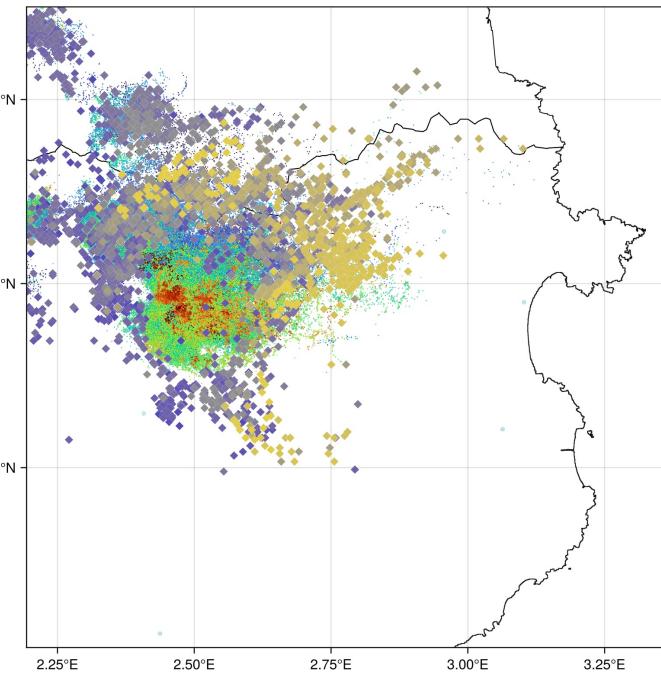


# Lightning ring signatures with the Meteosat Lightning Imager (MTG-LI) compared to the Lightning Mapping Array in northeastern Spain



meteo.cat | Servei Meteorològic de Catalunya



UNIVERSITAT POLITÈCNICA  
DE CATALUNYA  
BARCELONATECH

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<sup>4</sup>EUMETSAT, Darmstadt, Germany

## This talk

### The 3D Lightning Mapping Array in Catalonia (XCALMA)

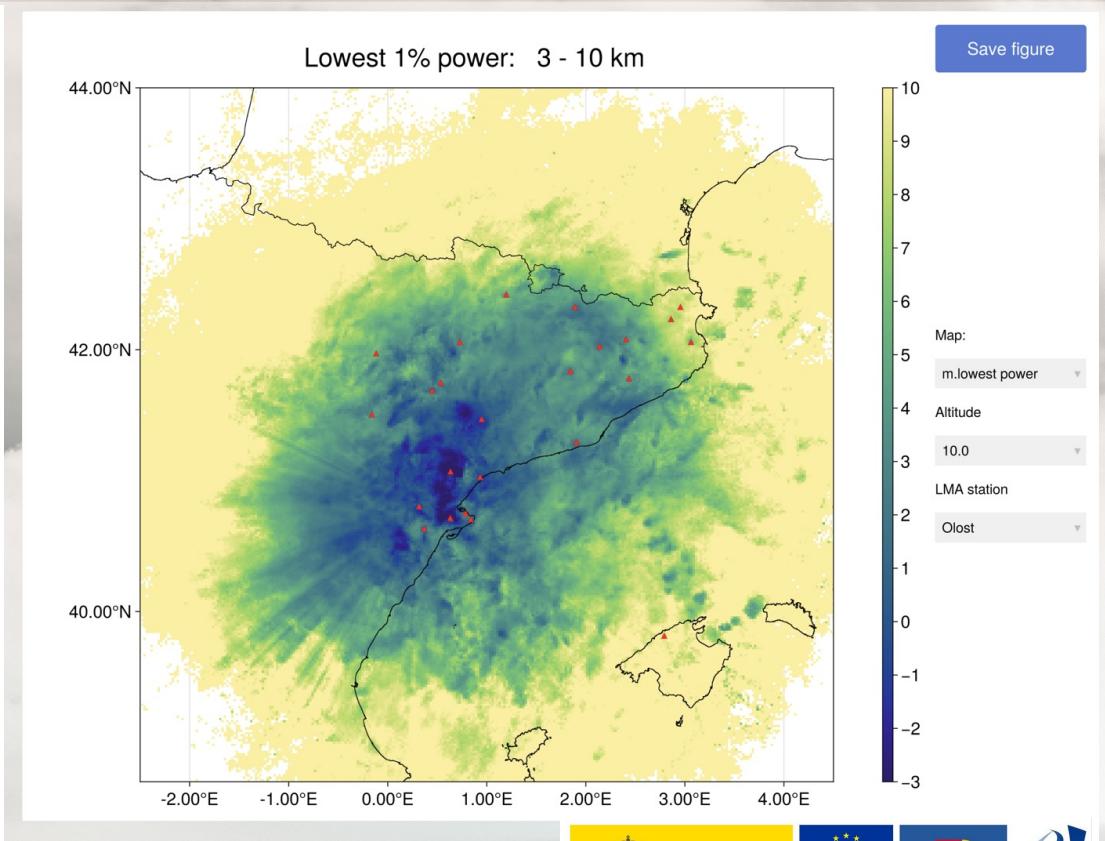
- LMA is the gold standard for flash detection efficiency, leader altitude, flash extent, charge structure
- eXtended Catalonia LMA is world's largest with 30 stations, operated by UPC and meteo.cat

### EUMETSAT Lightning Imager

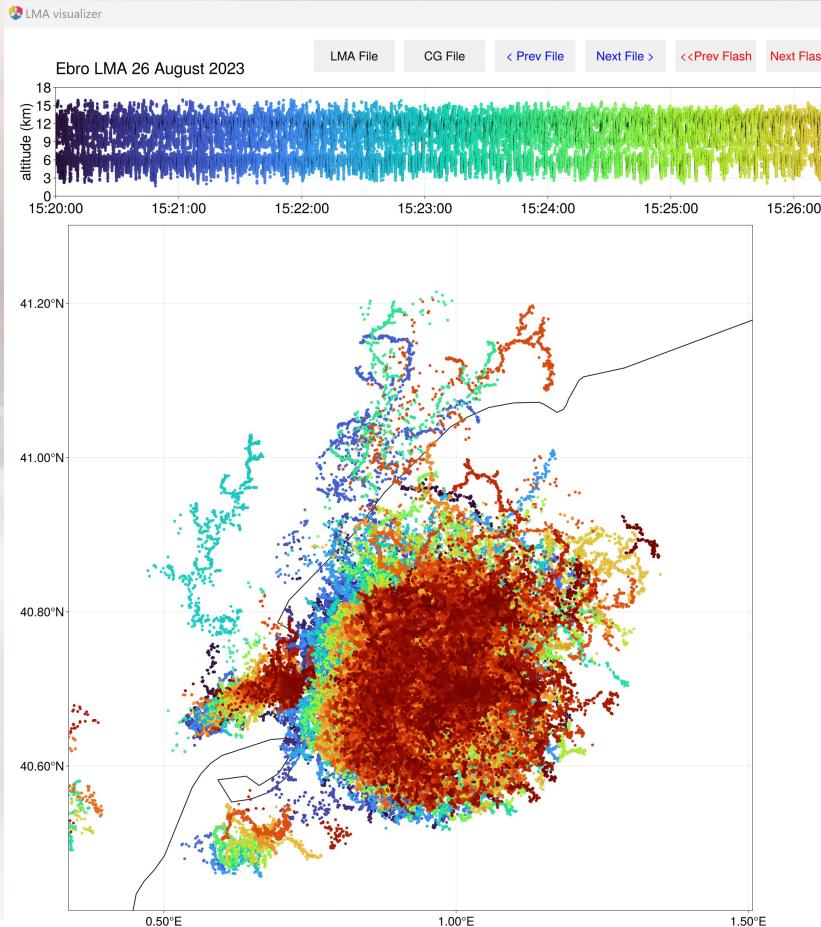
- What does its 'group' detections correspond to?
- Rings and arc effects vs LMA (lightning hole?)
- Flash rates vs LMA

# 7 – 13 stations **Ebro LMA** (2011-2022)

## → 30 stations **XCALMA** (2023, full size 2025)

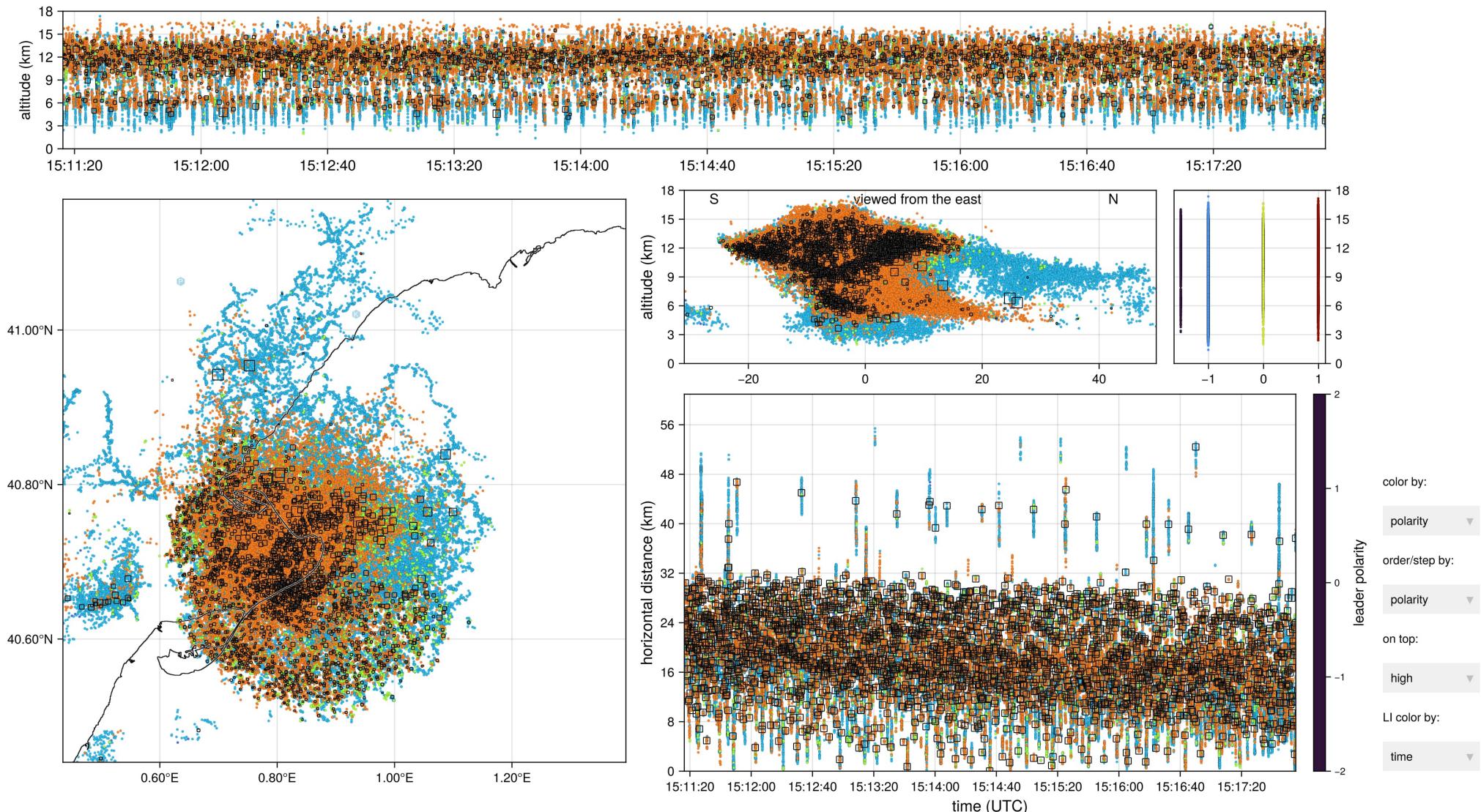


# New software development for LMA analysis

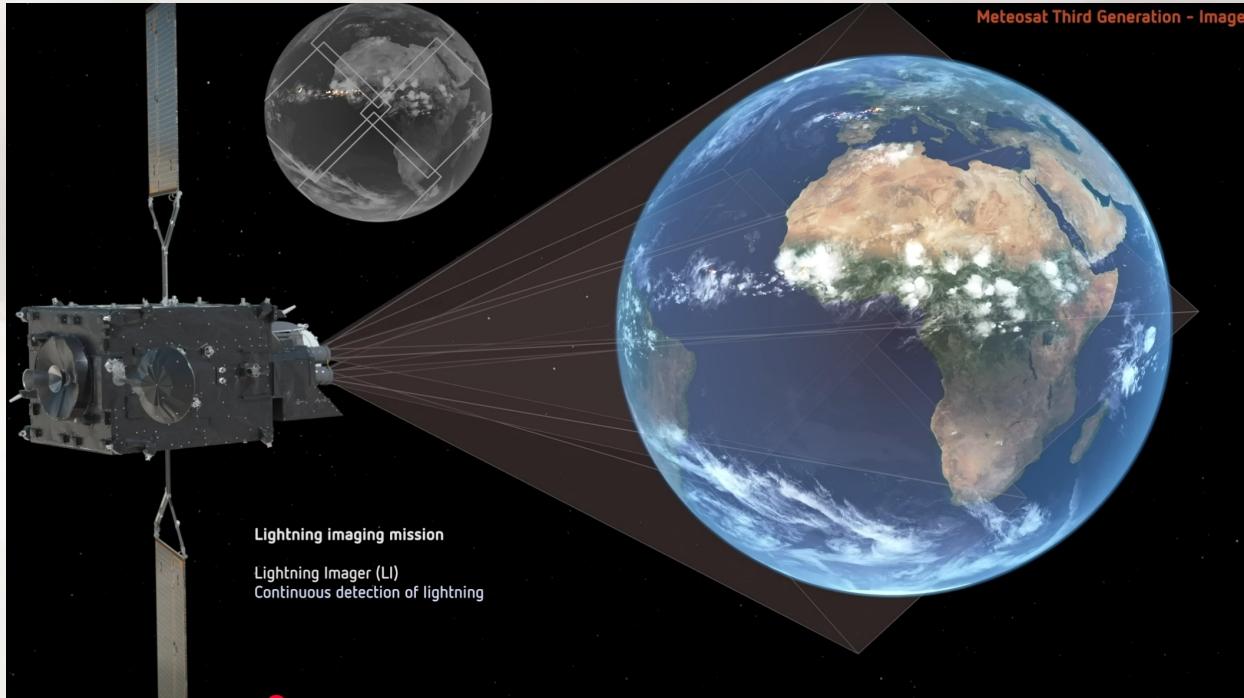


- New visualization tools, programmed in **Julia** (interactive, dynamically typed, compiled language – very fast)
- Test: my old code in **Scilab** (39 MB 10 minute file): **160 sec** for read + simple flash algo, **Julia: 6 sec** for read + various DBSCANs + 3D leader speed fitting + instant displaying
  - 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



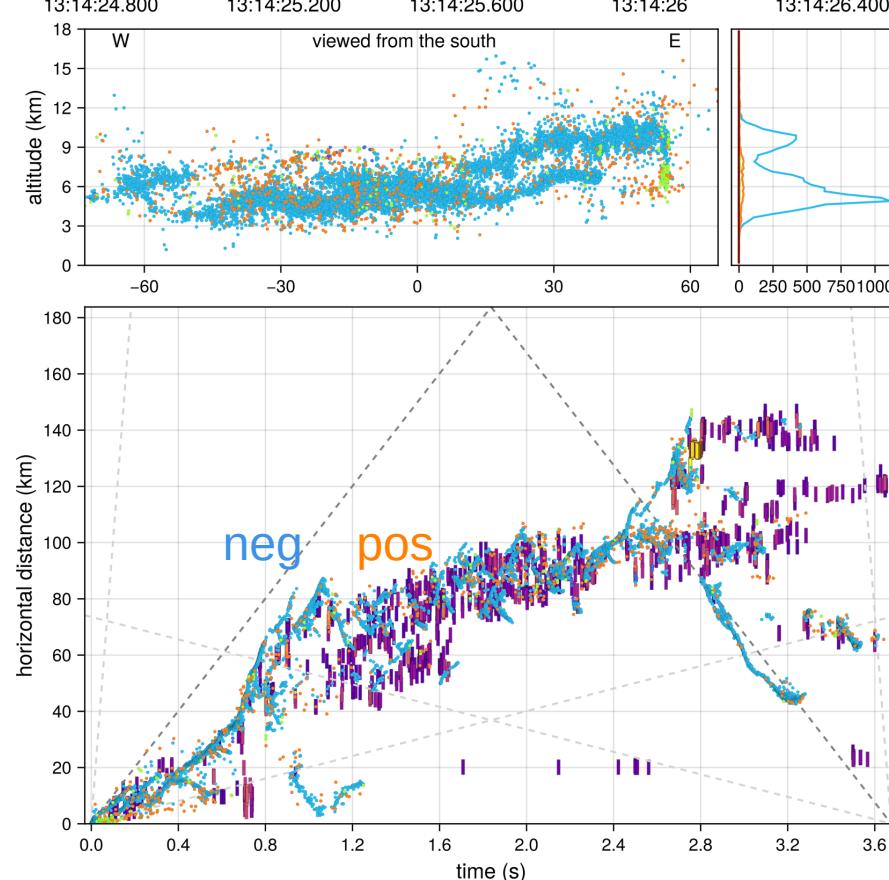
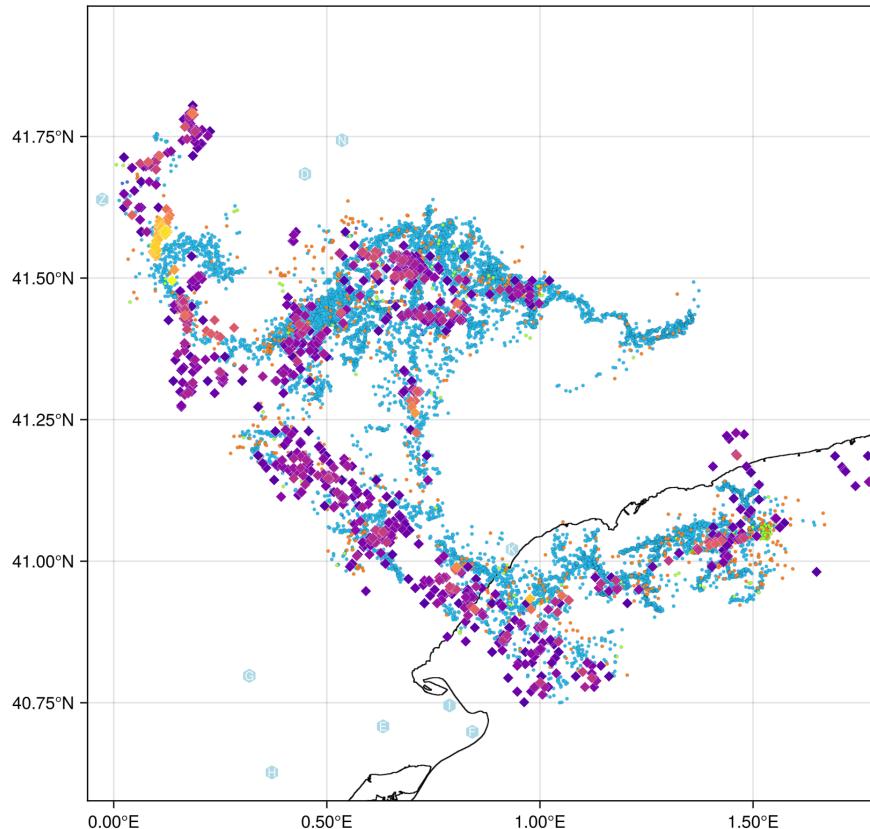
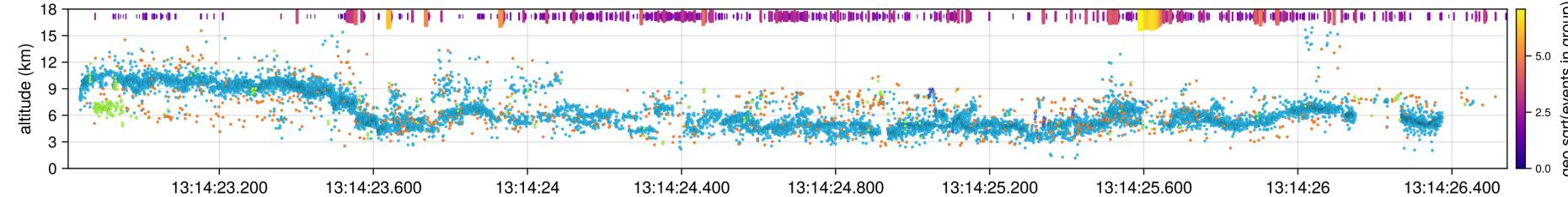
# Meteosat 12 Lightning Imager



## 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.

XCALMA (UPC × meteo.cat) 12 July 2025

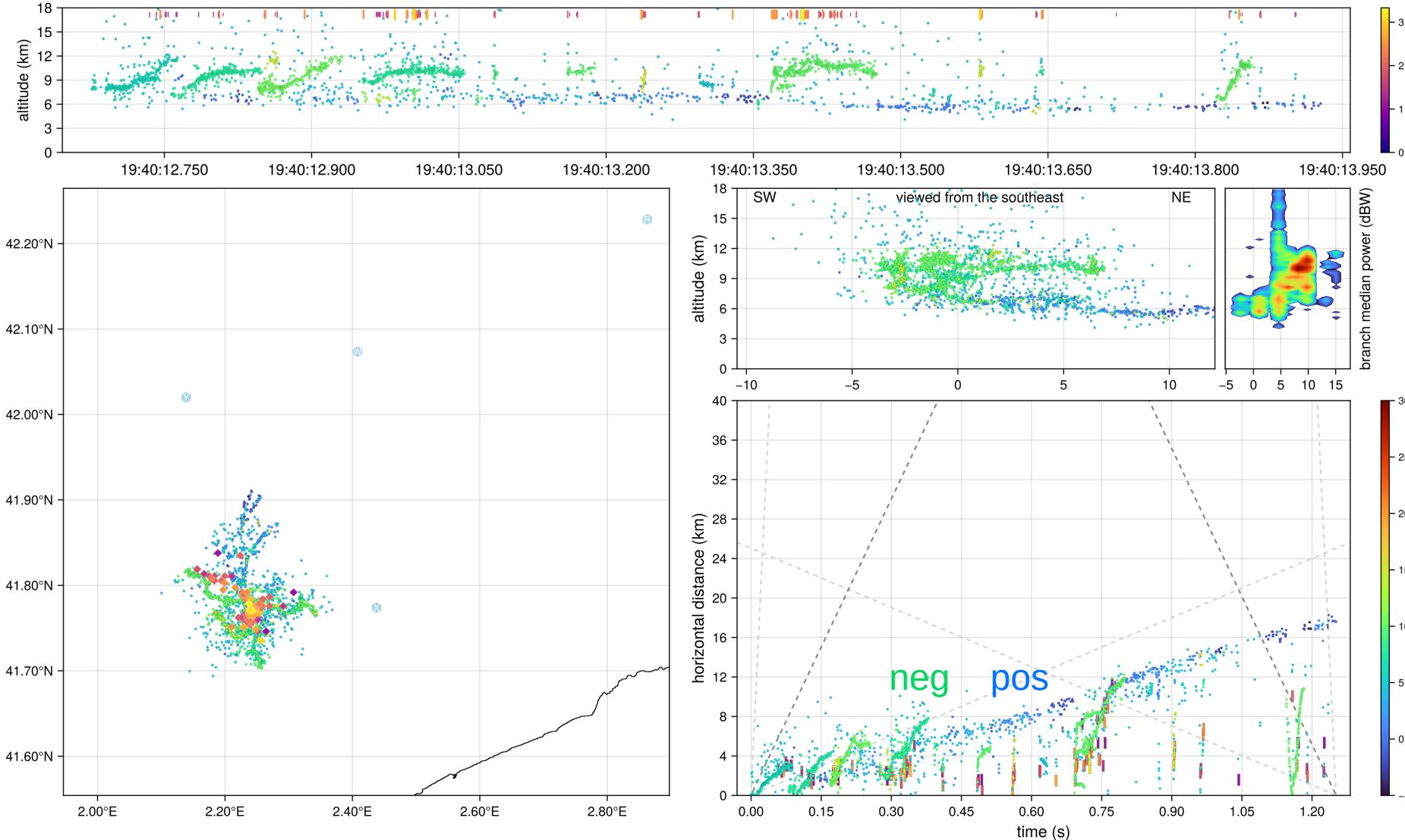


Color gradients:  
plasma

geo sqrt(events in group)

0 5 10 15 20

flash evolution:  
flash rate  
Geo color by:  
events in group  
LMA color by:  
polarity  
order/step by:  
polarity  
on top:  
high



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

LMA

Live

CG

LI

&lt; Prev File

Next File &gt;

&lt;&lt;Prev Flash

Next Flash&gt;&gt;

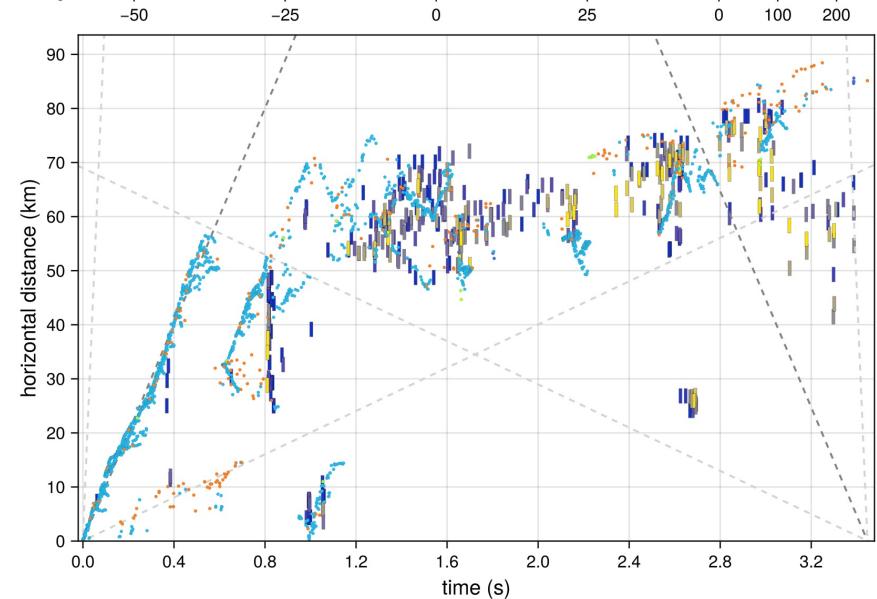
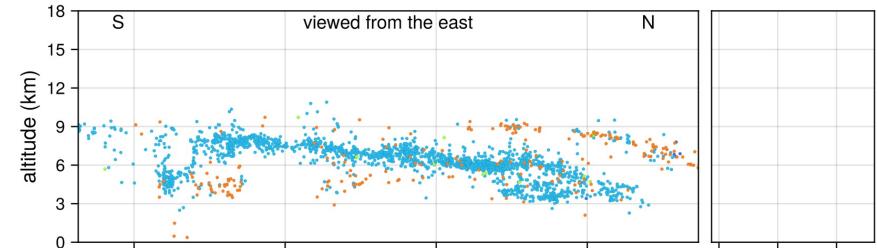
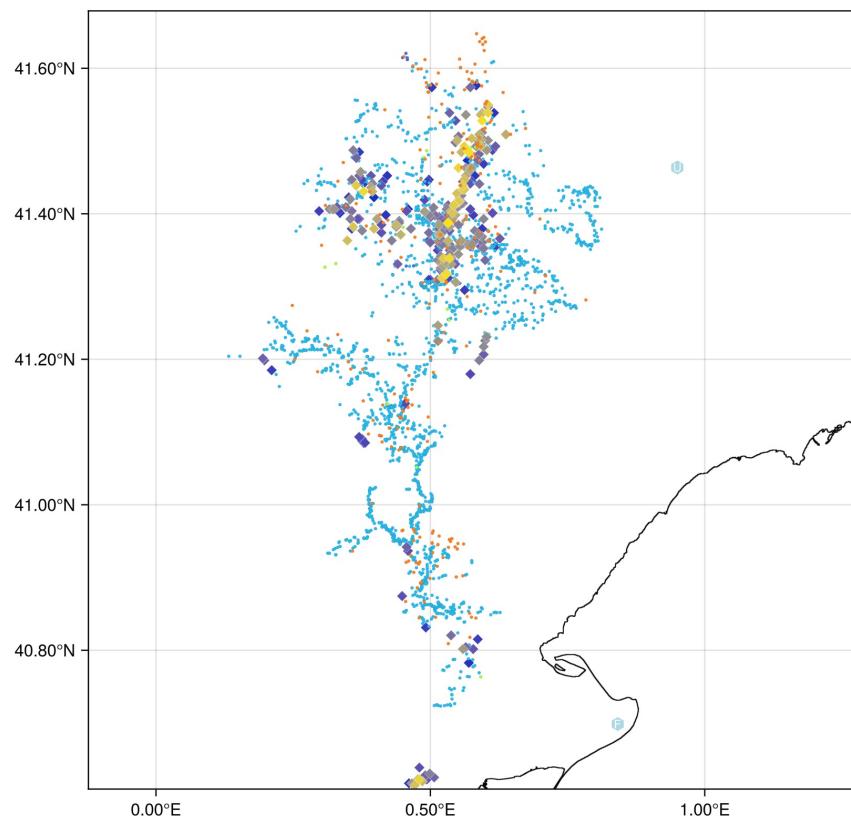
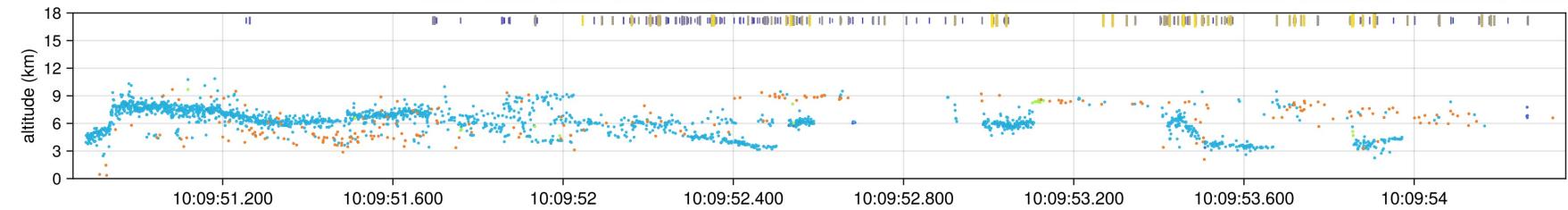
Zoom out

Reset time

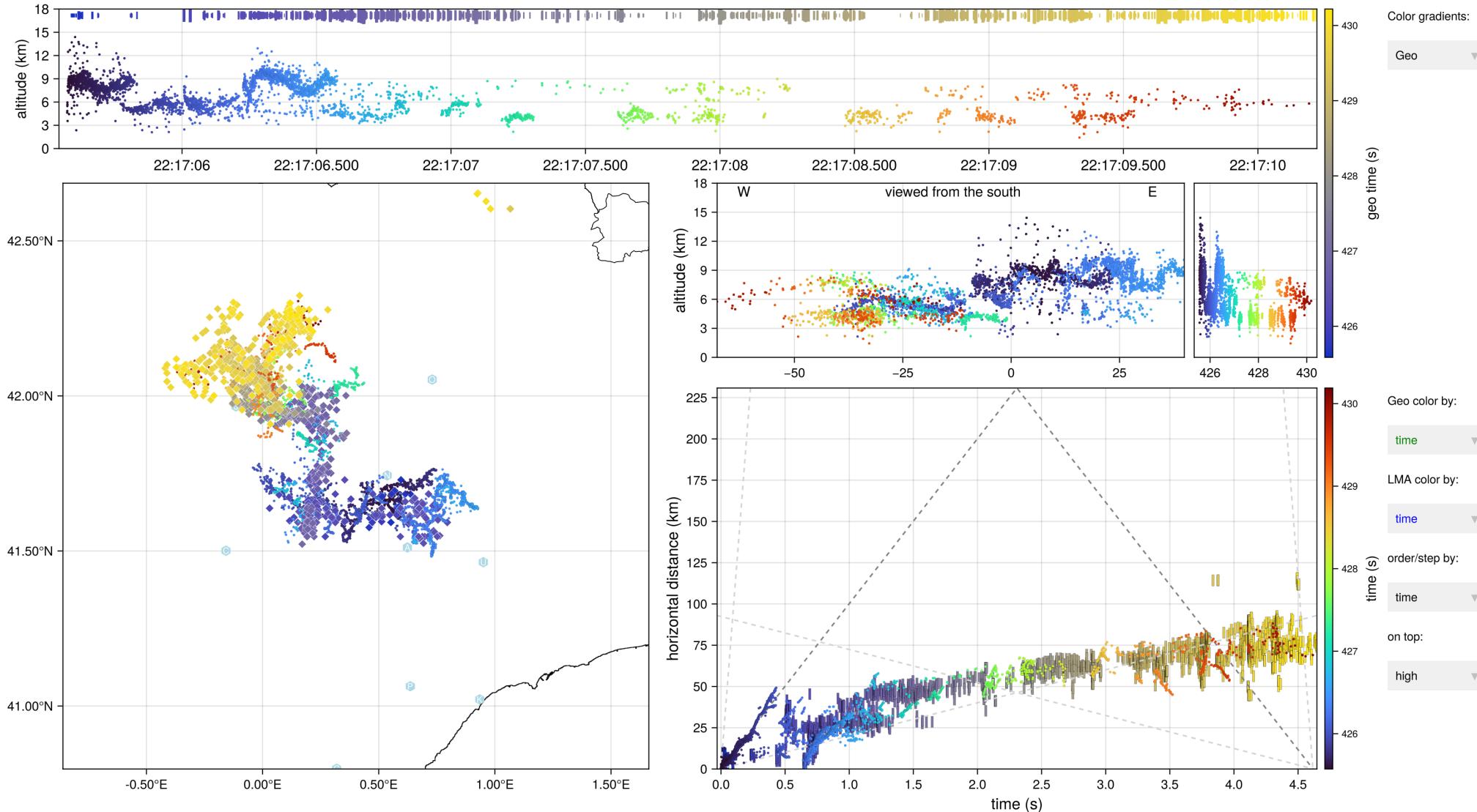
Reset area

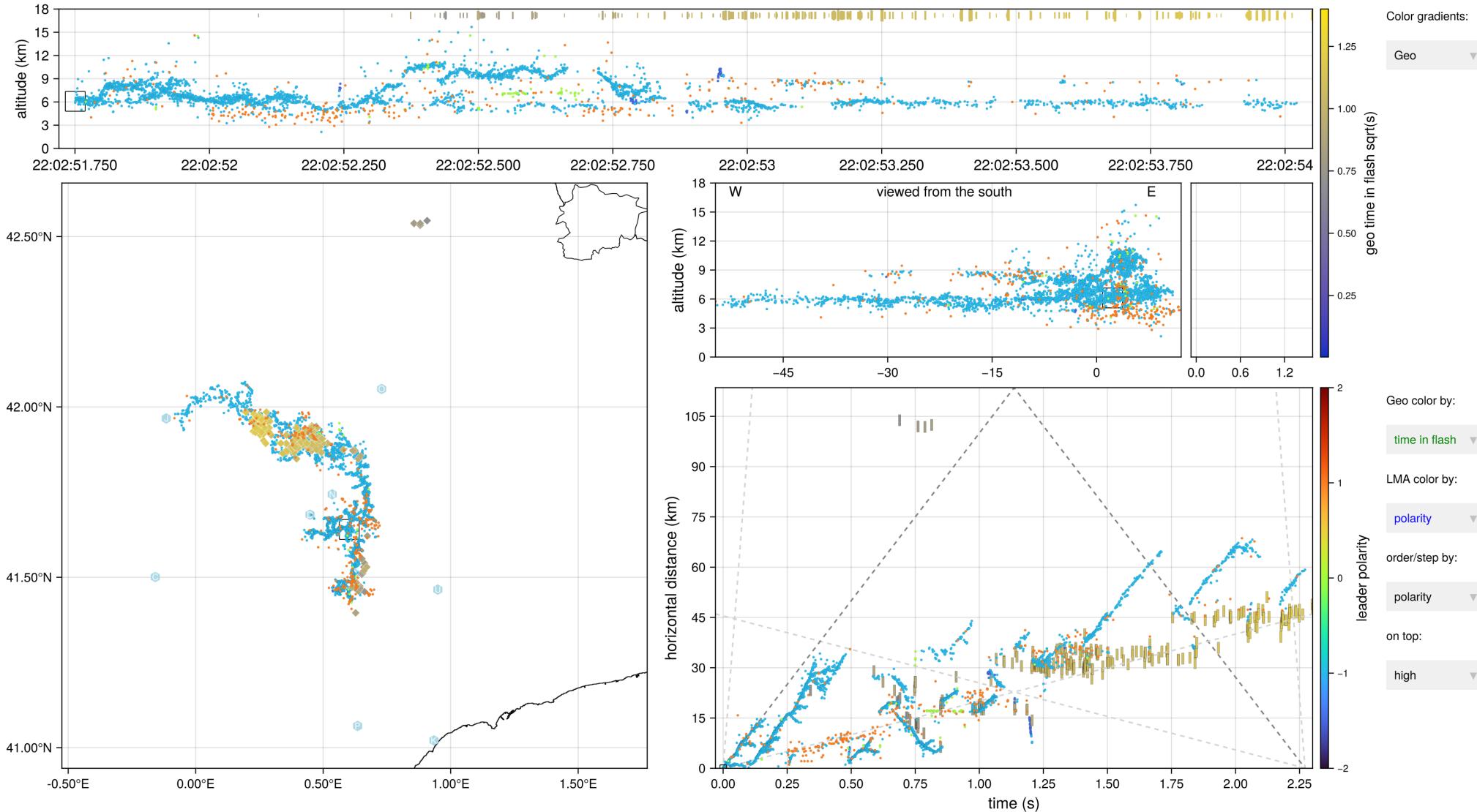
Save figure

Export

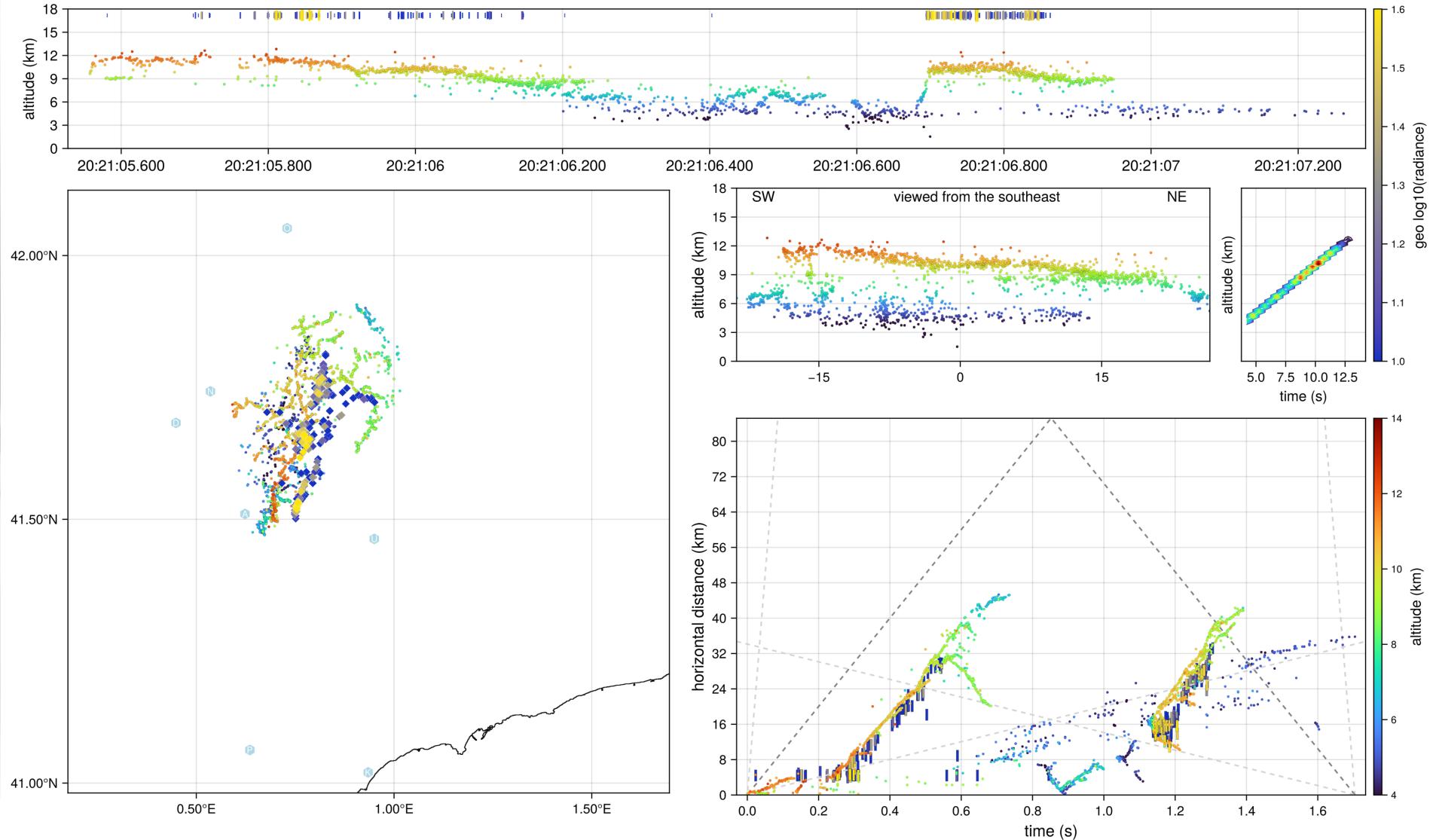


- Color gradients:
- Geo
  - LMA
- animate
- size
- fstart
- CG
- IC
- Geo
- flash rate
- Geo color by:
- cloud top energy
- LMA color by:
- polarity
- order/step by:
- polarity
- on top:
- high
- LMA filter:
- LI & sparkles
- leader polarity



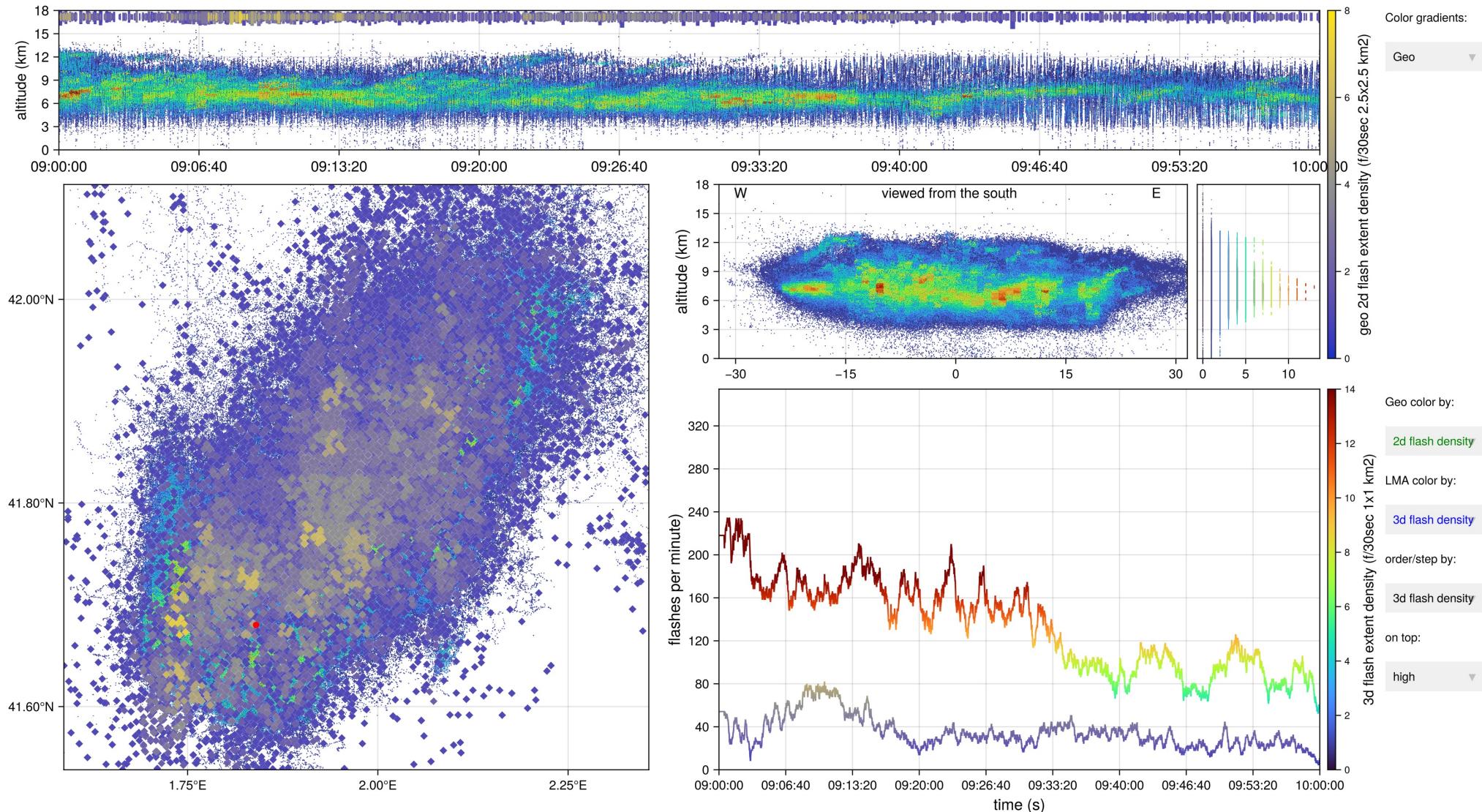


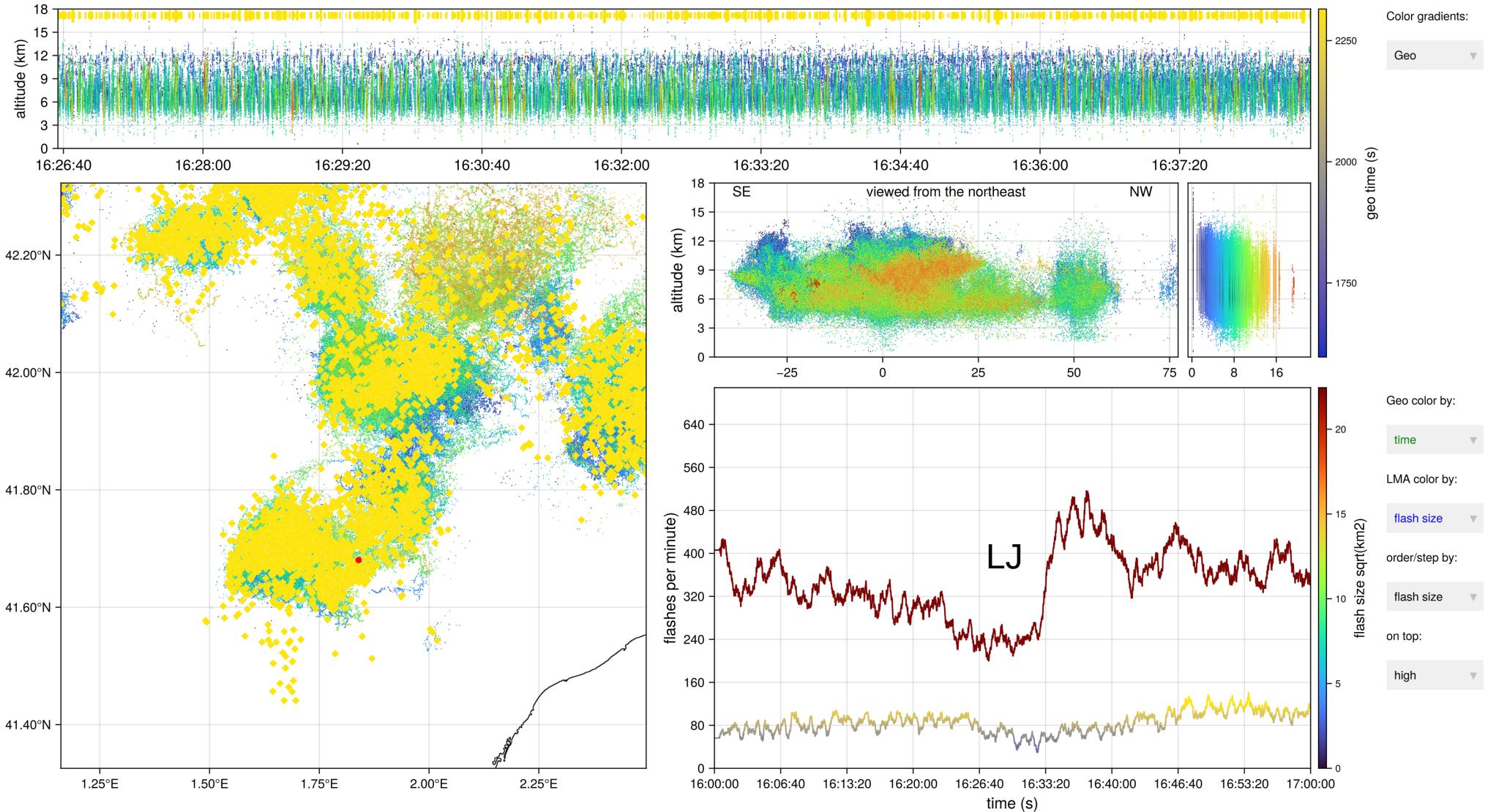
Real-time LMA: 2025-06-19 21:38:15

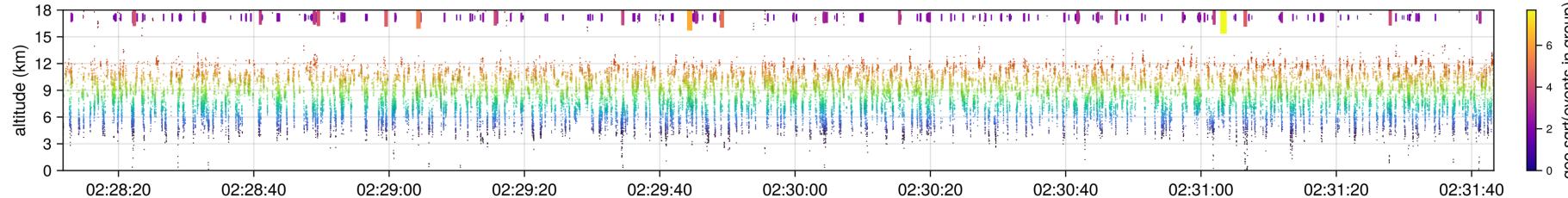


## LI group centroids correspond to:

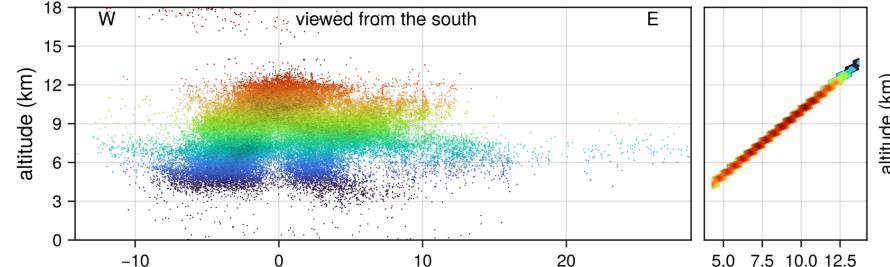
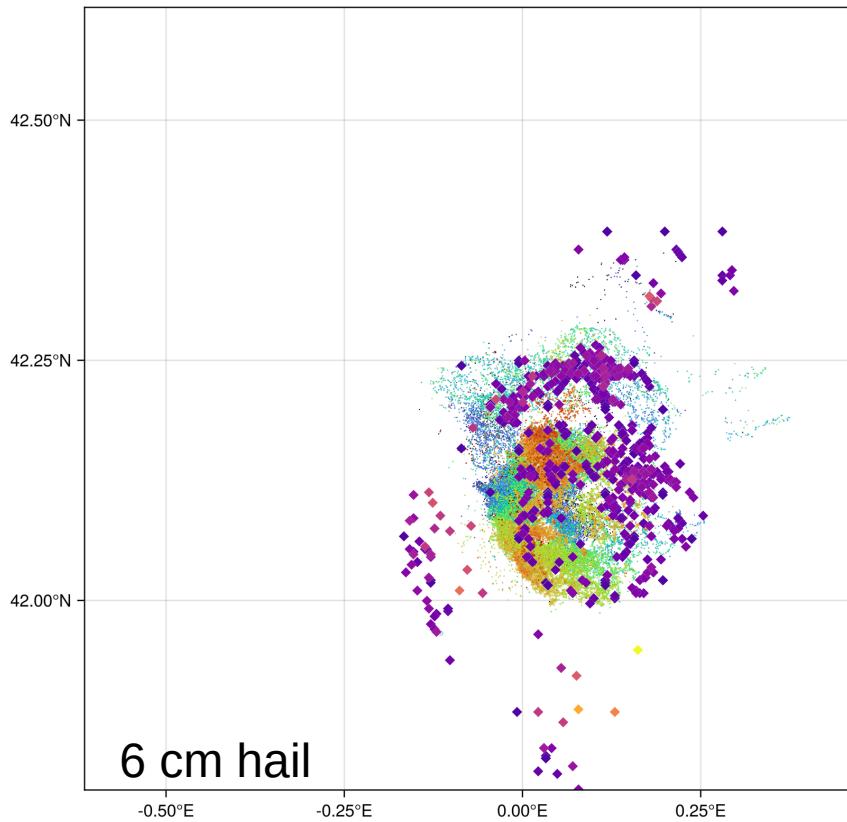
- Both positive and negative leader activity almost exclusively *above 9 km altitude* in summer storms (tops 11-15 km) (usually one polarity, not both)
- Energetic processes at lower altitudes, from recoil leaders, fast negative leaders/continuing currents and some cloud-to-ground strokes.
- Parts of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







Color gradients:  
plasma



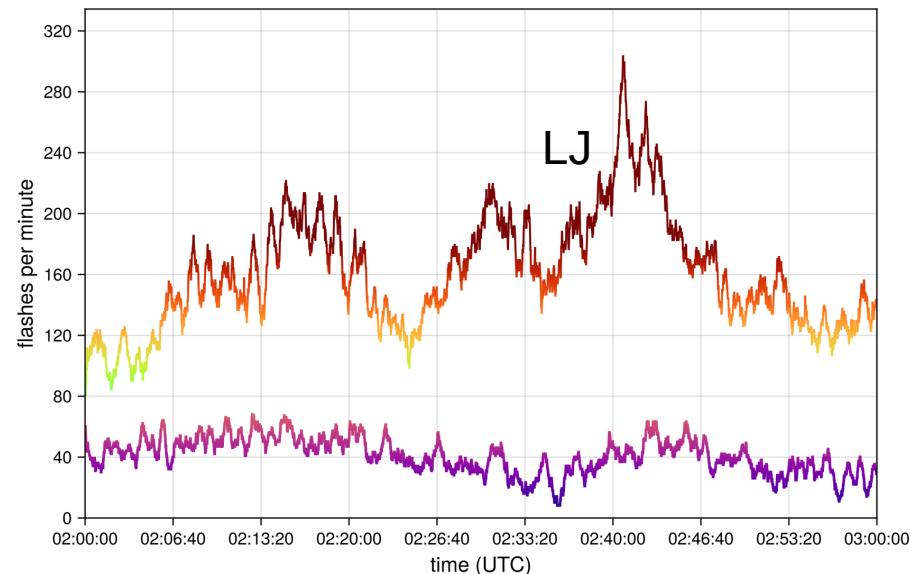
flash evolution:  
flash rate

Geo color by:  
events in group

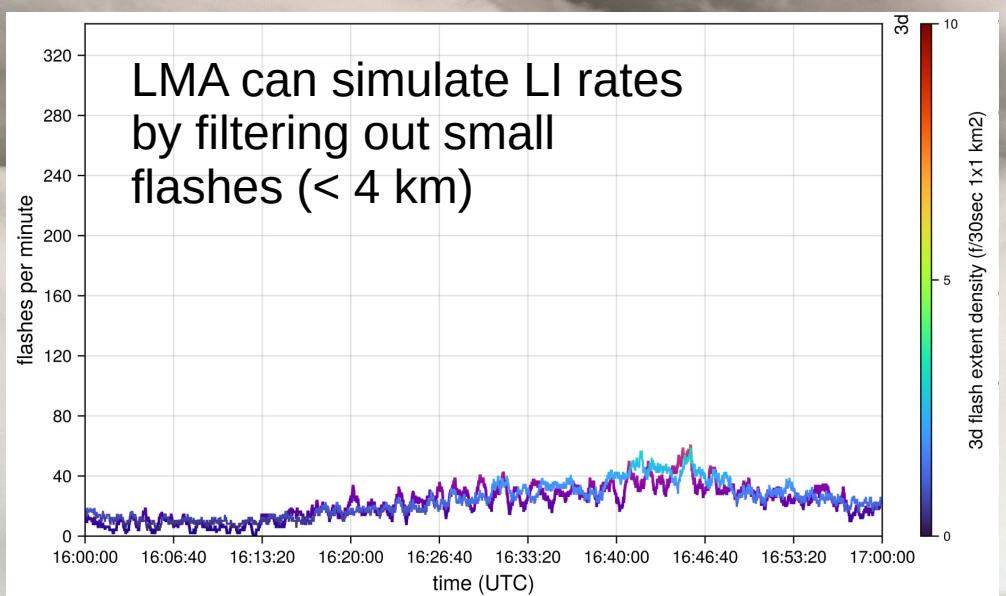
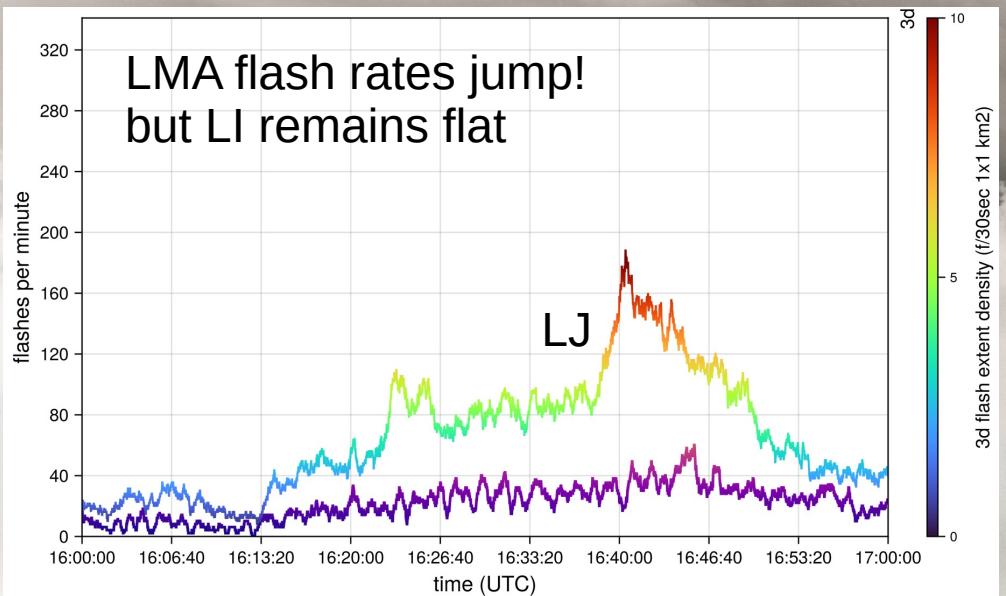
LMA color by:  
altitude

order/step by:  
altitude

on top:  
high



# Lightning jump



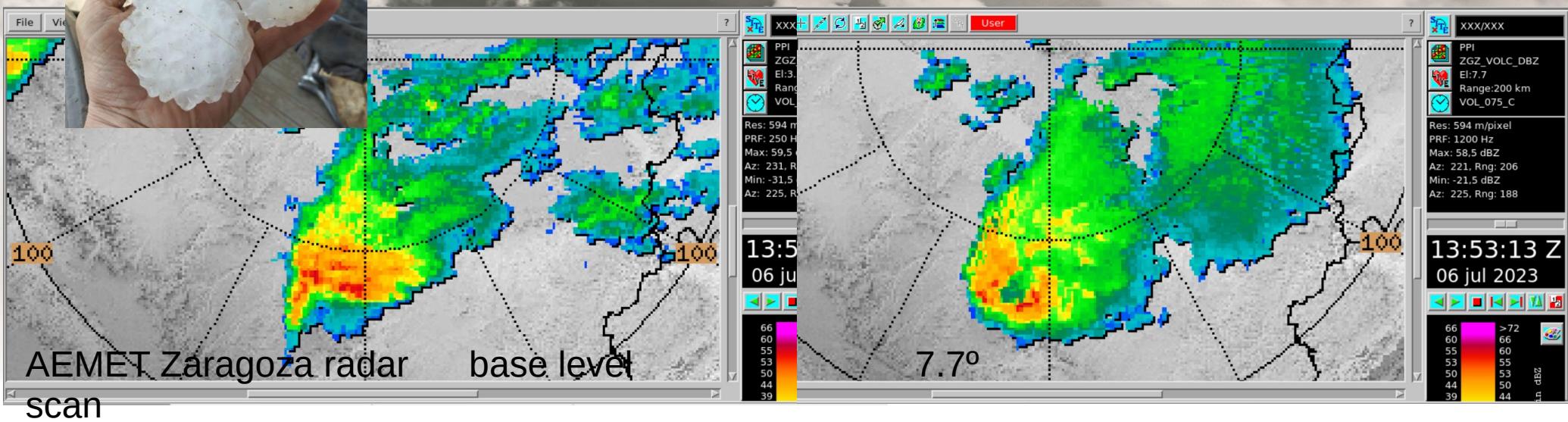
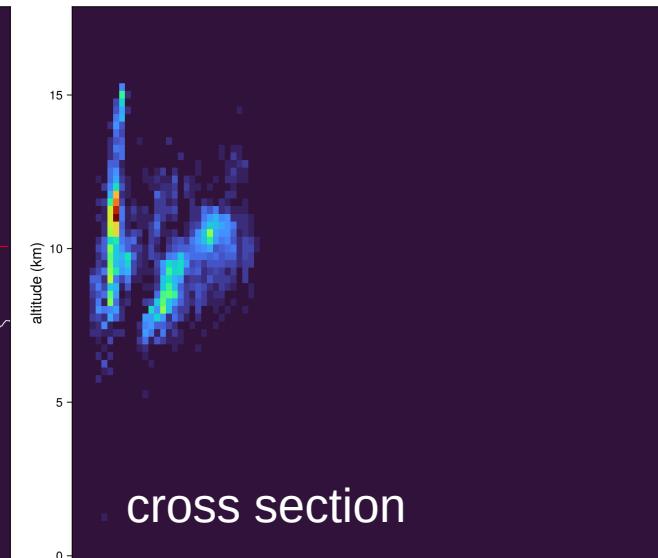
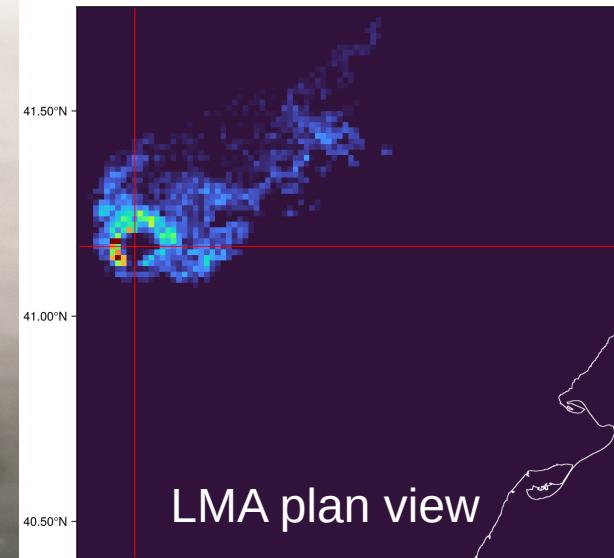
# Flash rates

- 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.

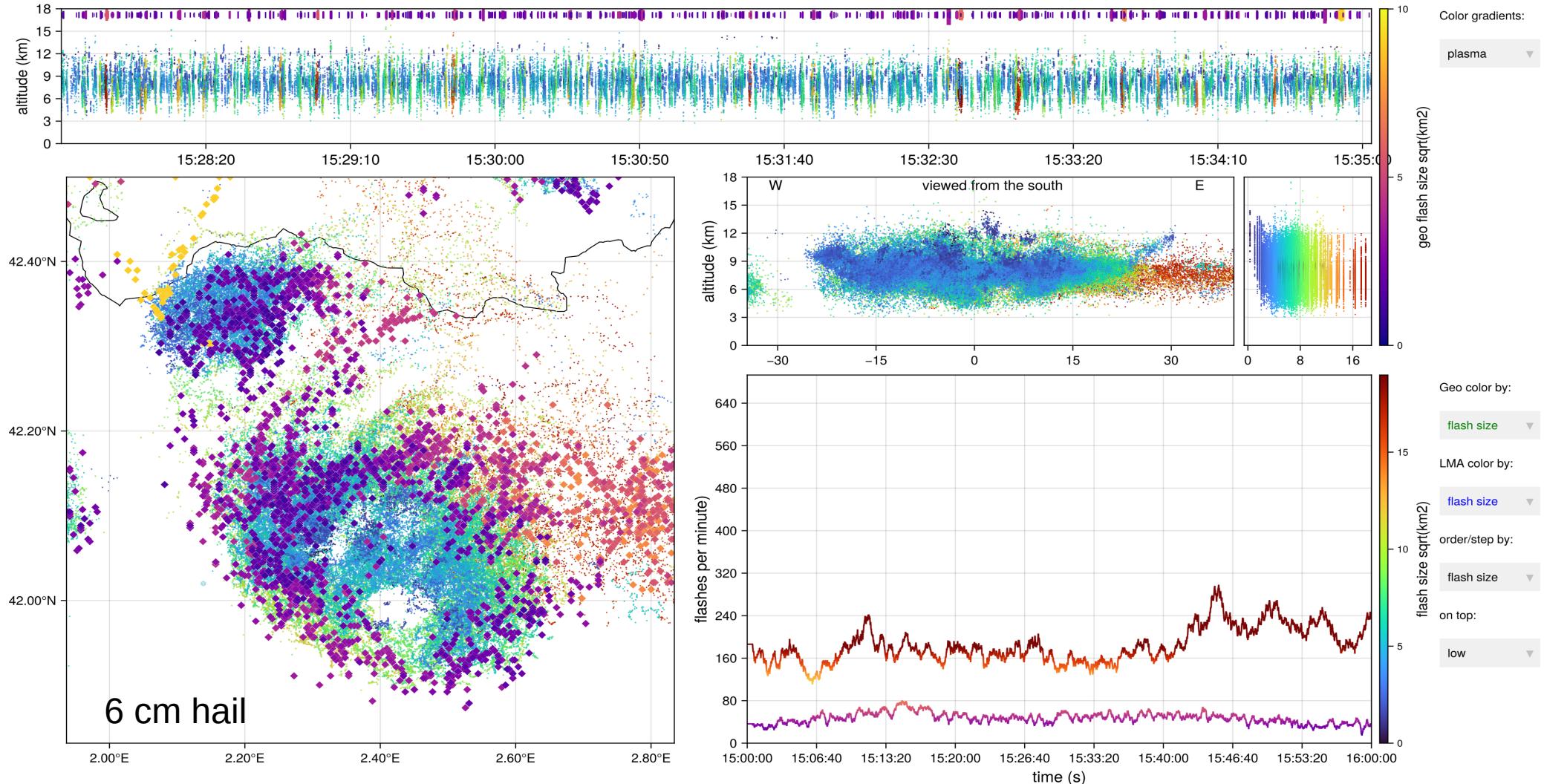
## What are lightning holes?

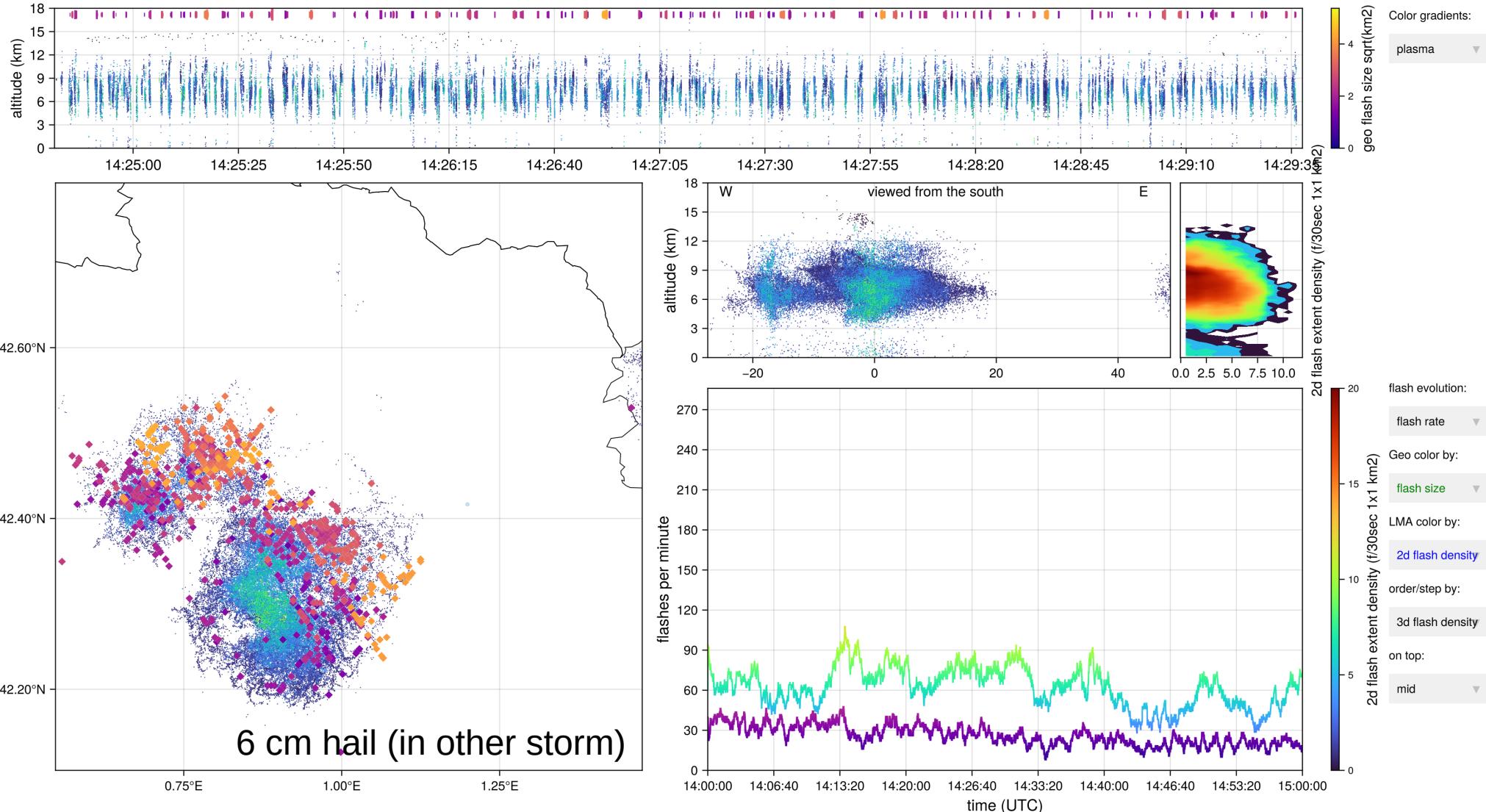
- LMA lightning holes are seen in some supercells
- Lightning seems to wrap around the mesocyclone
- Bounded weak-echo region
- Typically best seen when selecting 1.5 - 3 minutes of data

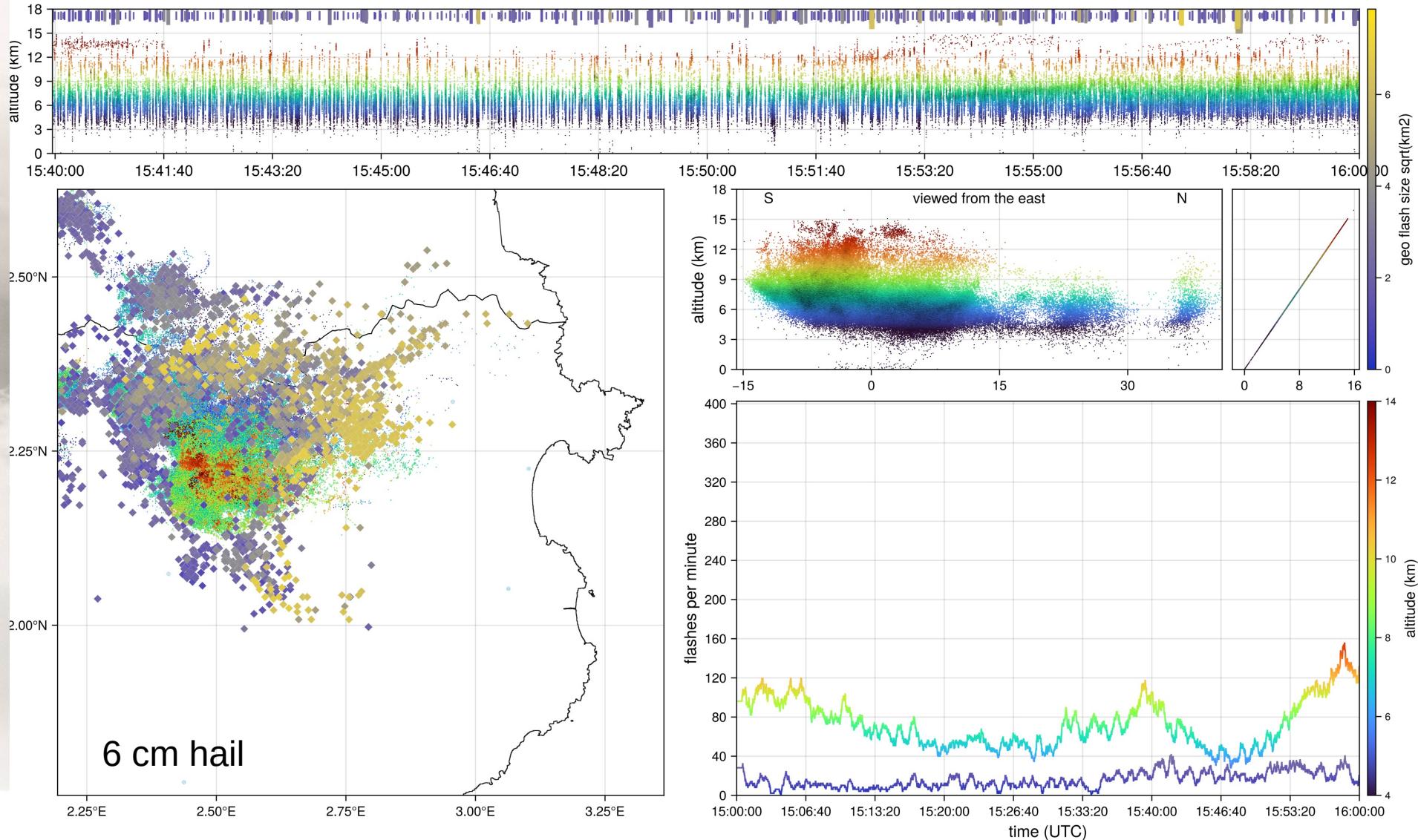
# Analysis 6-6-2023 case in Pineda et al. (submitted to EJSSM)

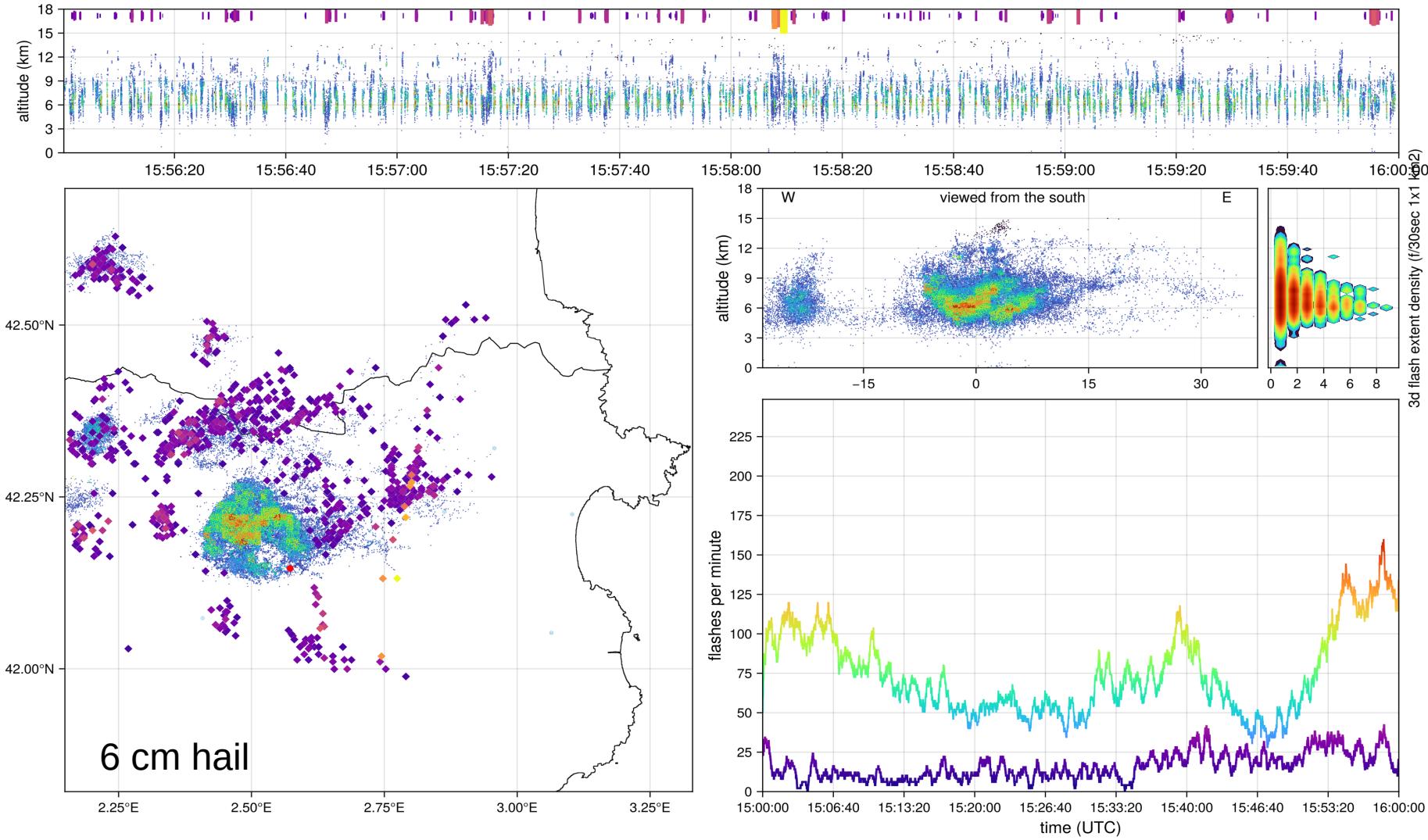


MCAT,UPC 2 August 2024









Geostationary 13 June 2025

LMA

Live

CG

LI

&lt; Prev File

Next File &gt;

&lt;&lt; Flash

Flash &gt;&gt;

&lt;

&gt;

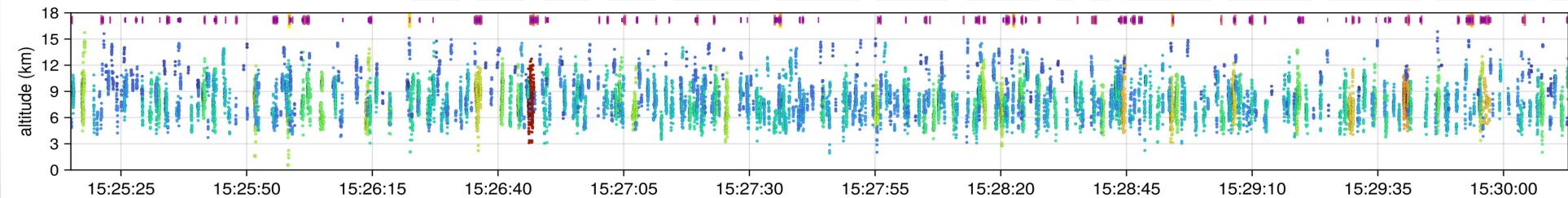
Zoom out

Reset time

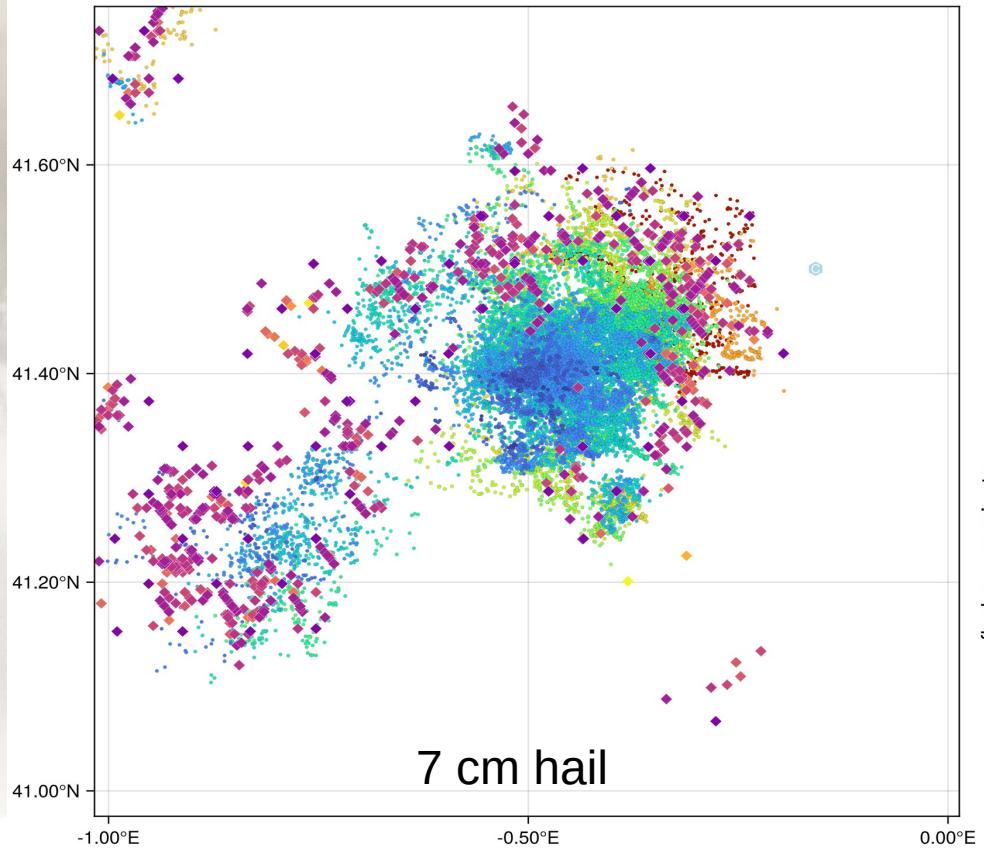
Reset area

Save figure

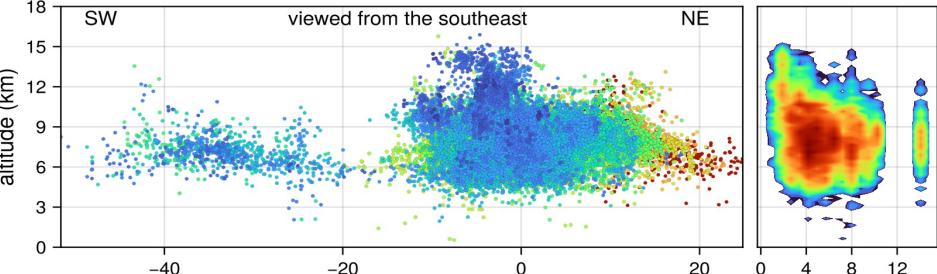
Export



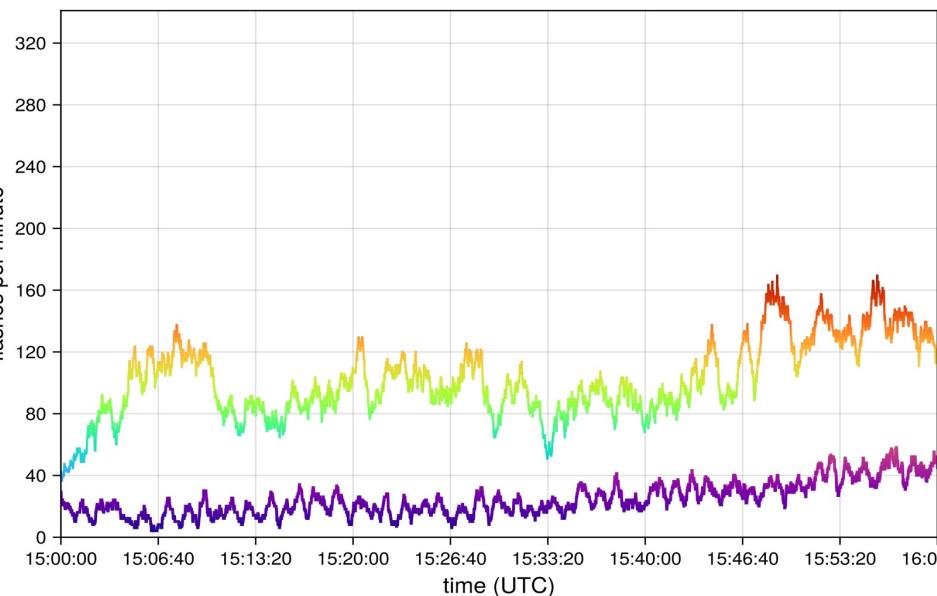
geo sqrt(events in group)



flash size sqrt(km<sup>2</sup>)

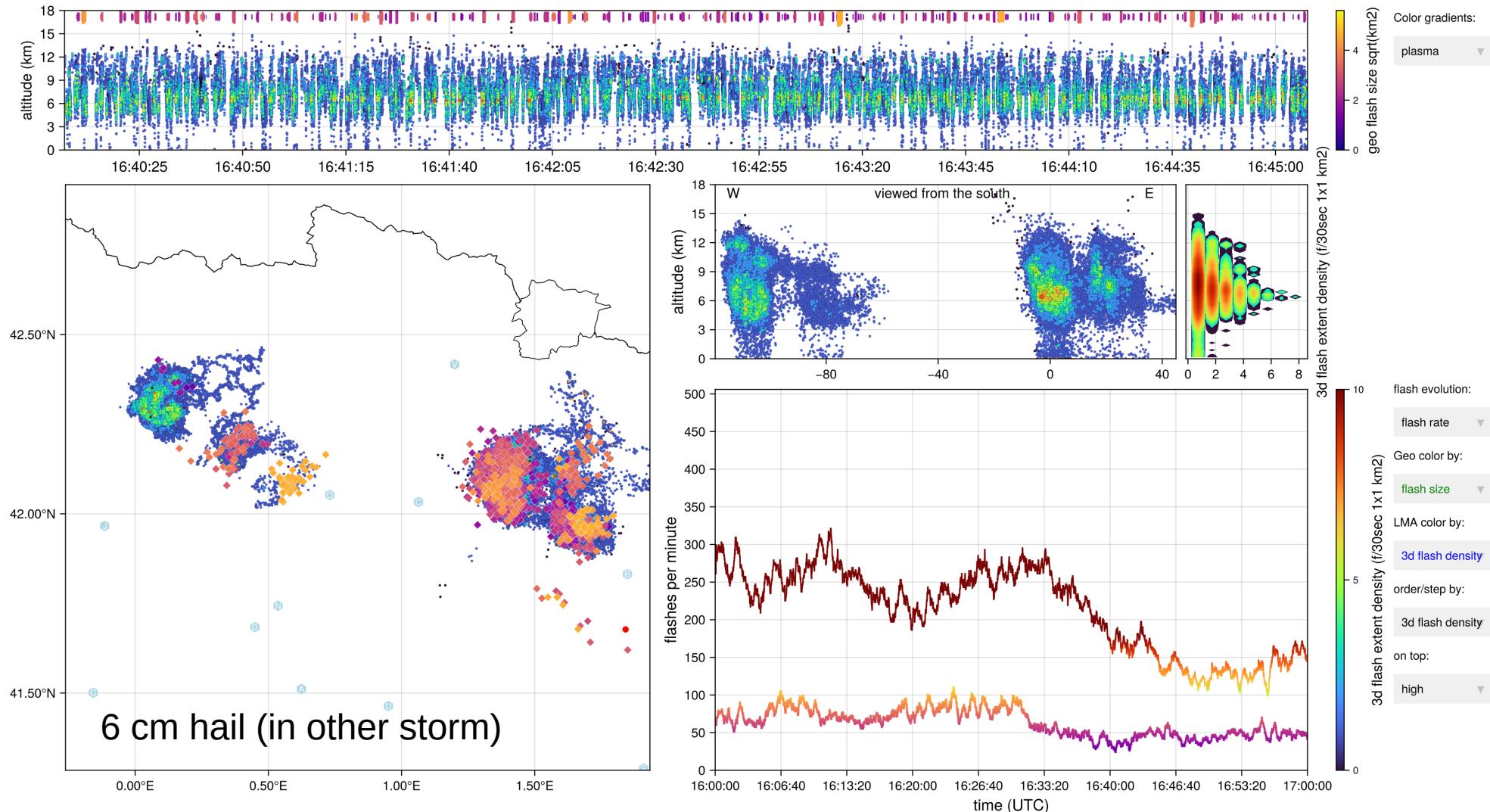


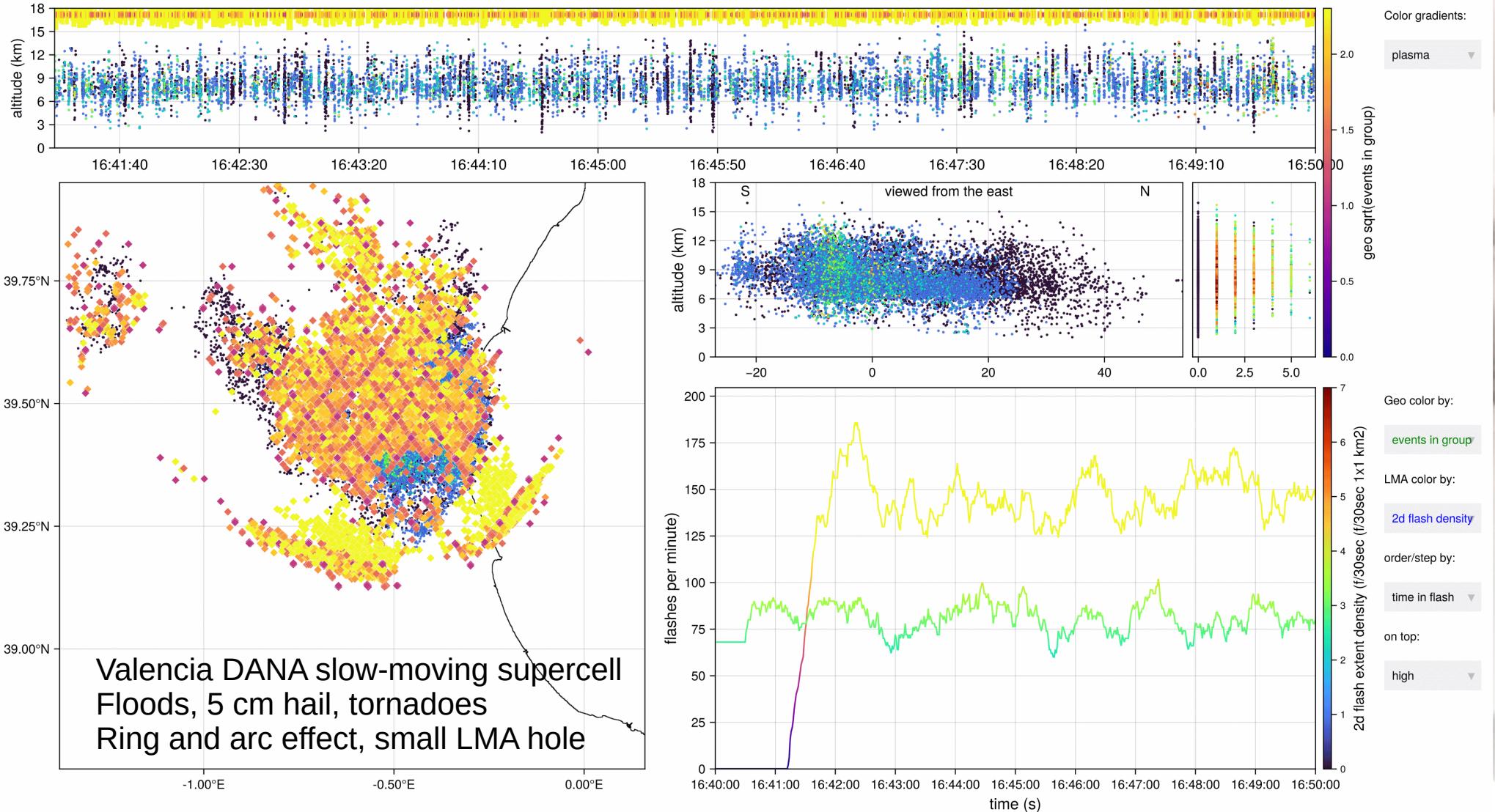
flash size sqrt(km<sup>2</sup>)

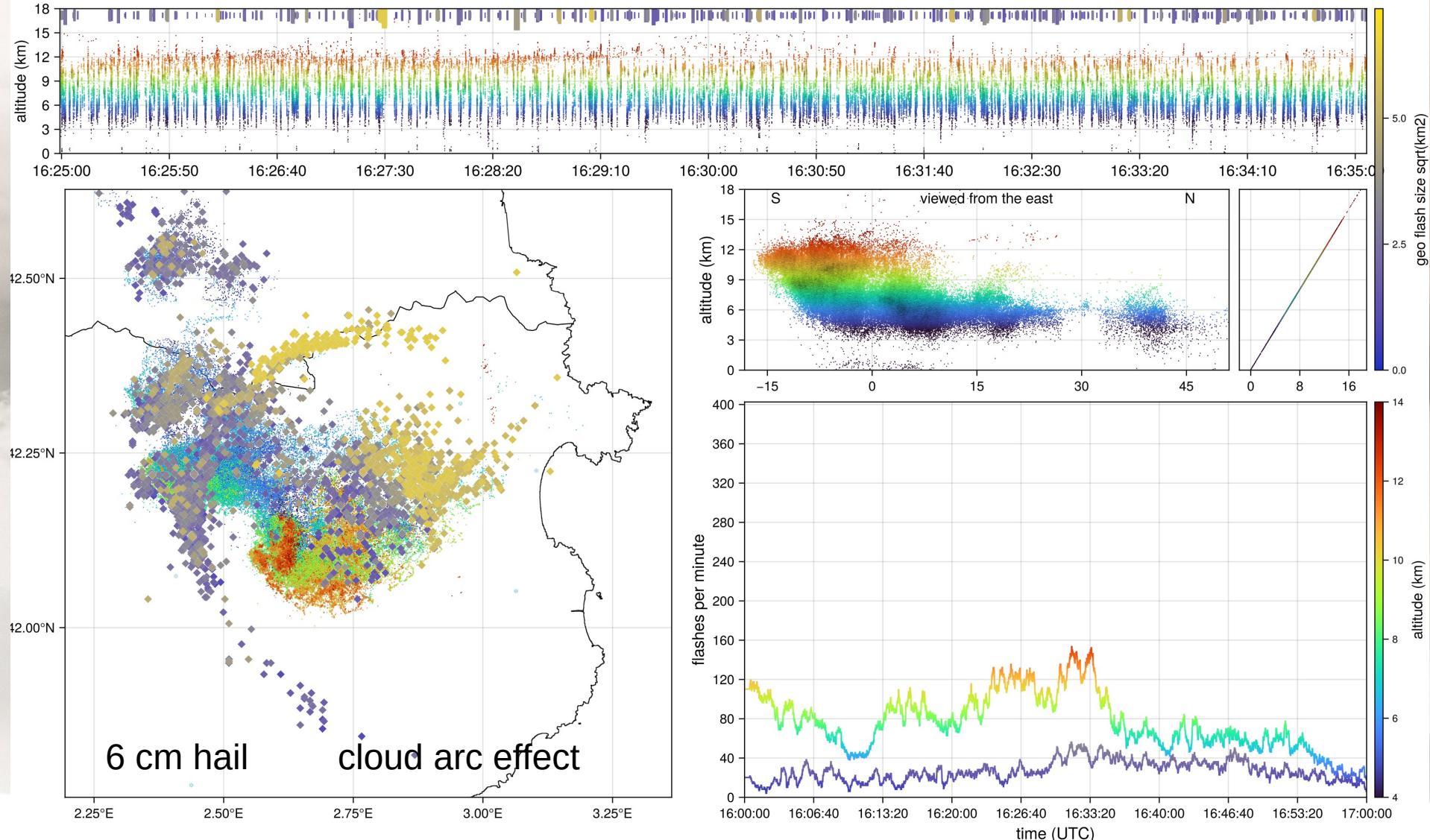


flash size sqrt(km<sup>2</sup>)

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 UPC Lightning Research Group

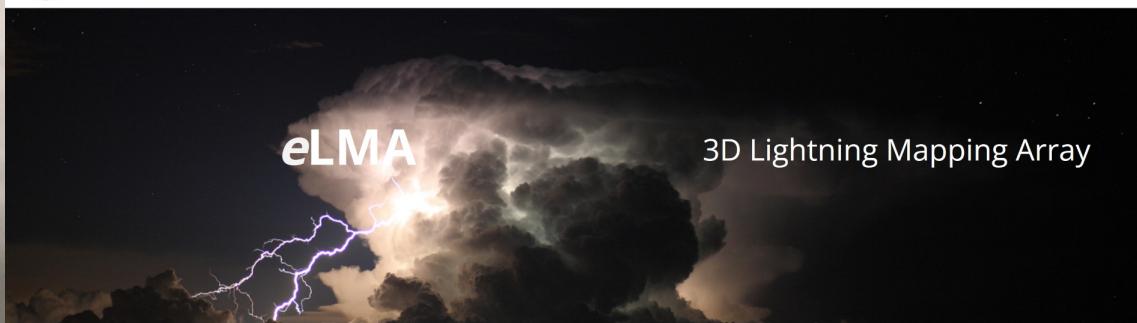
Inicio

Ebro LMA

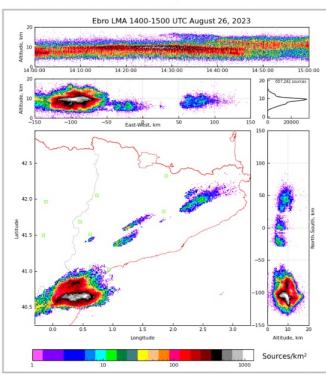
Cámara rápida

Rental

Contacto



[LIVE](#) - actividad rayos Ebro LMA



Servicio cámara rápida

