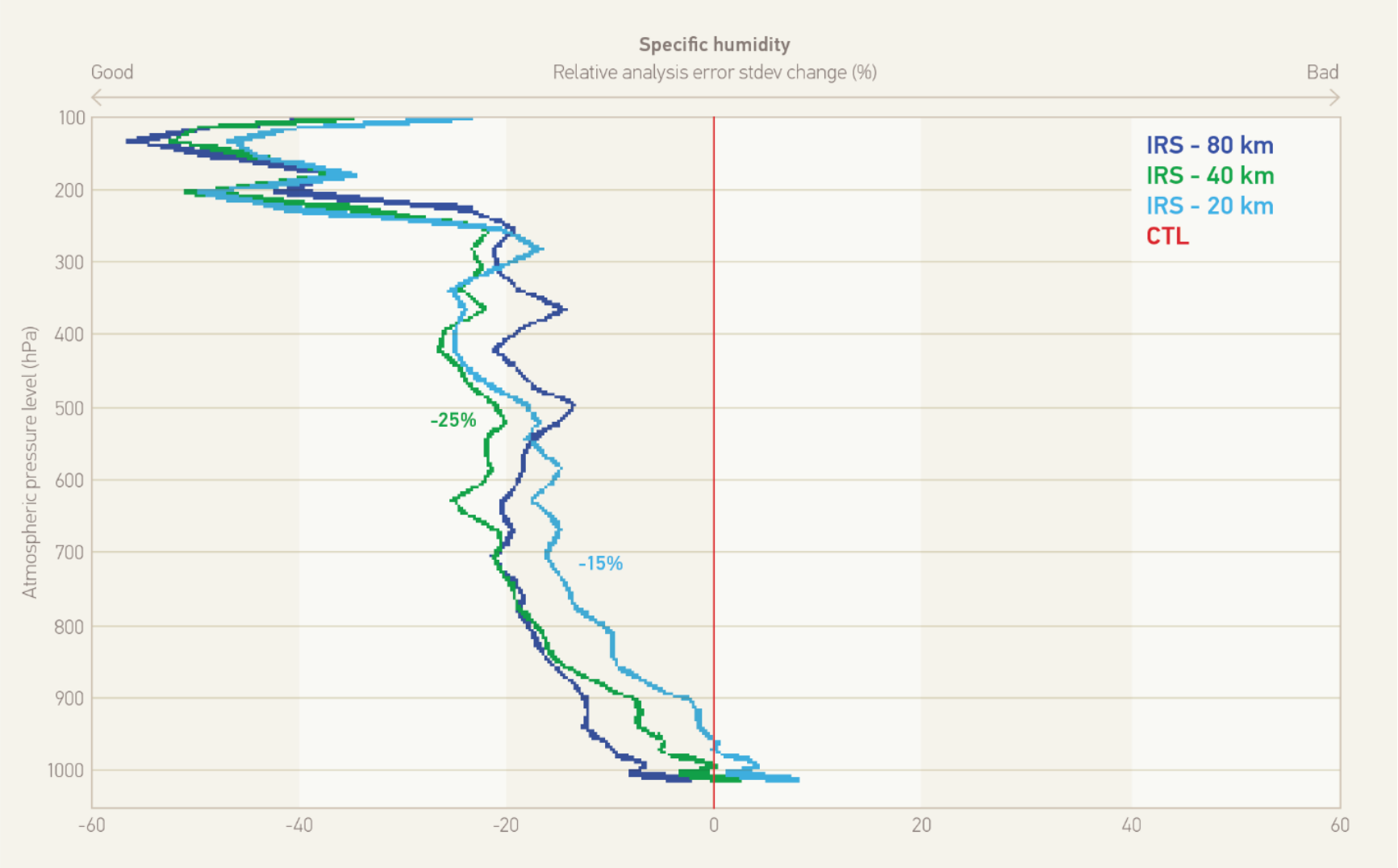
MTG Imager (FCI): New prospects for fire detection and monitoring





Bushfire line in Botswana as seen in imagery from current Meteosat (left panel) compared to future MTG imagery simulated by proxy data (right panel). MTG imagery will enable more precise detection of fire location and better fire intensity estimates.

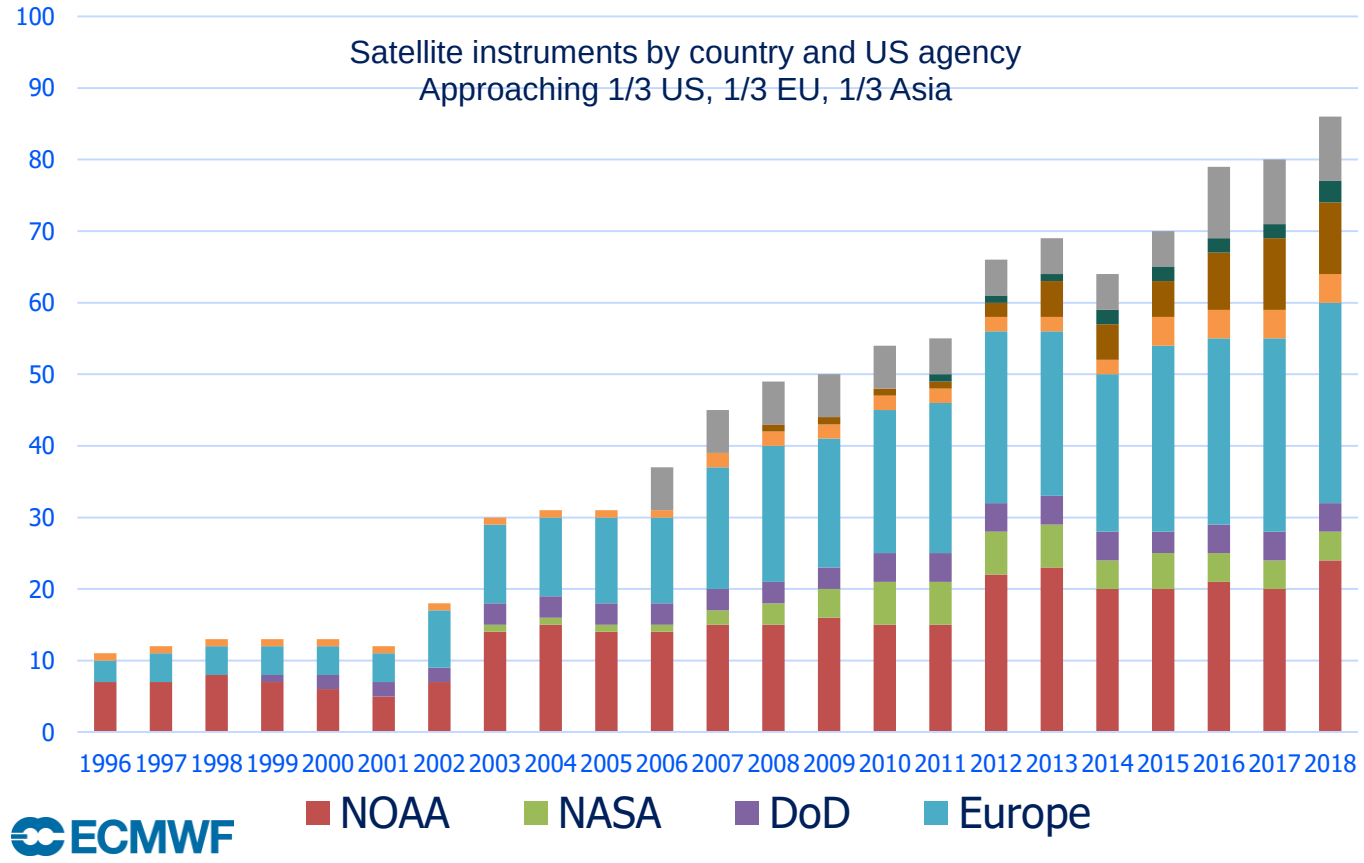
MTG InfraRed Sounder (IRS): Enhancing numerical weather prediction

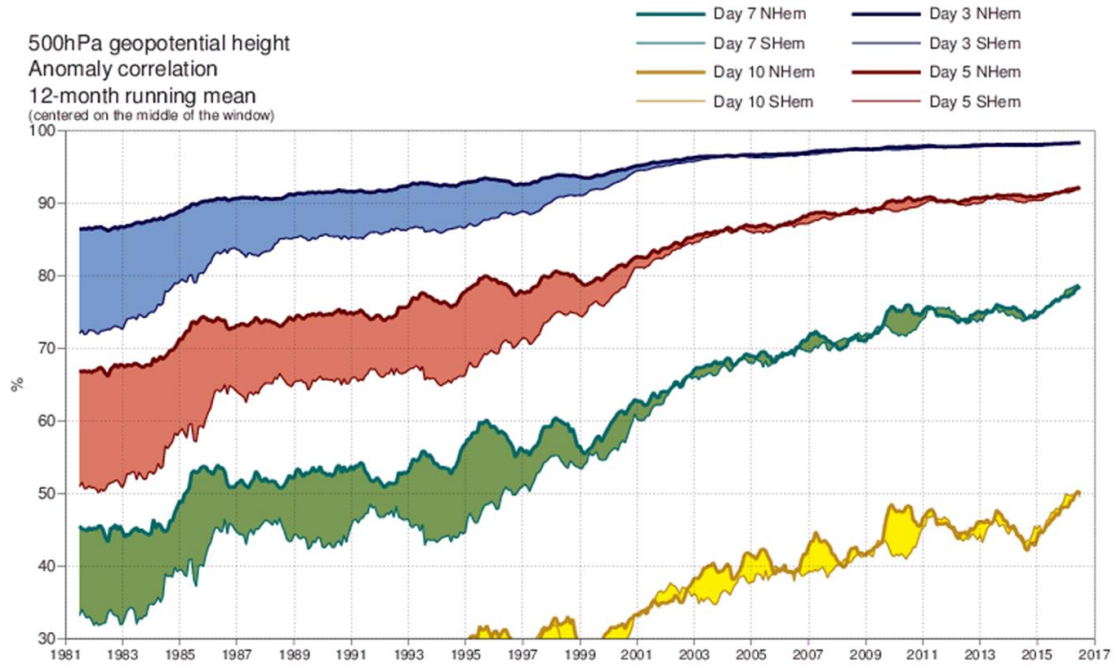


Simulated MTG infrared sounding data have a demonstrated positive impact on regional weather modelling, by reducing the error of forecasting specific humidity and other meteorological parameters

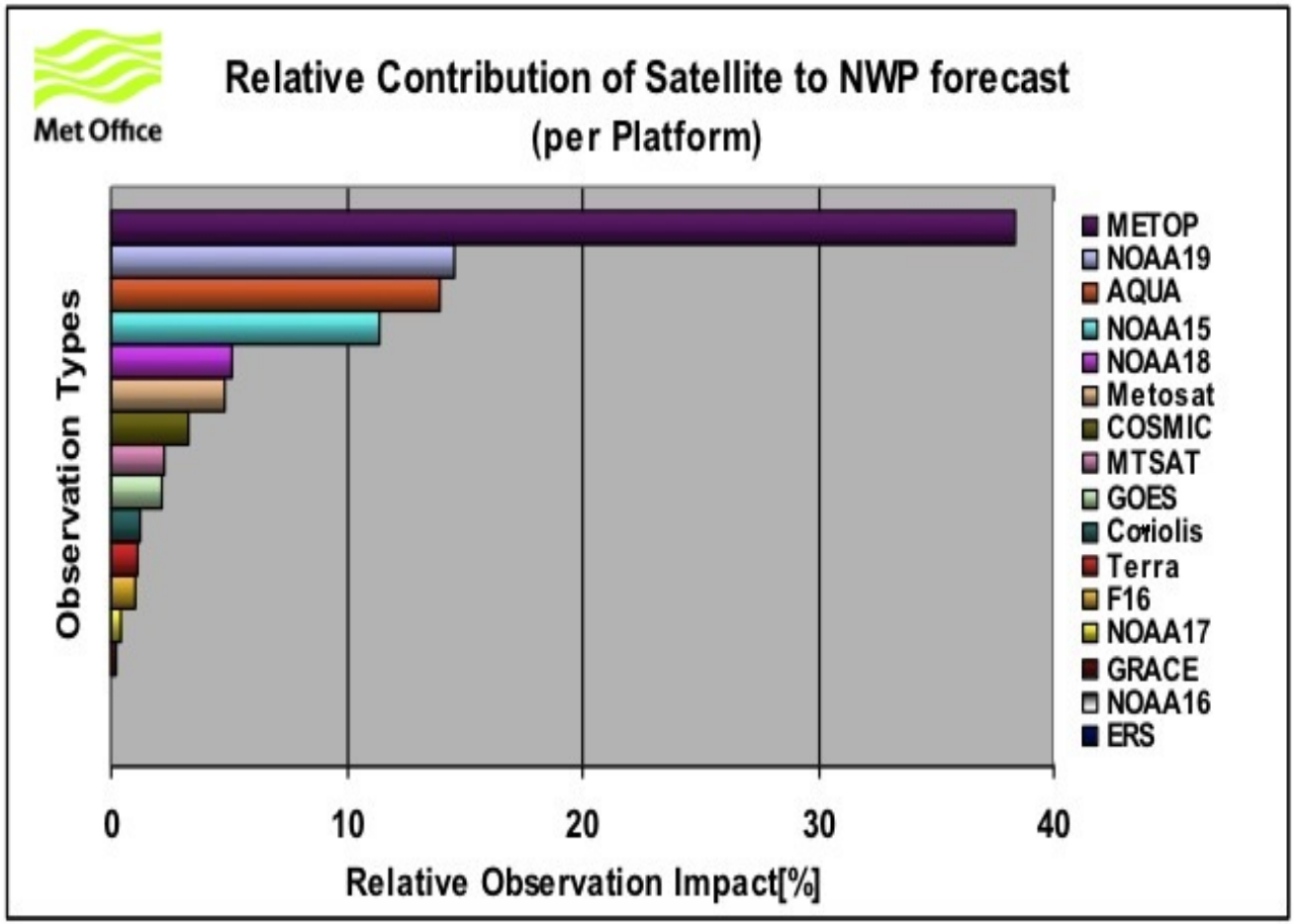
Source: Guedj et al., 2014

Application in global numerical weather prediction: EUMETSAT contributes to 1/3 of all Satellite Data Assimilated at ECMWF





Some figures from cost benefit analysis



- Operational EUMETSAT and NOAA polar satellites account for 45% of the impact of all observations on NWP forecasts
- Metop itself has the highest contribution at around 25% of all assimilated observations, and close to 40% of all satellite contributions
- Innovation pays off: Metop-A has 2.5 times the positive impact of one satellite from the previous generation (NOAA 19)
- Based on conservative assumptions, the benefits to cost ratio of the EPS-SG programme is certainly over 5 and likely to exceed 20

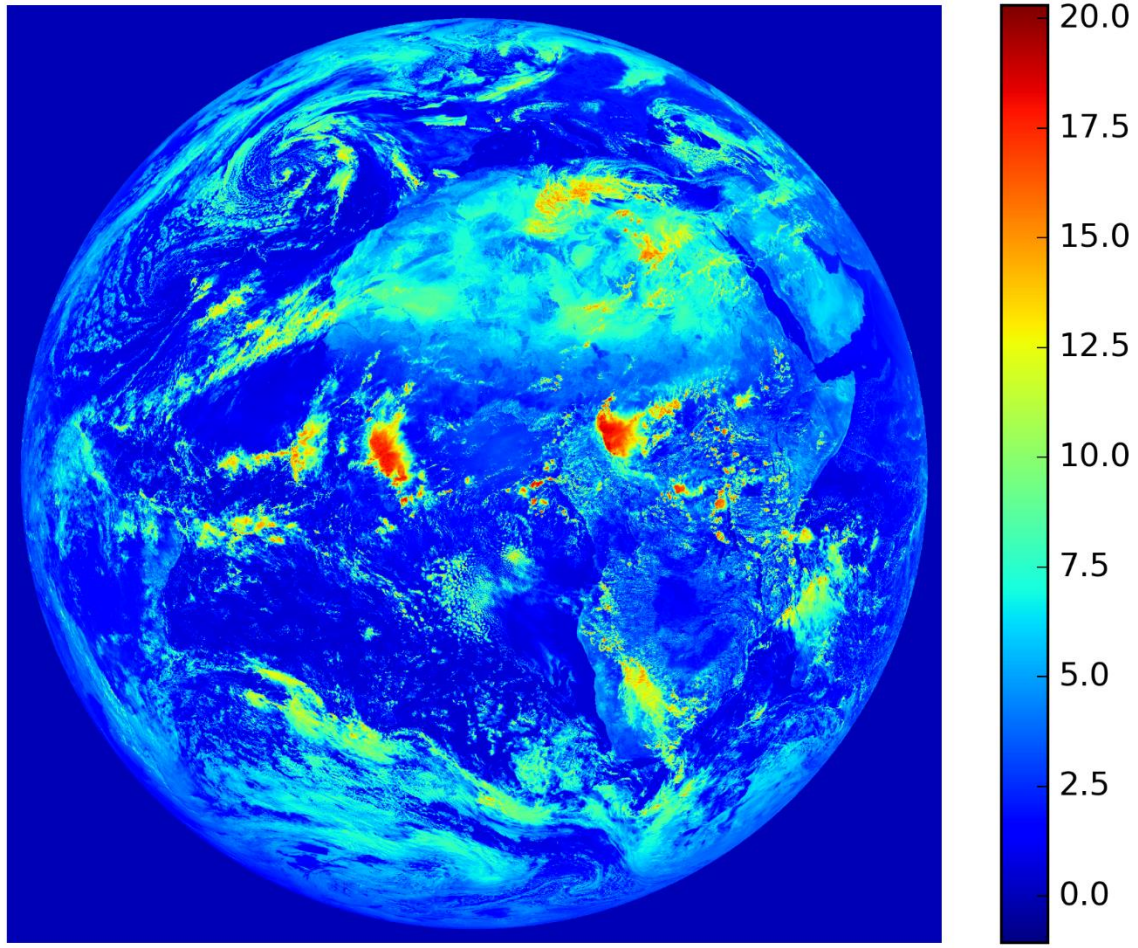
Application benefits from the MTG Lightning Imager (LI)

- **Main benefit from GEO lightning observations**:
  - homogeneous and continuous observations delivering information on location and strength of lightning flashes to the users with a timeliness of up to 30 seconds

- **Main objectives are to detect, monitor, track and extrapolate in time:**
  - Development of active convective areas and storm lifecycle
  - Lightning climatology
  - Chemistry (NOx production)

- **Furthermore:**
  - Good coverage in developed countries and around major airports
  - Most areas of the earth are without any good-quality lightning data from ground, but with significant severe weather and lightning causing risks for aviation (e.g. Africa)
  - This situation on the availability of ground-based data is not expected to change in the near future (technical/physical limitations)

MTG User Preparation: User Familiarisation Data



- User familiarisation (test) data comes in different degrees of maturity in science, data content and format specifications:
  - Synthetic data
  - Simulated data
  - Proxy data
  - Pre-operational data

  (CGMS/WMO Best Practices, 2016)

- In 2019, the following simulated data are made available by EUMETSAT:
  - FCI Level 1c data for format familiarisation
  - IRS Level 1b data for format familiarisation
  - LI Level 2 data for user familiarisation

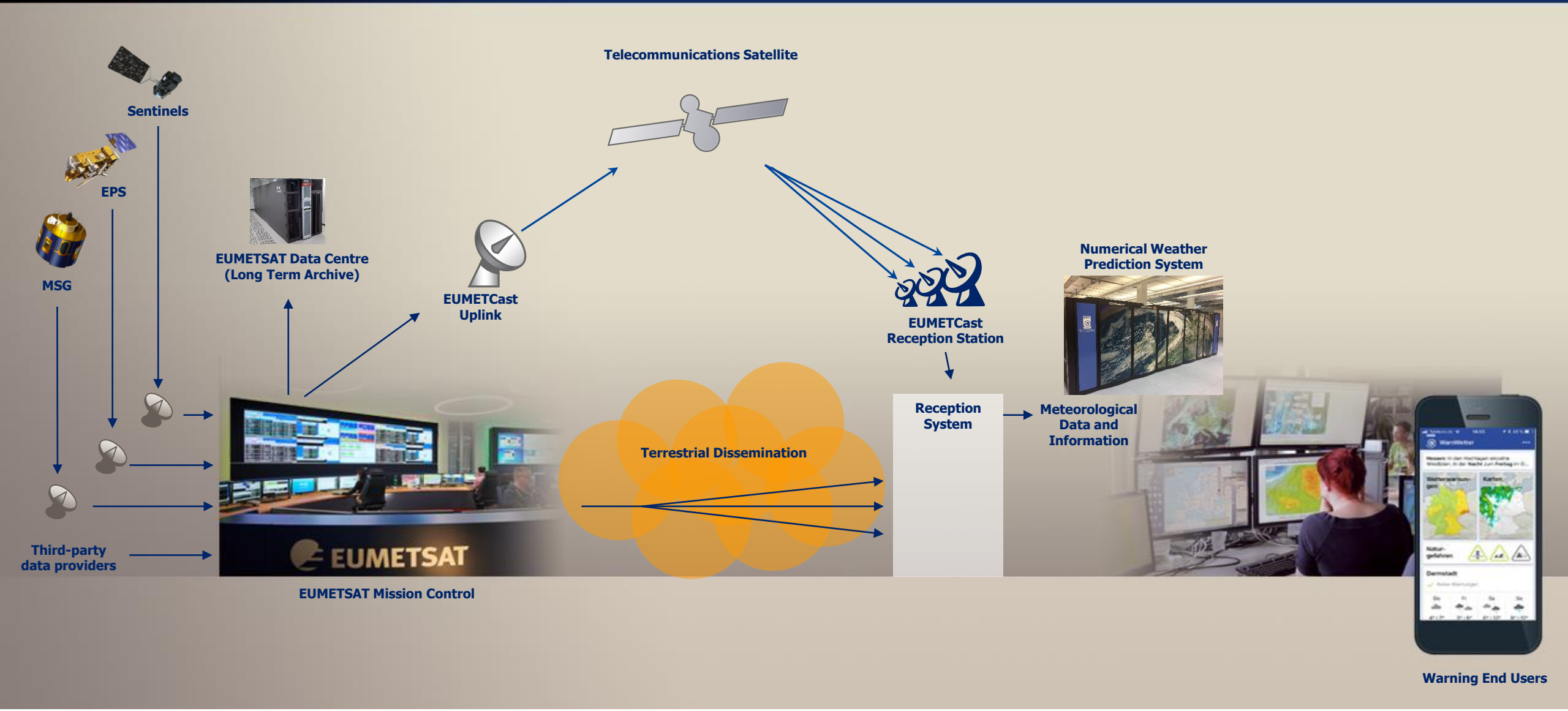
Example of simulated FCI L1c user familiarisation data (VIS 0.6um channel, 10 April 2017). To reduce data volumes in near-real-time services such as EUMETCast, the netCDF-4 near-real-time FCI Level 1c data will only be available in compressed form using the CharLS algorithm.

EUMETSAT ground segment

EUMETSAT Data Services

- EUMETSAT Data Services (near real-time & archive)
  - EUMETCast, EUMETView, EUMETSAT Data Centre
  - New, additional pilot services underway, including online data access

Delivering critical data in near-real time to users



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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