Visualizing the geometry of lightning detected by MTG's Lightning Imager

This work was supported by EUMETSAT

European Severe Storms Laboratory

Pieter Groenemeijer[1,2], **Alois M. Holzer**[1,2], and **Tomáš Púčik**[1]

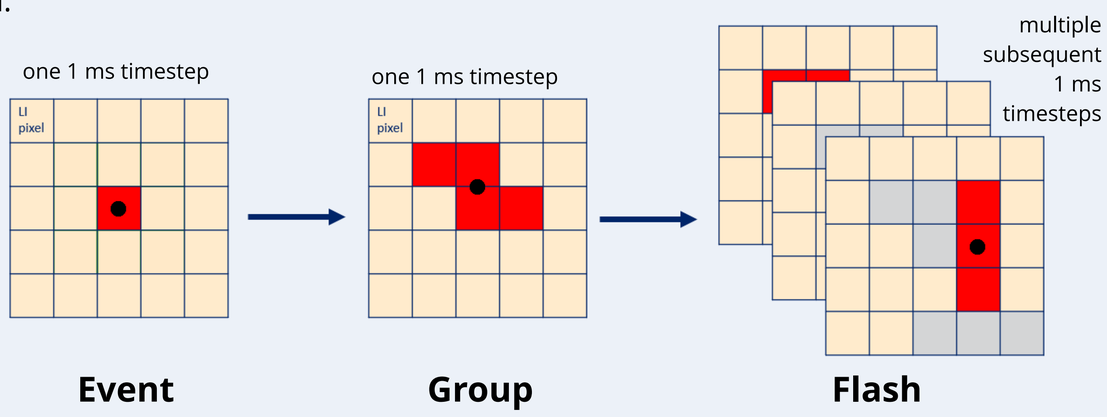
1. European Severe Storm Laboratory – Science & Training, Wiener Neustadt, Austria
2. European Severe Storms Laboratory e.V., Wessling, Germany

Introduction

The Lightning Imager instrument detects optical signals associated with lightning in near real-time, From the MTG-I1 satellite in geostationary orbit at 32,000 km above the earth.

Resolution of Lightning Imager:

Spatial (at the equator):	4.5 km
Temporal:	1 ms



Multiple Events (left) combine into Groups which combine into Flashes. Groups can have centroids (black) that do not align with a pixel. Adapted figure from EUMETSAT.

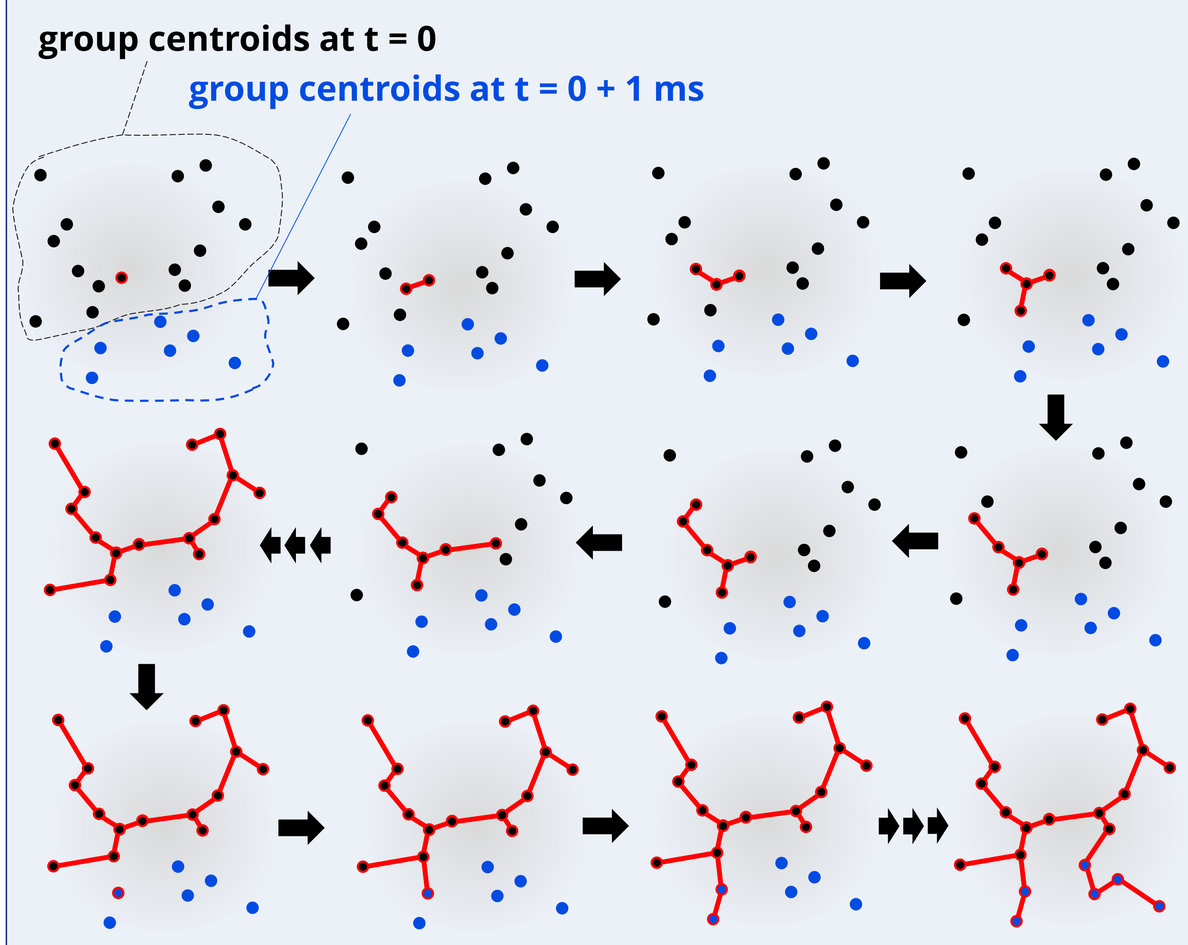
A multi-step procedure removes detections representing noise from detections of real lightning. Remaining detections are called **Events**.

Adjacent **Events** are joined into **Groups.** The centroids of groups may lie between individual pixels, i.e. creating sub-pixel resolution. **Groups** combine into **Flashes**.

We developed a visualization connecting group controids by line segments mimicking the geometry of a lightning channel, called "Flash Geometry".

Procedure to display flash geometry

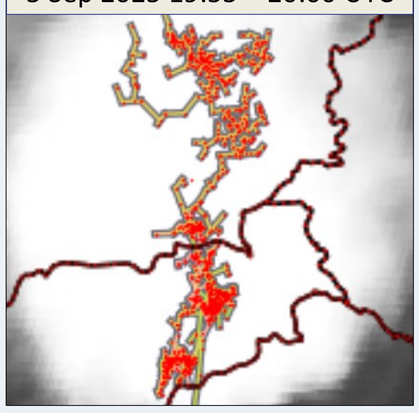
1. Take a Flash and consider all groups of the earliest 1 ms timestep of the Flash.
2. Start with the most central group centroid. Connect the centroids to form a dendritic structure consisting of nodes. *This is done by connecting the node closest to any still unconnected centroid with that centroid, until all controids have been connected to the structure. Optionally one can set a maximum connection length.*
3. Consider groups of the next 1 millisecond and connect them to the existing nodes like above (see illustration).
4. Repeat step 3 until the Flash has been processed.



Example:

Geometry product showing lightning activity during 5 minutes, by drawing line segments that connect individual group centroids (red dots) following to the algorithm presented above.

5 Sep 2025 19:55 – 20:00 UTC

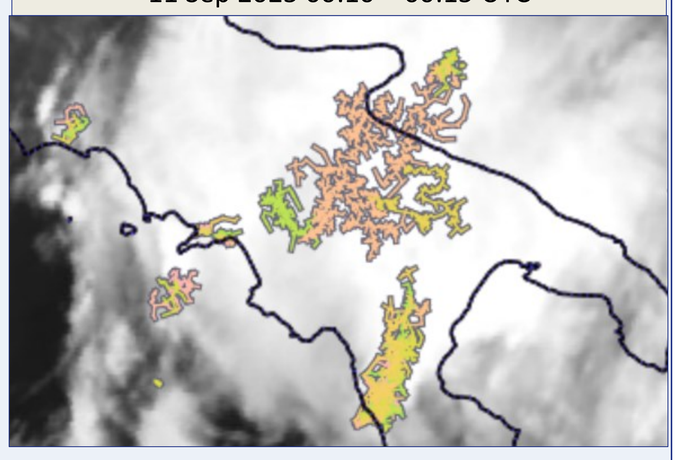


Combined visualizations & Artifacts

Geometry product showing lightning activity during 5 minutes.

Individual flashes have a different color shading.

11 Sep 2025 00:10 – 00:15 UTC

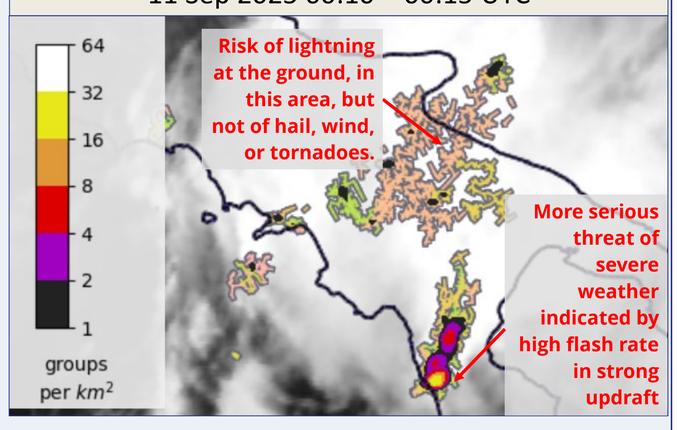


Geometry product combined with shaded group density:

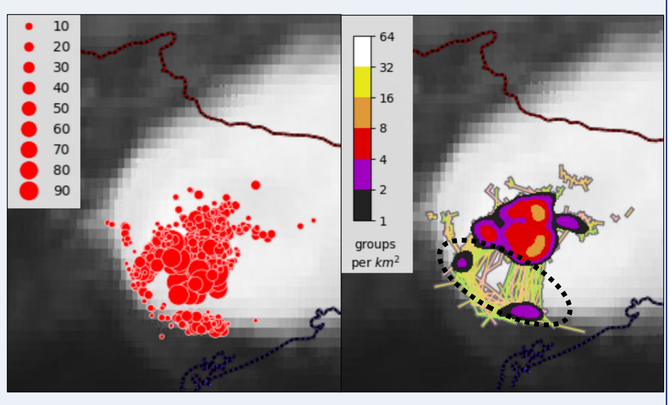
This combination shows both the large flashes in the stratiform region and the high number of short flashes near a severe storm.

Note that short segments have been filtered as explained below

11 Sep 2025 00:10 – 00:15 UTC



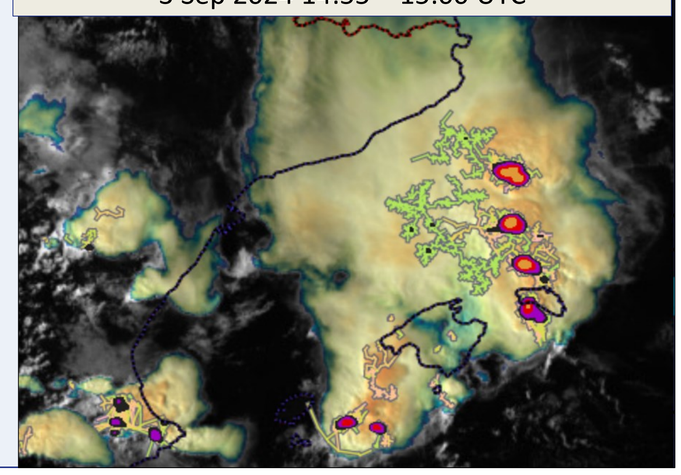
Detections of a single stroke in multiple locations:
The same lightning strike can be detected in multiple locations: where it shines through the anvil and at the edge of the anvil. Connections between those two do cannot be interpreted as lightning channels.



Example of combination with "IR/VIS sandwich" satellite imagery:

This example shows nicely where the active updrafts in a large convective system are located and the much larger region across which a lightning risk exists

3 Sep 2024 14:55 – 15:00 UTC



Benefits and Limitations of the visualization

The **Geometry & Density** product can:

1. **Indicate the extent of the flash**, unlike VLF/LF ground-based sensors
   - Such flashes can produce very powerful positive cloud-to-ground strikes
   - Especially relevant for aviation and energy sector
2. **Highlight the part of the storm with the highest flash rate**
   - Indicated by the group density fields

Limitation: There is **no guarantee** that inferred connections are real. In particular, secondary maxima of the optical signal can lead to suprious flash channel segments.

Acknowledgements and code availability

This work was supported by EUMETSAT as part of their programme to support the user uptake of MTG products. Contact pieter.groenemeijer@essl by e-mail to obtain the code used to generate the geometry product.

The **European Severe Storms Laboratory** is a non-profit organization located in Germany (Wessling) and Austria (Wiener Neustadt). It supports research by operating the European Severe Weather Database, organizing the ESSL Testbed and scientific meetings. It studies the climatology, impacts and forecasting of severe storms and provides forecaster training. Its members include European weather services, research centres and research departments as well as supporting members. For more information, visit: **www.essl.org**