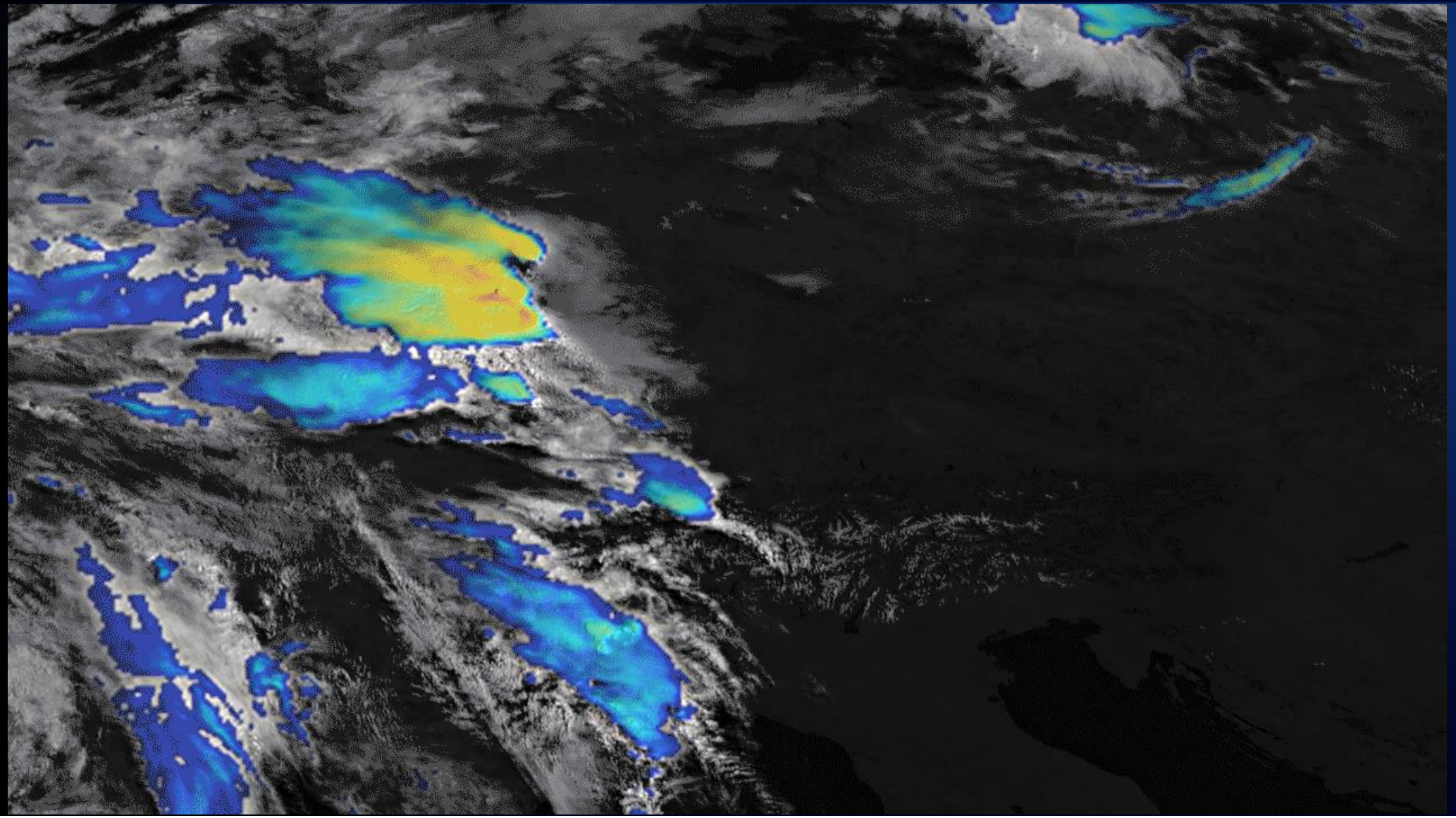
Meteosat Third Generation (MTG): Overview, impacts, timeline for transition

April 2021

MTG enhances current capability for nowcasting of severe weather



MTG – Contribution to predicting high-impact weather

Cloud Height

Bright sky / Humidity convergence / convective instability

Development of convective clouds

Anticipate storms

Time

Meteosat Third Generation: Imaging mission (MTG-I)

- Imagery mission implemented by two MTG-I satellites
- Full disc imagery every 10 minutes in 16 bands (→MTG-I1)
- Fast imagery of Europe every 2.5 minutes (MTG-I2)
- New Lightning Imager (LI)

- **Start of operations in 2023**
- **Operational exploitation: 2023-2042**

Meteosat Third Generation: Sounding mission (MTG-S)

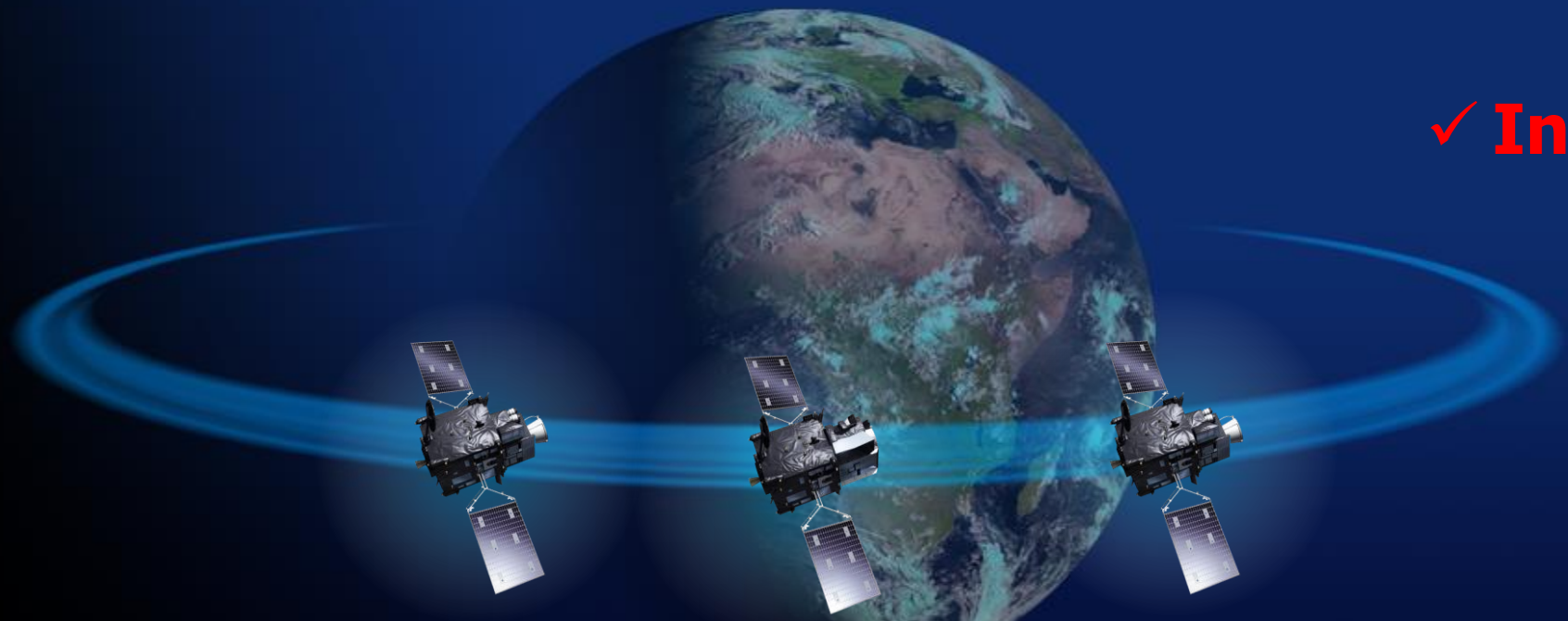
- Hyperspectral infrared sounding mission (InfraRed Sounder – IRS)
  - 3D weather cube: temperature, water vapour, O3, every 30 minutes over Europe
- Air quality monitoring and atmospheric chemistry in synergy with Copernicus Sentinel-4 instrument (UVN)

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

Meteosat Third Generation (MTG): Full operational configuration

✓ **Continuity**

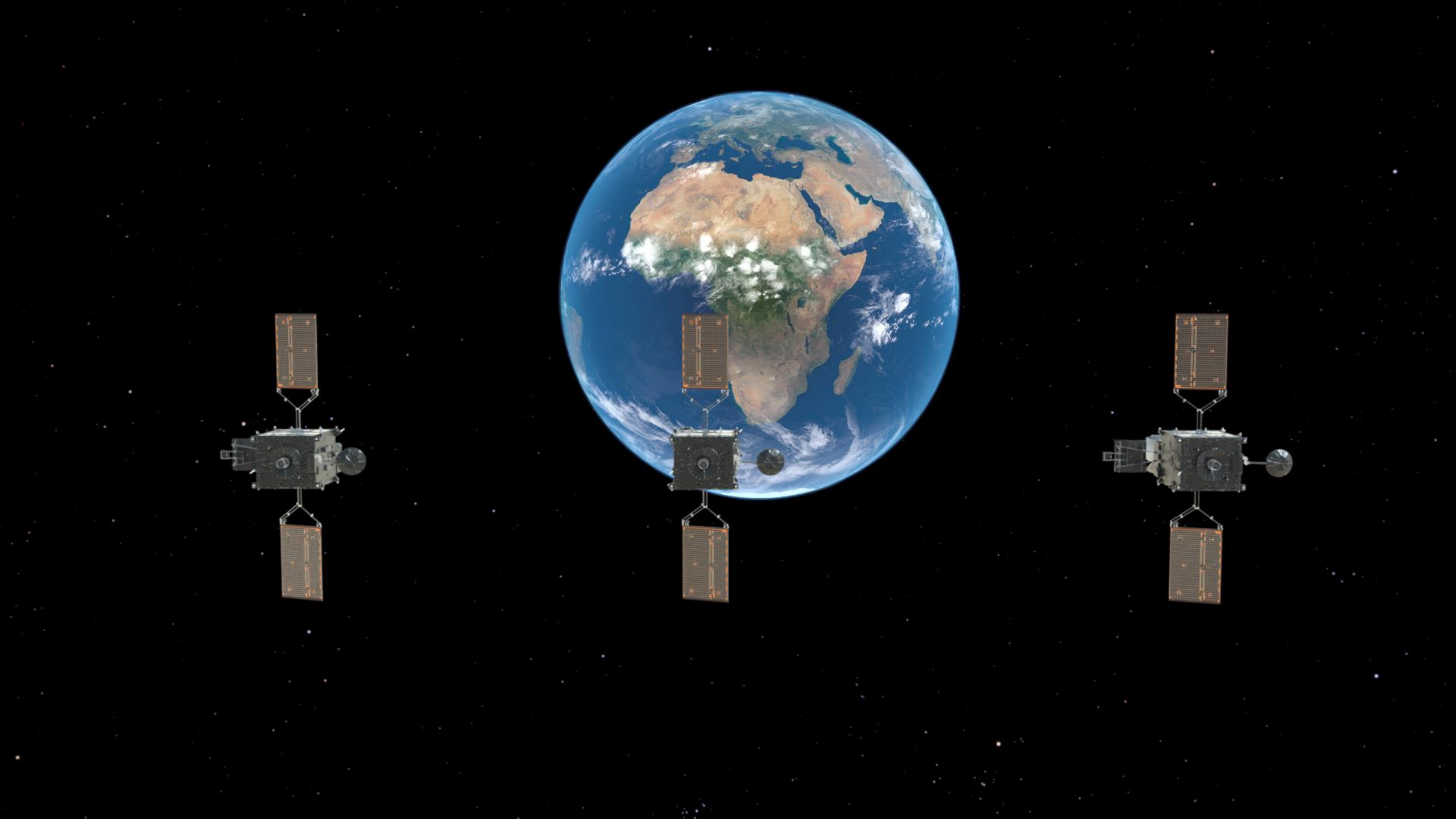
✓ **Innovation**



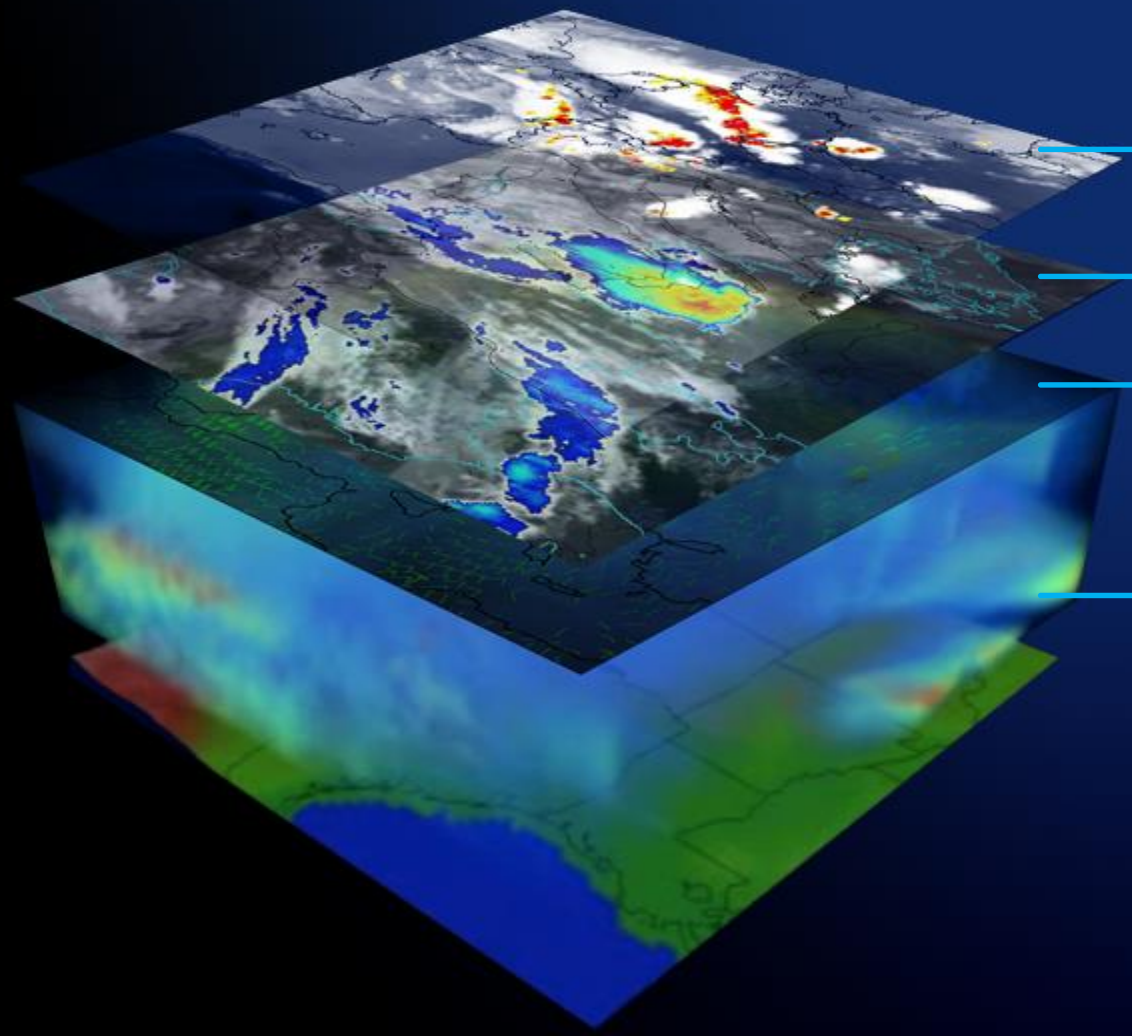
MTG-I
Rapid Scan Service

MTG-S
Sounding Service

MTG-I
Full Scan Service



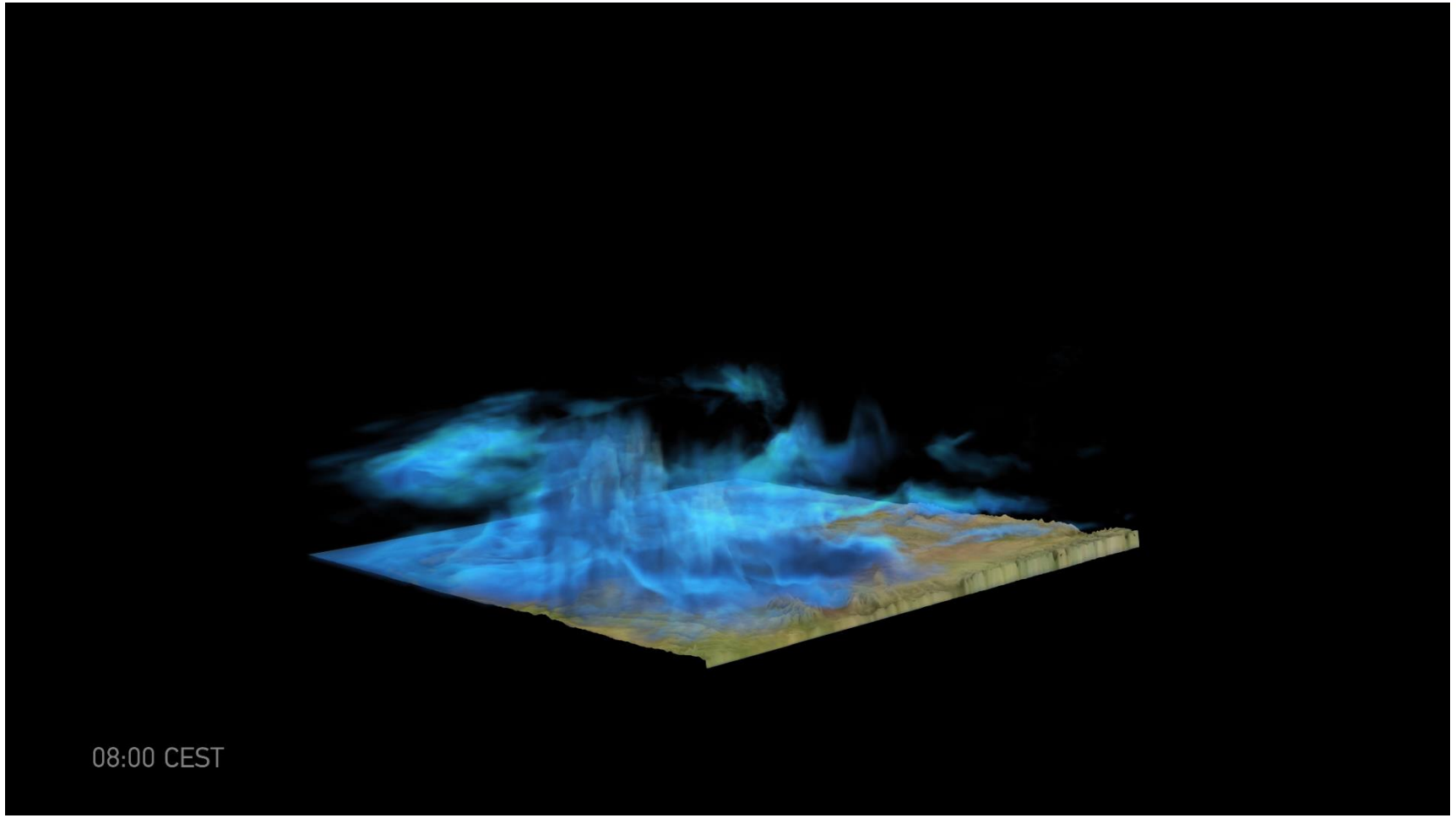
‘4D Weather Cube’: Probing the atmosphere to detect severe weather



Every 30 min over Europe and North Africa

Enabled by MTG

Visualising the “4D Weather Cube”



Based on 20 June 2013 data (convective day over Central Europe):

- DWD model output T/q Central European domain centered over Germany
- 2D Winds (AMV BUFR operational product)
- Sandwich product, based on SEVIRI
- Lightning, based on surface-based lightning detection data

Transition from MSG to MTG

Satellite	Orbital position	Launch	Start of Services	Capability of the MTG Services deployed
MTG-I1	0°	End 2022	1 year after launch	Initial Operational Capability (IOC)
MTG-S1	0°	End 2023	1 year after launch	Partial Operational Capability (POC)
MTG-I2	9.5°	2025	Six months after launch	Full Operational Capability (FOC)

	pability	Partial Operational Capability (POC)	Full Operational Capability (FOC)
	eosat-	MTG-I1 (back-up Meteosat-10 FES)	MTG-I1 (back-up MTG-I2)
Lightning Imager Service (LI)	MTG-I1 (no backup)	MTG-I1 (no backup)	MTG-I1 (back-up MTG-I2)
InfraRed Sounding Service (IRS)		MTG-S1 (no backup)	MTG-S1 (no backup)
Copernicus Sentinel-4 Service (UVN)		MTG-S1 (no backup)	MTG-S1 (no backup)
Rapid Scanning Service – RSS (FCI)	Meteosat-11 RSS	Meteosat-11 RSS	MTG-I2

Status: April 2021

Transition from MSG to MTG

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MTG-I1	0°	End 2022	1 year after launch	Initial Operational Capability (IOC)
MTG-S1	0°	End 2023	1 year after la	
MTG-I2	9.5°	2025	Six months a launch	

Services Deployment	Initial Operational Capability (IOC) (As of end 2023)	Partial Operational Capability (POC) (As of end 2024)	Full Operational Capability (FOC) (As of end 2025)
Full Disc Scanning Service – FDSS (FCI)	MTG-I1 (back-up Meteosat-10 FES)	MTG-I1 (back-up Meteosat-10 FES)	MTG-I1 (back-up MTG-I2)
Lightning Imager Service (LI)	MTG-I1 (no backup)	MTG-I1 (no backup)	MTG-I1 (back-up MTG-I2)
InfraRed Sounding Service (IRS)		MTG-S1 (no backup)	MTG-S1 (no backup)
Copernicus Sentinel-4 Service (UVN)		MTG-S1 (no backup)	MTG-S1 (no backup)
Rapid Scanning Service – RSS (FCI)	Meteosat-11 RSS	Meteosat-11 RSS	MTG-I2

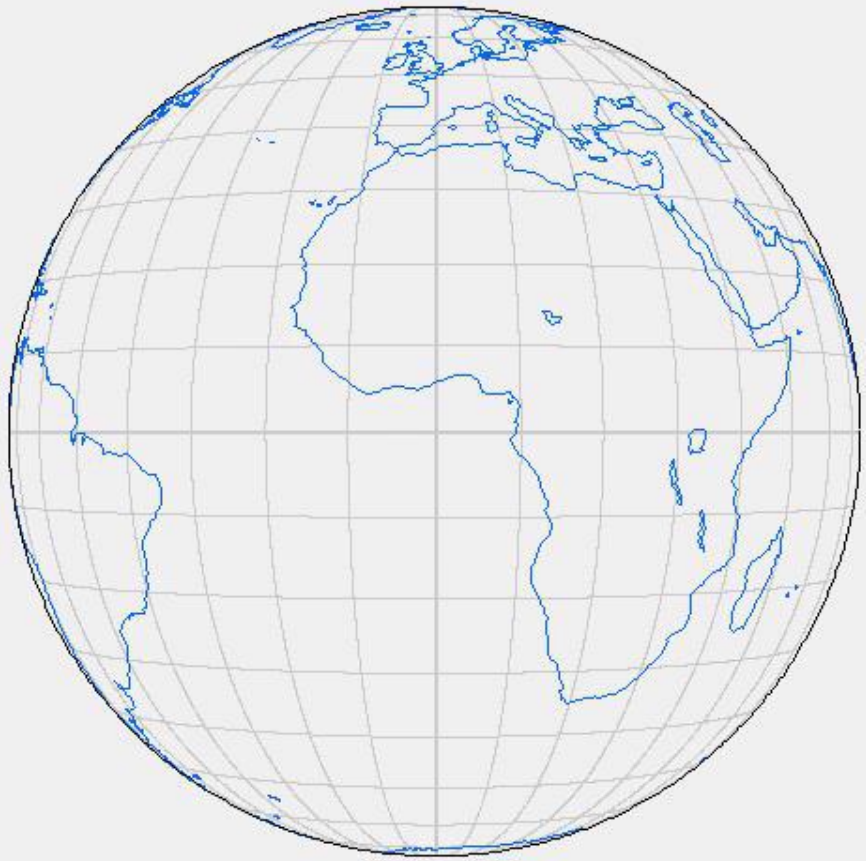
Status: April 2021

Indian Ocean Data Coverage

- Meteosat-8 SEVIRI at 41.5°E since 2016, reaching end of lifetime
- Meteosat-9 SEVIRI to move to 45.5°E position in Feb-Apr 2022
- Two months of parallel operations of Met-8 and Met-9, to support user transition
- Meteosat-9 to take over as IODC prime as of 1 July 2022

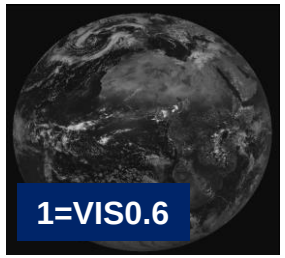
MTG Spectral imaging mission: Main improvements

- Better spectral resolution:
  - from 11/12 to 16 channels
- More frequent:
  - 10 min vs 15 min
  - 2.5 min vs 5 min
- Increased radiometric resolution:
  - 12 bit vs 10 bit
- Better spatial resolution



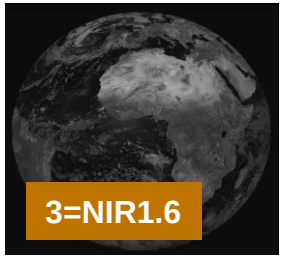
FCI full-disc scanning pattern (over 10 minutes)

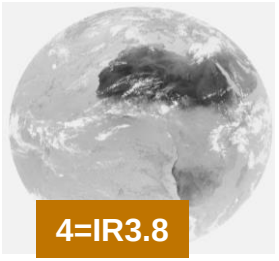
Current and future imagers channels: MSG SEVIRI and MTG FCI

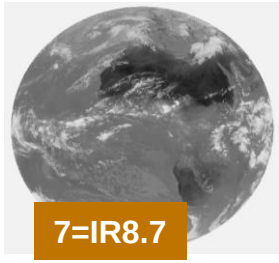


SSD: 1km

SSD: 3km

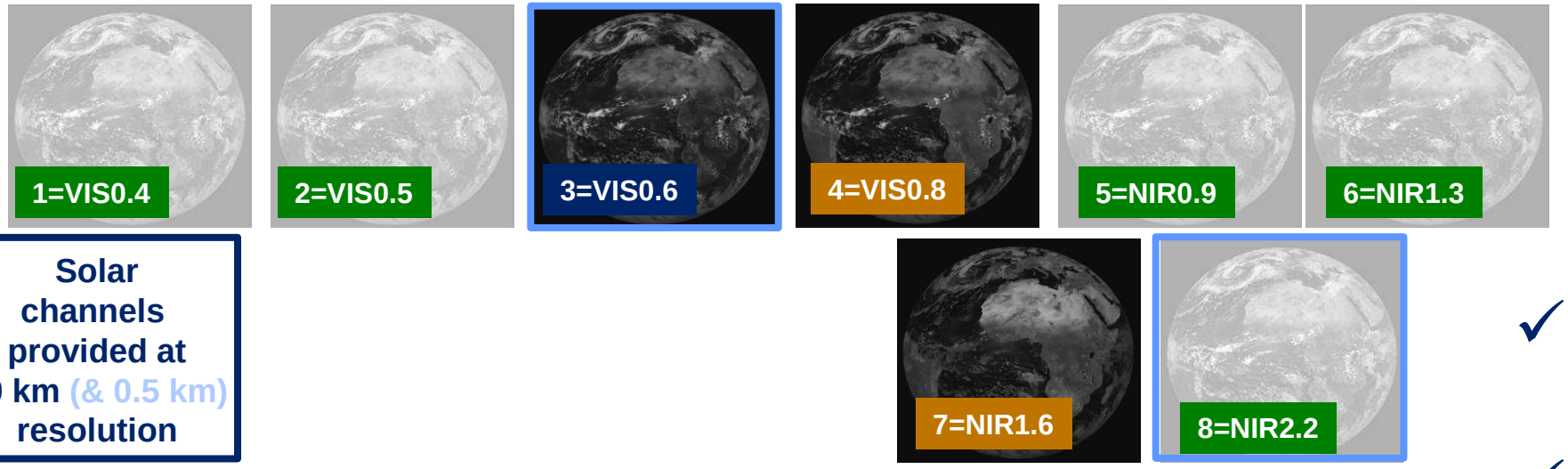




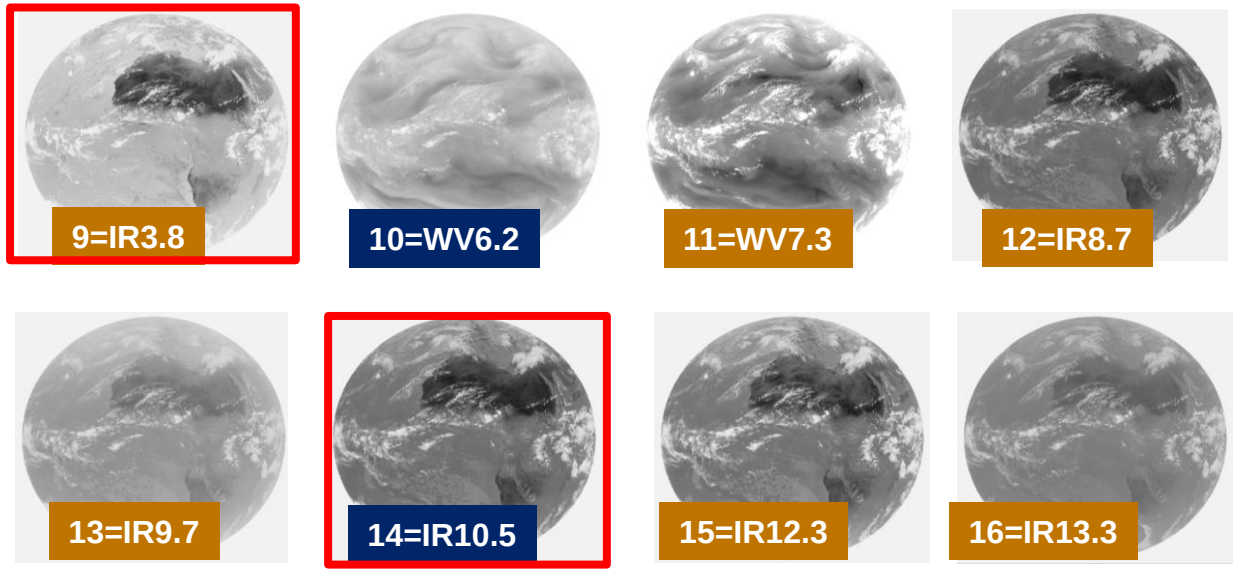


Current SEVIRI

Current and future imagers channels: MSG SEVIRI and MTG FCI



Solar channels provided at 1.0 km (& 0.5 km) resolution



Thermal channels provided at 2 km (& 1 km) resolution

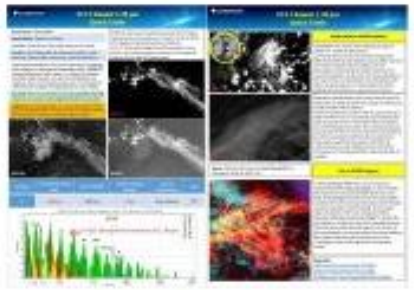
✓ **Continuity**

✓ **Innovation**

Future FCI

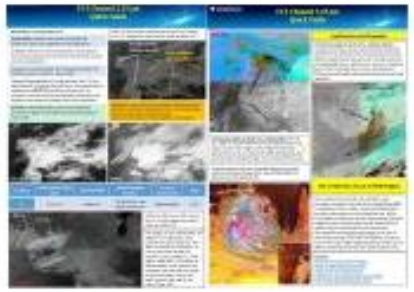
Guidance on FCI channels

Quick Guide - 1.37 µm Channel



Download Quick Guide

Quick Guide - 2.25 µm Channel



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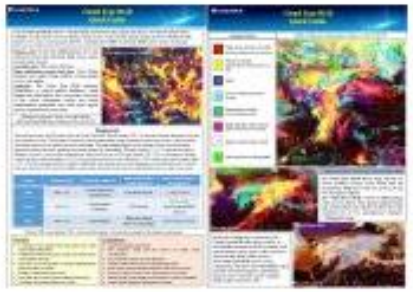
RGB Quick Guide - Cloud Type



Download Quick Guide

RGB Quick Guide - Cloud Phase

Download Quick Guide

RGB Quick Guide - True Colour

Download Quick Guide

RGB Quick Guide - Fire Temperature

Download Quick Guide

http://eumetrain.org/rgb_quick_guides/index.html

MTG Lightning imaging mission

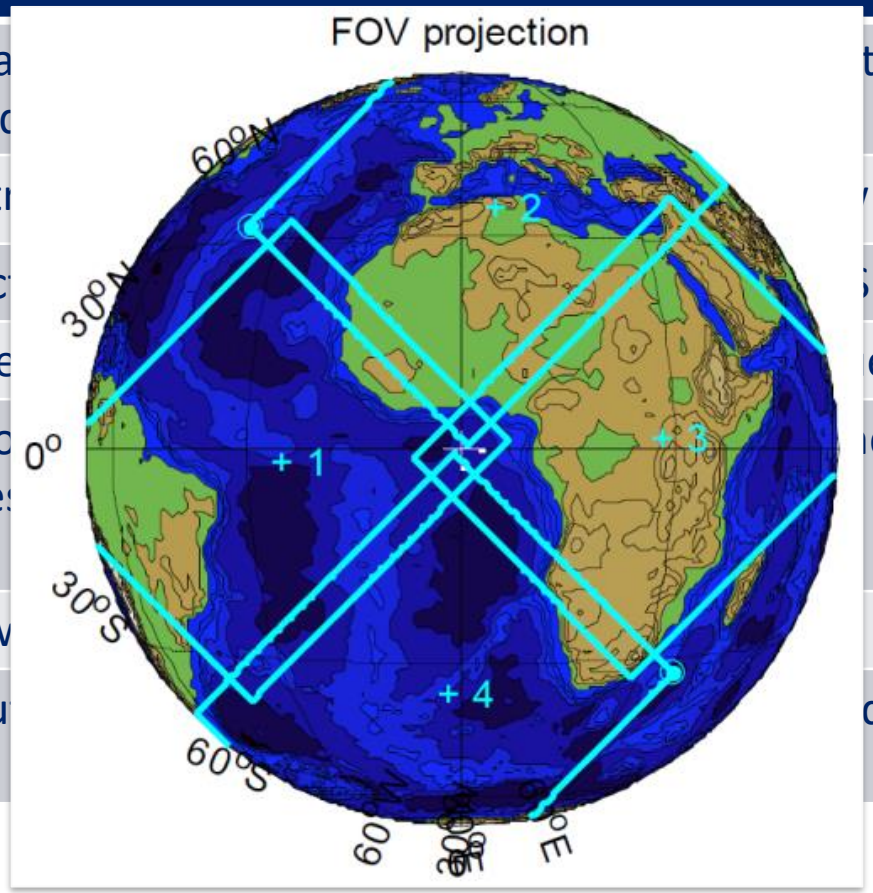
- Lightning is a precursor of severe weather, with a lead time of tens of minutes
- Most ground-based lightning location systems are mainly sensitive to cloud-to-ground lightning (CG)
- Often, no increase in CG due to “weather intensification” observable
  → Total lightning is the parameter of interest

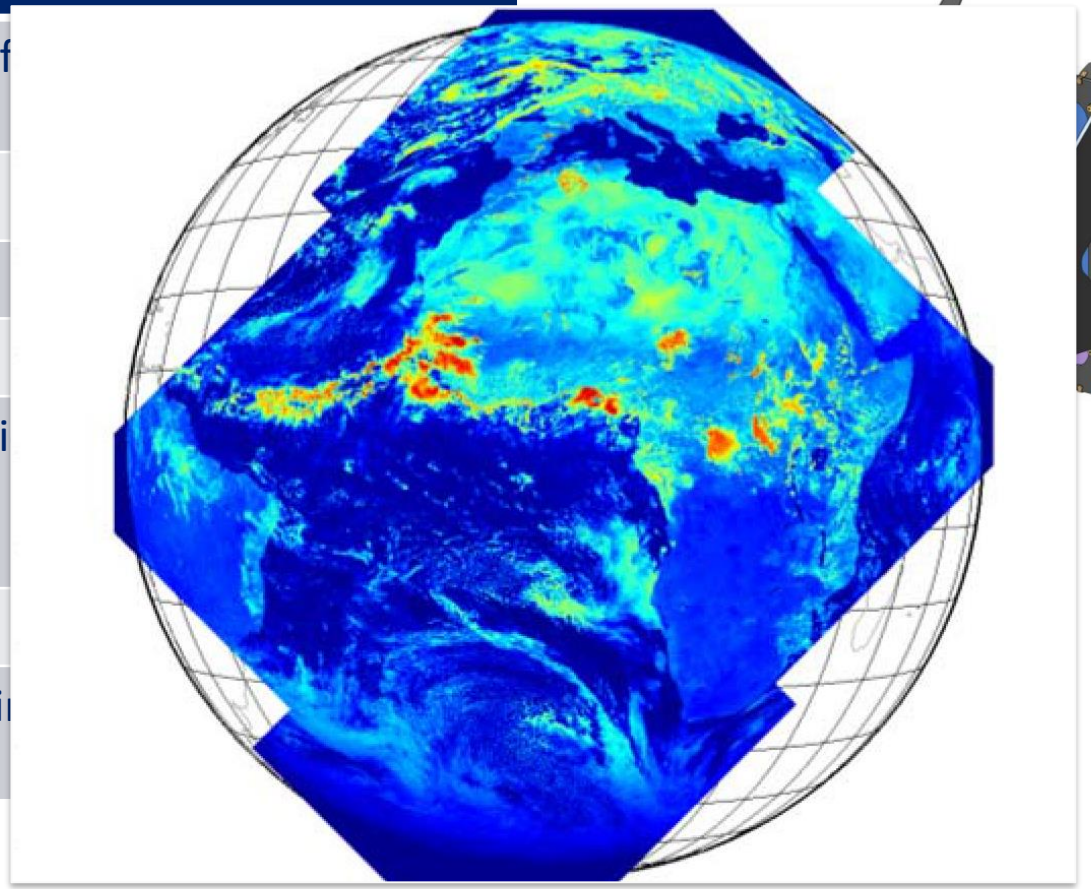
Total lightning =
cloud-to-ground
+ cloud-to-cloud lightning

MTG Lightning imaging mission: LI instrument and detection principle

LI in a nutshell

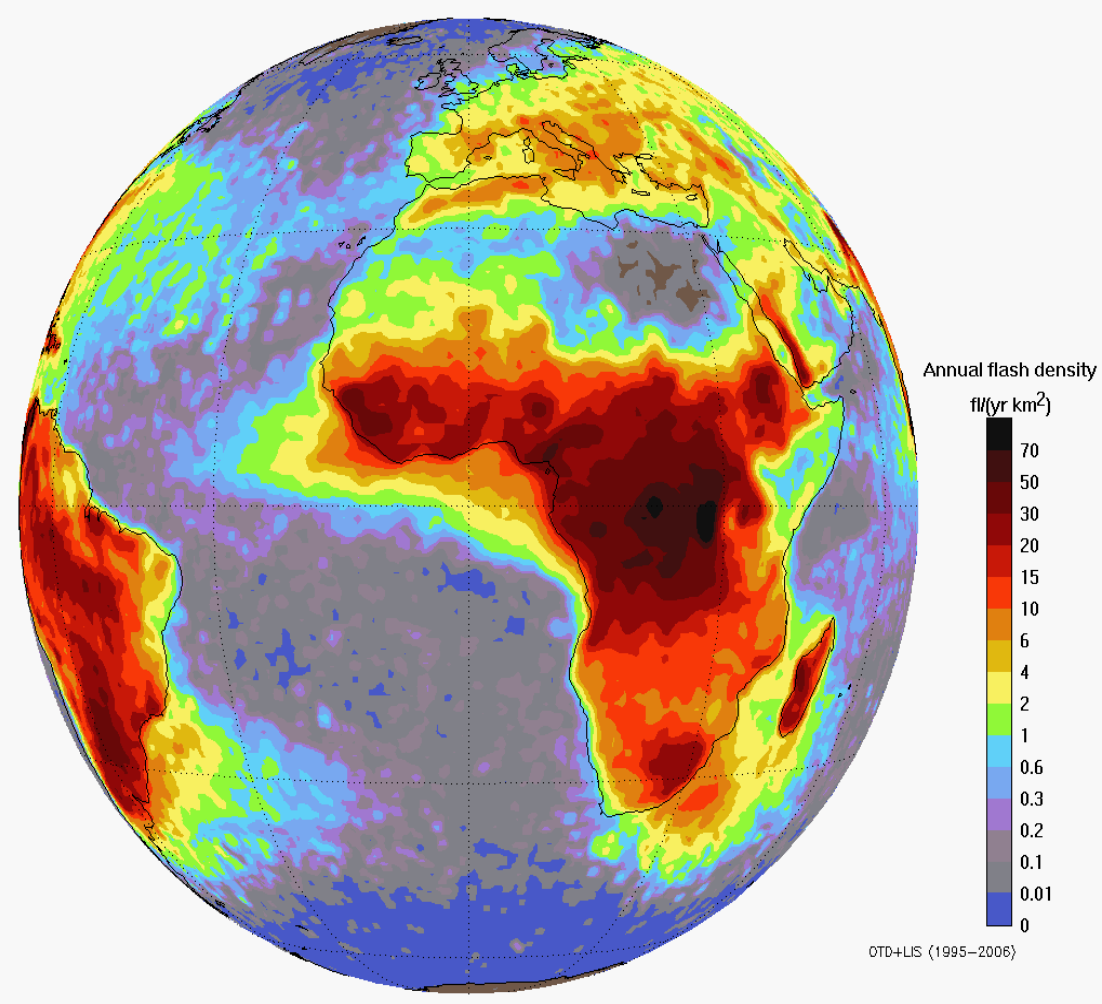
Spatia at Nac	the Filed of
Spectr	band
Detec	
Frame	ency)
On-bc proces	d subtracti
Bandv	
Manu	dustrial pri

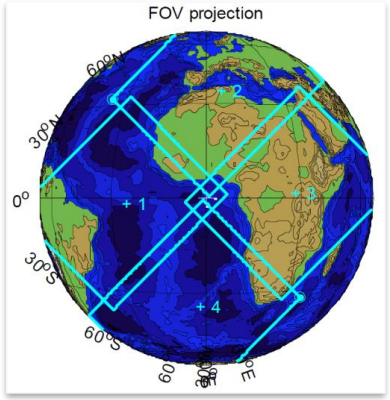




MTG: Lightning imaging mission

Flash density in the MTG LI field of view

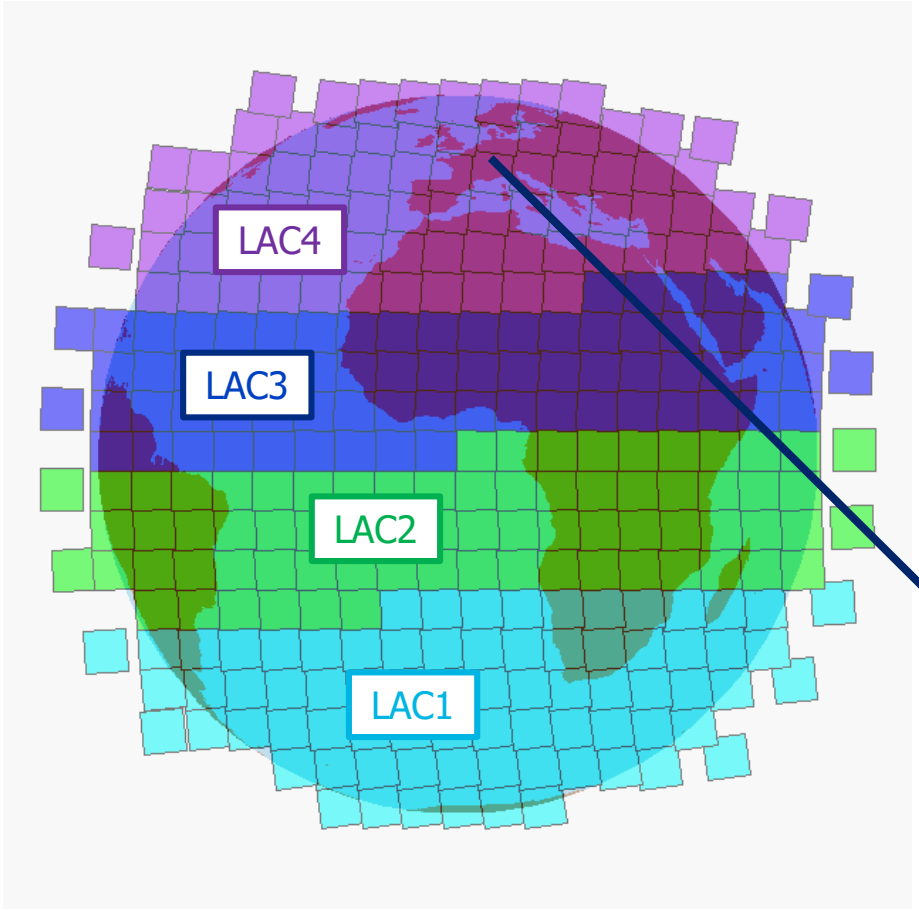




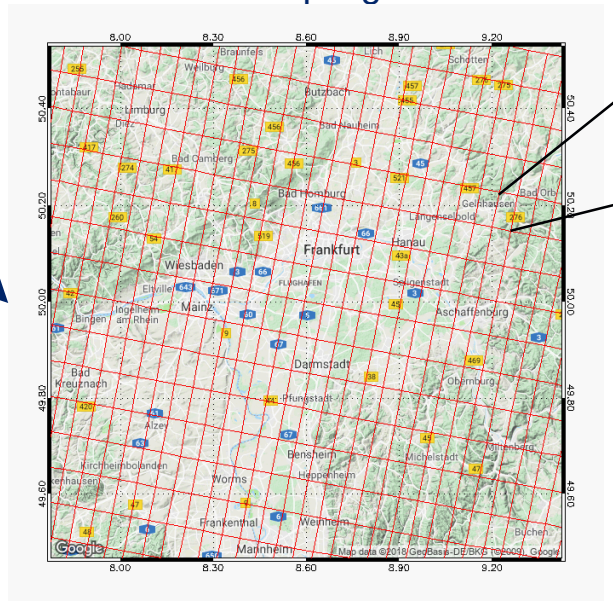
- High flash density over South and SE Europe, and sub-Saharan Africa
- Total lightning can be a precursor of severe weather, with a lead time of tens of minutes
- MTG LI measures total lightning, whereas ground-based networks are mostly sensitive to cloud-to-ground lightning

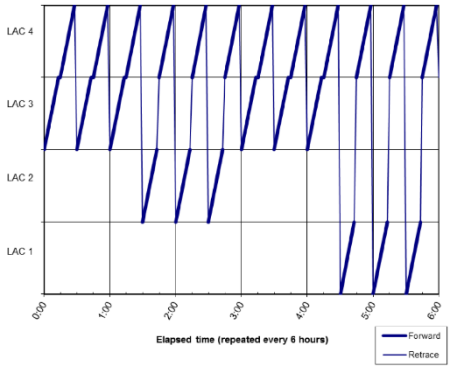
MTG Infra-Red Sounder (IRS) scanning sequence

- ✓ The Earth disk is split in 4 Local Area Coverage (LAC) zones, each of them covered in 15 min by a succession of “steps and stares” called dwells
- ✓ LAC4 (northern mid-latitudes) will be covered every 30 minutes
- ✓ LAC1, 2, 3 will be alternatively viewed in-between

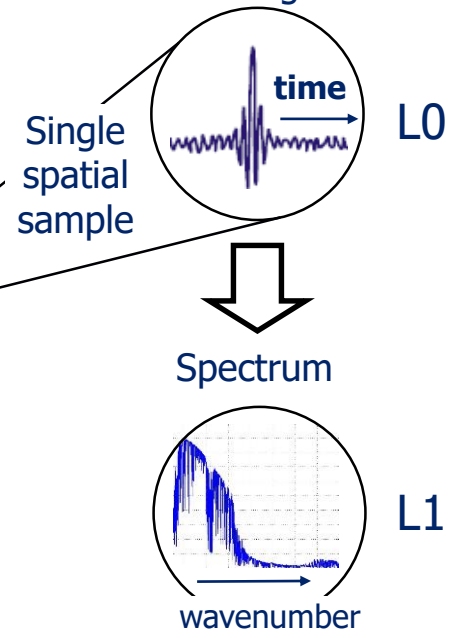


Each dwell consists of 160x160 pixels yielding a high spatial sampling

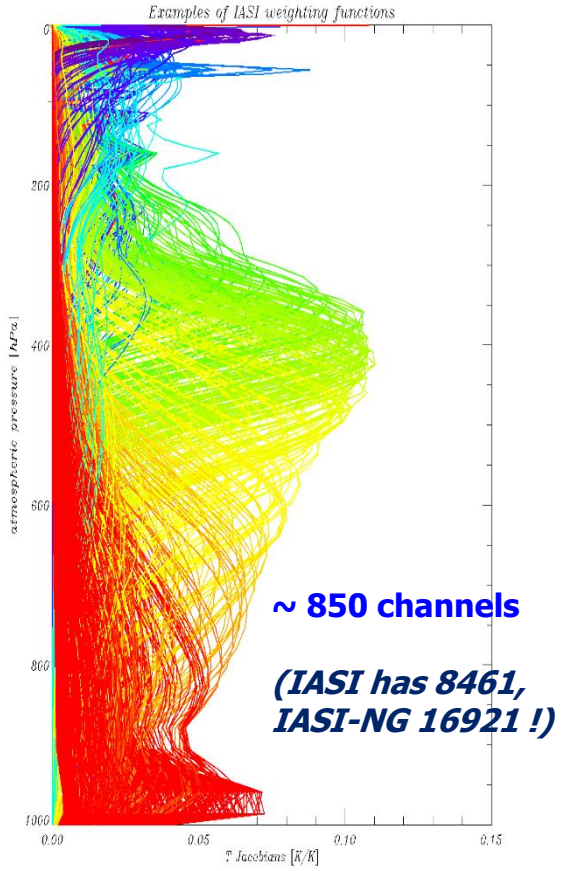


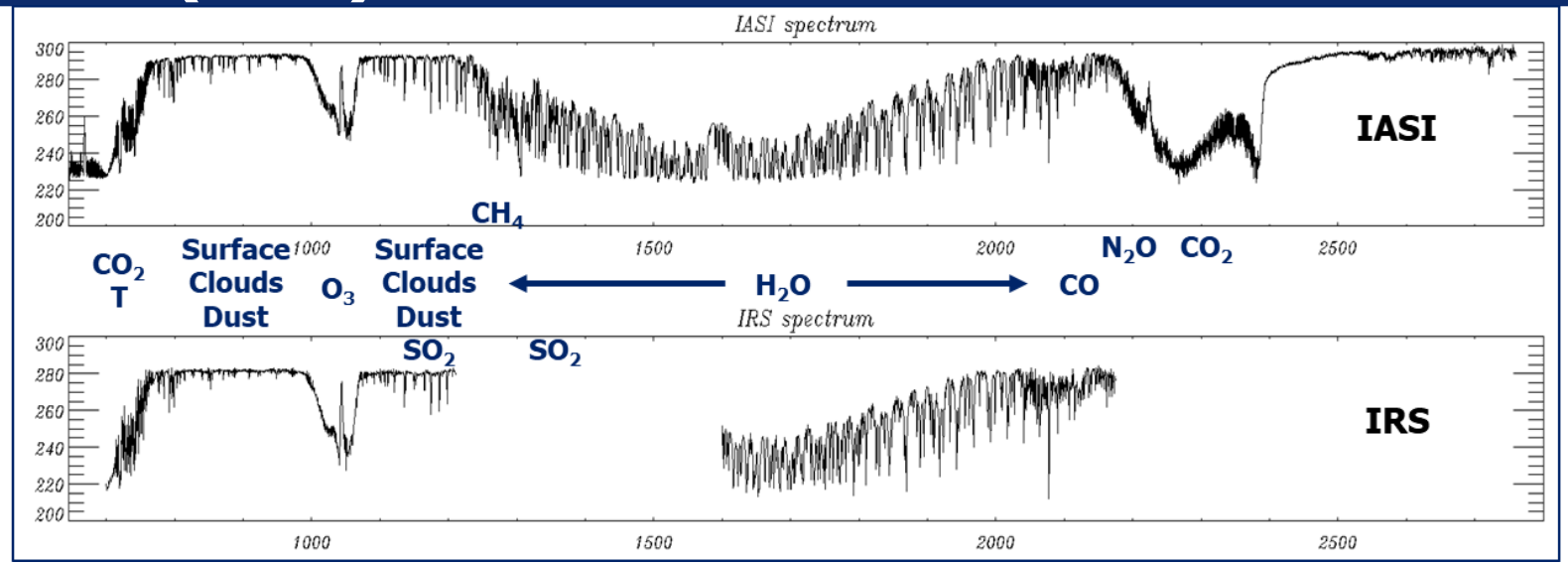


Interferogram



MTG Infra-Red Sounder (IRS)

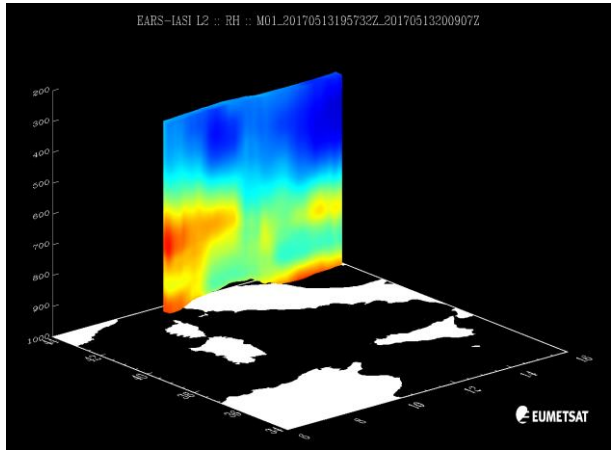




Operational spectro-imagery at high spectral, spatial & temporal resolution:

Two spectral bands: MWIR: 1600 to 2250 cm-1 (4.44–6.25 µm) and LWIR: 680 to 1210 cm-1 (8.26–14.70 µm)

Sampling: 0.6cm-1 spectral, 4km at nadir spatial, 30min temporal over Europe and parts of North Africa



For Nowcasting and NWP

MTG – Contribution to predicting high-impact weather

Cloud Height

Bright sky / Humidity convergence / convective instability

IRS

Development of convective clouds

IRS + FCI

Anticipate storms

LI

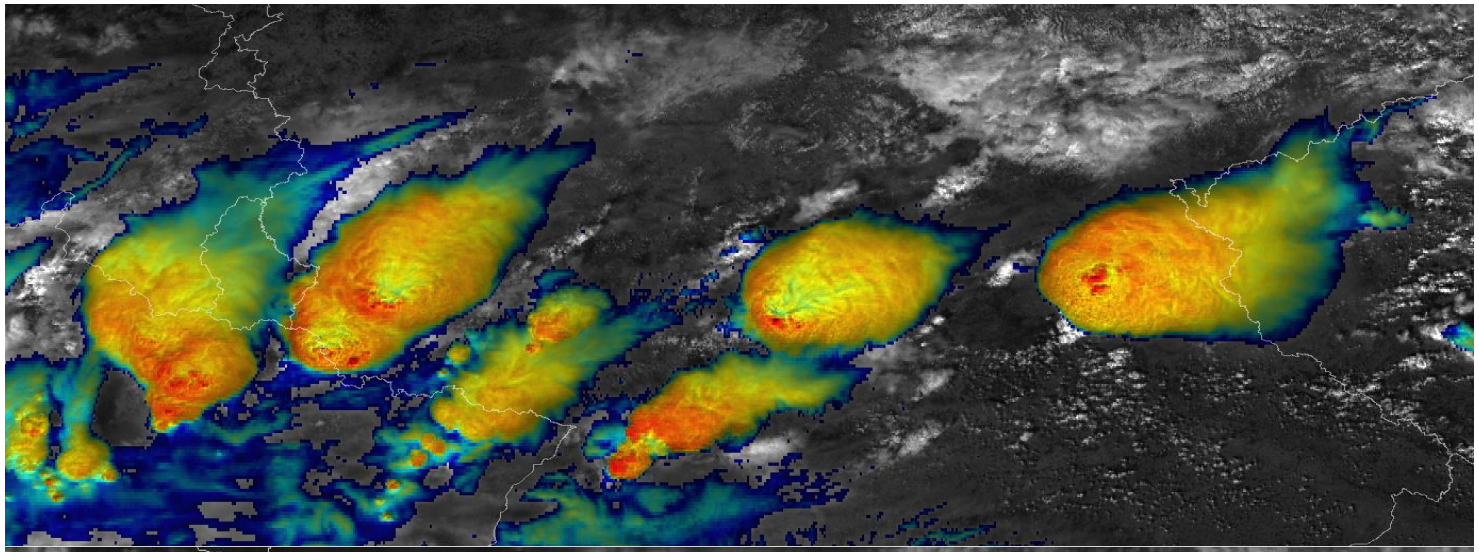
Time

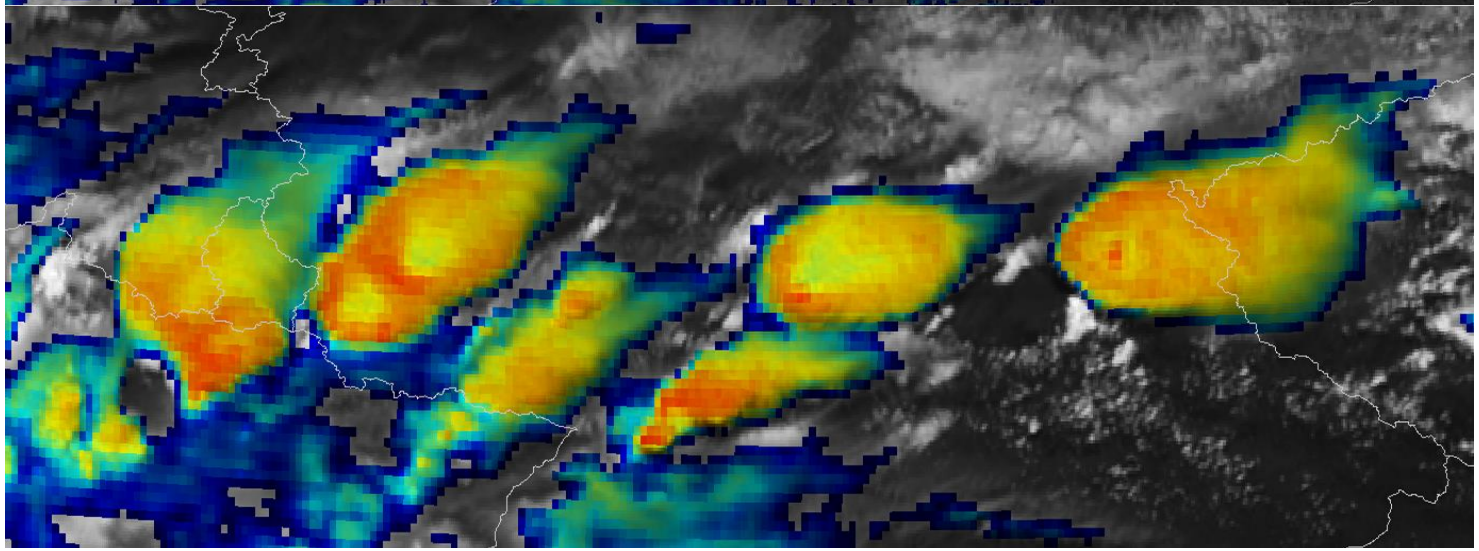
Application scenarios for MTG data

Monitoring and nowcasting severe convective storms

MTG Spectral imaging mission (FCI): New insights into convective storms through higher spatial resolution

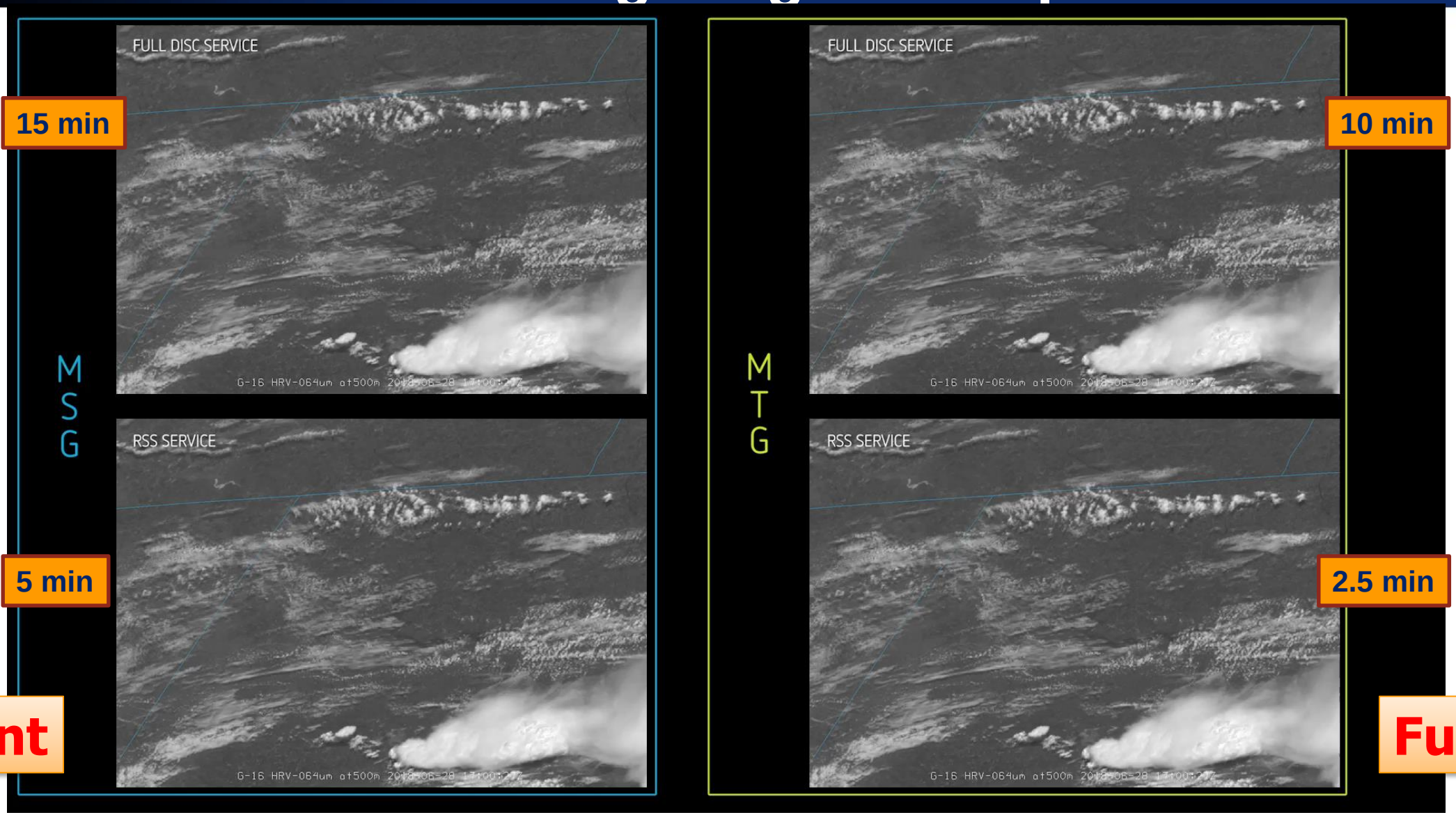
Future





Current

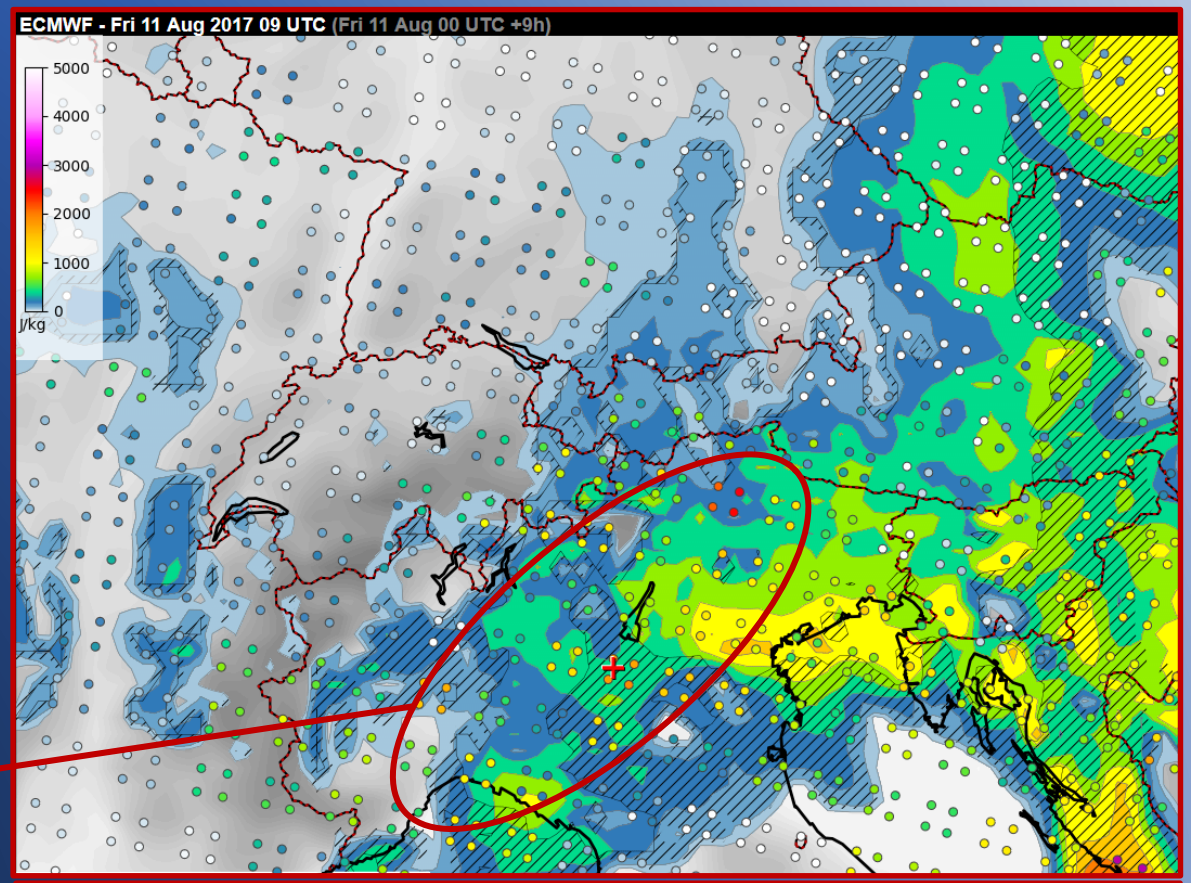
MTG Spectral imaging mission (FCI): New insights into convective storms through higher temporal resolution



Application scenarios for MTG data

Detecting convective initiation, a precursor of potentially severe storms

Use of Infrared Sounders in forecasting convection



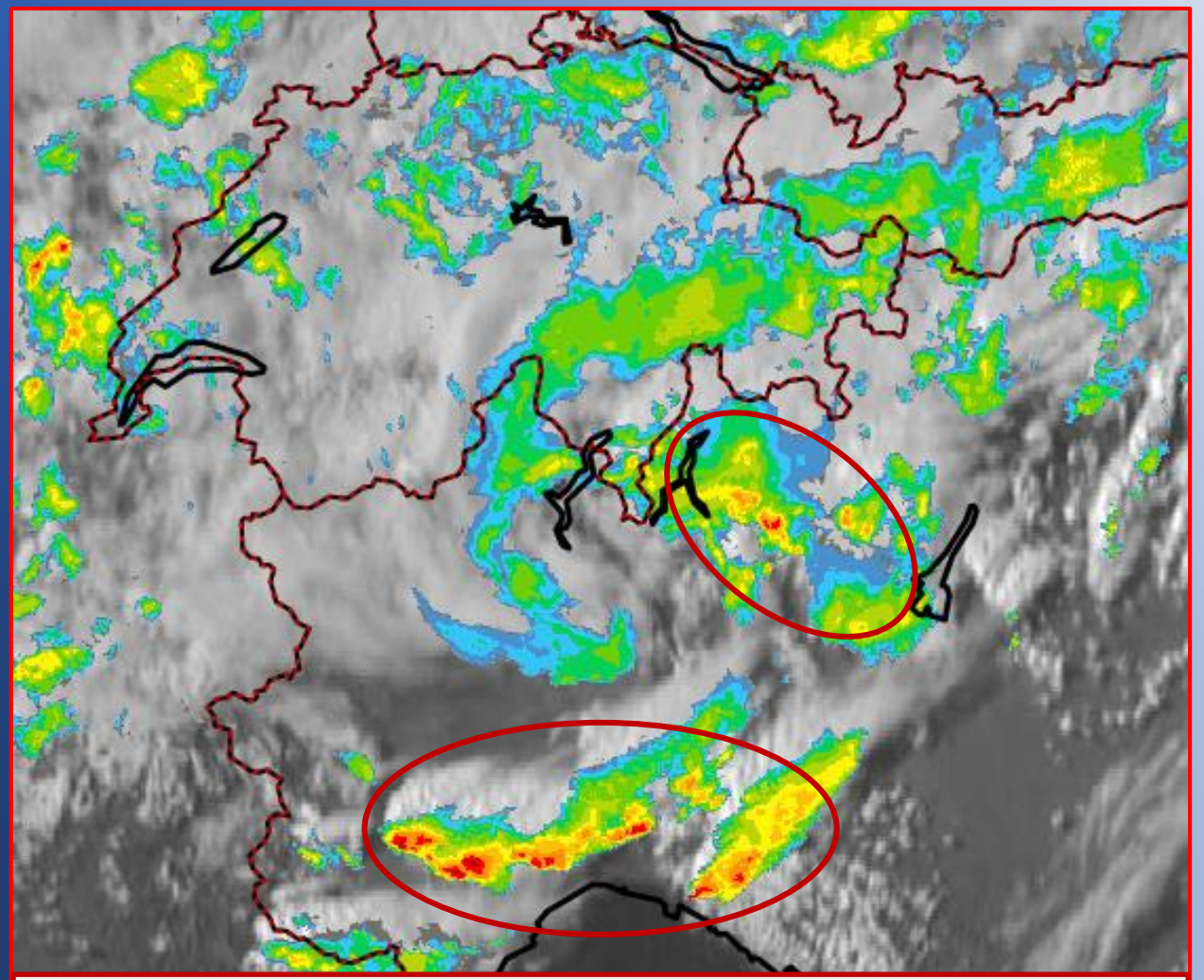
area with higher CAPE according to IASI than in the ECMWF model

background: values derived from +9 h model forecast (ECMWF IFS). Dots indicate IASI-derived values

Source: *Groenemeijer and Pucik:Hyperspectral sounding for severe storm forecasting; contract EUM/CO/184600002214/TA*

Use of Infrared Sounders in forecasting convection

widespread convective storm development by 1500 UTC



radar and VIS satellite at 1500 UTC

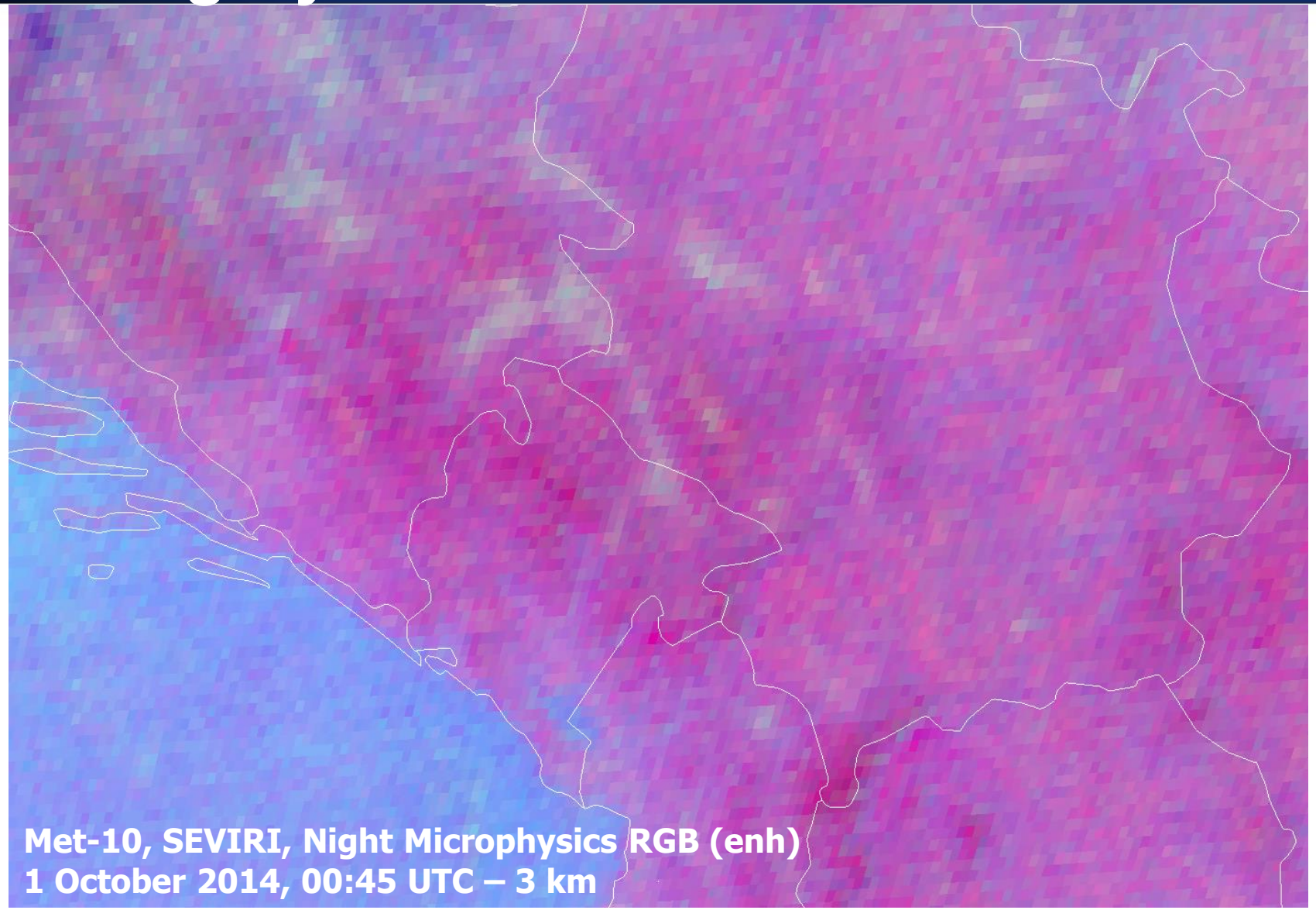
Source: *Groenemeijer and Pucik:Hyperspectral sounding for severe storm forecasting; contract EUM/CO/184600002214/TA*

Application scenarios for MTG data

Fog detection for transport safety

MTG Spectral imaging mission (FCI): higher spatial resolution imagery

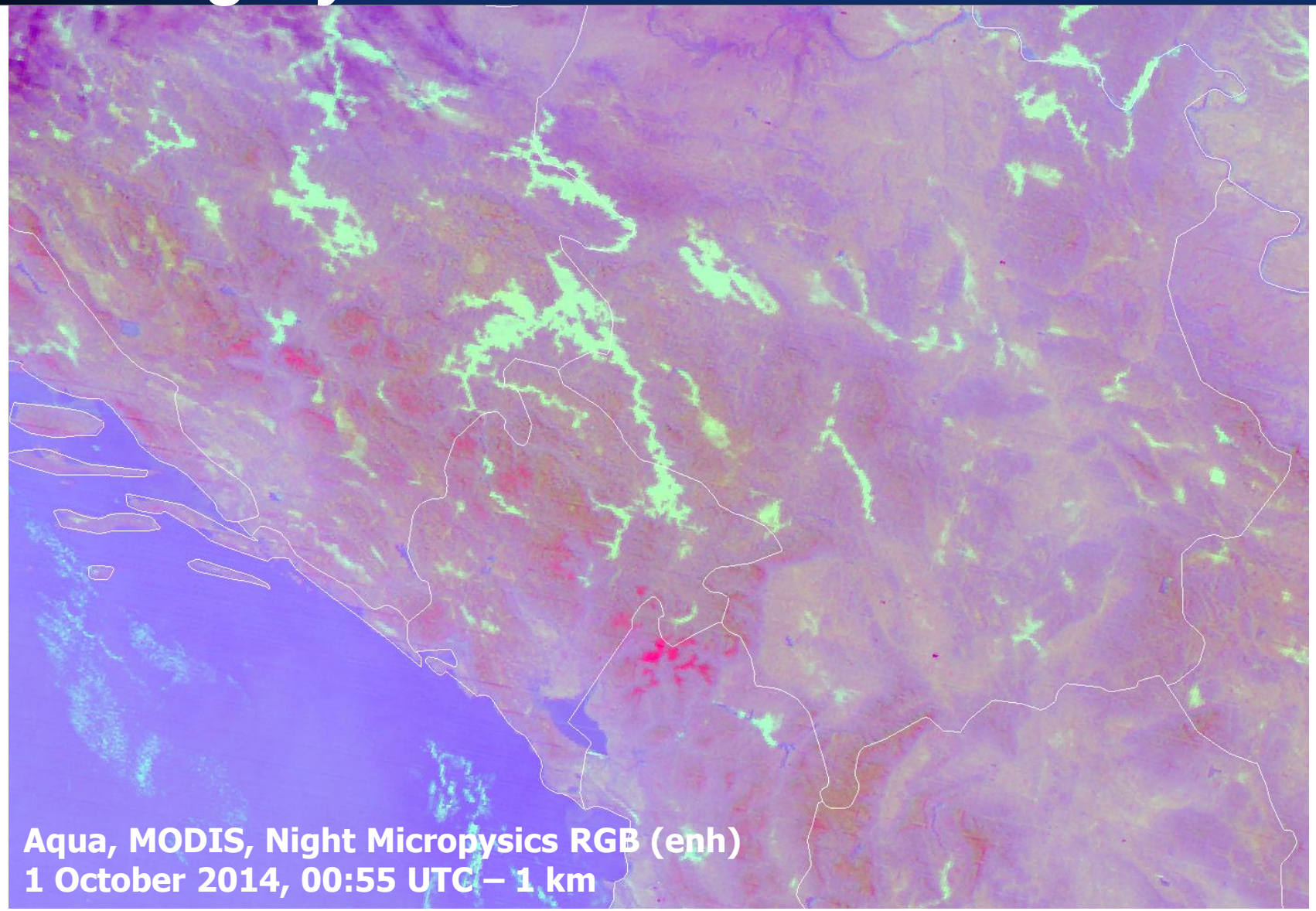
Fog detection over Western Balkans



Current

MTG Spectral imaging mission (FCI): higher spatial resolution imagery

Fog detection over Western Balkans

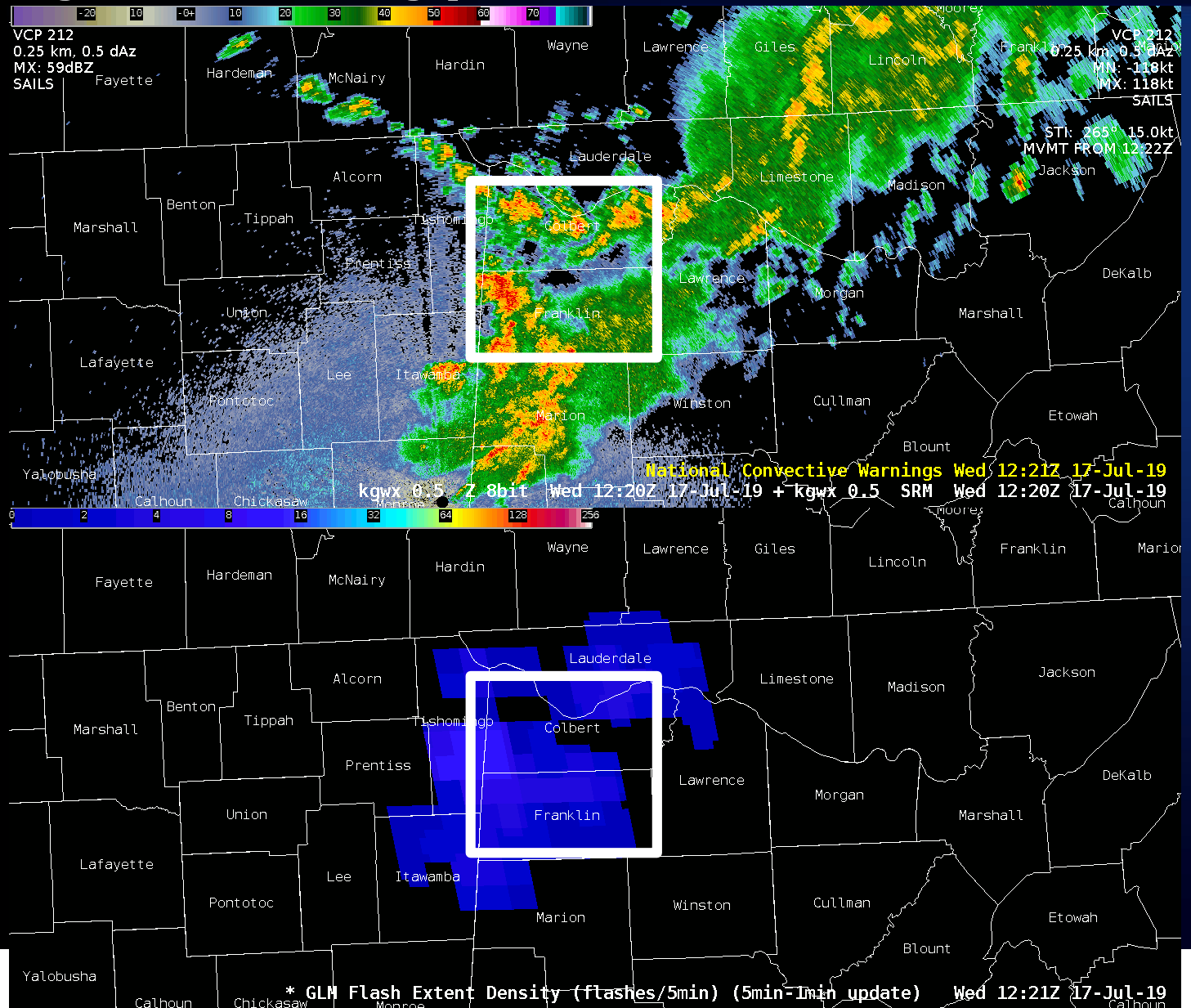


Future

Application scenarios for MTG data

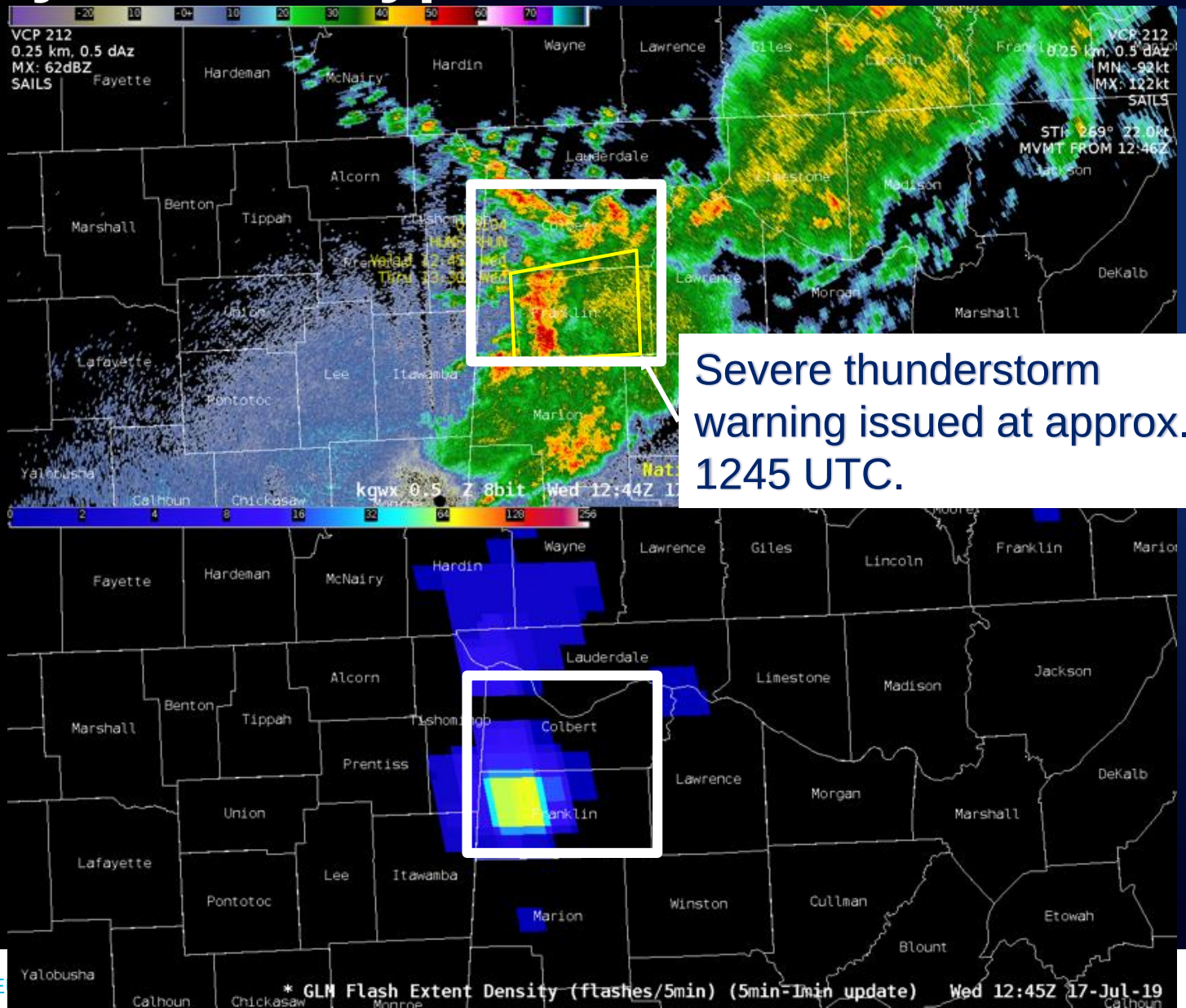
Lightning monitoring for storm tracking over oceans

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



GLM Flash Extent Density product (FED)

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

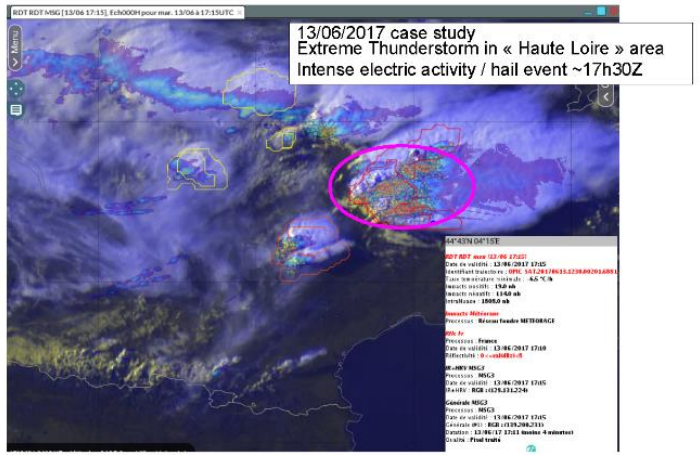


Chris White / NWS-Alabama:

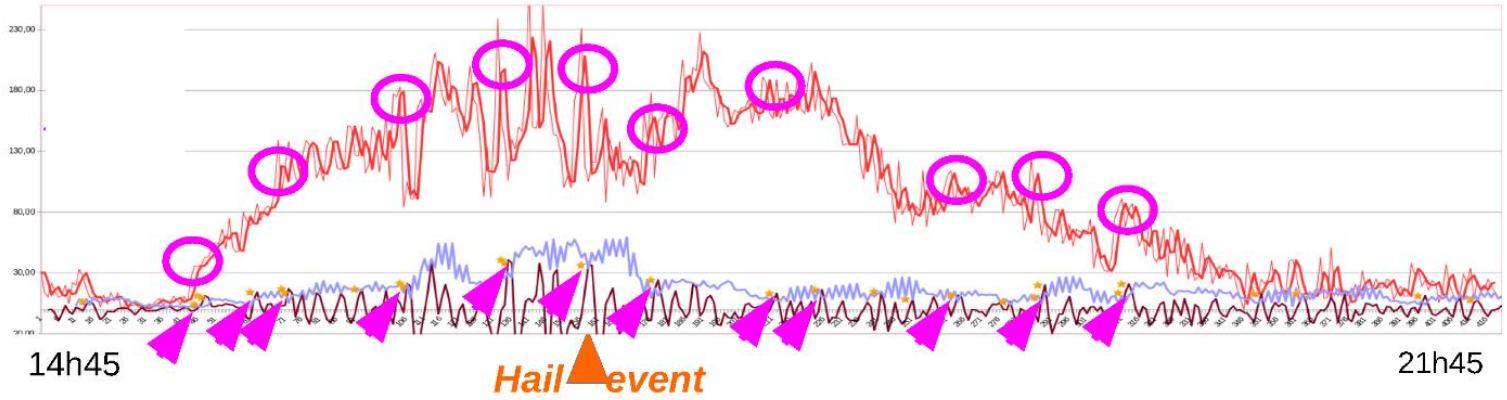
- Watching for jumps or increases in GLM to provide focus for strongest updraft
- GLM can provide evidence that a storm, which is considered “near severe”, may be about to produce severe weather, tipping the scales in favor of issuing a warning.
- **But GLM alone is not sufficient to determine thunderstorm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

RDT Lightning Jump (LJ)

- ✔ Total Lightning rate analysis
  - Need input data at **fine time-scale** (*second*).
  - 1st step: pairing lightning data with RDT cell
  - **Jump** if
    - ✗ *Condition 1: Lightning **rate** > 10 min^{-1}*
    - ✗ *Condition 2 : **Acceleration** of Lightning rate : Lightning rate trend > 2 x rms (rms computed during previous 12 minutes)*
- ✔ Implementation **RDT v2018**



RDT:
Rapidly Developing Thunderstorm
Product of NWCSAF Software



References and past studies: LJ a proxy to severe weather hazards (hail, gusts, etc.)

Credit:
Jean-Marc Moisselin
(Météo-France)

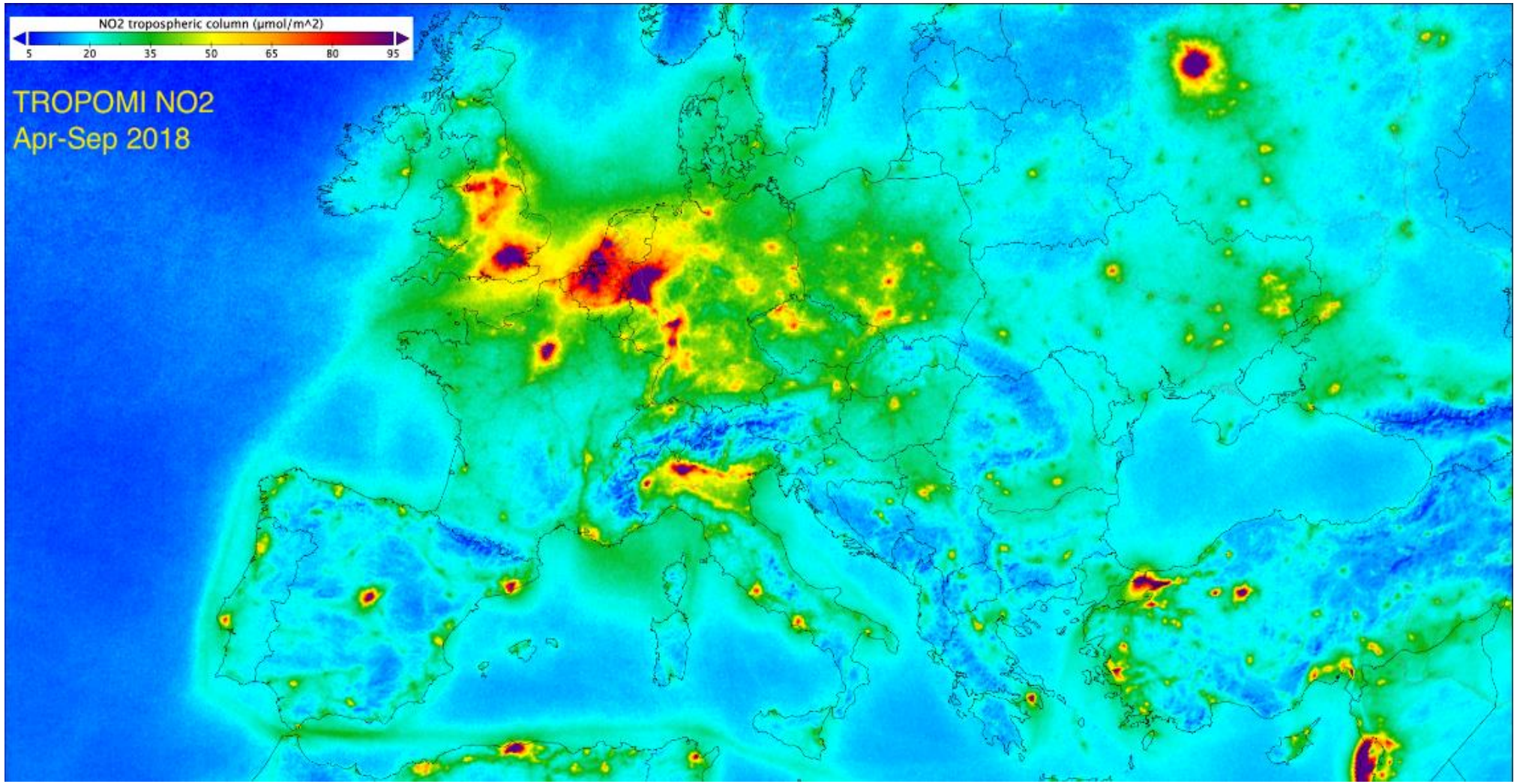
Application scenarios for MTG data

Air quality monitoring

Copernicus Sentinel-4 on MTG-S: Monitoring air pollution

- Air quality monitoring and management is an important part of environmental regulation.
- The monitoring of **air pollutants such as nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone, formaldehyde, and fine particles** is of increasing societal importance.
- The Copernicus Sentinel-4 Ultraviolet, Visible and Near-infrared Sounder (UVN) instrument will provide hourly information on tropospheric NO_2, and many other air quality parameters over **Europe and North Africa**, at a sampling distance of 8 km.

Copernicus Sentinel-4 on MTG-S: Monitoring air pollution



Seasonal average NO_2 tropospheric column map at horizontal resolution of 2 km; TROPOMI instrument on Sentinel-5P. © ESA/KNMI, Henk Eskes

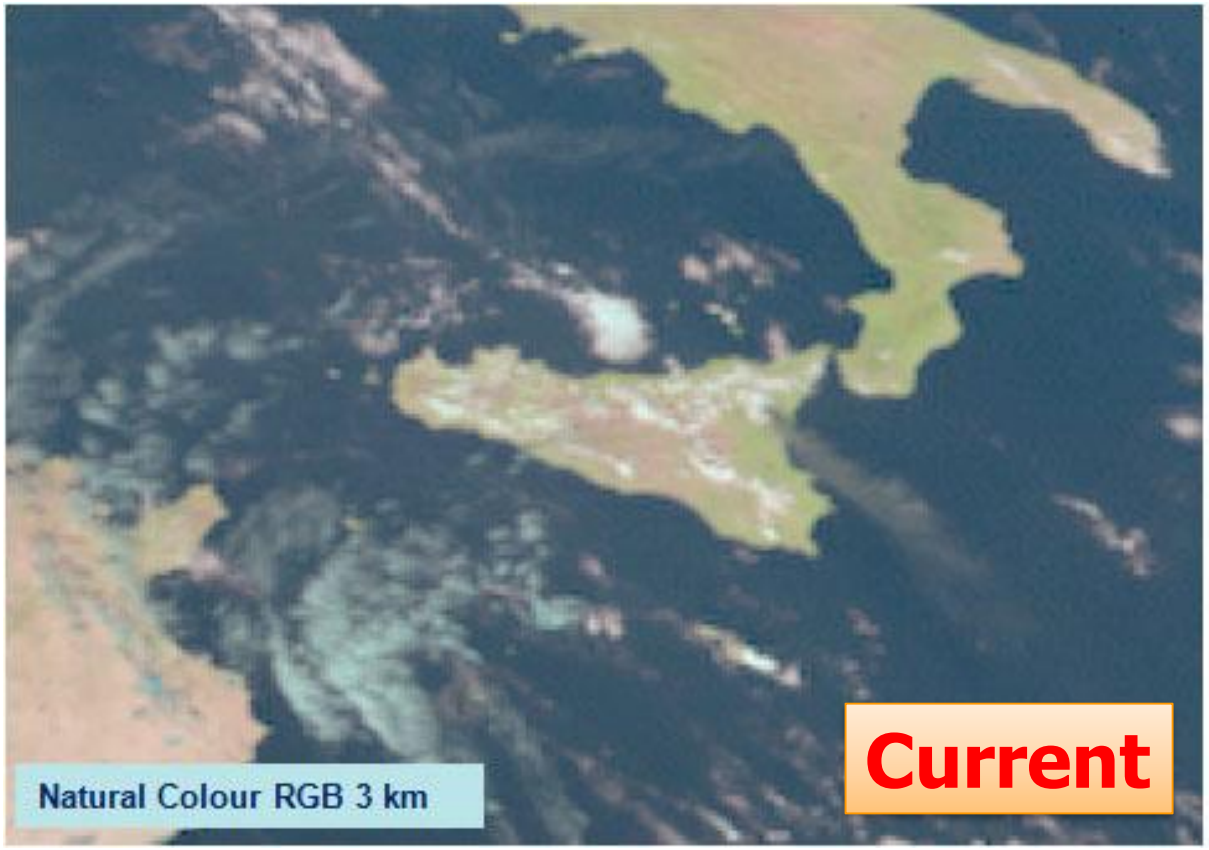
Application scenarios for MTG data

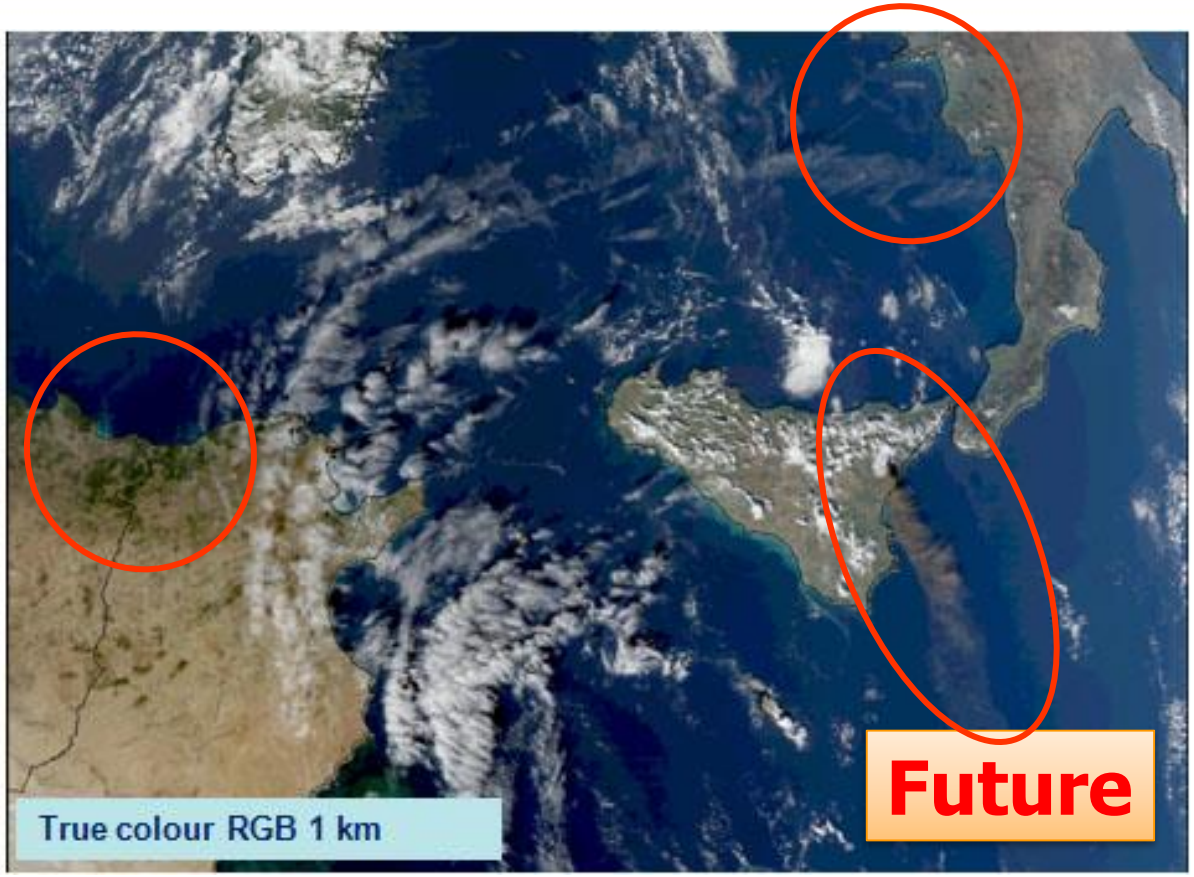
Detection of dust and aerosols

Surface feature detection and analysis

MTG Spectral imaging mission: enhanced continuity of MSG

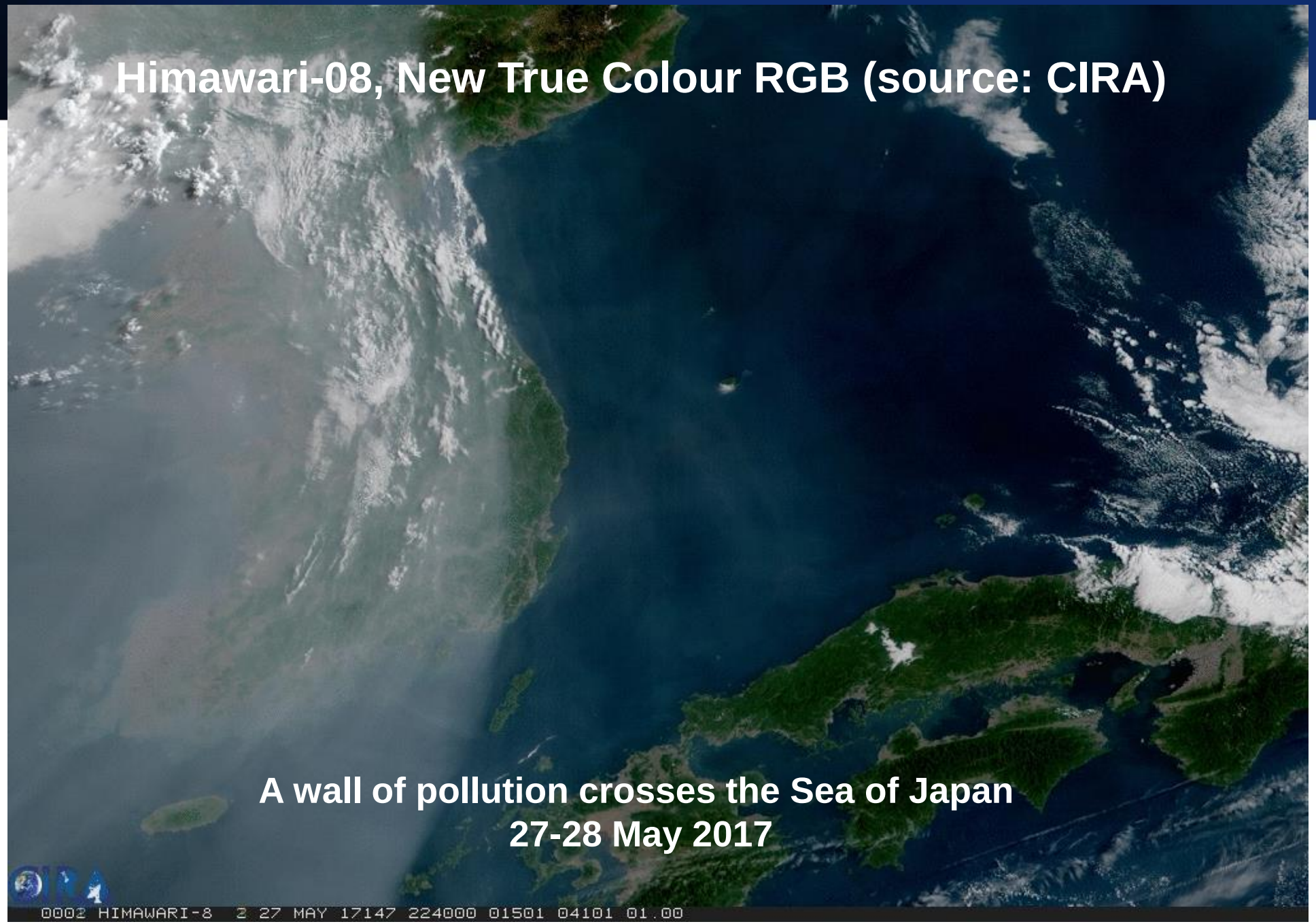
MTG Spectral imaging mission (FCI): higher spatial resolution imagery





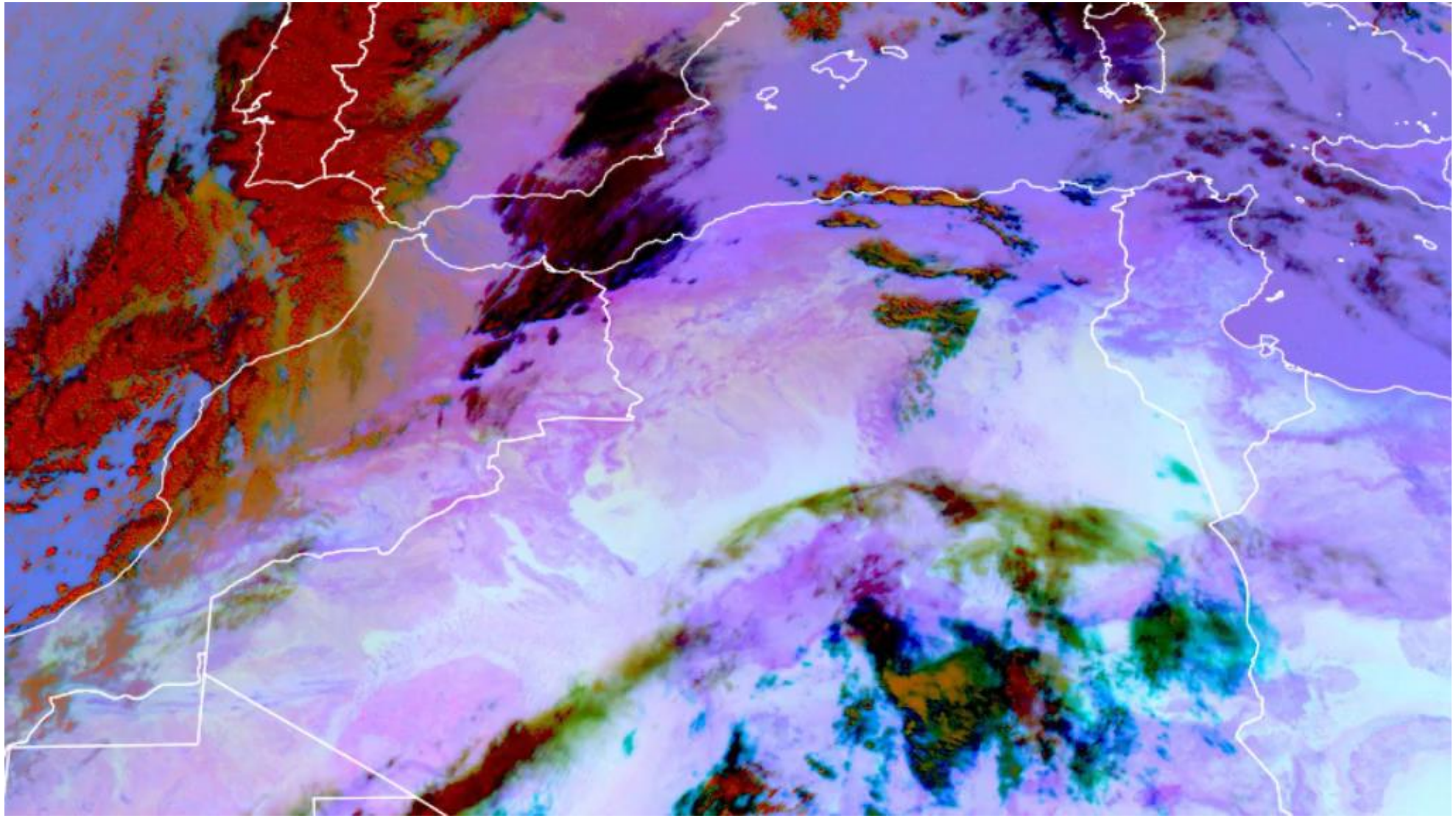
Example of ash detection, SEVIRI Natural Colour RGB, 12:15 UTC, 26 November 2006 (left), MODIS True Colour RGB, 12:20 UTC, 26 November 2006

Himawari-08, New True Colour RGB (source: CIRA)



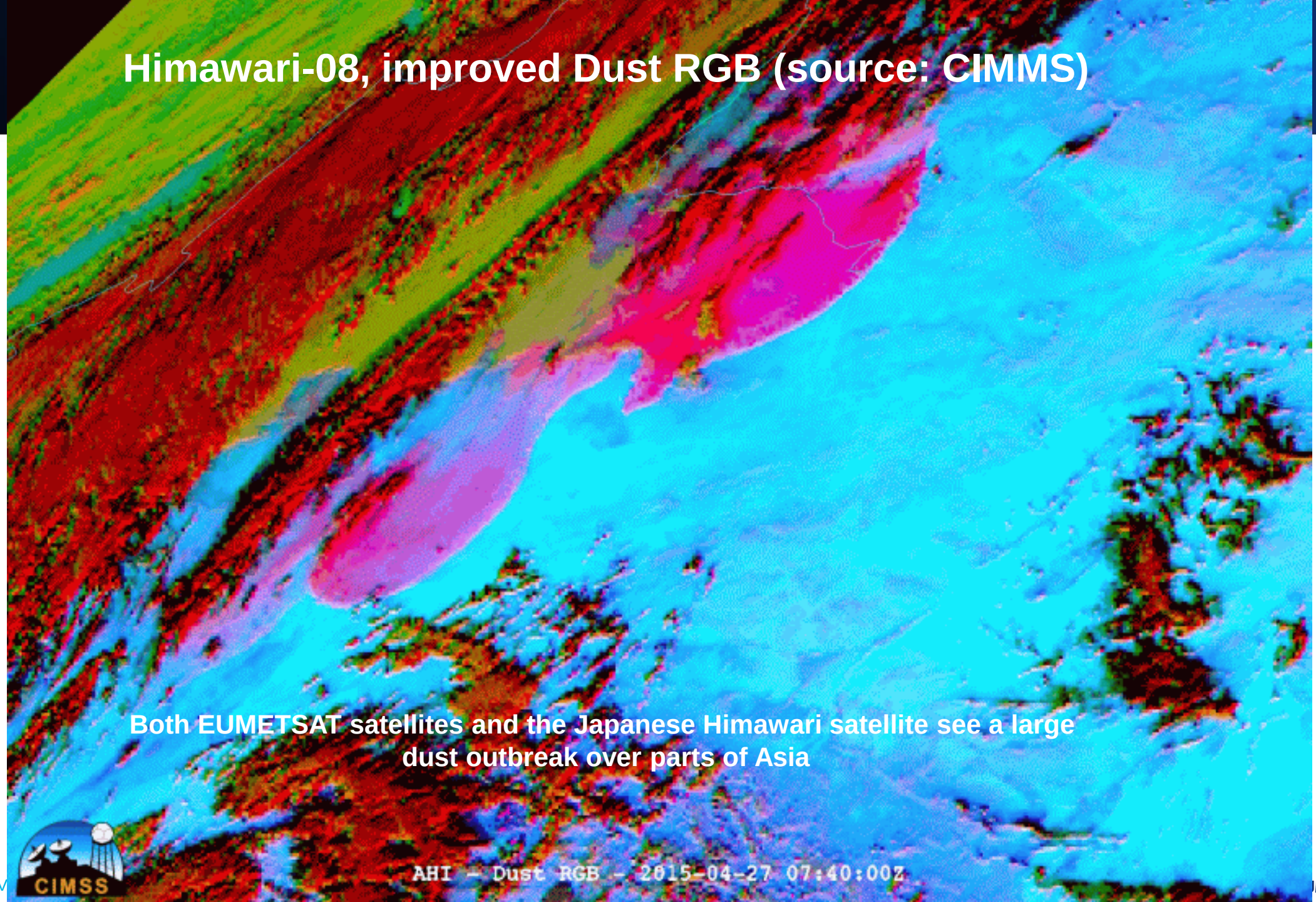
A wall of pollution crosses the Sea of Japan
27-28 May 2017

MTG Spectral imaging mission (FCI): Dust RGB



Meteosat-11 captures plume of Saharan dust coming from northern Africa | EUMETSAT Website

Himawari-08, improved Dust RGB (source: CIMMS)

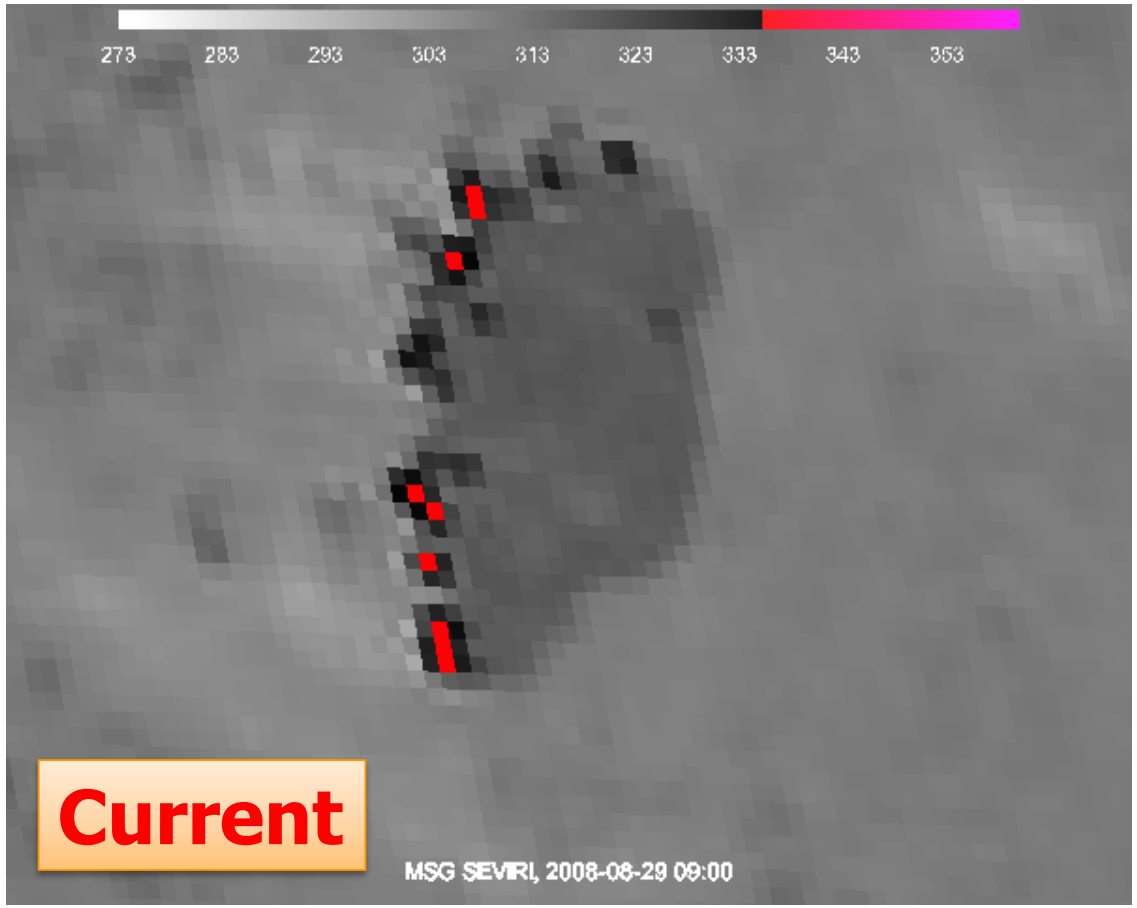


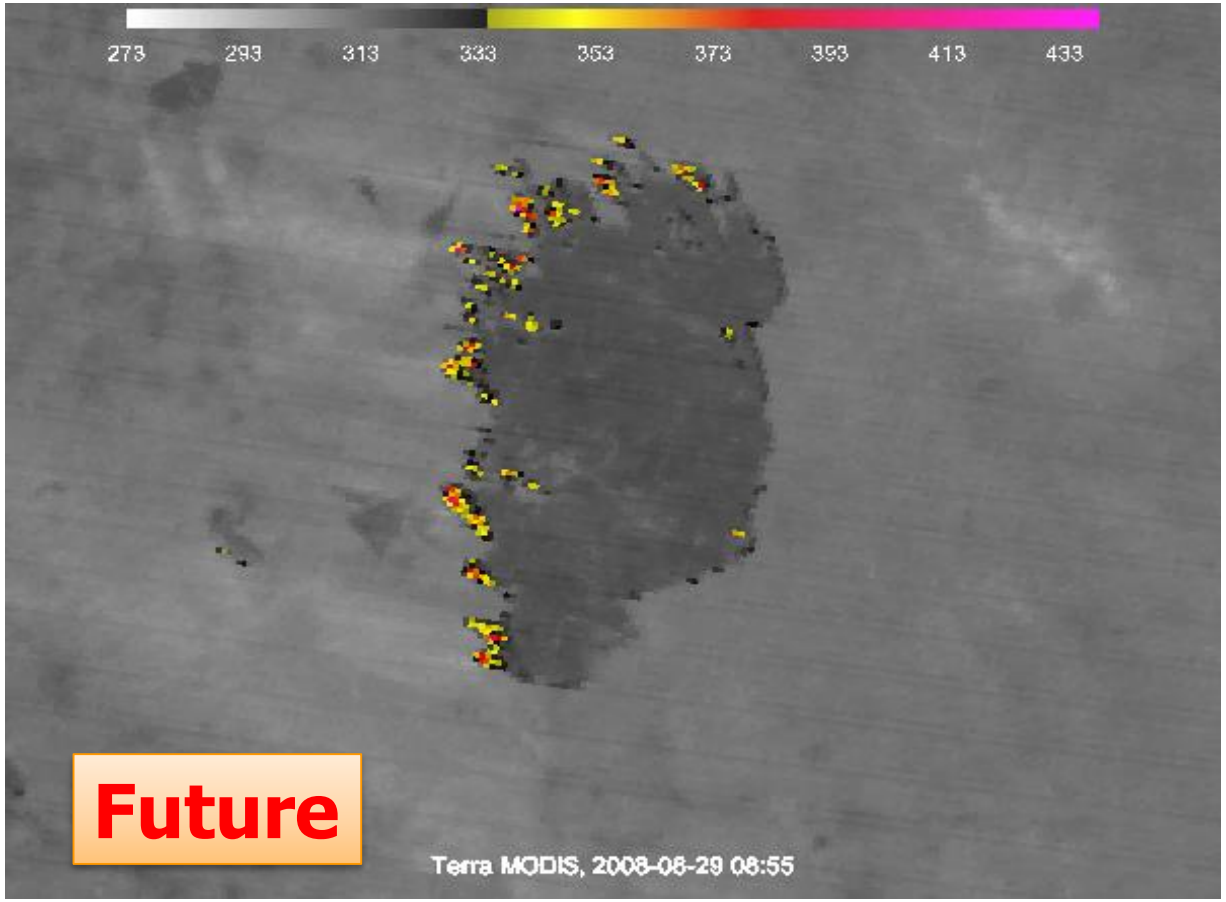
Both EUMETSAT satellites and the Japanese Himawari satellite see a large dust outbreak over parts of Asia

Application scenarios for MTG data

Fire detection and monitoring

MTG Spectral imaging mission (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.

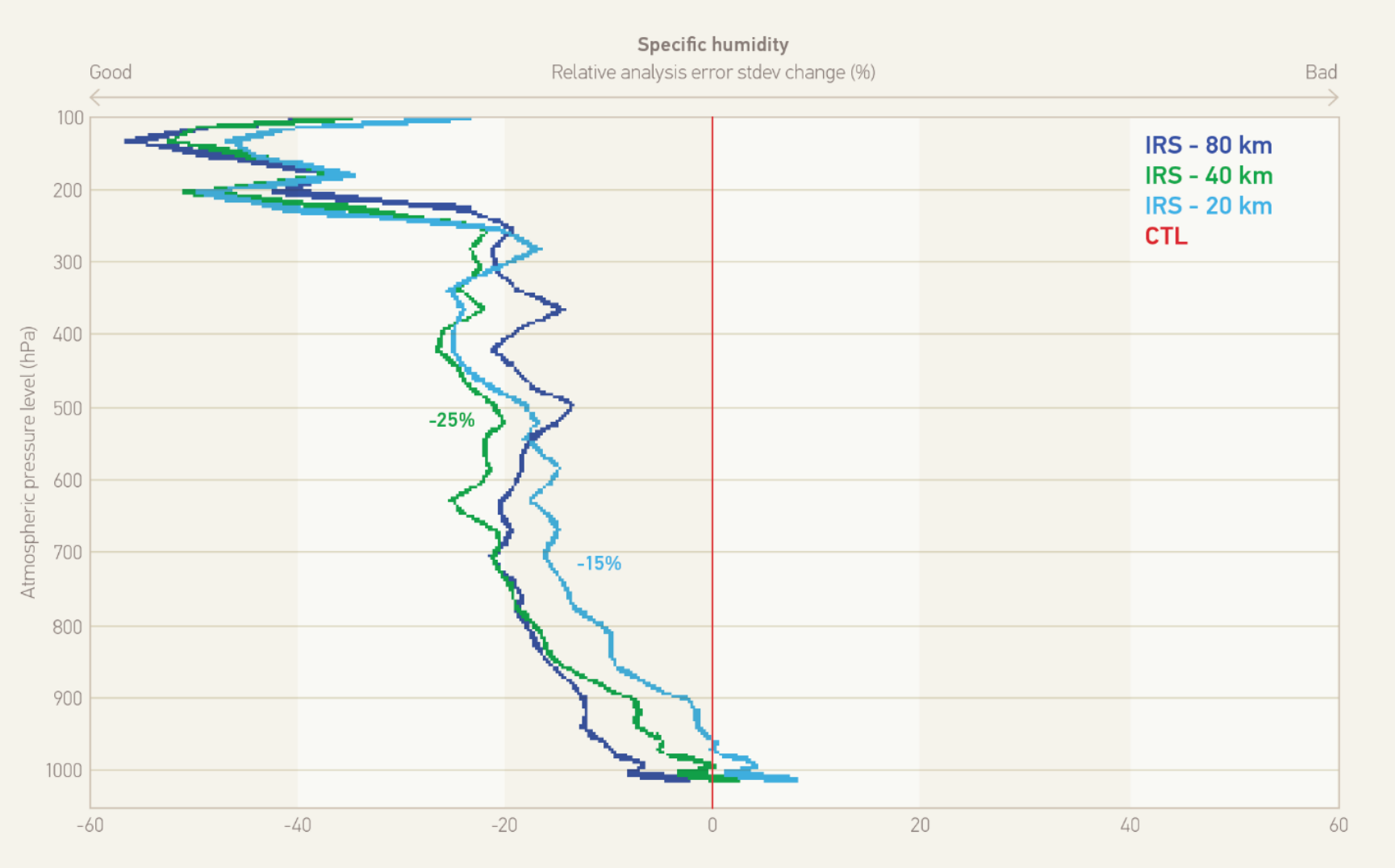
MTG Spectral imaging mission (FCI): New prospects for fire detection and monitoring

Fires in Croatia and Montenegro | EUMETSAT Website

Application scenarios for MTG data

Enhancing numerical weather prediction

MTG Hyperspectral infrared sounding mission (IRS): Enhancing numerical weather prediction



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

Source: Guedj et al., 2014

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	Via EUMETCast Europe (Satellite)	Compressed using CharLS algorithm: • Full Disc Scanning Service (FDSS, 16 imager channels at normal resolution) • Rapid Scanning Service (RSS and RSS-HR: 4 imager channels at normal and high resolution)	None	Principal component scores	None
	Via EUMETCast Terrestrial	• As above + • Full Disc Scanning Service High Resolution (FDSS-HR, 4 imager channels at high resolution)	None	Principal component scores	None
Available from data archive		Everything disseminated in near-real time	None	Full spectral channels, Principal component scores	Daytime Earth radiances and solar irradiances in NIR and UV/VIS bands

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

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

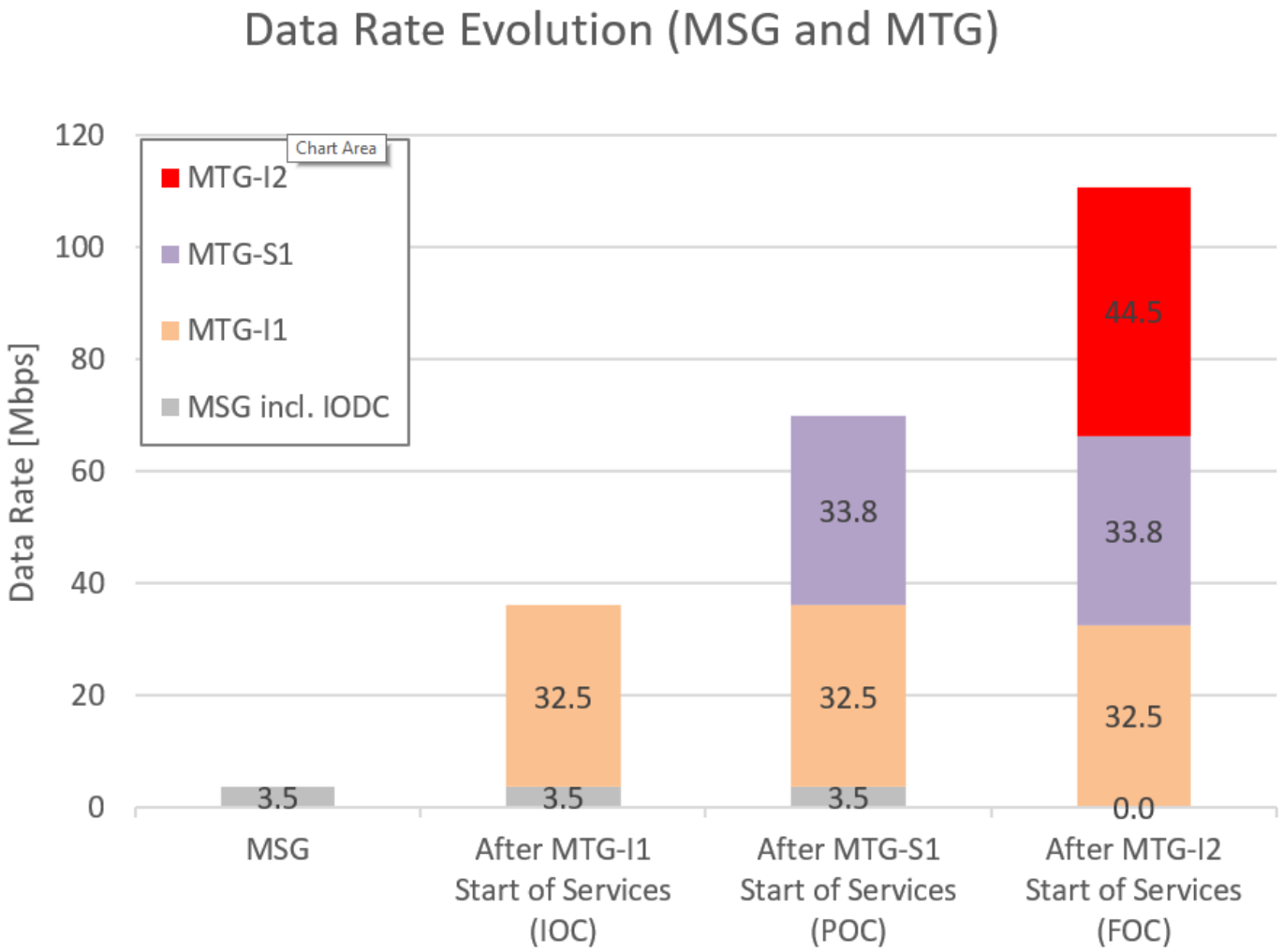
Ref: [MTGDIS]

MTG Data Products – Level 2 Geophysical products from SAFs

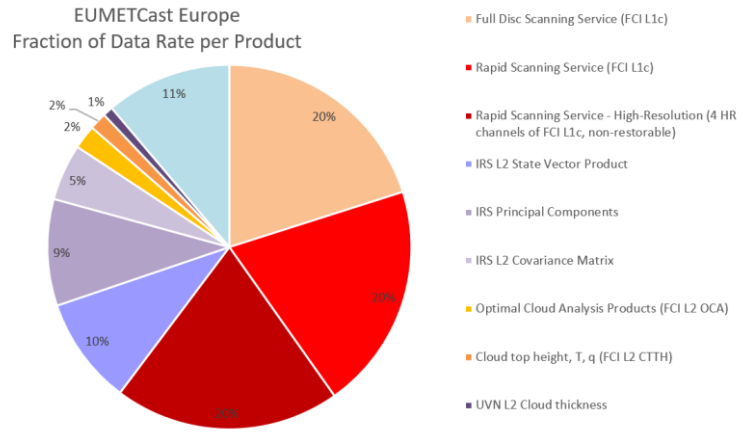
Product	SAF
Precipitation rate at ground by GEO/IR supported by LEO/MW and MTG FCI	Hydrology SAF
Accumulated precipitation at ground by blended MW+IR and MTG FCI - Daily	Hydrology SAF
Accumulated precipitation at ground by blended MW+IR and MTG FCI - Hourly	Hydrology SAF
Hydrology SAF – Snow detection and coverage	Hydrology SAF
Hydrology SAF – Rainfall intensity from MTG LI	Hydrology SAF
Surface Albedo	Land SAF
Land Surface Temperature	Land SAF

Product	SAF
Downward Longwave Irradiance combined with the Solar Surface Irradiance - Daily	Ocean and Sea Ice SAF
Downward Longwave Irradiance combined with the Solar Surface Irradiance - Hourly	Ocean and Sea Ice SAF
Sea Surface Temperature	Ocean and Sea Ice SAF
4 products on clouds 2 precipitation products 1 clear-air product (profiles) 2 winds products 2 convection products	NWC SAF (software)
• Radiative transfer code for FCI, LI, IRS (RTTOV) • Radiance simulator • Cloud and aerosol detection, 1D-VAR software for retrieval and analysis, preprocessing software for MTG IRS	NWP SAF (software)

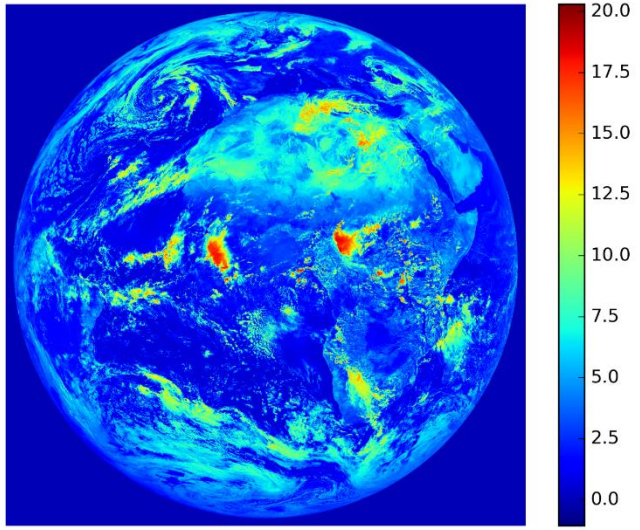
MTG: Data Access and Processing



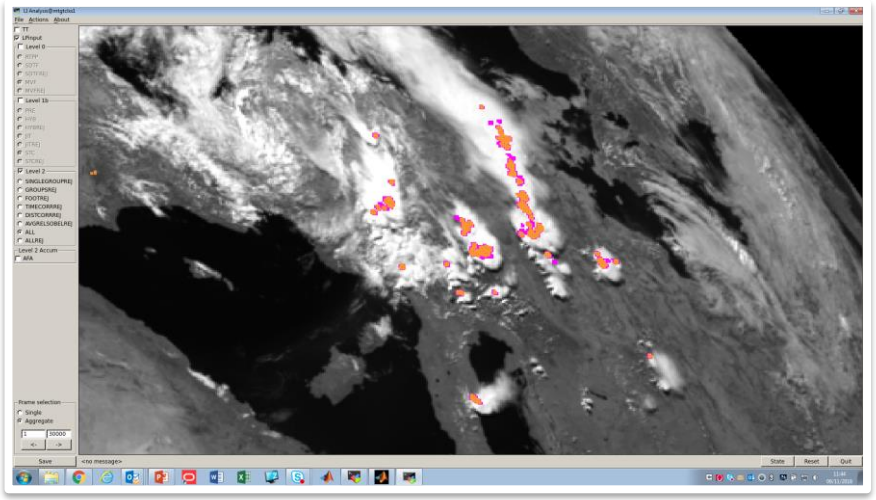
Evolution of data rates from current MSG to the full MTG operations.



MTG: User Familiarisation Data



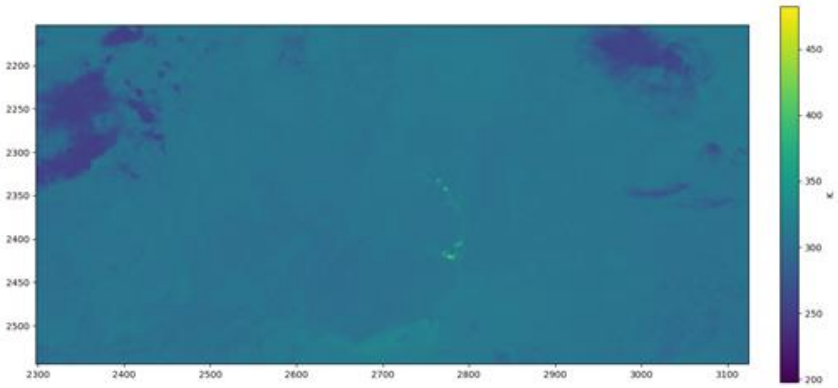
Example of simulated FCI L1c user familiarisation data (VIS 0.6um channel, 10 April 2017). To reduce data volumes in near-real-time services such as EUMETCast, the netCDF-4 near-real-time FCI Level 1c data will only be available in compressed form using the CharLS algorithm.



Simulated LI L2 detected transients which correspond to the occurrence of optical pulses and lightning in the atmosphere (20 June 2013 SEVIRI data used as background)

- To ensure user readiness, it is extremely important that users have access to data that will, in a best possible way, resemble the data that will be available from the future instruments.
- User familiarisation (test) data should have the best possible maturity in data content and in format specifications attached to different data. This is valid both for the pre-launch development period and during post-launch commissioning activities
- Up to now, the following simulated data are made available by EUMETSAT:
  - FCI Level 1c data for format familiarisation (24h)
  - FCI Level 1c data for scientific familiarisation (1 full-disc)
  - IRS Level 1b data for format familiarisation
  - LI Level 2 data for format familiarisation
- https://www.eumetsat.int/mtg-test-data

MTG Test Data: FCI L1c enhanced and non-nominal test data (June 2020, TD-272)



Simulation of fires to simulate the IR 3.8 µm channel and its extended dynamic range

Mapping very hot surfaces up to 500K w/o saturation

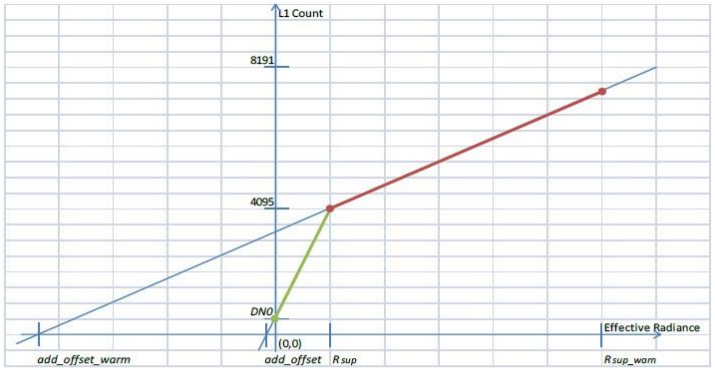
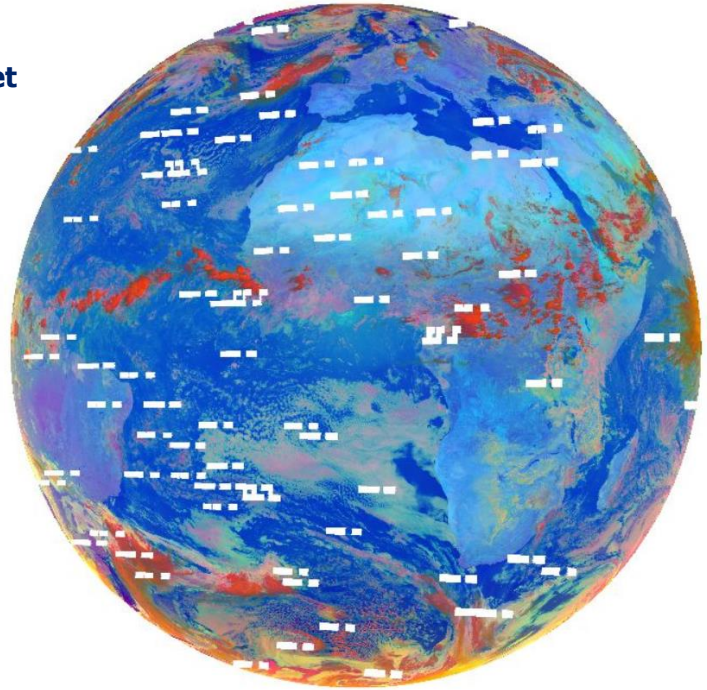
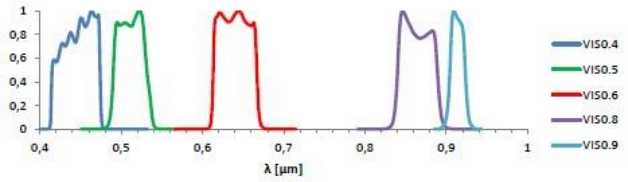
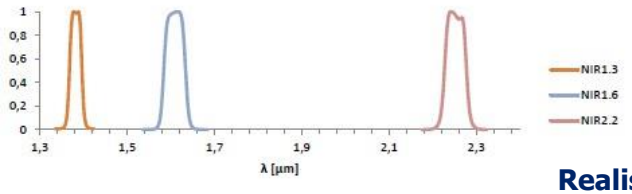


Figure 15 Illustration of the encoding of the combined IR 3.8m channel with offsets and scale factors for the "cold" (green) and "warm" (red) measurements

Simulation of day-microphysics RGB with missing segments due to data packet losses







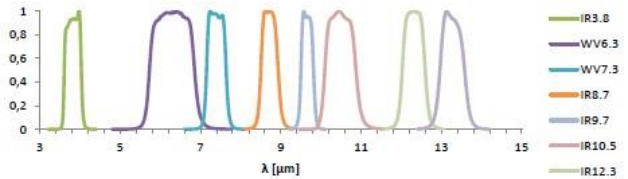


Figure 2 Averaged FCI Spectral Response Functions of each spectral channel as a function of wavelength.

Realistic simulation of new FCI channels

Ref: FCI L1b Product User Guide v1J

How EUMETSAT can help

User Support

- The EUMETSAT User Service Helpdesk can answer your questions regarding MTG. Contact our team at ops@eumetsat.int

Training

- Building on years of experience in training operational meteorologists, the EUMETSAT training programme has started to focus on MTG applications. There will be a range of opportunities for staff of NMHS to engage.

- https://twitter.com/eumetsat_users or contact ops@eumetsat.int

User Preparation Webinar Series

- In 2020-2021, online technical briefings on all next-generation (MTG and EPS-SG) Observation Missions and key Applications

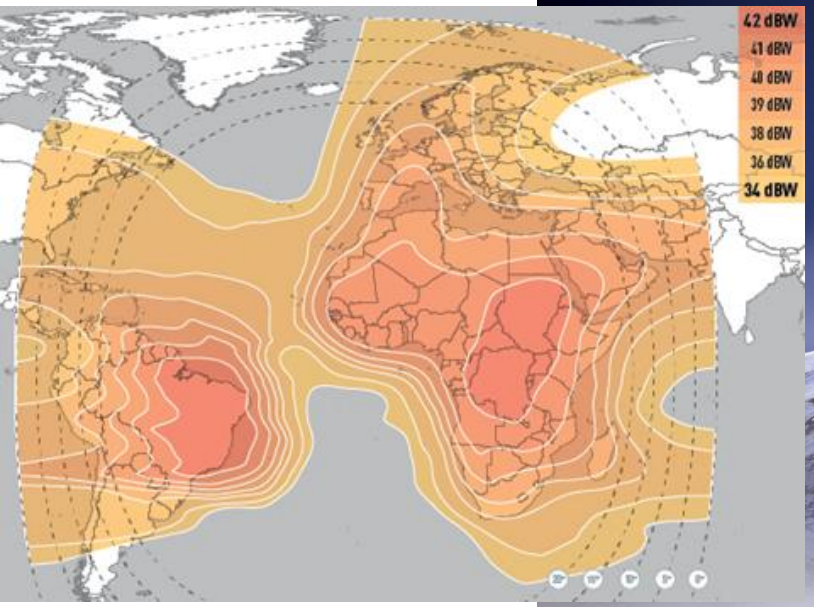
Observation Mission	Webinar Dates
IRS and IASI-NG	13-14 Oct 2020
LI	16-17 Feb 2021
SCA	20 May 2021
FCI and METimage	8-10 Jun 2021
3MI	14-15 Jun 2021
…	…

- Recordings, presentations and Q&A available (https://www.eumetsat.int/mtg-resources)

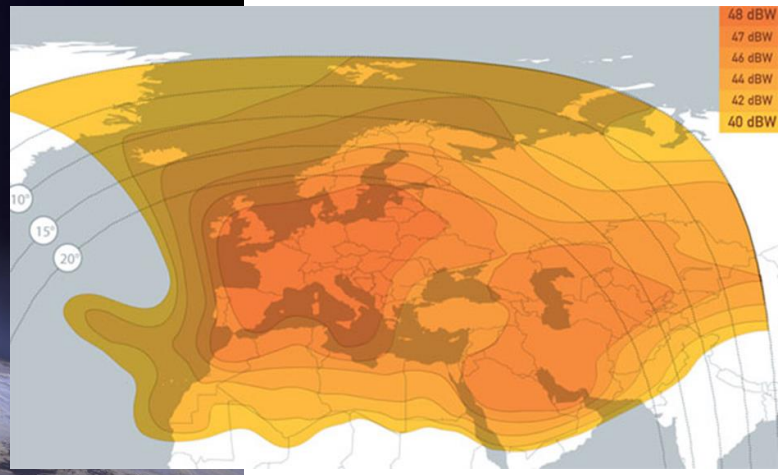
Thank you for your attention.

EUMETCast Satellite

Africa footprint



Europe footprint



EUMETCast Satellite

Africa

- Currently partial transponder used, 14 Mbps
- Moderate increase foreseen ~3.5 Mbps for MTG full disc mission

Europe

Until end 2022:

- Currently 2 full transponder used, max 140 Mbps, supporting MTG-I1

From Q4 2022:

- Significant capacity increases foreseen for EPS-SG, MTG-S / I2
- Backup Satellite usage foreseen