Combined EarthCARE–MTG-LI Observations of Convective Storm Structure and Lightning

Blanka Piskala, ESA – ESRIN, Italy
Johanna Mayer, Thorsten Fehr, Edward Malina, Daniele Gasbarra, Saskia Brose, Ondrej Nedelcev

EarthCARE Science and Validation Workshop 2025

MOTIVATION & BACKGROUND

- EarthCARE is a new satellite – first Doppler cloud radar in space
- Brings a unique opportunity to look at clouds, aerosols, and dynamics in detail
- Explore if **EarthCARE measurements can describe or anticipate lightning activity**

What I'll show today

- How I **combine EarthCARE with lightning sensors** (MTG-LI, GOES-GLM)
- A few **case examples** and **research ideas**

1 COMBINATION WITH LIGHTNING SENSORS

COMBINATION WITH LIGHTNING SENSORS

Spatial matching:

- The geostationary satellites can introduce horizontal displacement errors (parallax) for lightning data due to the viewing geometry
- Correction algorithms (based on Satpy and cloud height from EarthCARE) match the geostationary lightning detection with EarthCARE's MSI

Temporal matching:

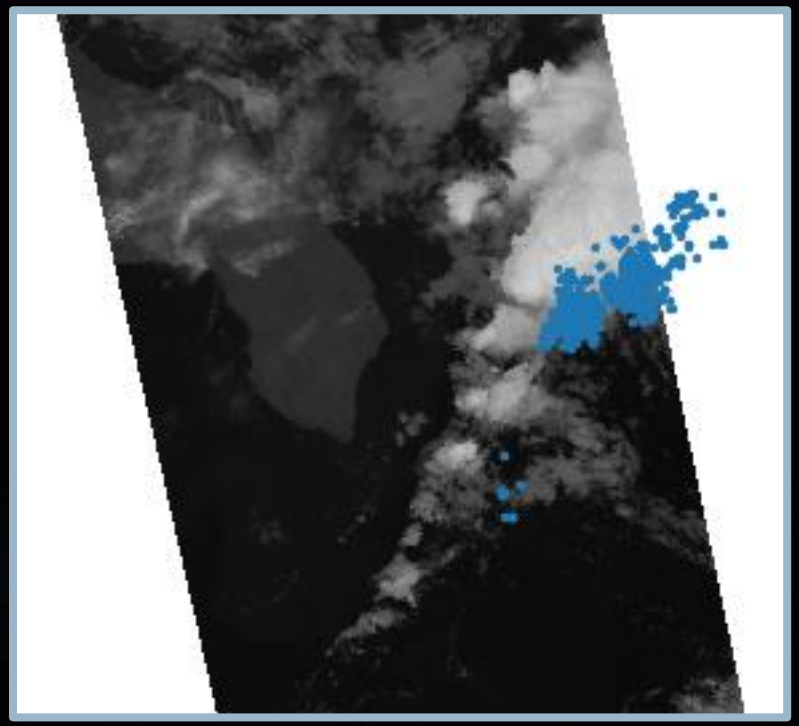
- EarthCARE has a certain revisit time and narrow swath vs. geostationary continuous coverage
- Identify overlapping time windows (within ±60 minutes) to capture simultaneous events and have reasonable information about the storm development

COMBINATION WITH LIGHTNING SENSORS

Challenges in EarthCARE–lightning matching:

- Large viewing angle at higher latitudes → strong horizontal displacement
- Parallax correction works only when the lightning comes from the **upper cloud layer**
- When optical flashes reflect off **lower clouds**, the apparent position becomes unreliable
- Ground-based networks could help to correct lightning locations

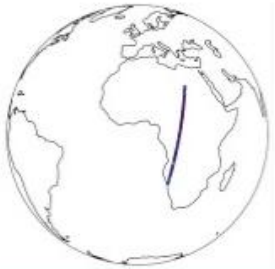
EarthCARE MSI + MTG-LI groups
2024/12/10 00:20



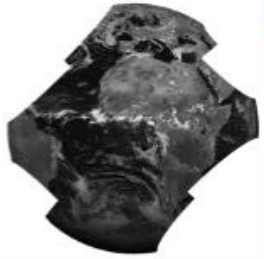
COMBINATION WITH LIGHTNING SENSORS

Spatio-temporal matching

EarthCARE MSI + CPR



MTG LI groups

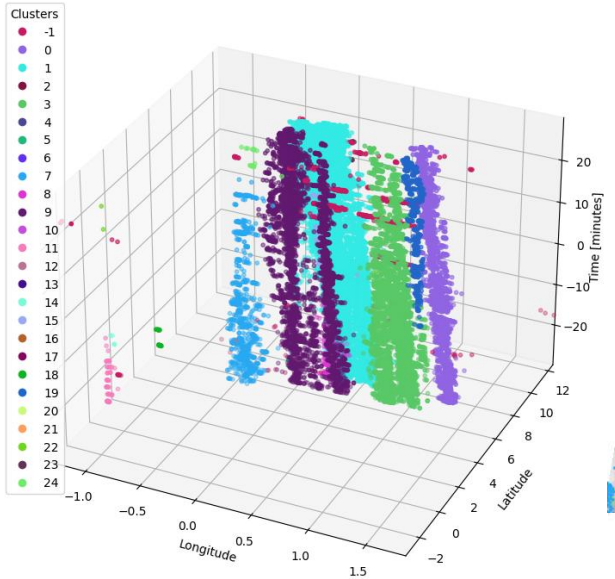


New dataset creation

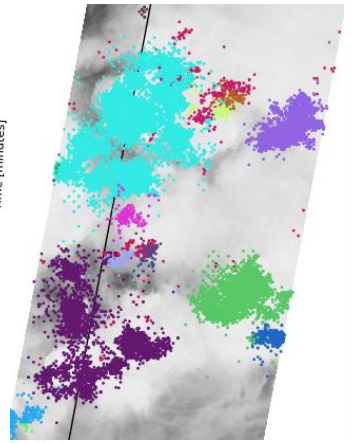
Lightning data matched with EarthCARE frame
Time difference ± 60 min,
parallax corrected lat/lon, distance from CPR track

Storm detection

Clustering of lightning data using DBSCAN algorithm applied to space-time (lat, lon, time)



EarthCARE MSI
+ MTG-LI groups



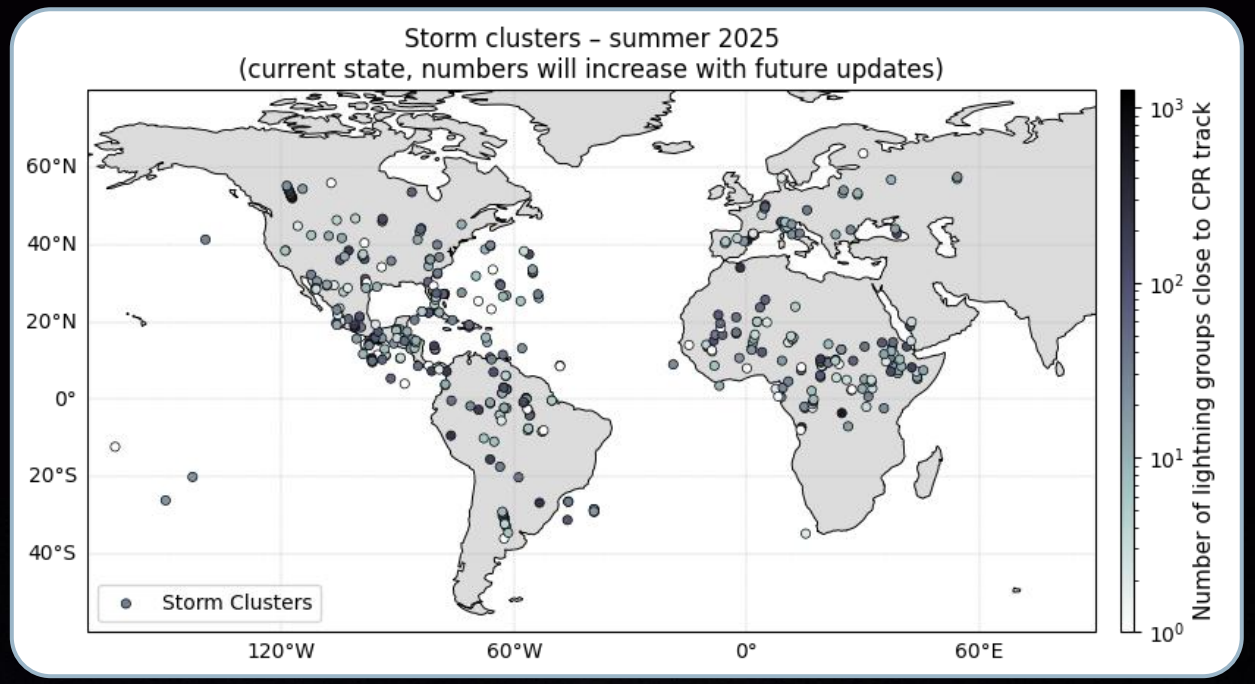
Storm catalogue creation

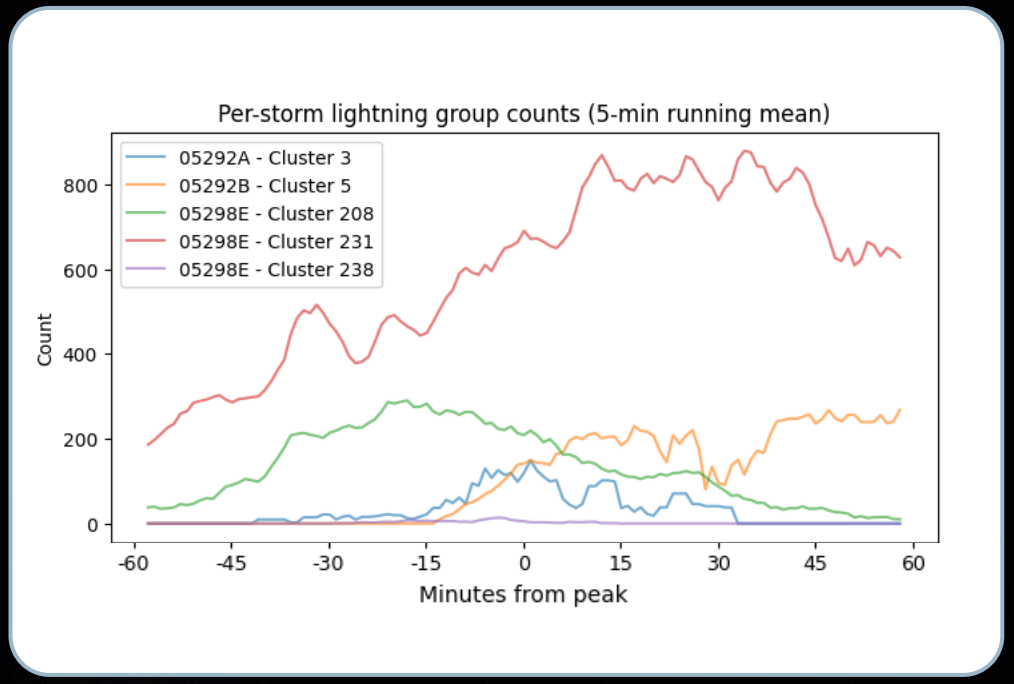
Storms crossed by EarthCARE CPR
Saved to storm catalogue with indication of lightning activity, flash rate evolution, storm trajectory

Joint Analysis
with EarthCARE vertical profiles and LMA

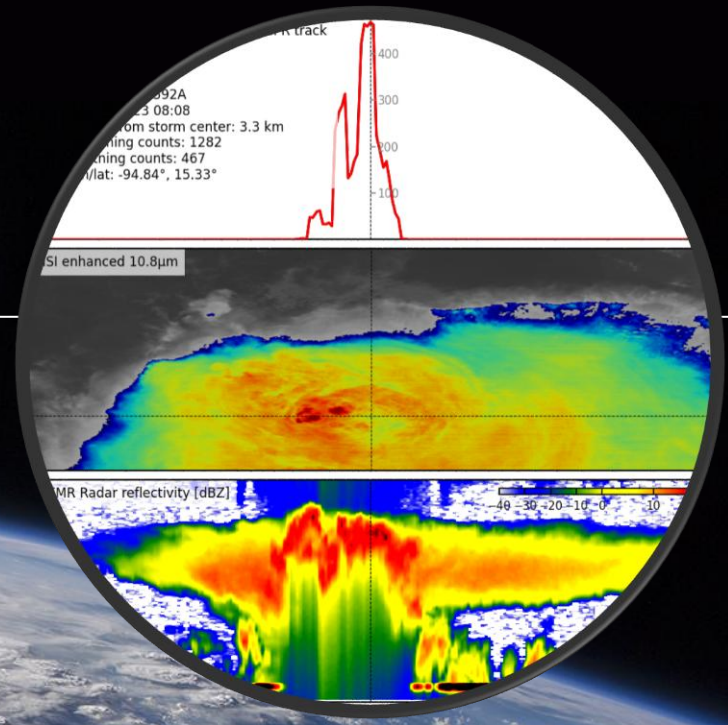
COMBINATION WITH LIGHTNING SENSORS

EarthCARE storm catalogue

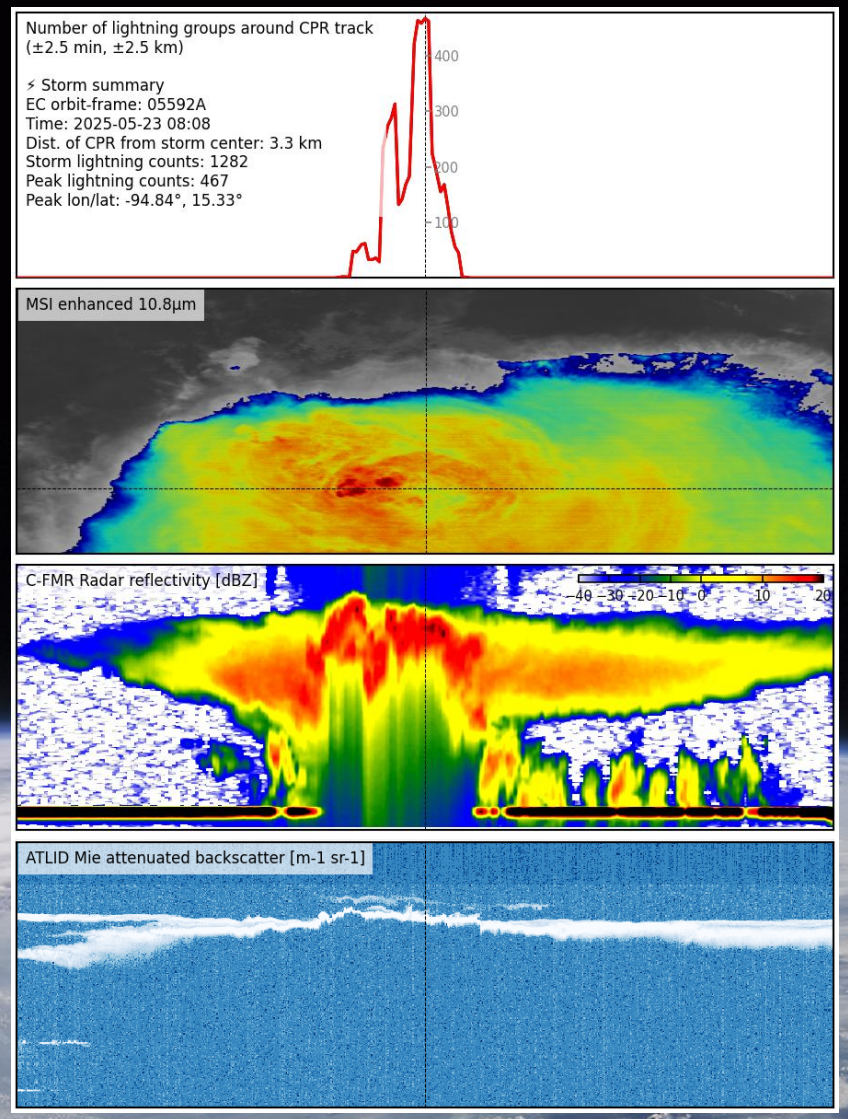




2 EXPLORING THE DATA



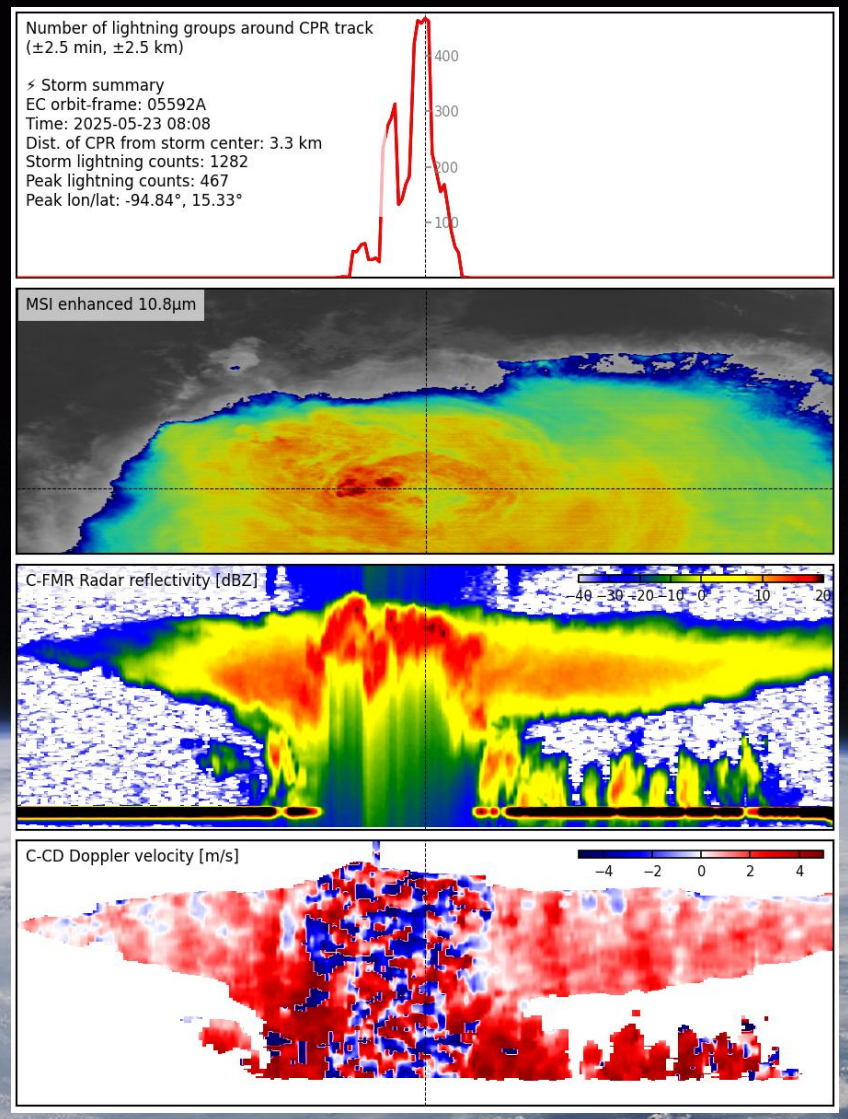
EXPLORING THE DATA



Case 1: Multi-sensor view of a convective storm

- Geostationary **lightning groups** (±2.5 min; ±2.5 km around nadir)
- **MSI enhanced-IR image**: overshooting tops clearly visible
- **CPR vertical slice**: overshoot + upper cloud structure; strong attenuation & multiple scattering below
- **ATLID backscatter**: cannot penetrate core, but reveals thin cirrus above the storm

EXPLORING THE DATA

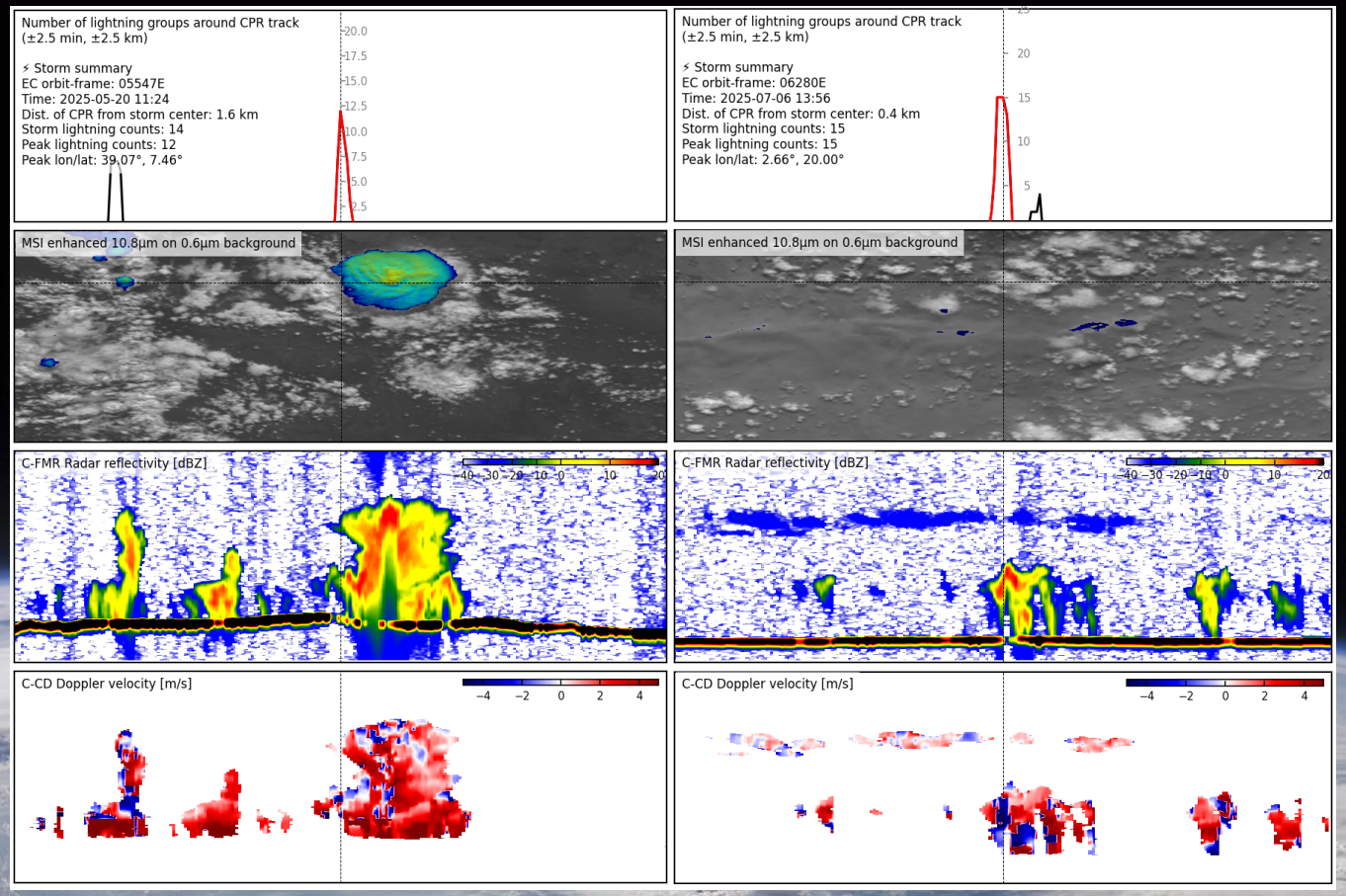


Case 1: Multi-sensor view of a convective storm

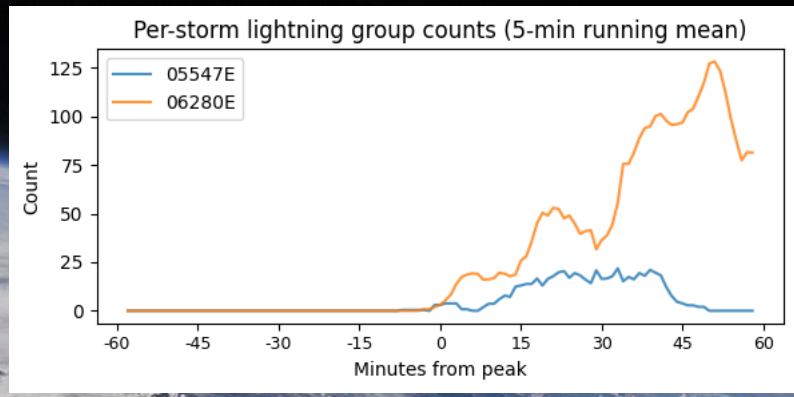
- Geostationary **lightning groups** (±2.5 min; ±2.5 km around nadir)
- **MSI enhanced-IR image**: overshooting tops clearly visible
- **CPR vertical slice**: overshoot + upper cloud structure; strong attenuation & multiple scattering below
- **ATLID backscatter**: cannot penetrate core, but reveals thin cirrus above the storm
- **CPR Doppler velocity**: absolute values fold in cores (Nyquist ±5–6 m/s), but the variability highlights turbulent, high vertical velocity regions

EXPLORING THE DATA

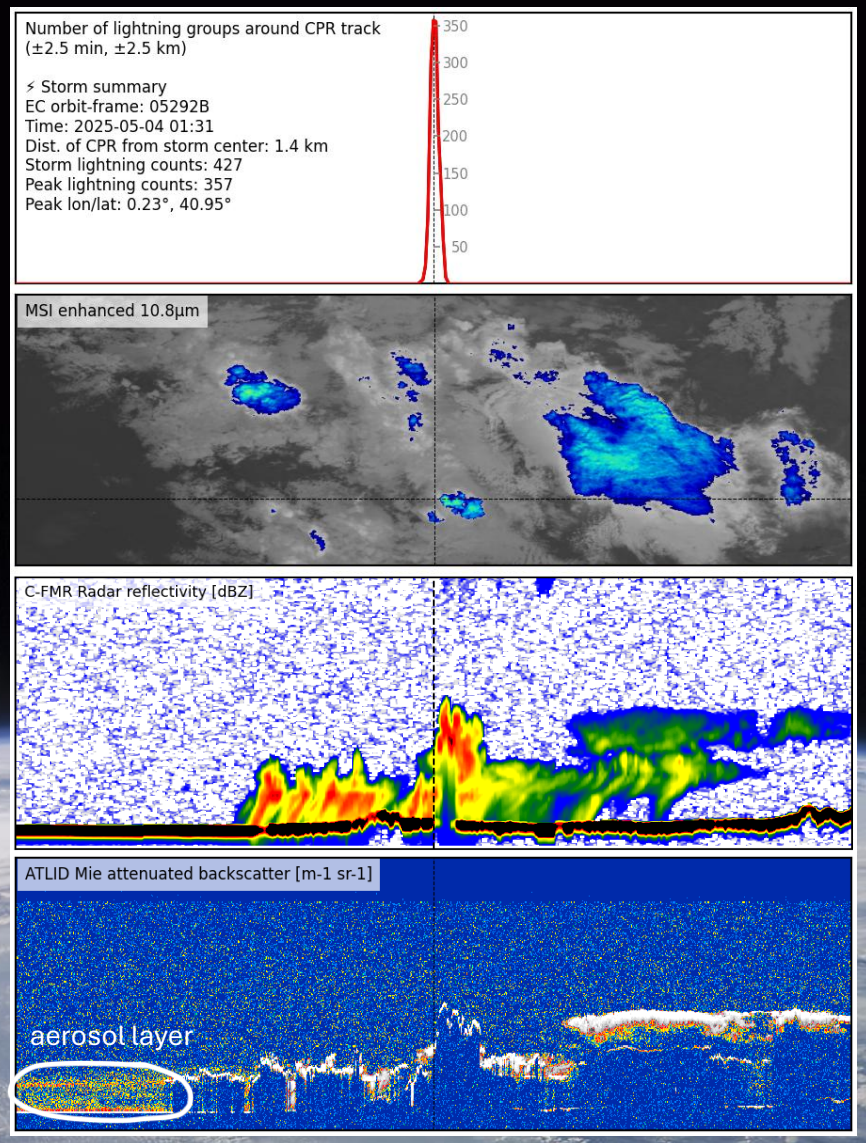
Case 2: Identifying storm life-cycle stage



- Storm lifecycle stage (developing, mature, dissipating) is crucial for correctly interpreting EarthCARE observations
- Lightning evolution (±1 hour) + clustering allows tracking each storm in time
- Here: two storms in early development stage
- Early-stage convection provides cleaner view of initial updraft conditions; Doppler velocities contain fewer foldings → easier to interpret / unfold



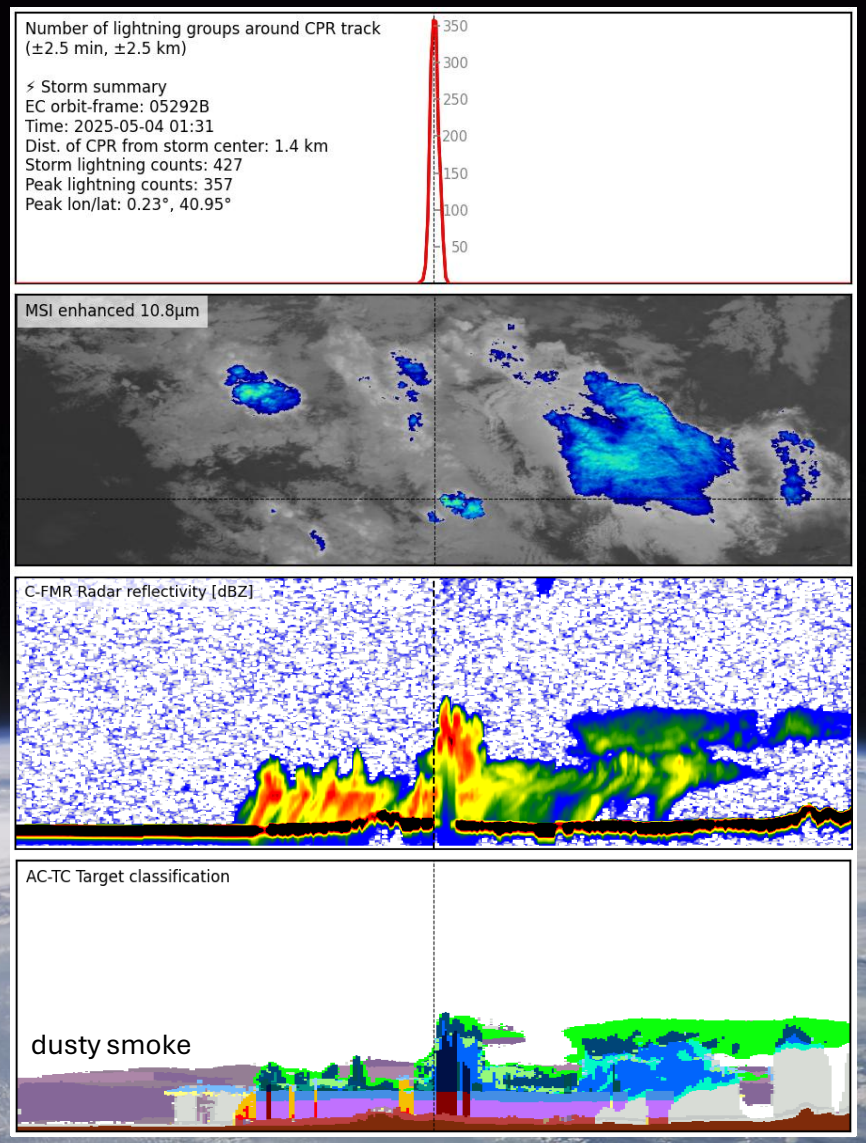
EXPLORING THE DATA



Case 3: Small storm over Spain

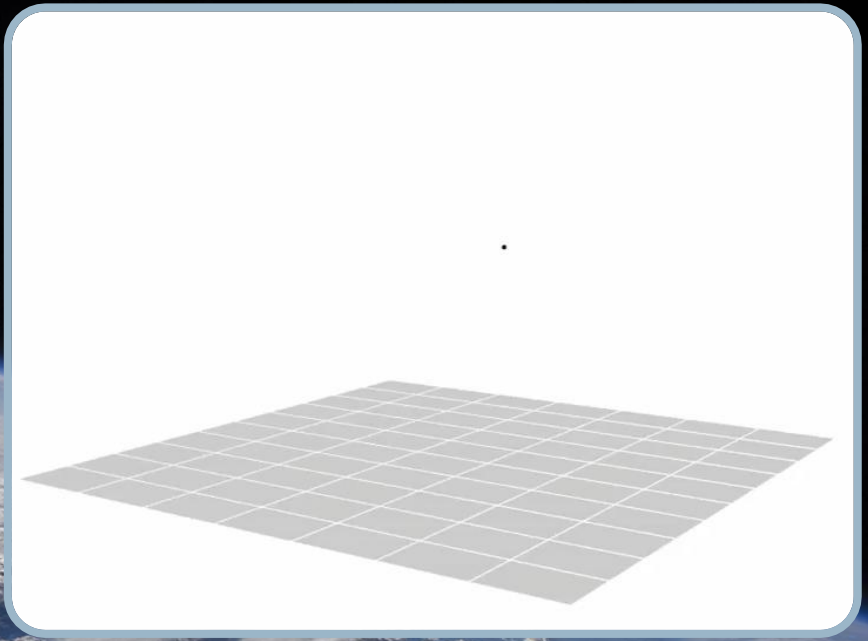
- High number of lightning groups despite small storm size – possible influence of aerosol layer?
- Surrounding environment classified as **dusty smoke** (EarthCARE target classification)
- ATLID cannot see inside core, but shows aerosol layers around the storm

EXPLORING THE DATA



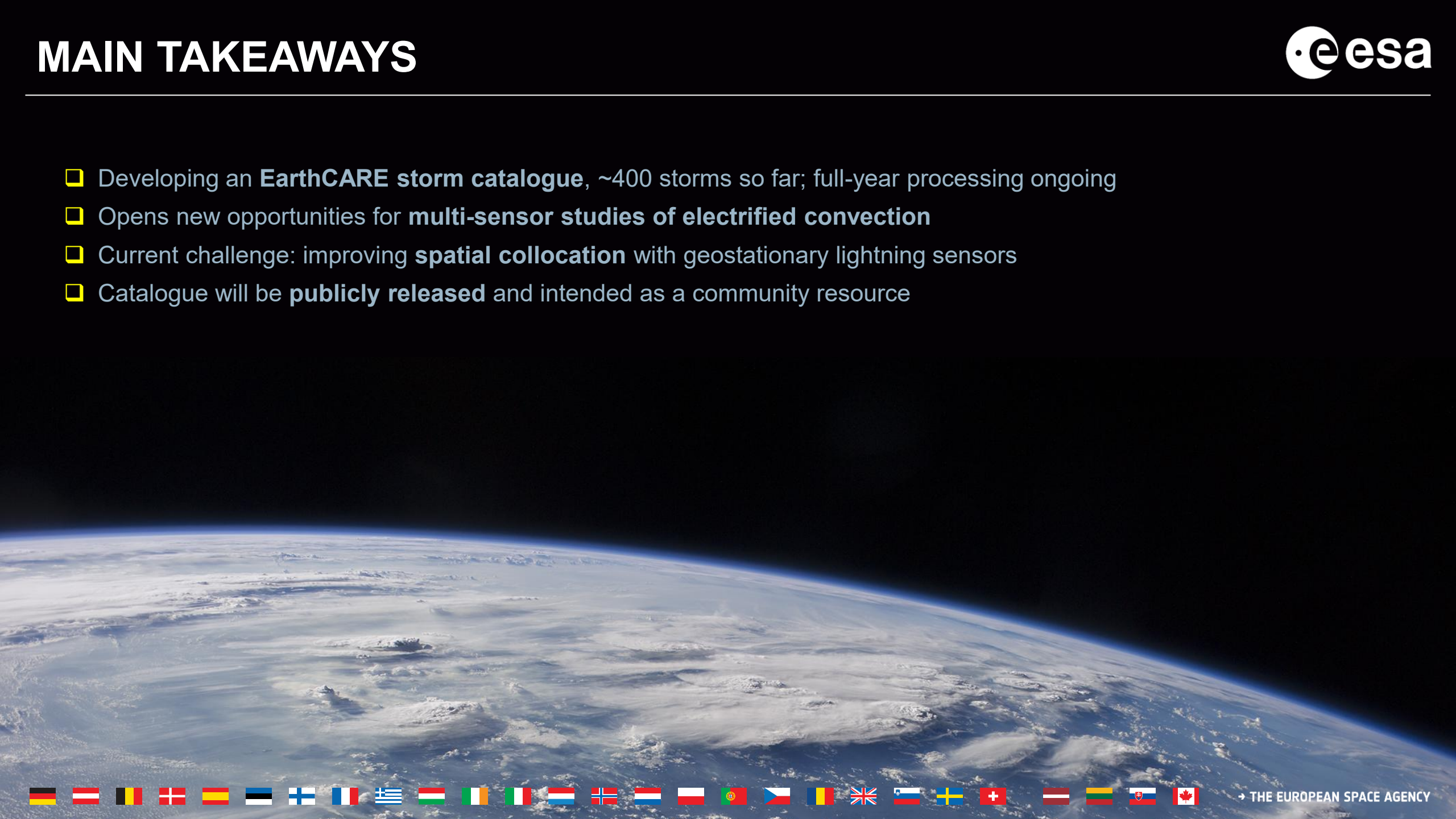
Case 3: Small storm over Spain

- High number of lightning groups despite small storm size – possible influence of aerosol layer?
- Surrounding environment classified as **dusty smoke** (EarthCARE target classification)
- ATLID cannot see inside core, but shows aerosol layers around the storm
- eLMA data provide 3D lightning source heights – enables direct comparison of lightning geometry with CPR dynamical features



MAIN TAKEAWAYS

- Developing an **EarthCARE storm catalogue**, ~400 storms so far; full-year processing ongoing
- Opens new opportunities for **multi-sensor studies of electrified convection**
- Current challenge: improving **spatial collocation** with geostationary lightning sensors
- Catalogue will be **publicly released** and intended as a community resource



THANK YOU!

Blanka.Piskala@esa.int

Blanka Piskala, ESA – ESRIN, Italy
Johanna Mayer, Thorsten Fehr, Edward Malina, Daniele Gasbarra, Saskia Brose, Ondrej Nedelcev