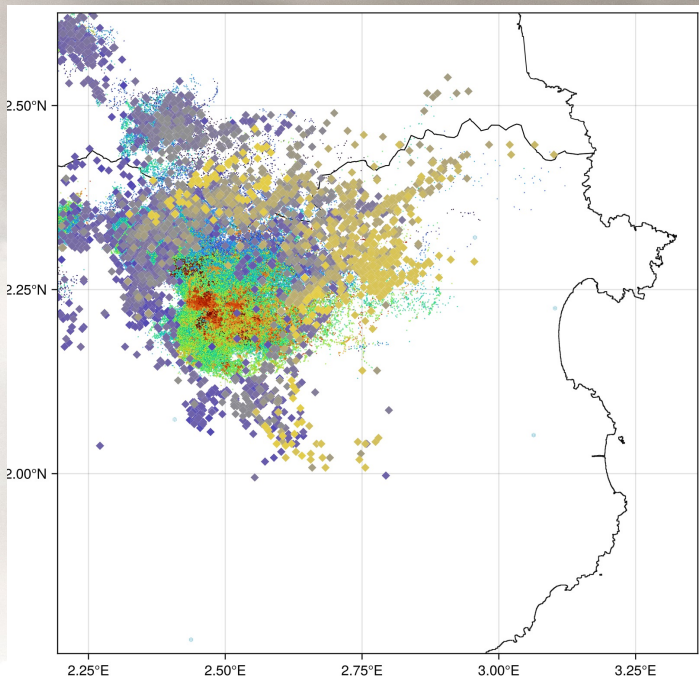


Lightning ring signatures with the Meteosat Lightning Imager (MTG-LI) compared to the Lightning Mapping Array in northeastern Spain



meteo.cat | Servei Meteorològic de Catalunya



UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH

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This talk

The 3D Lightning Mapping Array in Catalonia (XCALMA)

- LMA is the gold standard for flash detection efficiency, leader altitude, flash extent, charge structure
- eXtended **Catalonia LMA** is world's largest with 30 stations, operated by UPC and meteo.cat

EUMETSAT Lightning Imager

- What does its 'group' detections correspond to?
- Rings and arc effects vs LMA (lightning hole?)
- Flash rates vs LMA

7 – 13 stations **Ebro LMA** (2011-2022) → 30 stations **XCALMA** (2023, full size 2025)



A - Alfés



C - Bujaraloz



D - Raimat



E - Amposta



F - Illa de Buda



G - Els Ports



H - Els Valentins



I - Canal Vell (Deltebre)



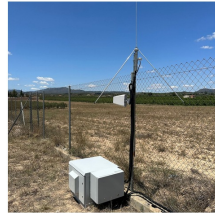
J - Torres de Alcanadre



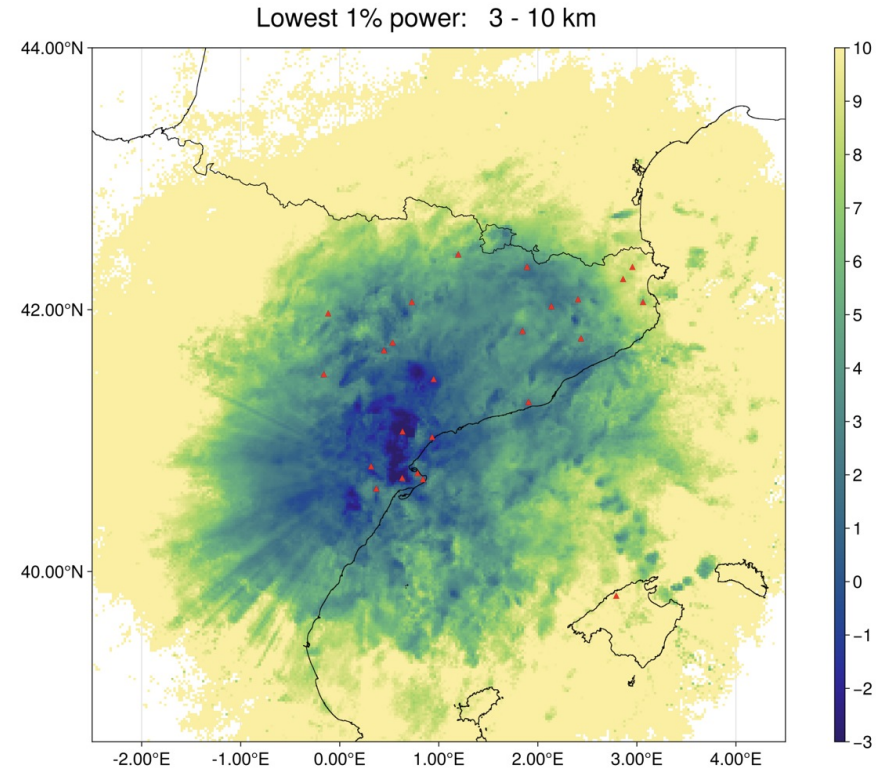
K - Mont-roig



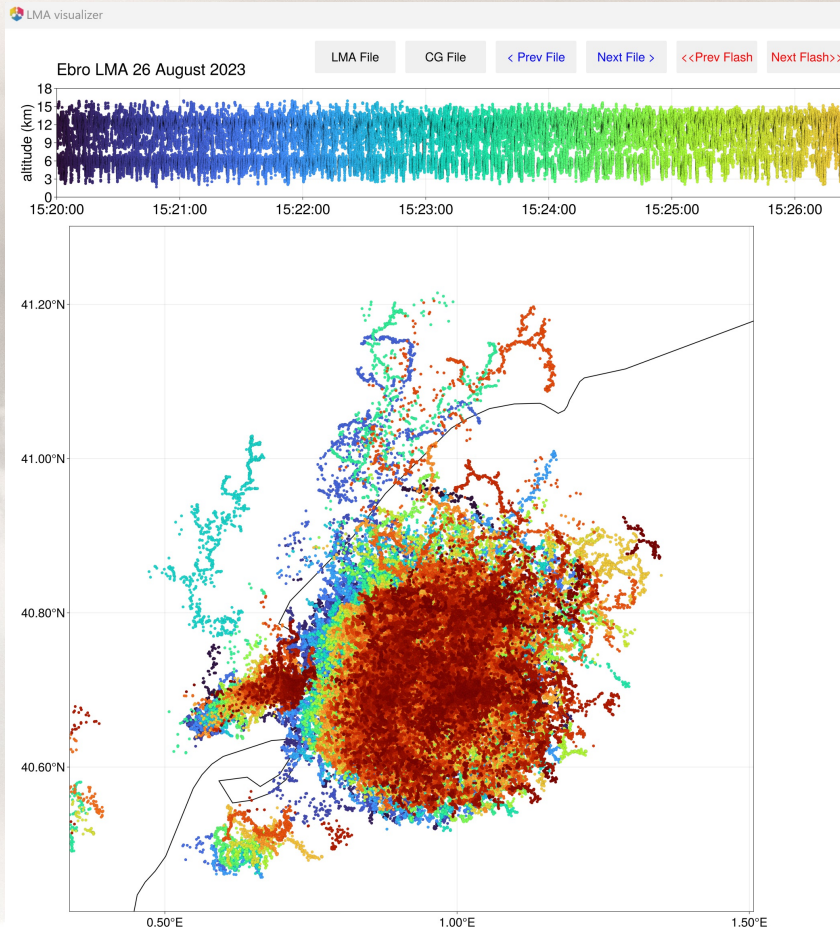
O - Montsec



P - Benissanet

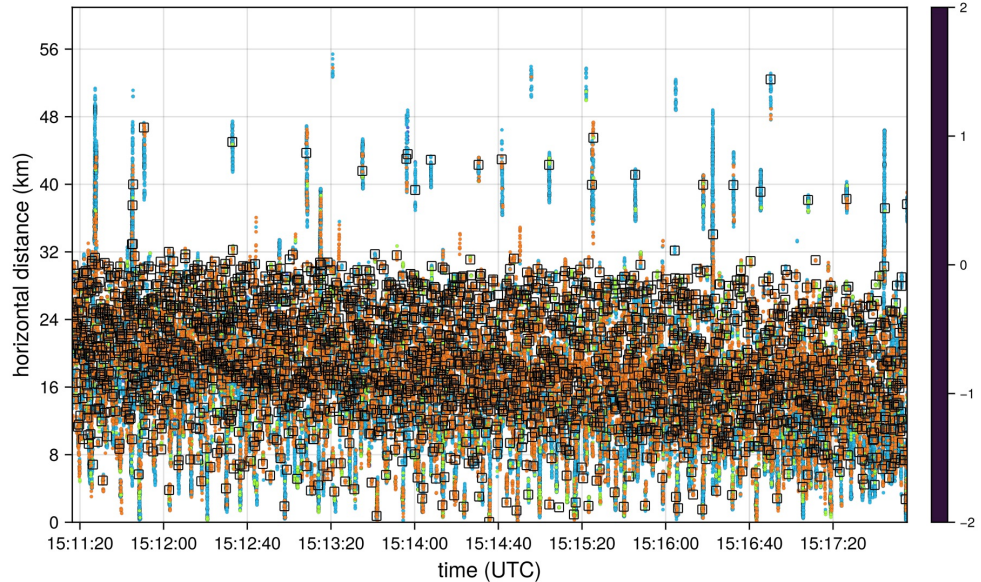
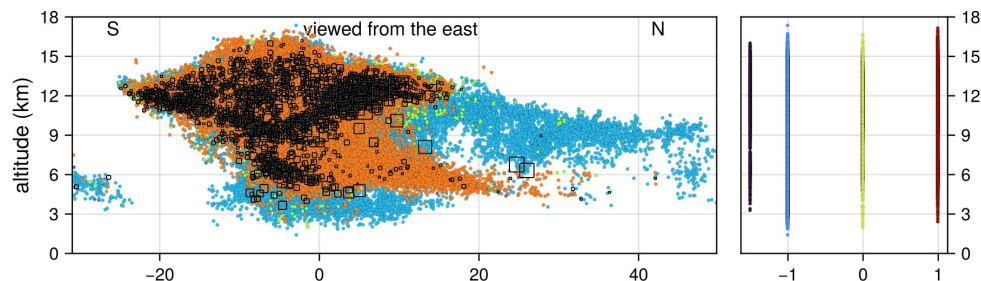
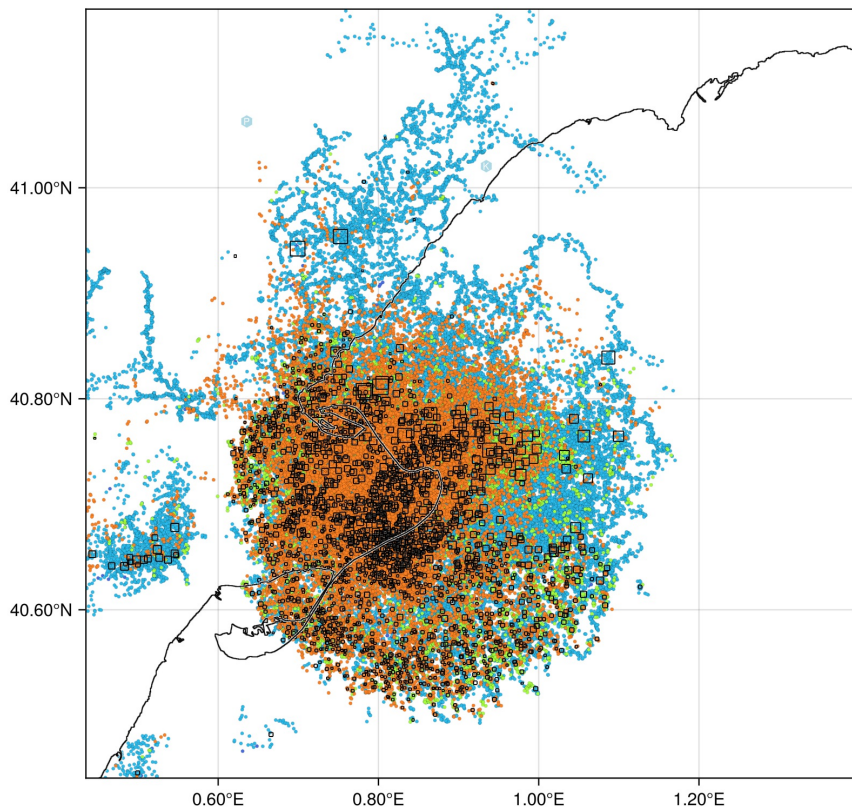
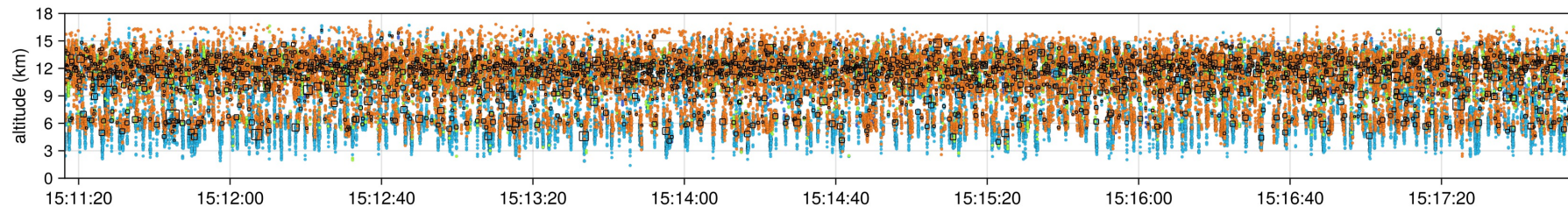


New software development for LMA analysis



- New visualization tools, programmed in **Julia** (interactive, dynamically typed, compiled language – very fast)
- Test: my old code in **Scilab** (39 MB 10 minute file): **160 sec** for read + simple flash algo, **Julia: 6 sec** for read + various DBSCANs + 3D leader speed fitting + instant displaying
- Flash analysis tool
- Storm activity analysis tool (gridded)
- LMA station contribution maps
- Integration of GLM and MTG-LI
- Plan to release in 2026

Ebro LMA 26 August 2023



color by:

polarity

order/step by:

polarity

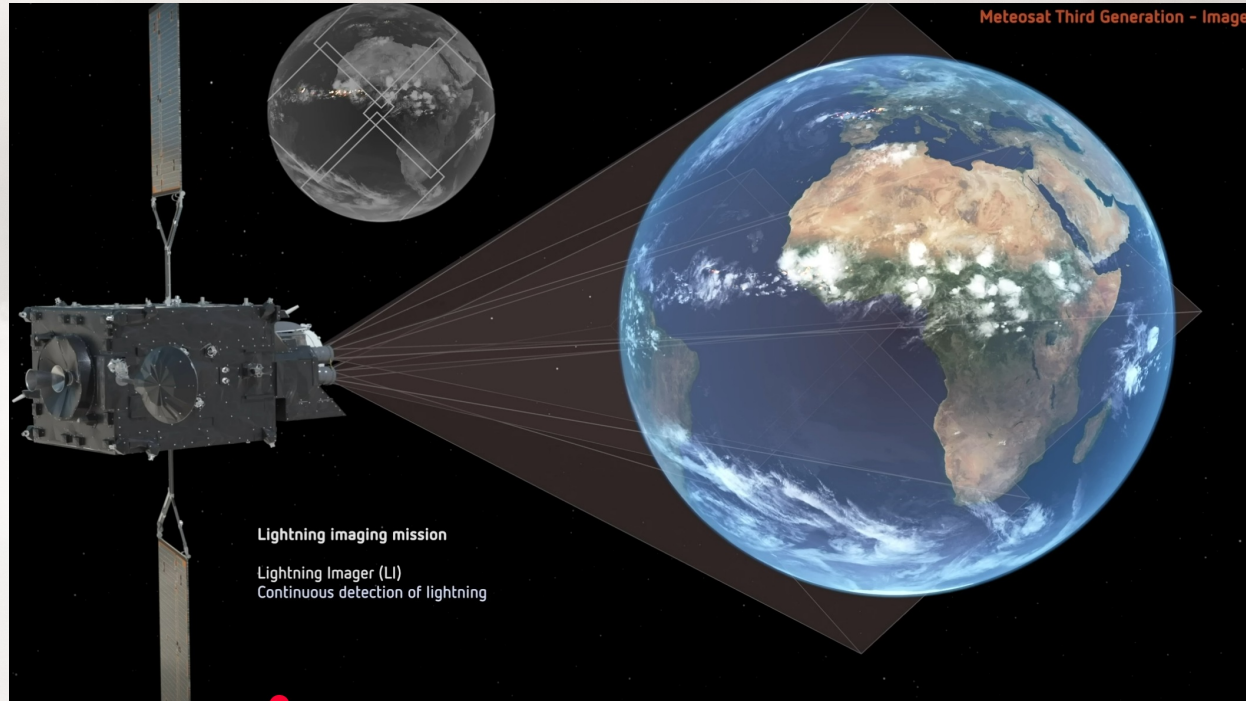
on top:

high

L1 color by:

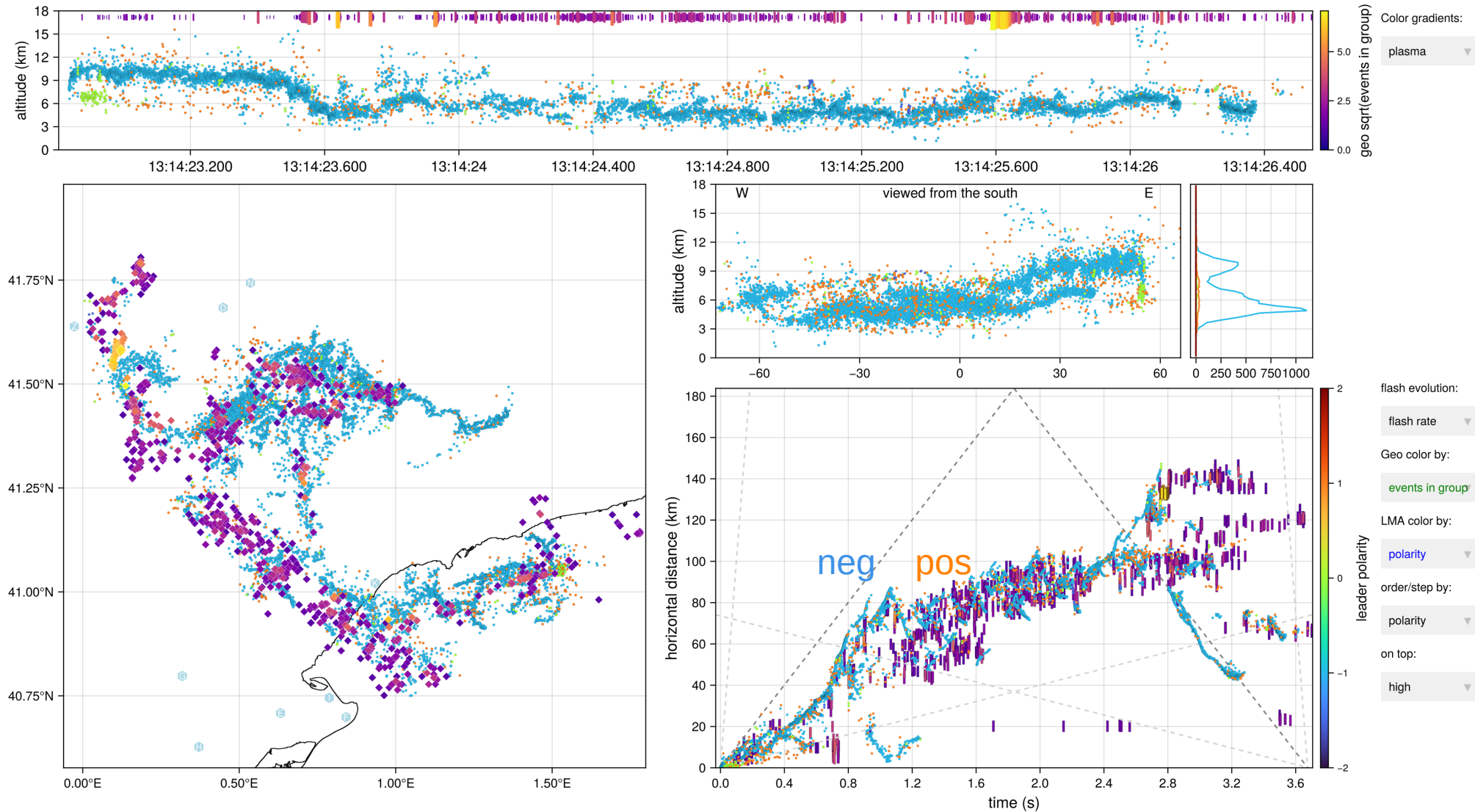
time

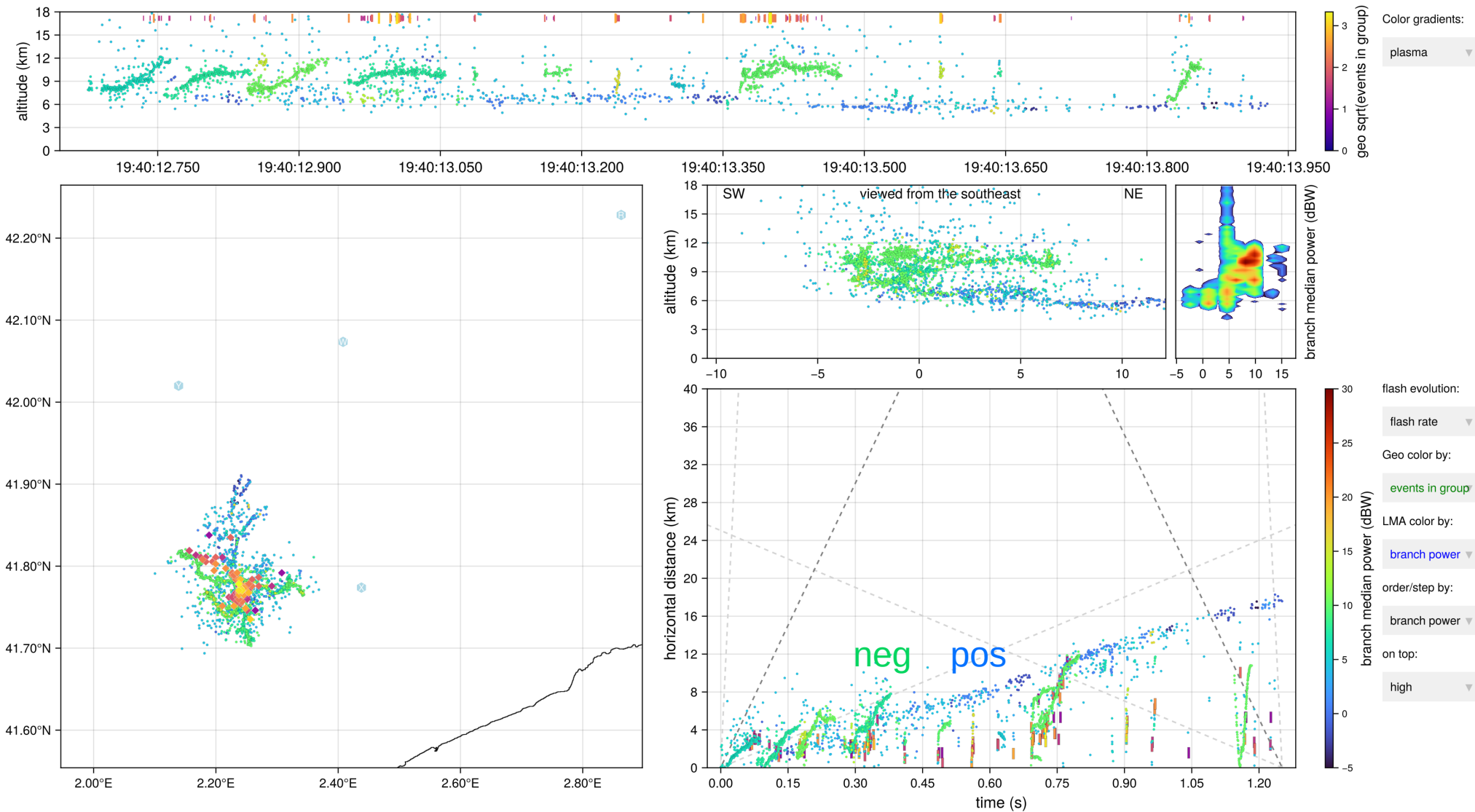
Meteosat 12 Lightning Imager



Compared to GLM:

- Footprint at nadir: 4.5 km (GLM: 8 km)
- Footprint mid-lat: 6-12 km (GLM: 8 km)
- Data:
 - groups and flashes (points)
 - gridded products
- **Groups are centroids of triggered event pixels per 1 ms** (GLM: 2 ms), with size and brightness information.





Real-time LMA: 2024-09-03 15:30:23

LMA

Live

CG

LI

< Prev File

Next File >

<< Prev Flash

Next Flash >>

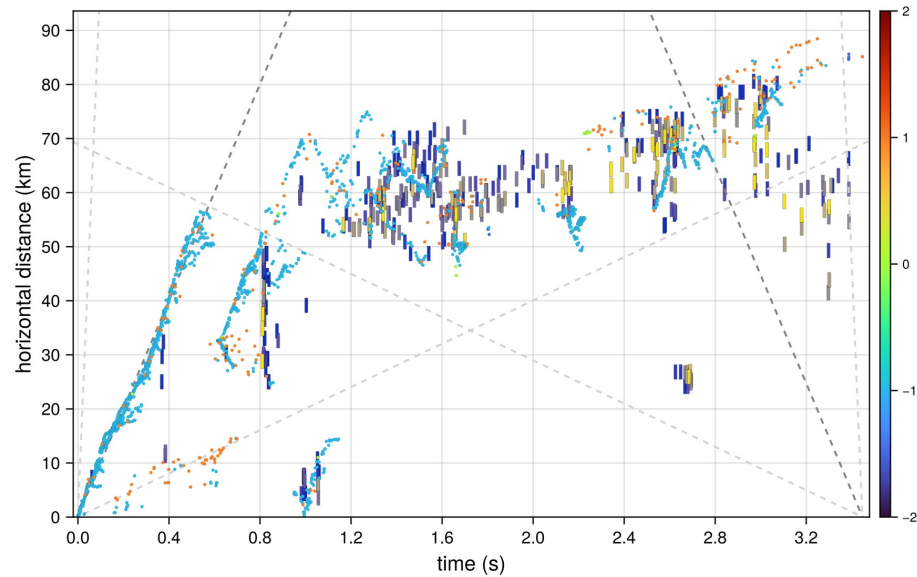
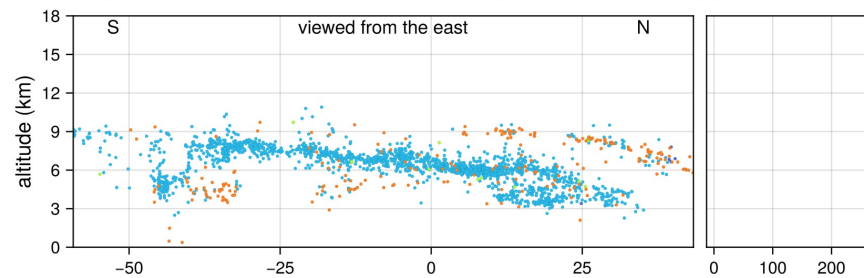
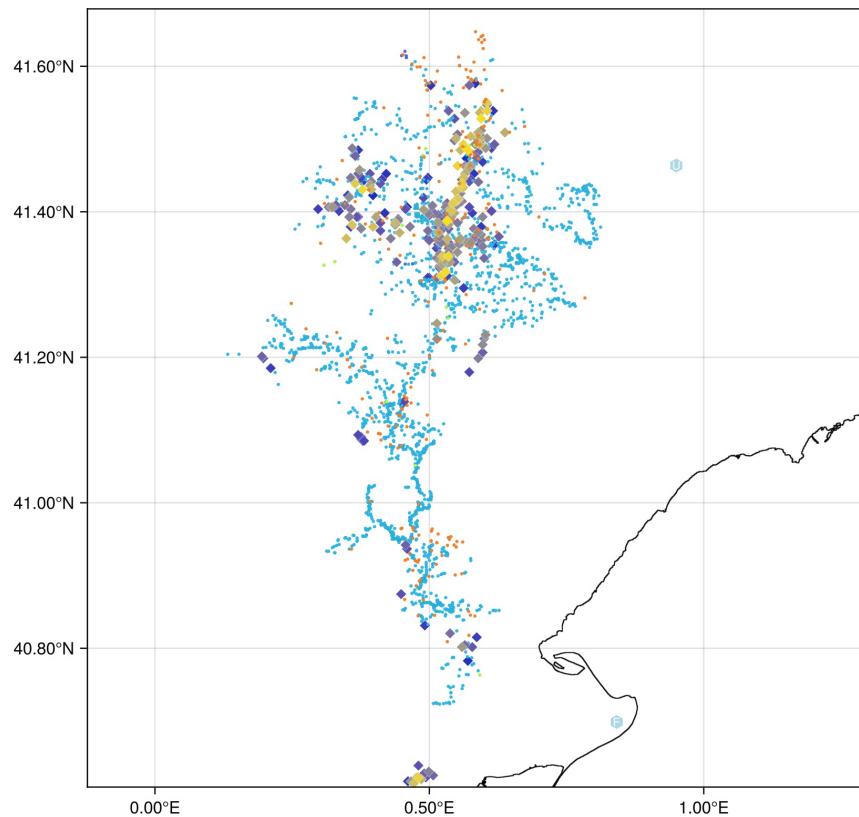
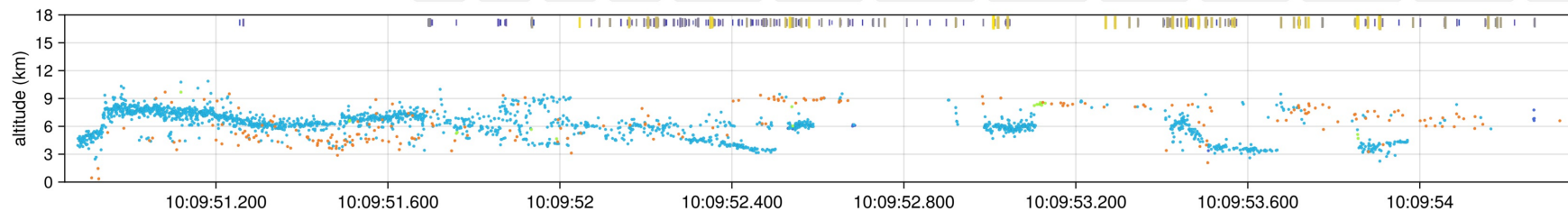
Zoom out

Reset time

Reset area

Save figure

Export



Color gradients:

Geo

LMA

☒ animate☒ size☐ fstart☐ CG☐ IC☒ Geo☐ flash rate

Geo color by:

cloud top energy

LMA color by:

polarity

order/step by:

polarity

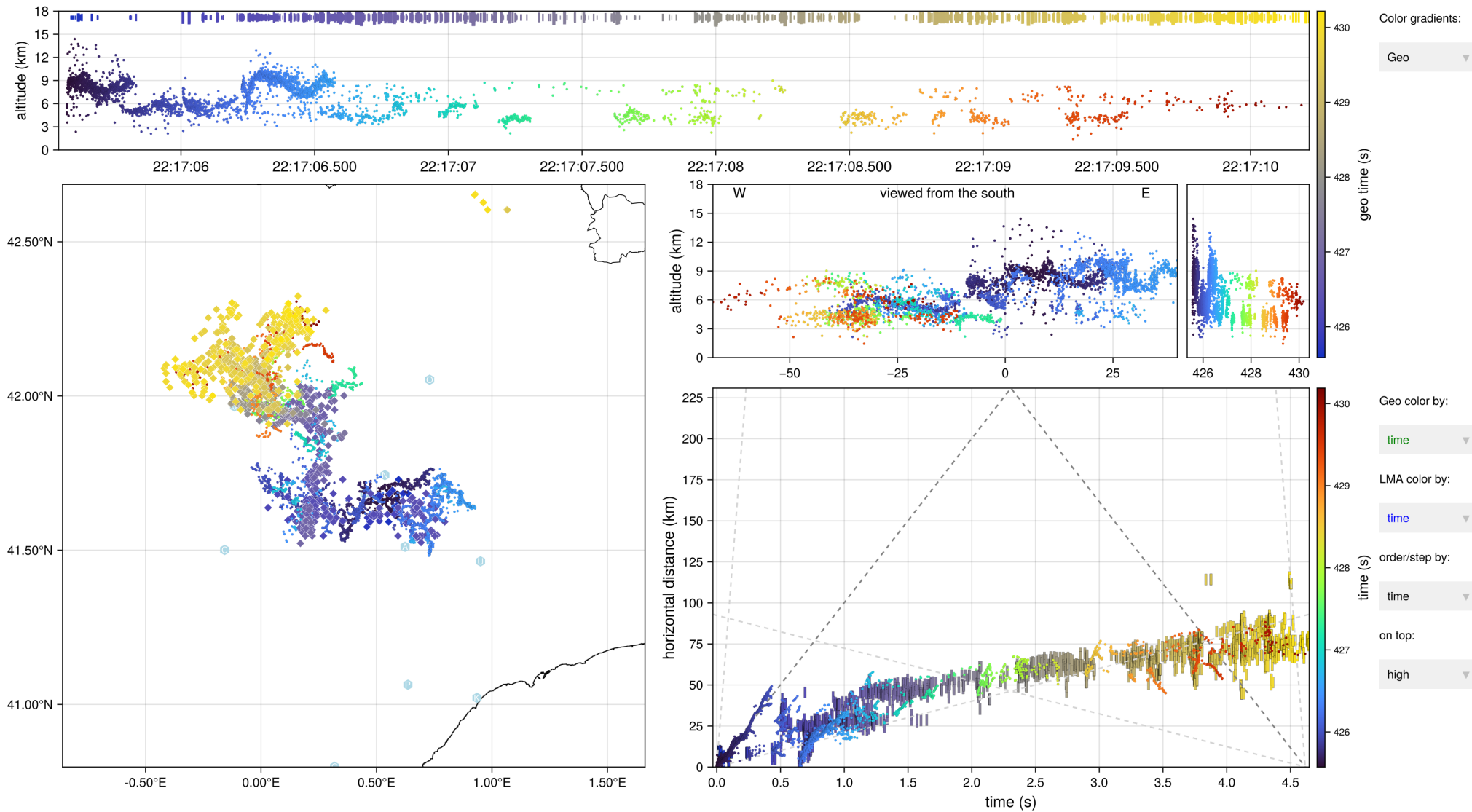
on top:

high

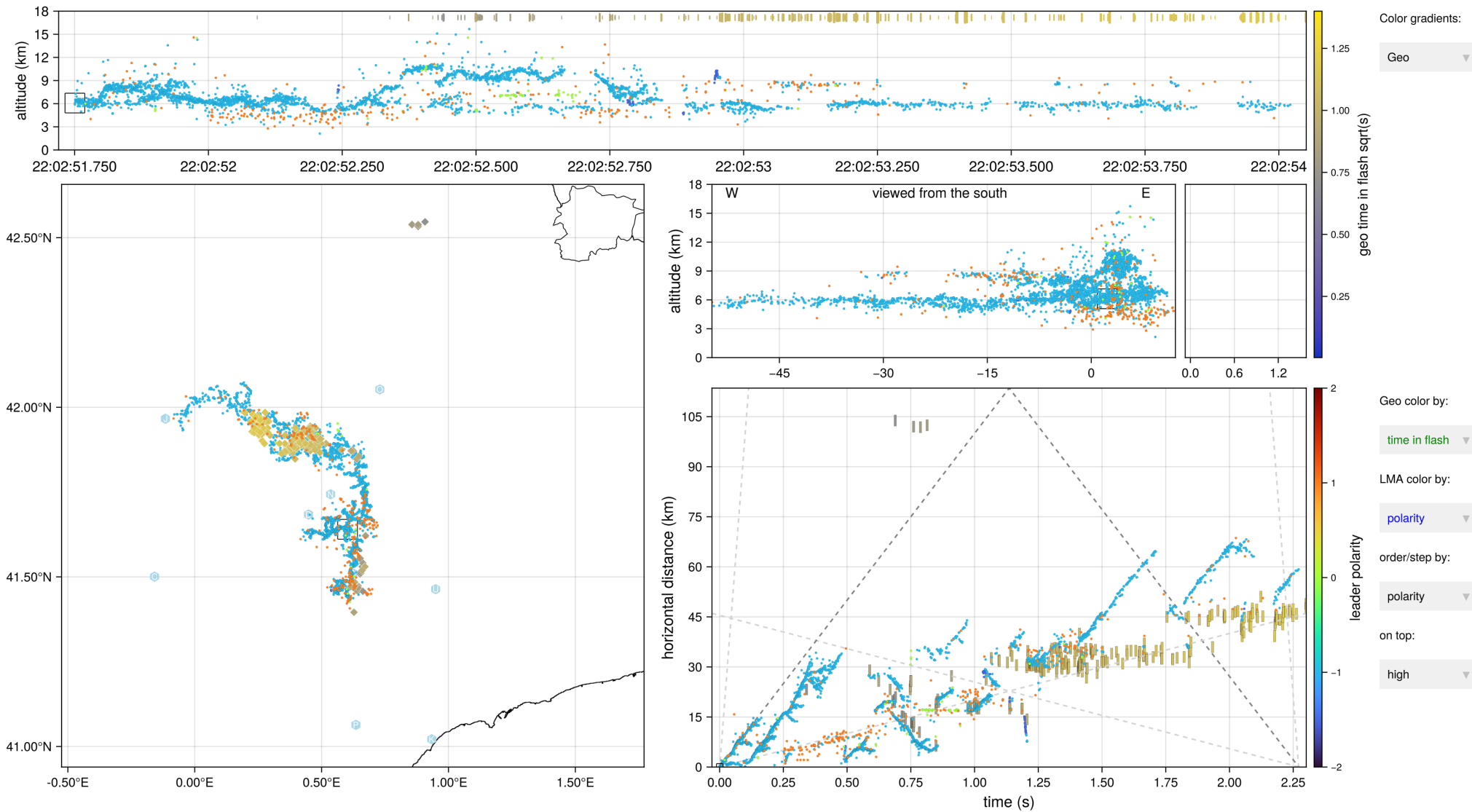
LMA filter:

li & sparkles

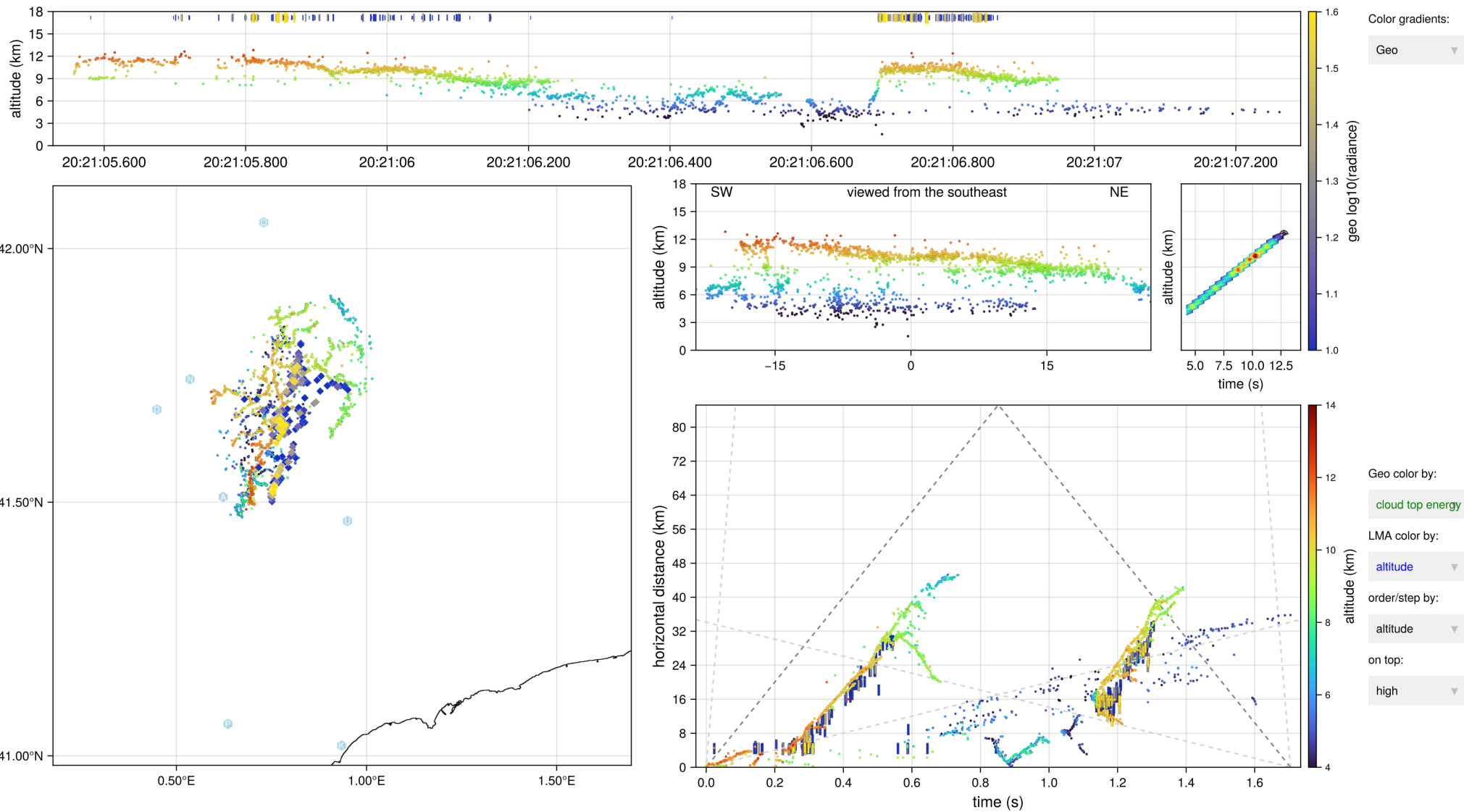
MCAT,UPC 5 July 2024



MCAT,UPC 5 July 2024

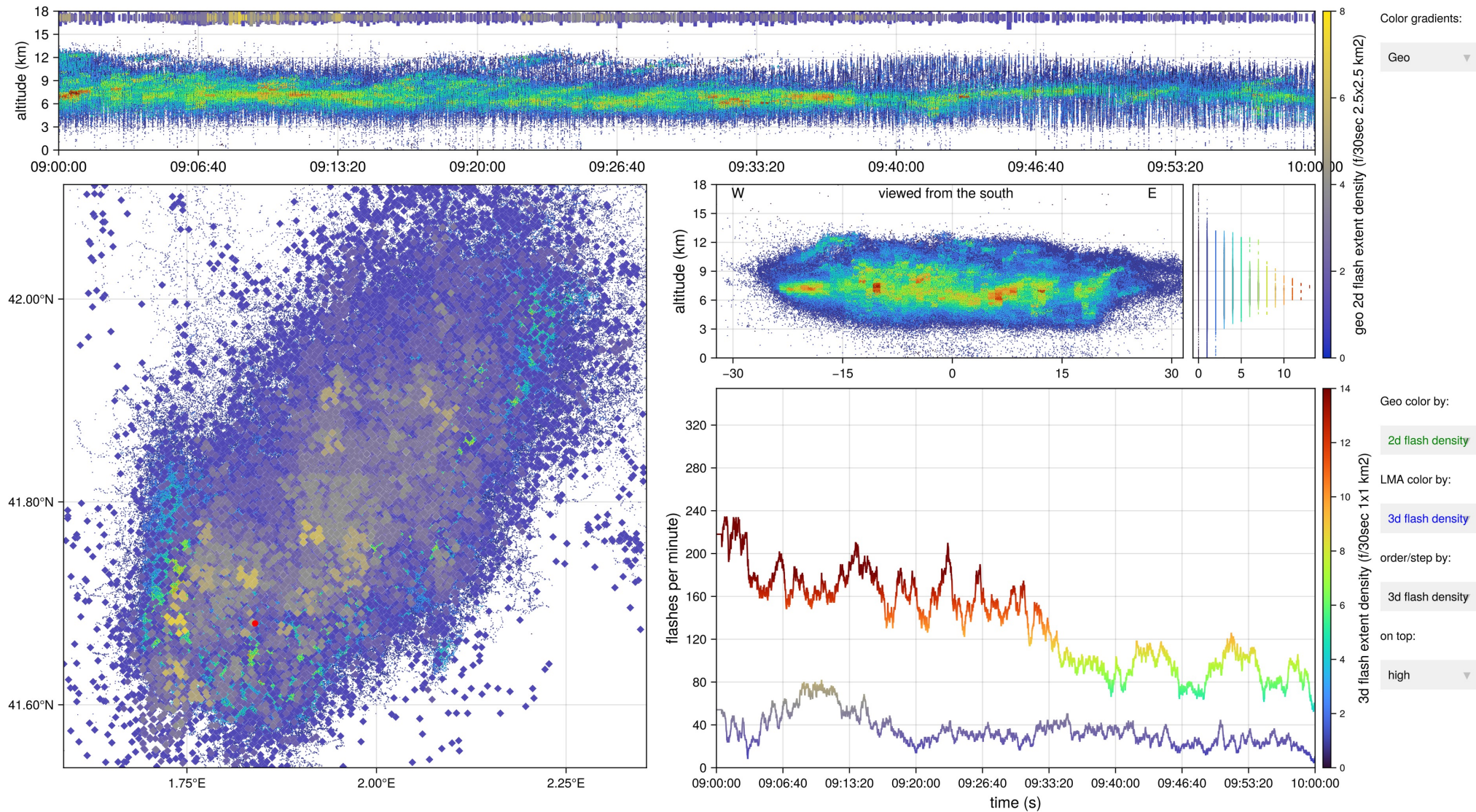


Real-time LMA: 2025-06-19 21:38:15

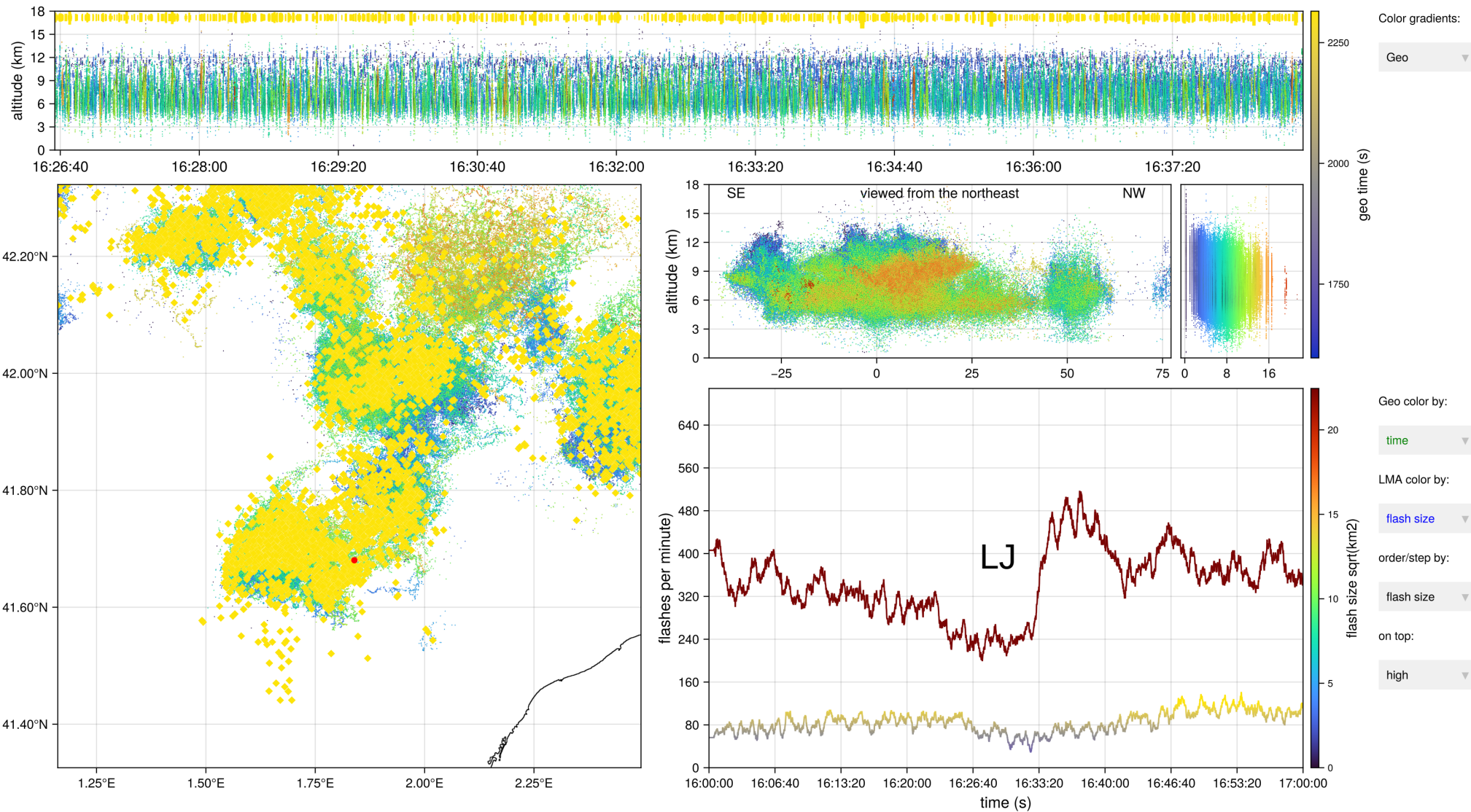


LI group centroids correspond to:

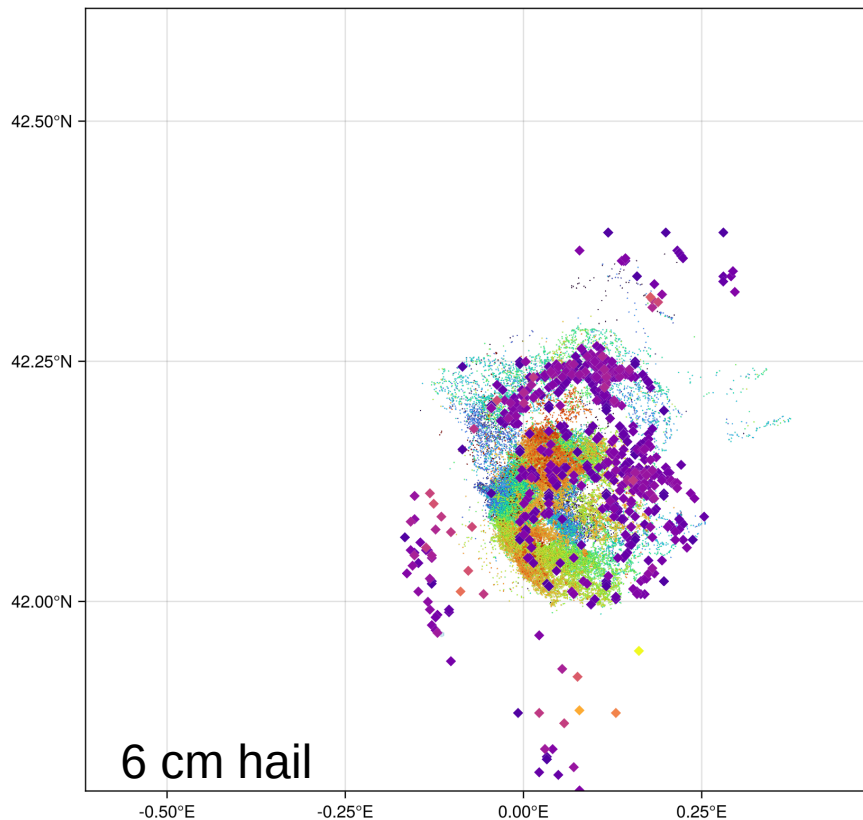
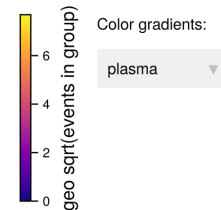
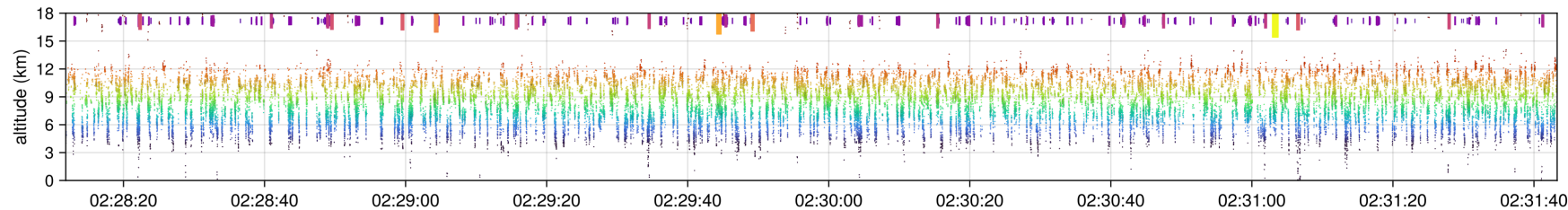
- Both positive and negative leader activity almost exclusively *above 9 km altitude* in summer storms (tops 11-15 km) (usually one polarity, not both)
- Energetic processes at lower altitudes, from recoil leaders, fast negative leaders/continuing currents and some cloud-to-ground strokes.
- Parts of large flashes deeper in the cloud are usually missed.



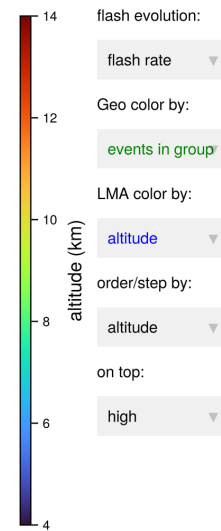
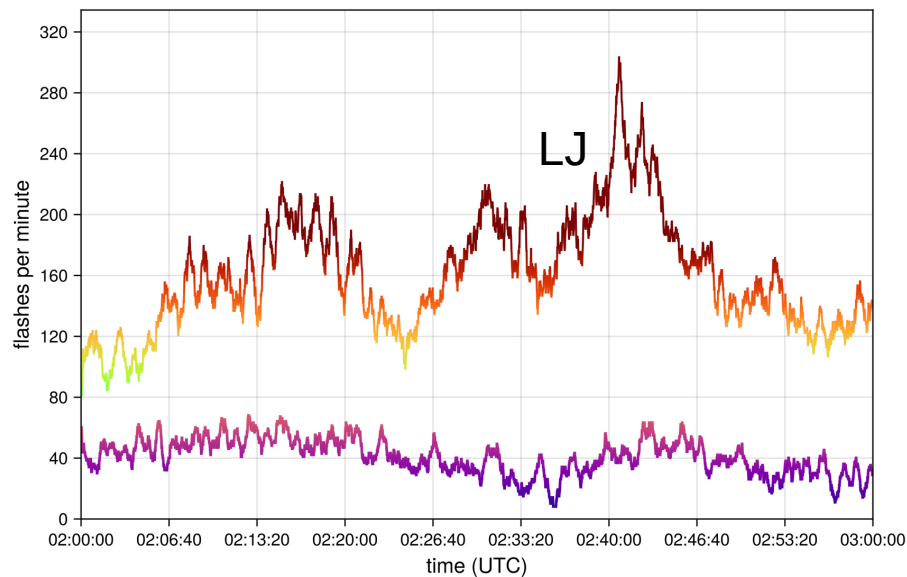
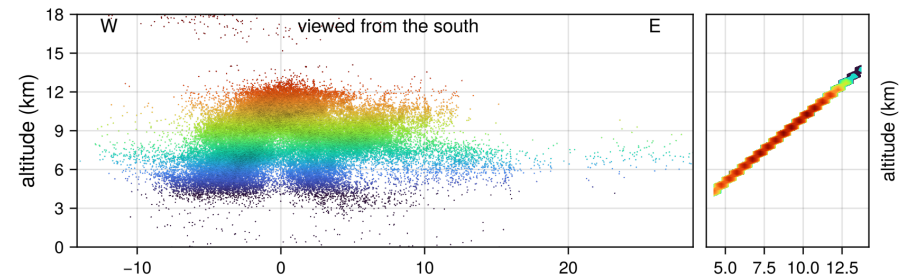
MCAT,UPC 2 August 2024



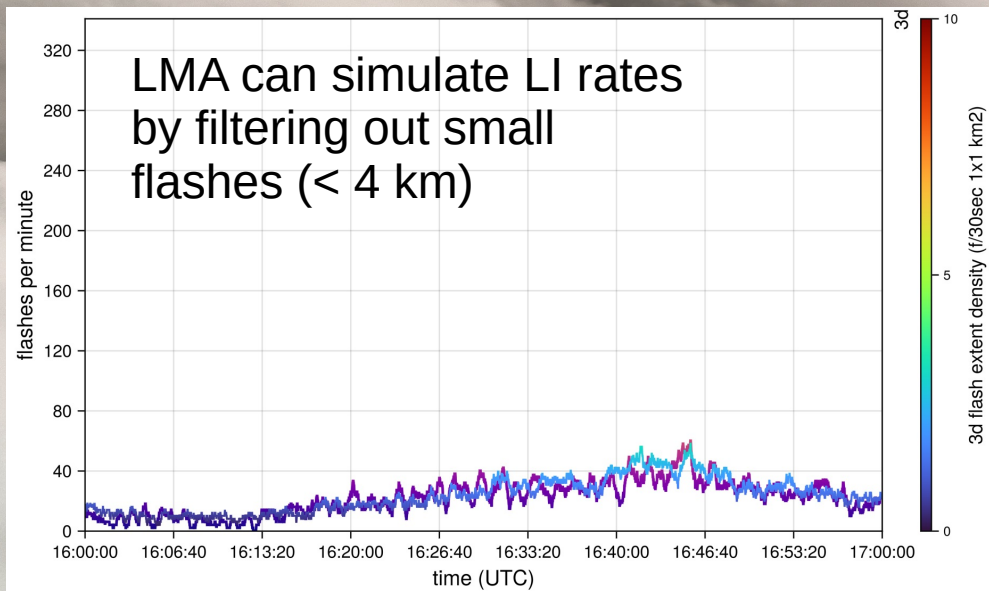
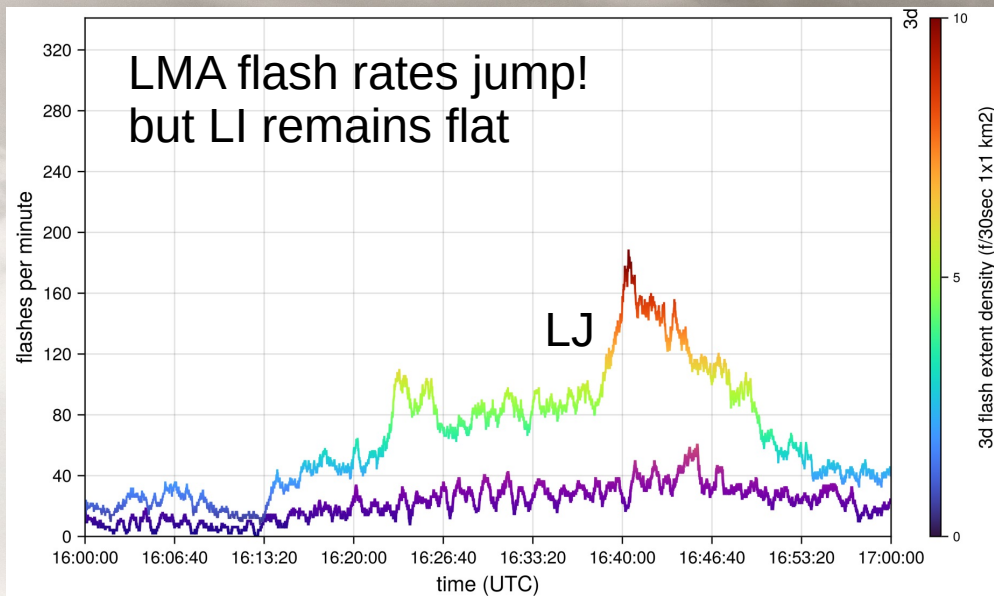
MCAT,UPC 13 September 2025



6 cm hail



Lightning jump



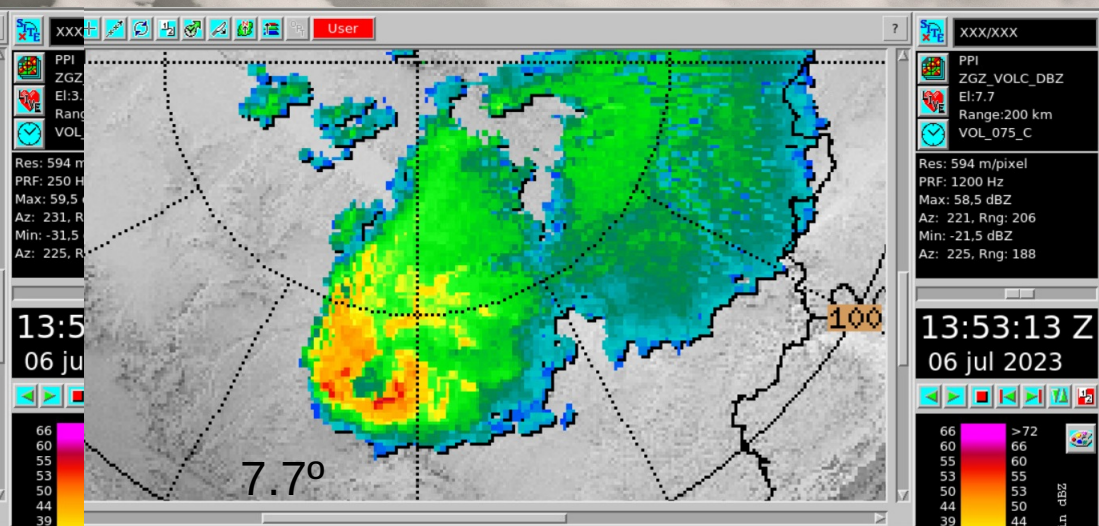
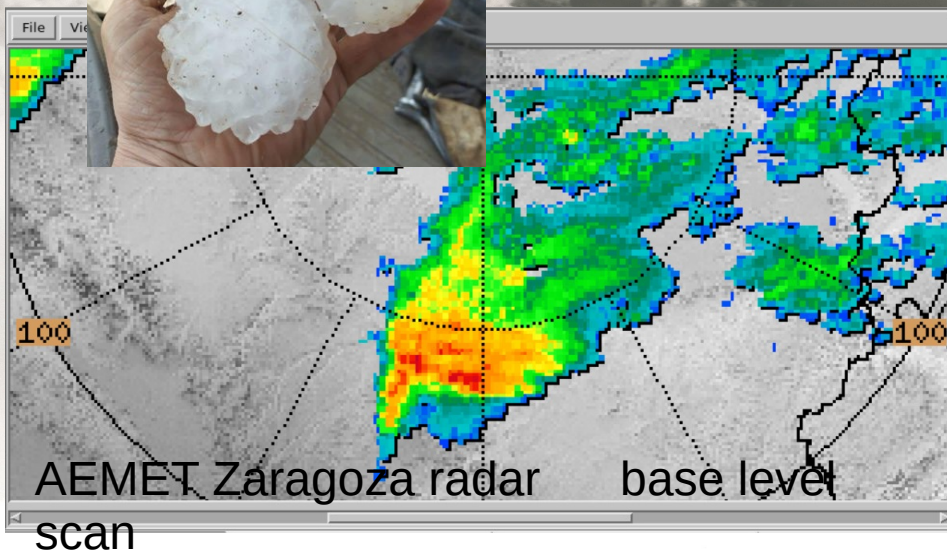
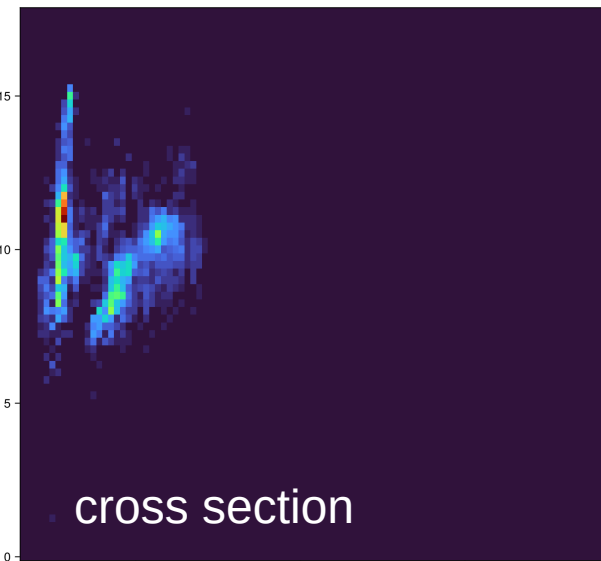
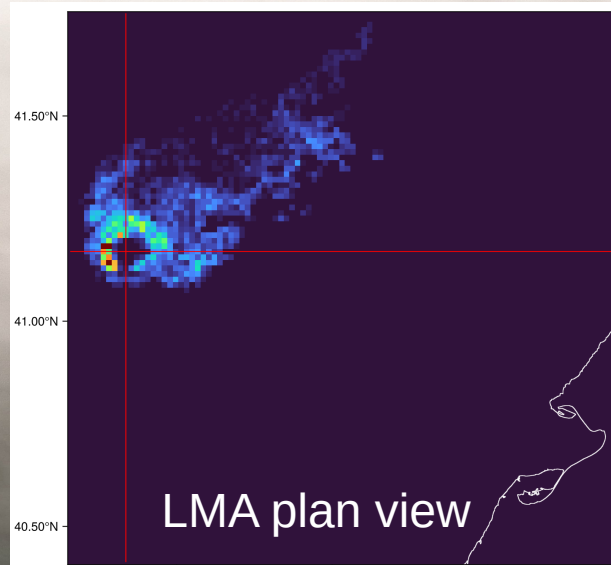
Flash rates

- LI tracks rates well for storms with medium/large flashes
- LMA lightning jumps are missed (like GLM)
- LI behaves like LMA that does not detect the smallest flashes, because they are optically weak.

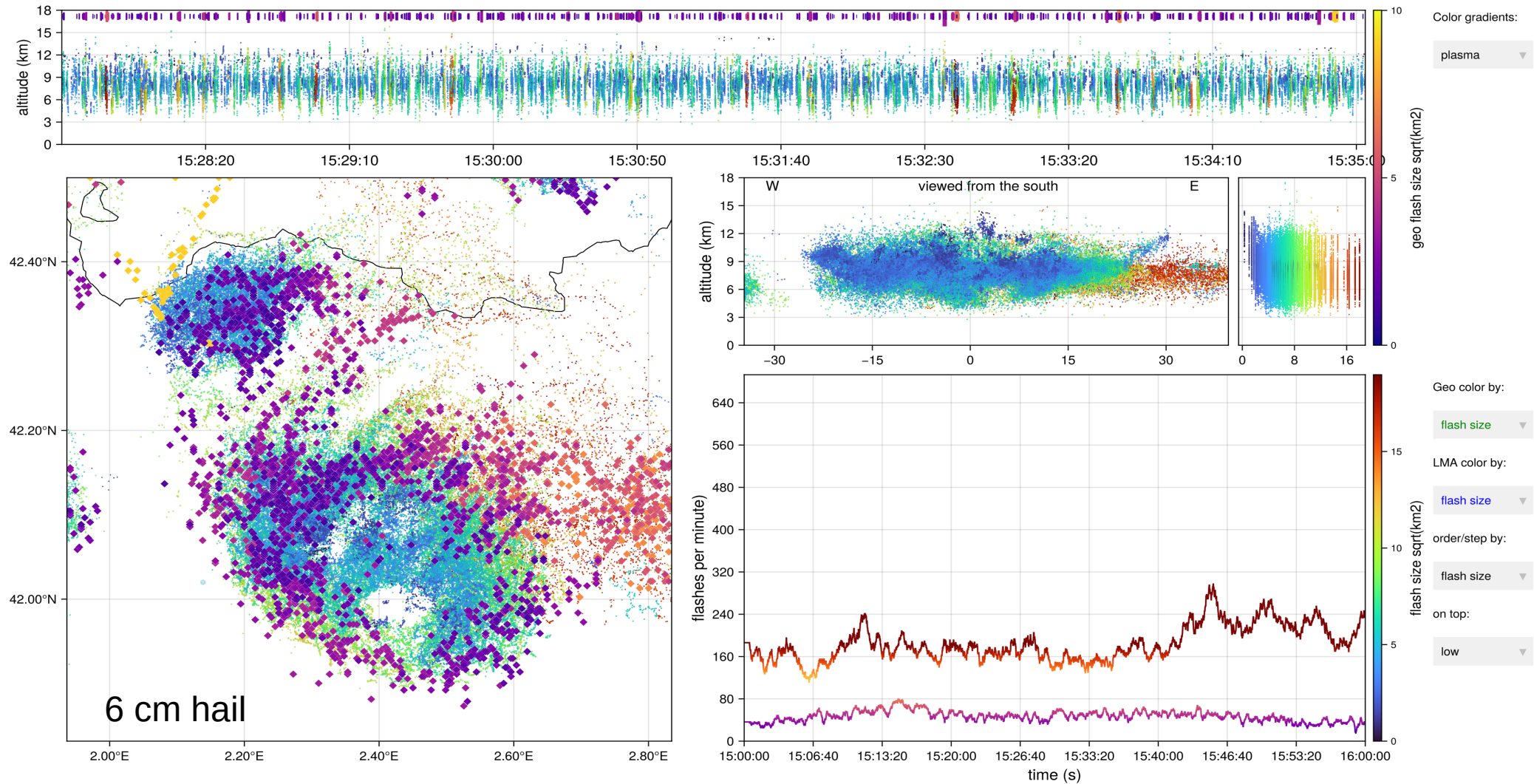
What are lightning holes?

- LMA lightning holes are seen in some supercells
- Lightning seems to wrap around the mesocyclone
- Bounded weak-echo region
- Typically best seen when selecting 1.5 - 3 minutes of data

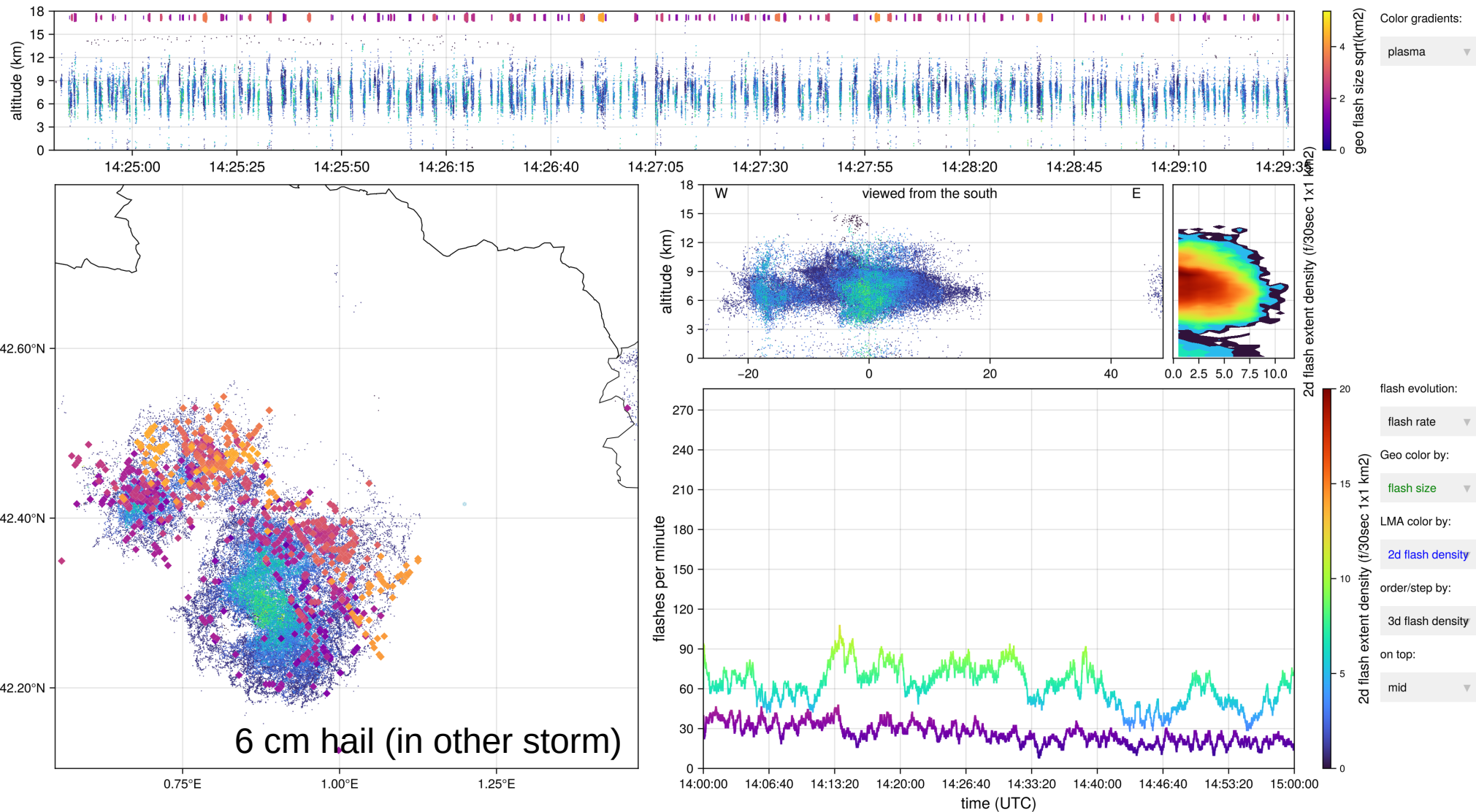
Analysis 6-6-2023 case in Pineda et al. (submitted to EJSSM)

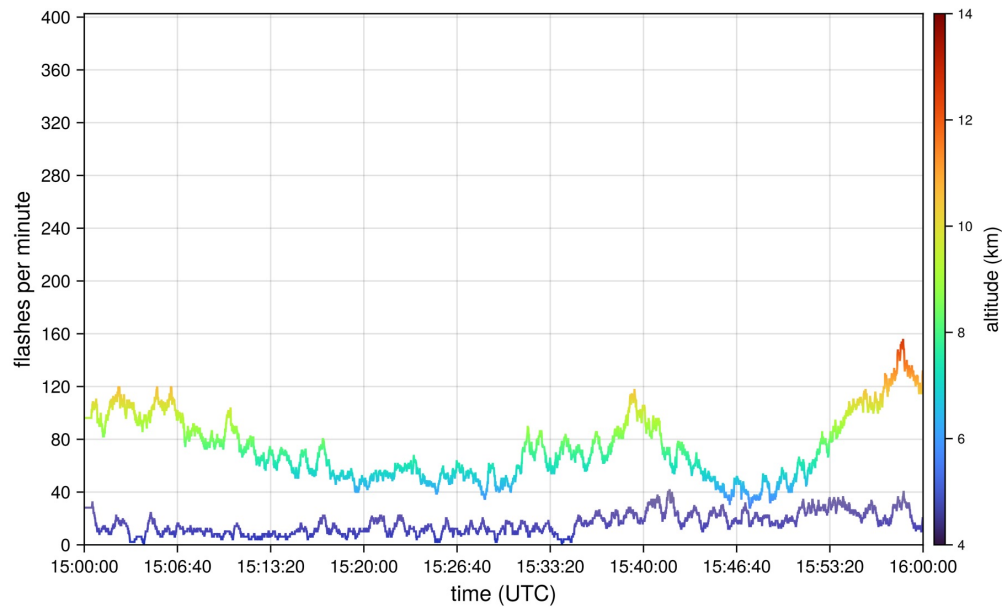
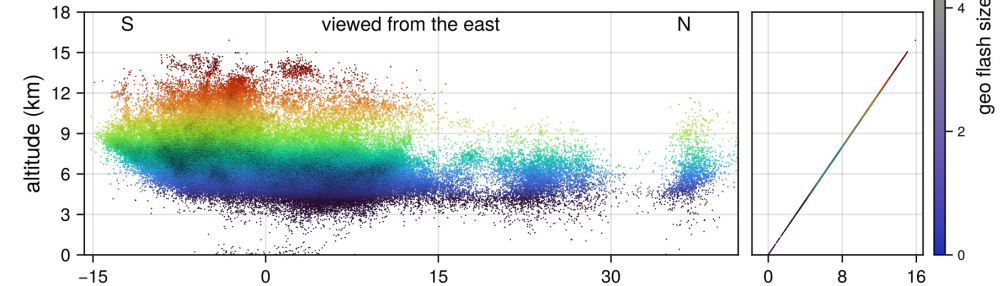
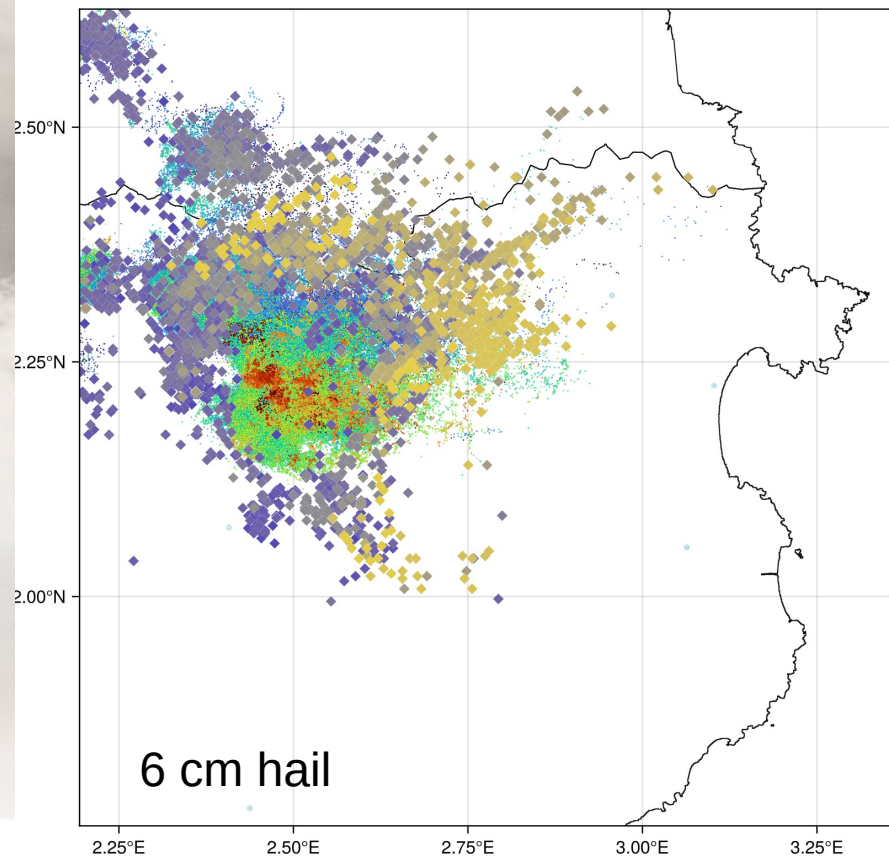
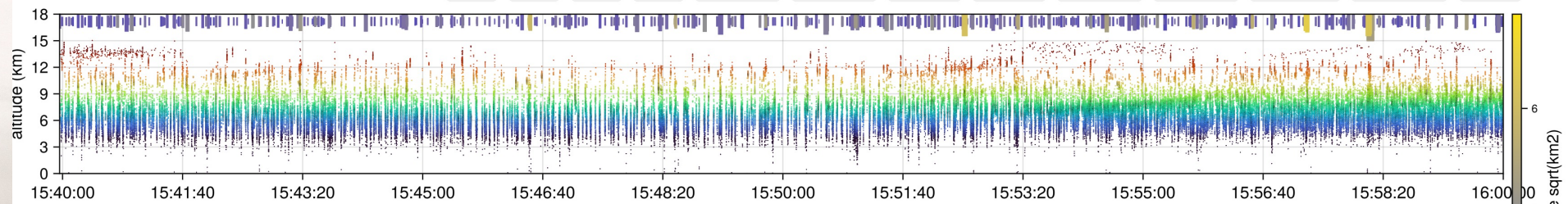


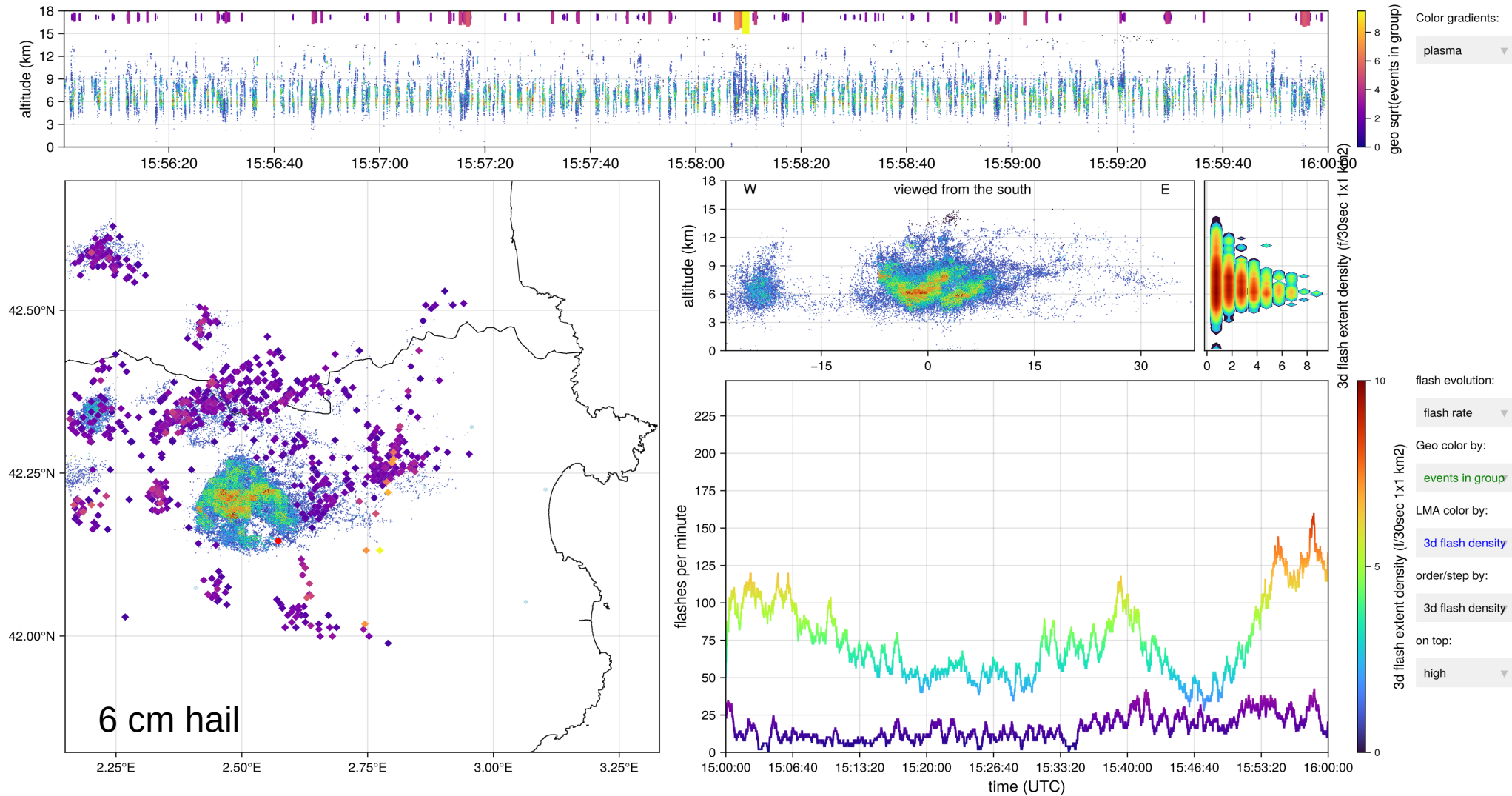
MCAT,UPC 2 August 2024



MCAT,UPC 11 July 2025







Geostationary 13 June 2025

LMA

Live

CG

LI

< Prev File

Next File >

<< Flash

Flash >>

<

>

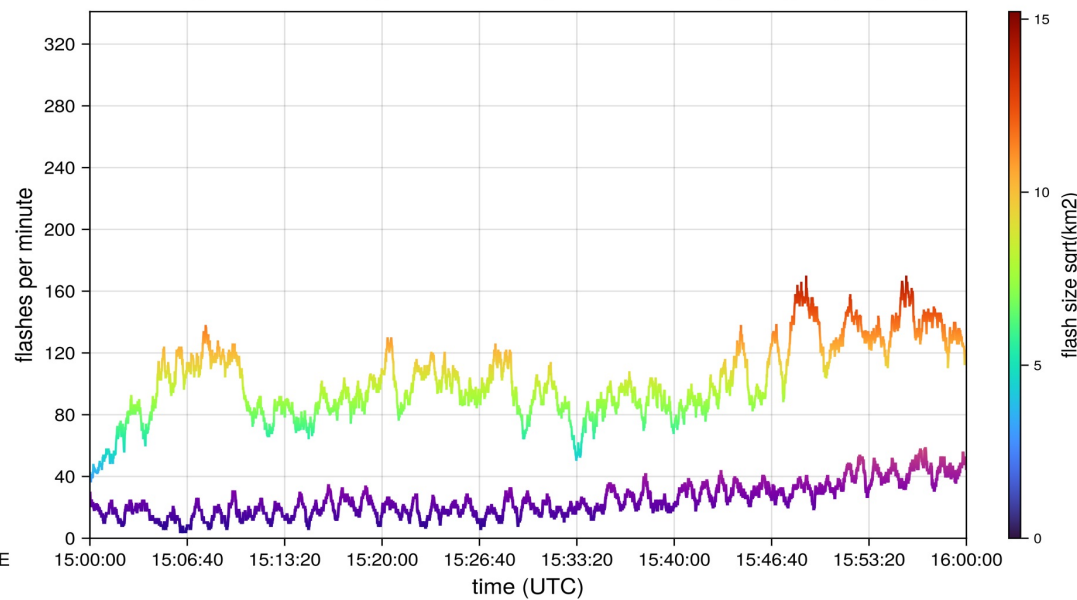
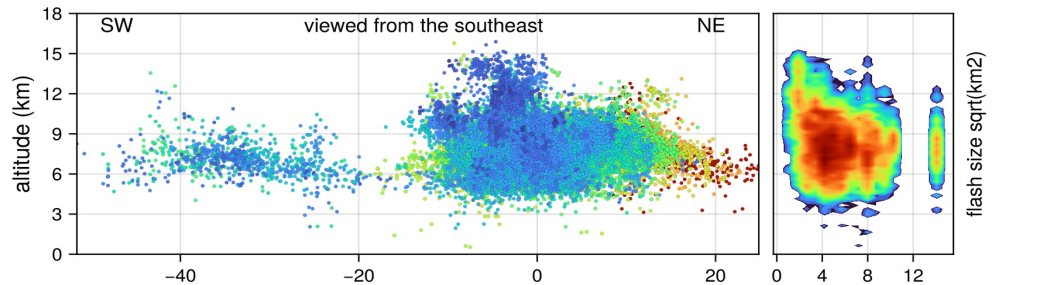
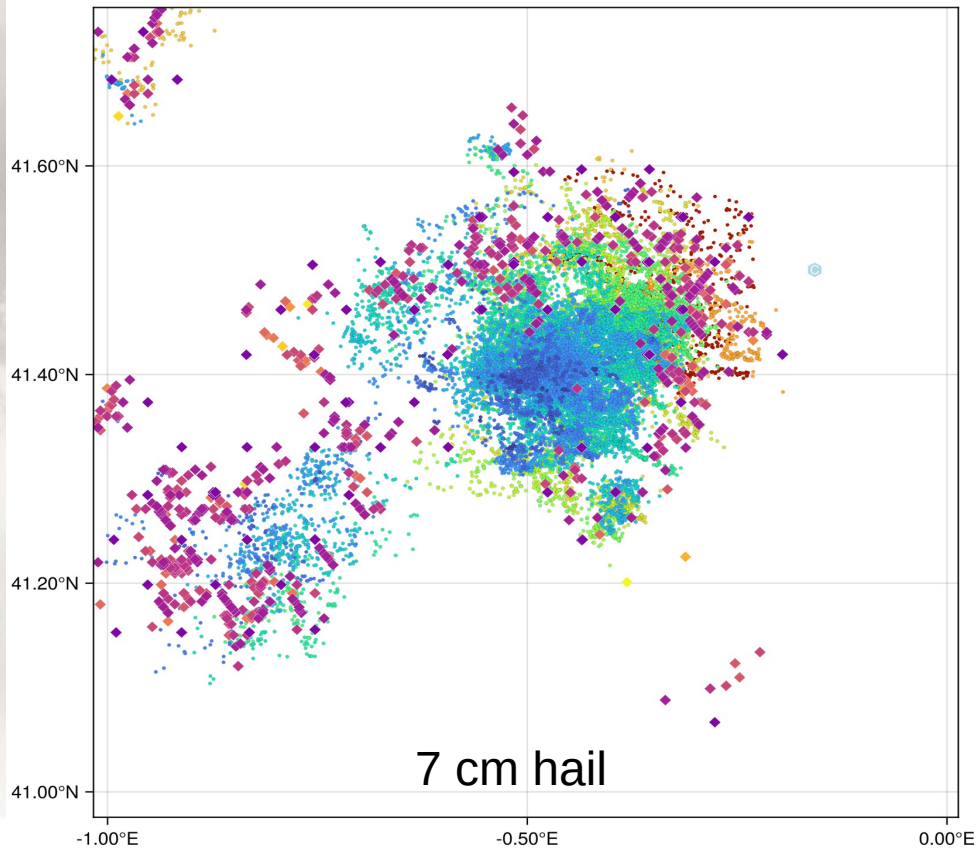
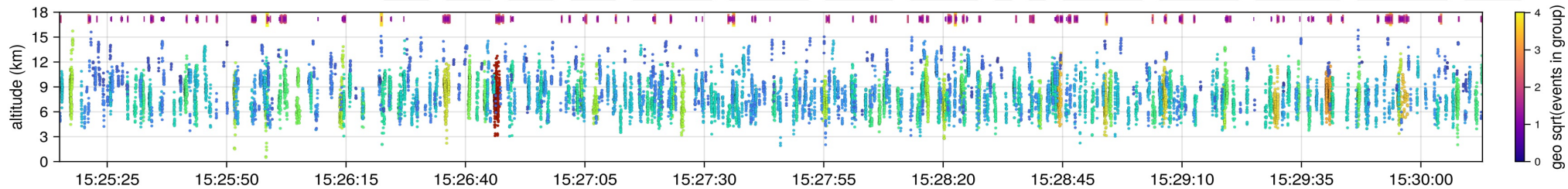
Zoom out

Reset time

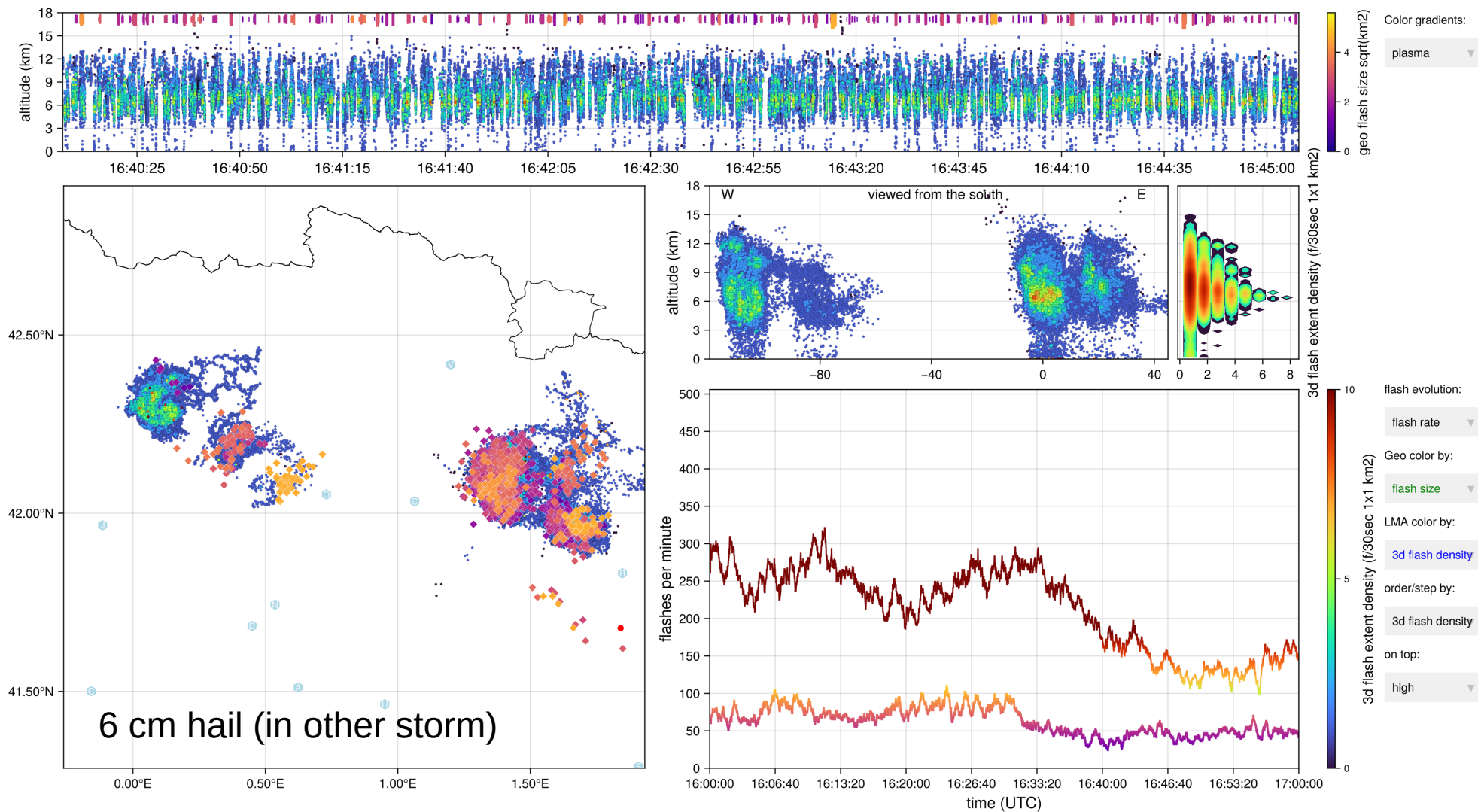
Reset area

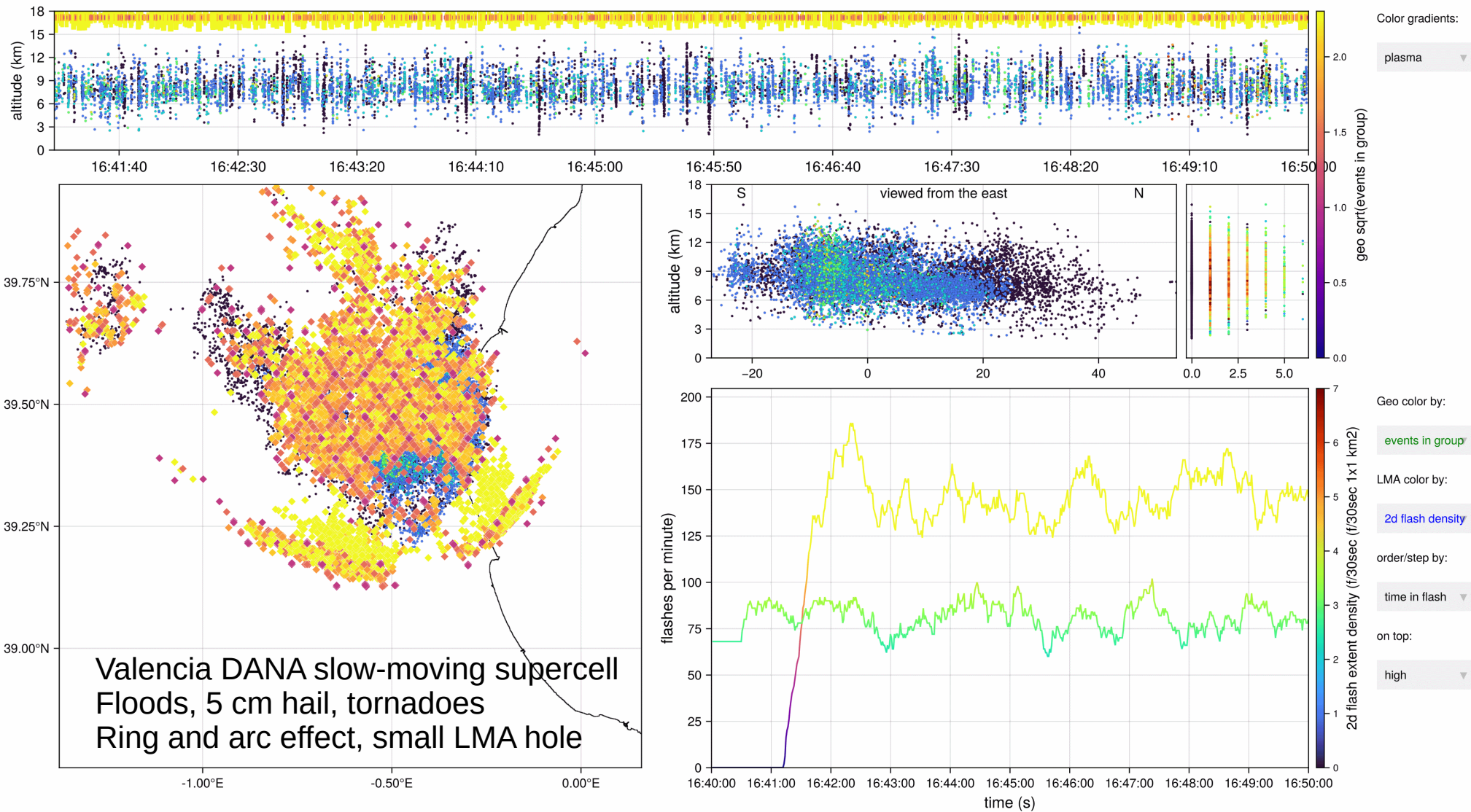
Save figure

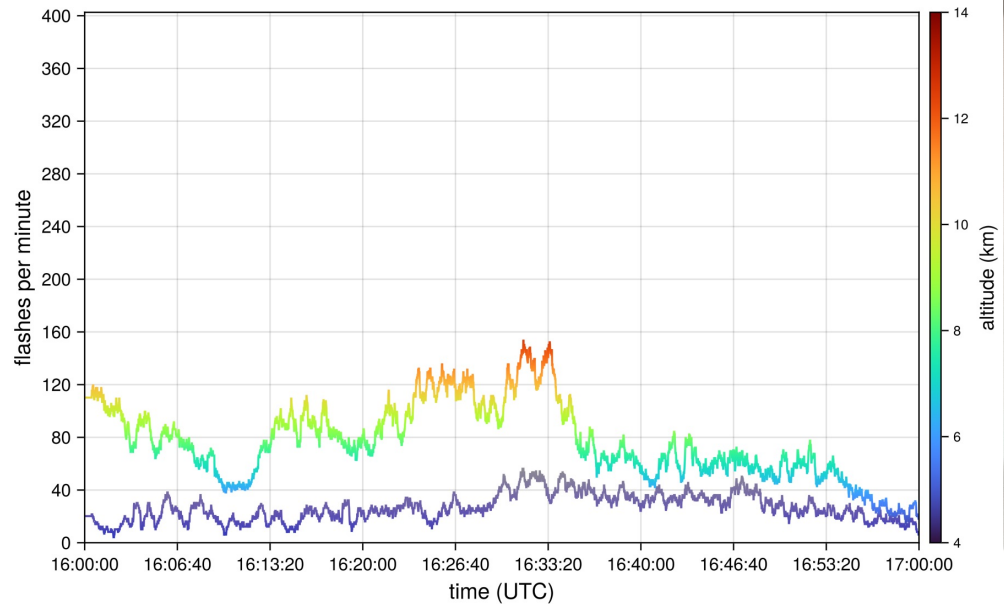
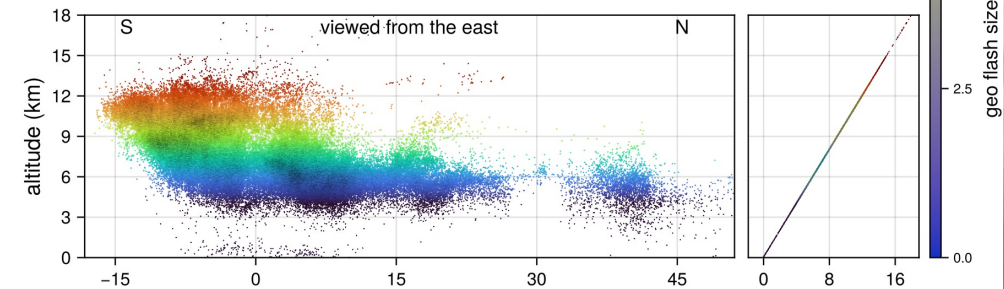
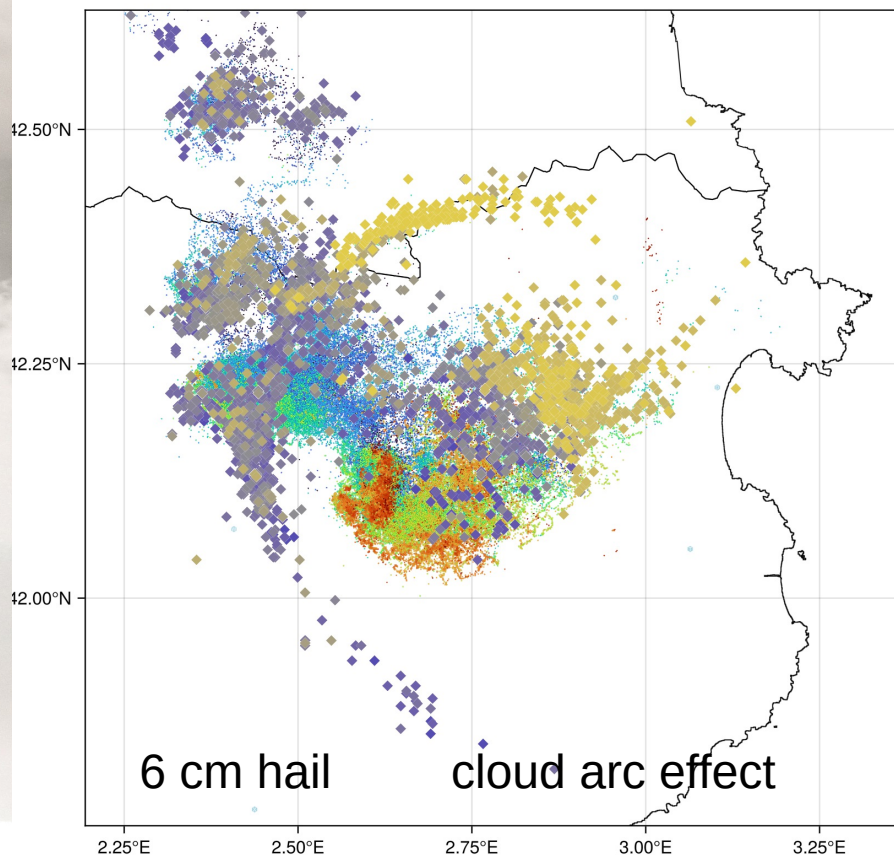
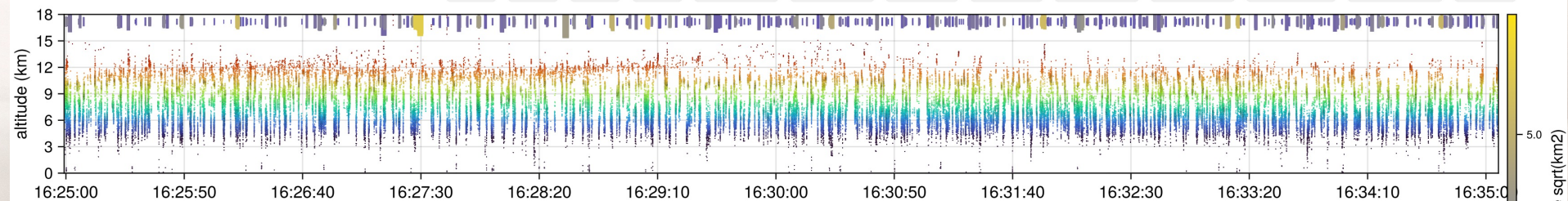
Export



MCAT,UPC 11 July 2025







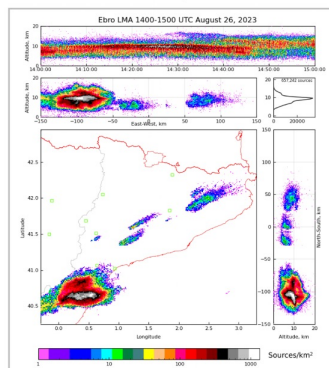
Conclusions

- 1) Storms with mesocyclonic lightning holes in LMA and very large hail typically show **LI lightning rings** (wider than holes) or **absence of flashes altogether** (see also Tomas Pucik's talk and in GLM known as "lightning dive")
- 2) **LI rings** also occur with dense lightning activity underneath, so **is an optical effect indicative of high ice crystal, graupel or hail density in the cloud top**.
- 3) LMA flash size is not necessarily very small around the hole. **Filtering out small LMA flashes does not simulate the LI ring**.
- 4) LI group centroid product **enhances the detectability of this effect** (brightness-weighted away from the optically dense cloud)
- 5) **This is a feature when combined with other ways to confirm the presence of a strong cell** (taking into account parallax), if forecasters are prepared. (see also Tomas Pucik's talk)

eLMA

3D Lightning Mapping Array

LIVE - actividad rayos Ebro LMA



Servicio cámara rápida

