# Meteosat Third Generation Lightning Imager (MTG-LI): Flash and Accumulated products and test data for user readiness activities

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Remote Sensing Scientist – Lightning Imager

# Outline

- Lightning detection from space

- MTG Lightning Imager (LI) and user products

- LI test data

- Cal/Val (calibration and validation) activities
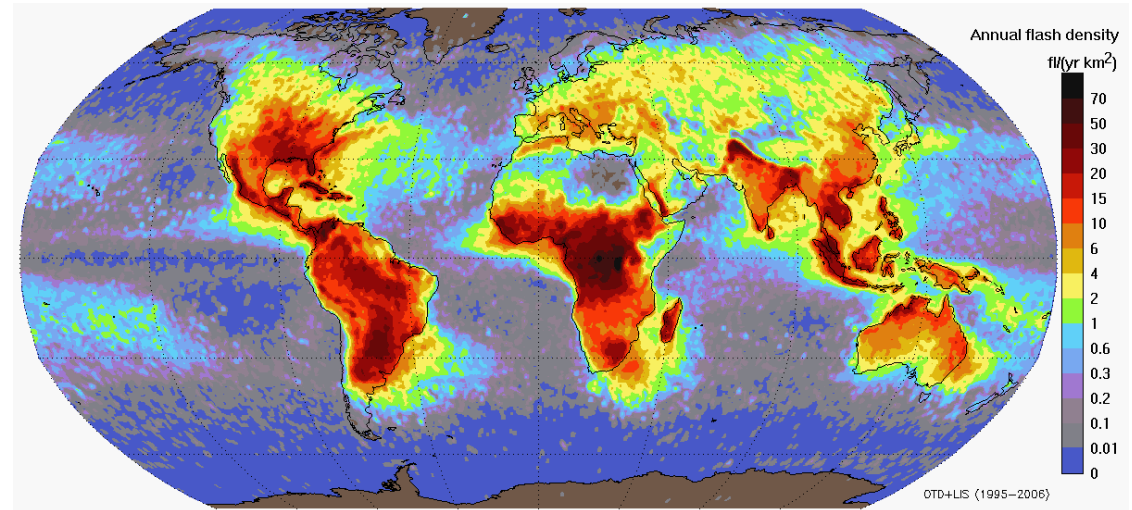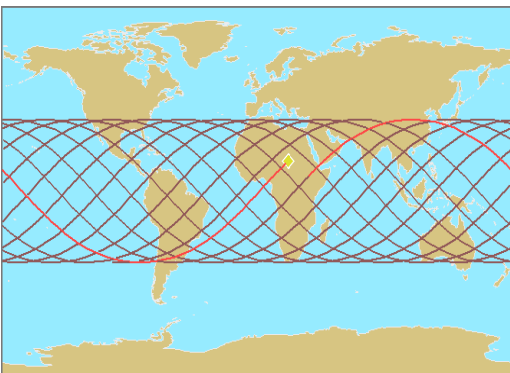
- Summary and way forward

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# Lightning Detection from Space – from LEO to GEO

- Feasibility of lightning detection from space by optical sensors has been proven by NASA instruments since 1995 on low earth orbits (LEO)
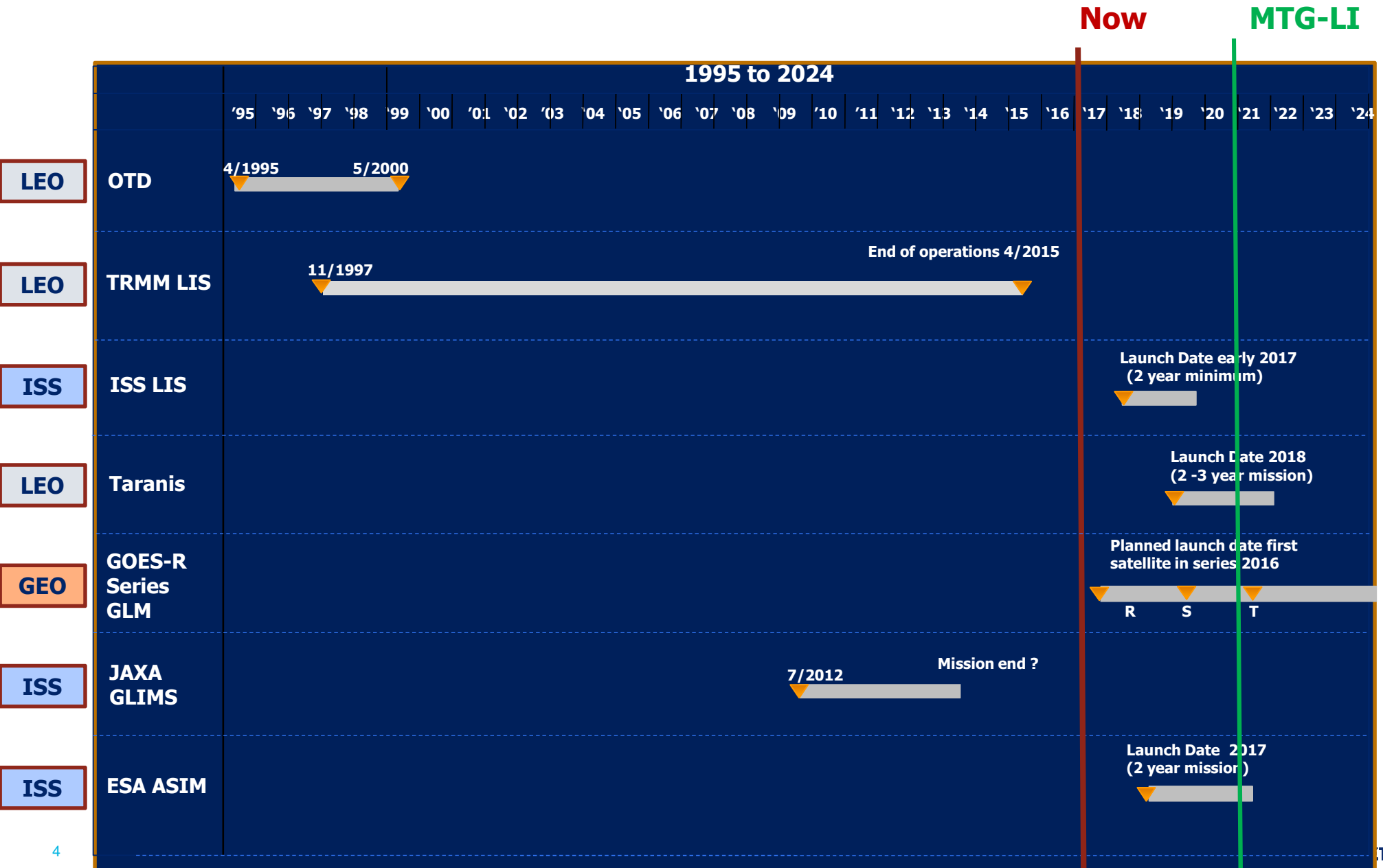
**OTD (1995-2000)**

**LIS (1997-2015)**

Annual flash density
fl/(yr km$^2$)

OTD+LIS (1995–2006)
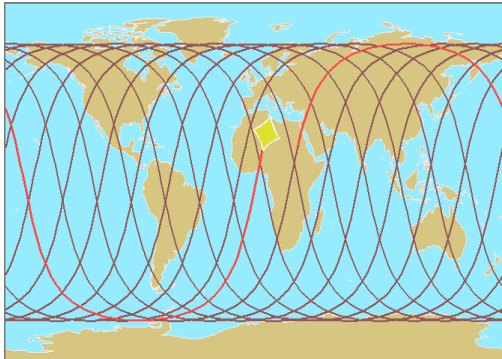
**Results from LIS/OTD:**
**Global lightning distribution, annual flash density**

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# Lightning related space missions
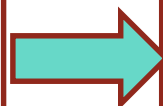
# The MTG Lightning Imager (LI)

**Measures total Lightning:**
**Cloud-to-Cloud Lightning (CC) and Cloud-to-Ground Lightning (CG)**

**Benefit of GEO observation:**

- **Homogeneous and continuous observations**
- **Strength and location of flashes**
- **Timeliness of 30 seconds accumulated product**

**Main objectives:**

- **Intensity and movement of an active convective areas**
- **Monitoring of storm lifecycle – extrapolation in time**
- **Lightning climatology & Chemistry (NOx production)**



Annual flash density
fl/(yr·km²)

70
50
30
20
15
10
6
4
2
1
0.6
0.3
0.2
0.1
0.01
0

OTD+LIS (1995–2006)
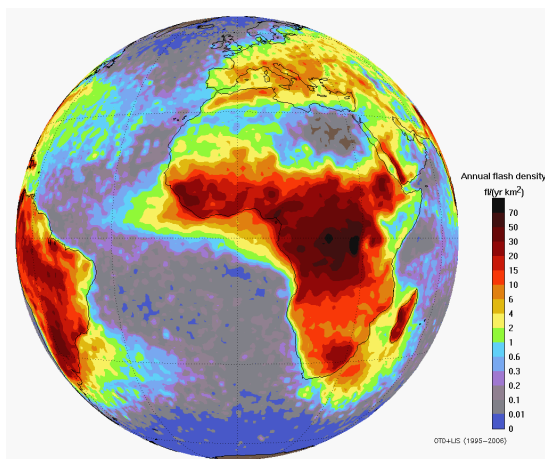
**LIS/OTD flash density in the MTG LI field of view**

**Location accuracy 5-10 km:**

**GEO observation of lightning is** <u>**complementary**</u> **to ground-based networks**
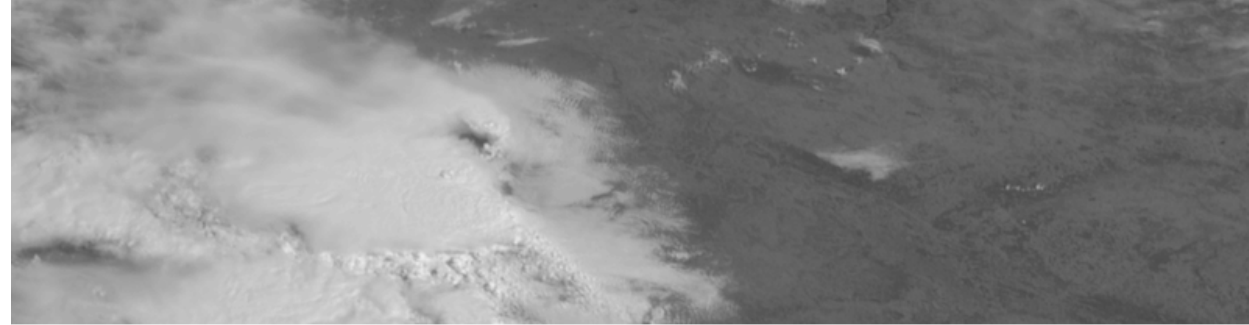
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# Linking also to other enhanced capability of MTG

- 2.5 min rapid scanning provided by the MTG Flexible Combined Imager (MTG-FCI)
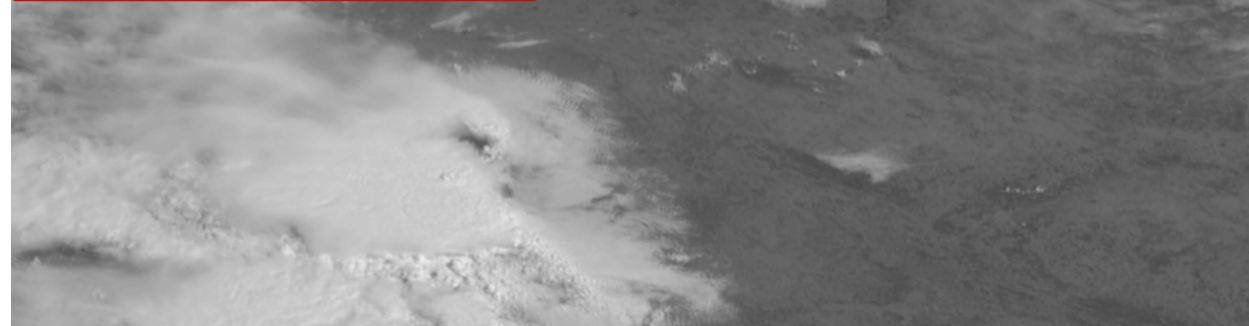
Allows a combination of:

- 0.5 min update of MTG-LI accumulated lightning
- 2.5 min update of MTG-FCI rapid scan imagery
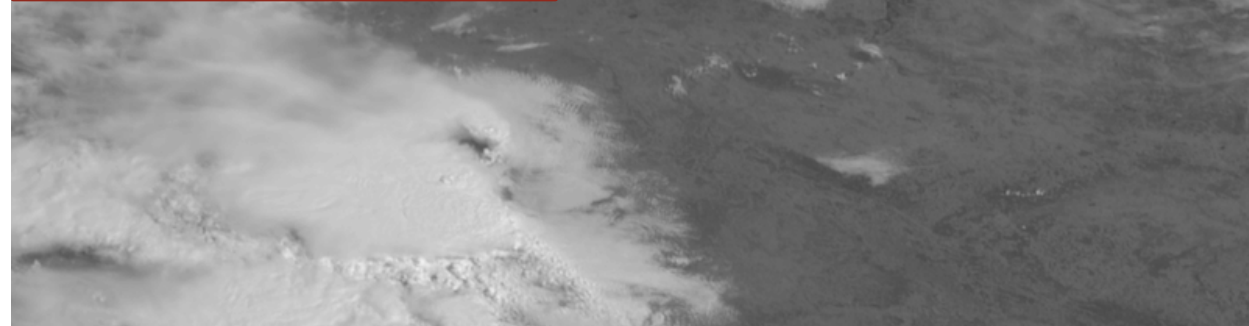
**2.5 min – MTG FCI RSS**

20 JUN 13 09:02:14
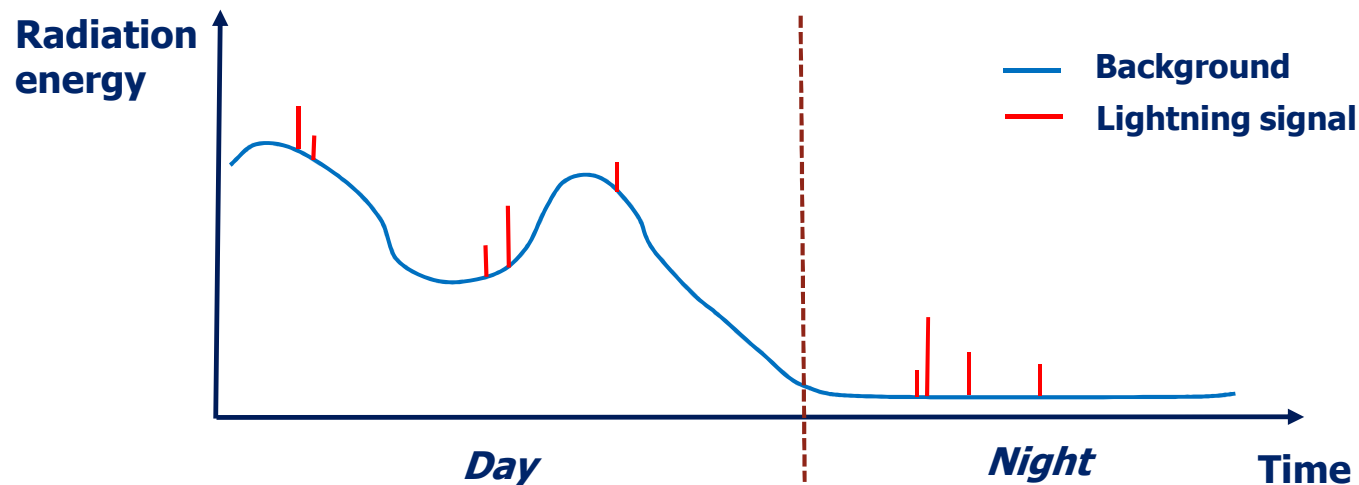
**5 min – MSG SEVIRI RSS**

20 JUN 13 09:02:14

**15 min – MSG SEVIRI FDS**

20 JUN 13 09:02:14

# Detection of a Lightning Optical Signal

- Lightning observations with a background signal changing with time:



- Lightning on top of a bright background is not recognised by its bright radiance, but by its **transient short pulse character (~777 nm)**
- Variable adapting **threshold has to be used for each pixel** taking into account the change in the background radiance

# Spatial Pattern of Lightning from Space

- **Characteristics:**
  - According to studies mean area of lightning pulses corresponds well to a 10 km x 10 km footprint
  - Size scales to cloud thickness above source

**Optical pattern of lightning on cloud surface (observed from space shuttle)**
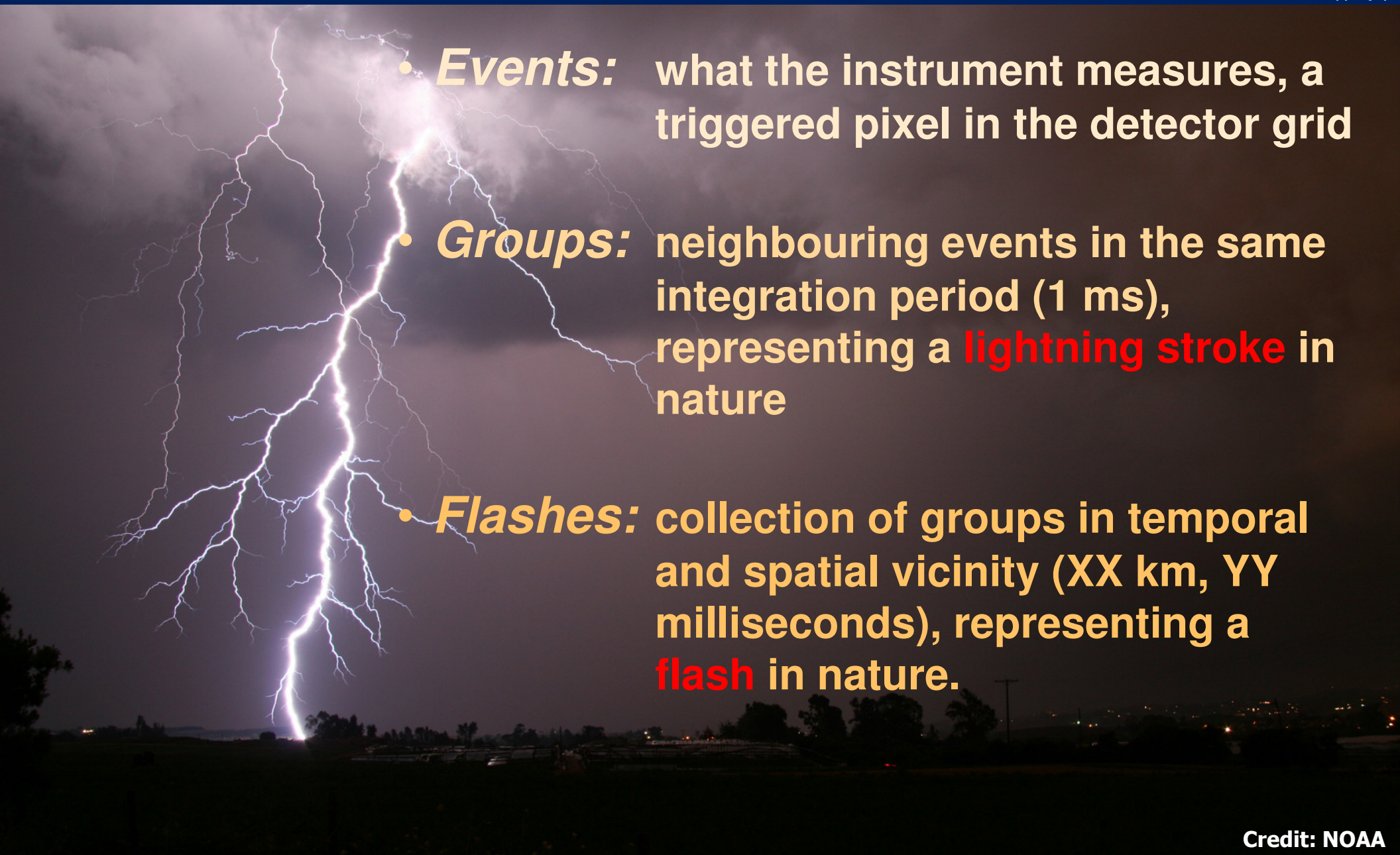
10 km
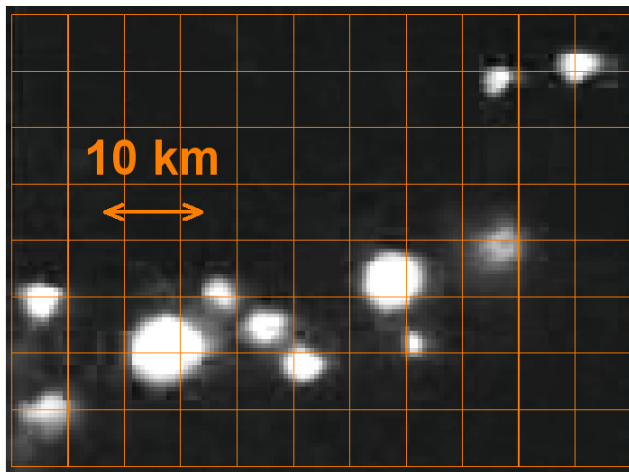
1. Background scene tracking and removal
2. Thresholding
3. Event detection

**Possible schema of detected lightning pulses**

MTG LI Events

# Product terminology
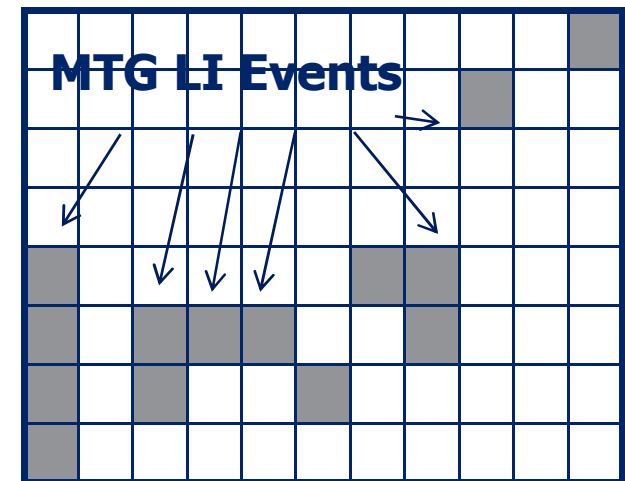
- ***Events:*** what the instrument measures, a triggered pixel in the detector grid

- *Groups:* neighbouring events in the same integration period (1 ms), representing a **lightning stroke** in nature

- *Flashes:* collection of groups in temporal and spatial vicinity (XX km, YY milliseconds), representing a **flash** in nature.

Credit: NOAA

# Groups and Flashes

Example/Conceptual representation of a L2 processing sequence:
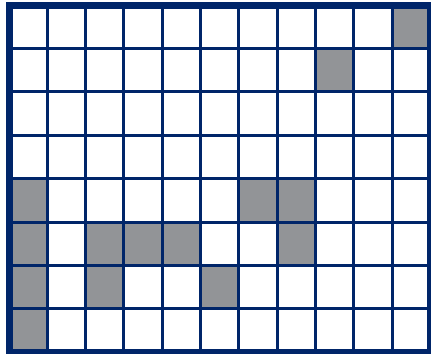
LI grid of 4.5 km at SSP          LI grid of 4.5 km at SSP          LI grid of 4.5 km at SSP

SSP = Sub-Satellite Point

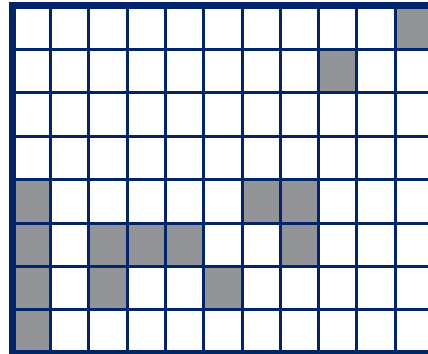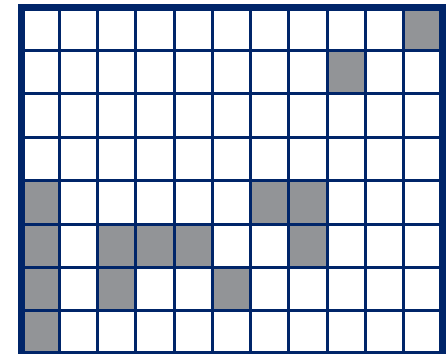EUMETSAT

# Groups and Flashes

Example/Conceptual representation of a L2 processing sequence:

LI grid of 4.5 km at SSP                LI grid of 4.5 km at SSP                LI grid of 4.5 km at SSP

"Events"

SSP = Sub-Satellite Point

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# Groups and Flashes

**Example/Conceptual representation of a L2 processing sequence:**

**LI grid of 4.5 km at SSP**     **LI grid of 4.5 km at SSP**     **LI grid of 4.5 km at SSP**
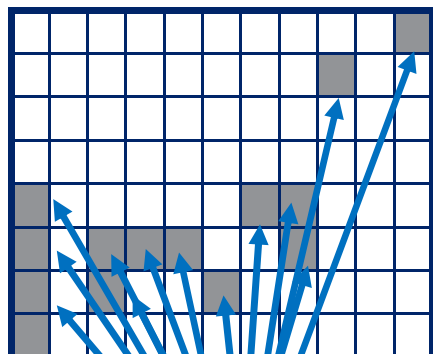


**"Events"** ⟹ **"Groups"** ⟹

**SSP = Sub-Satellite Point**
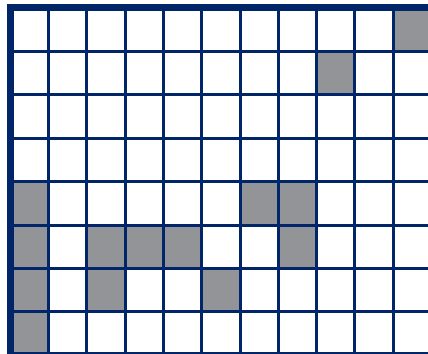
# Groups and Flashes



Example/Conceptual representation of a L2 processing sequence:

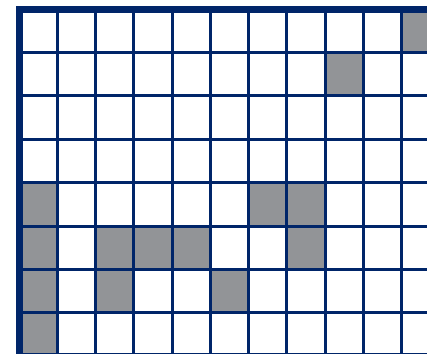LI grid of 4.5 km at SSP          LI grid of 4.5 km at SSP          LI grid of 4.5 km at SSP
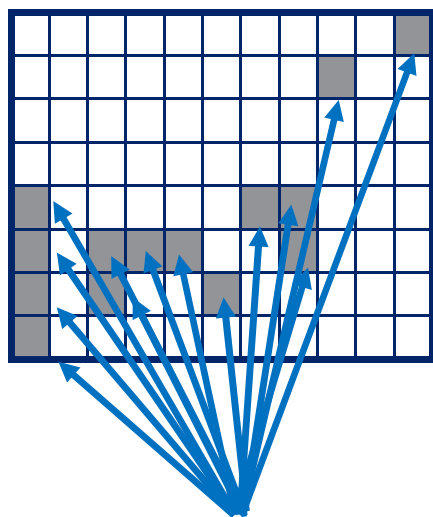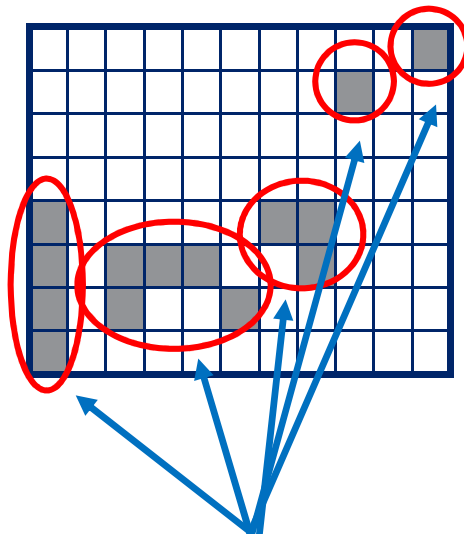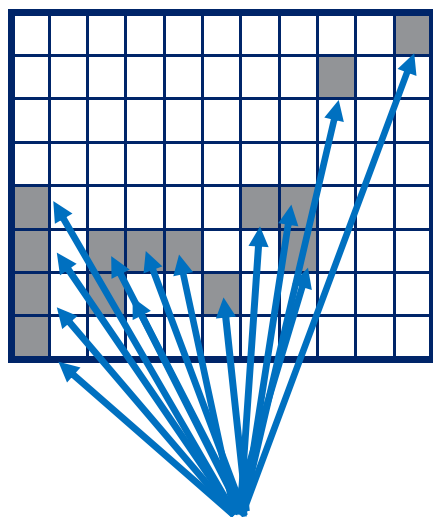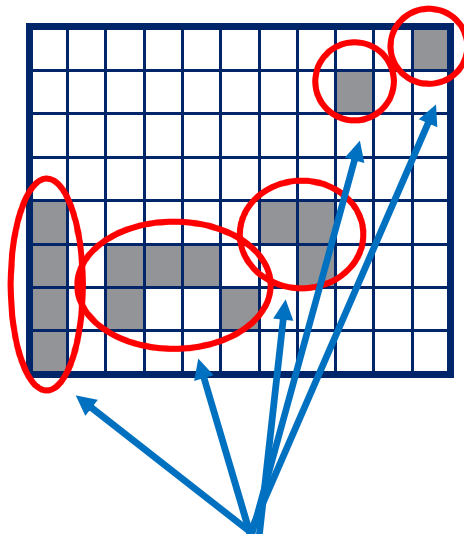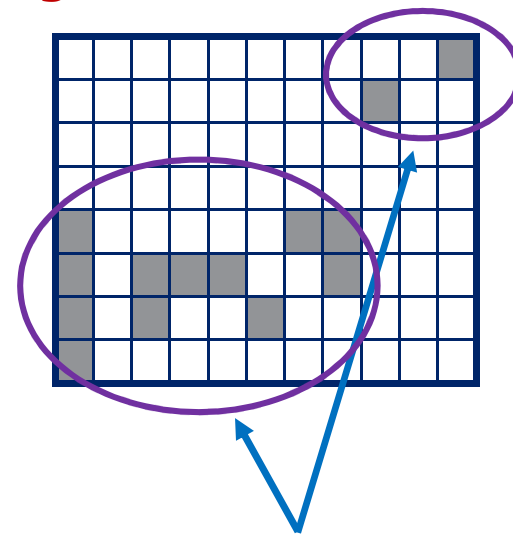
"Events"  →  "Groups" (strokes)  →  "Flashes"

SSP = Sub-Satellite Point

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# Lightning Imager (LI) – User Products

- ## LI Initial Processing => point data
  - ### Groups (~strokes) & Flashes with geographical coordinates

- ## Accumulated products => gridded data
  - ### Product density shown in the fixed MTG-FCI (\*) imager grid (same grid as for the FCI IR channels in the 2 km FDHSI resolution)
  - ### Accumulation time 30 sec

  (\*) FCI = Flexible Combined Imager on MTG

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# Benefits of accumulated Products

- **Allows users to get in** one look information on the flashes/groups/strokes

- **The** extent of lightning activity **in a time period**

- **Especially** useful for real-time users (forecasters) **using lightning information together with other data sources**

- **The initial** accumulated product can be stacked **for users' personal preference (from 30 seconds upwards)**

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# Trailer: MTG-LI coming soon (in space terms...)

Example **test data** product: "Accumulated flash area" integrated over 15 minutes and updated every 30 seconds



201306200000 LINET — Accumulated Flash Area over 15 min

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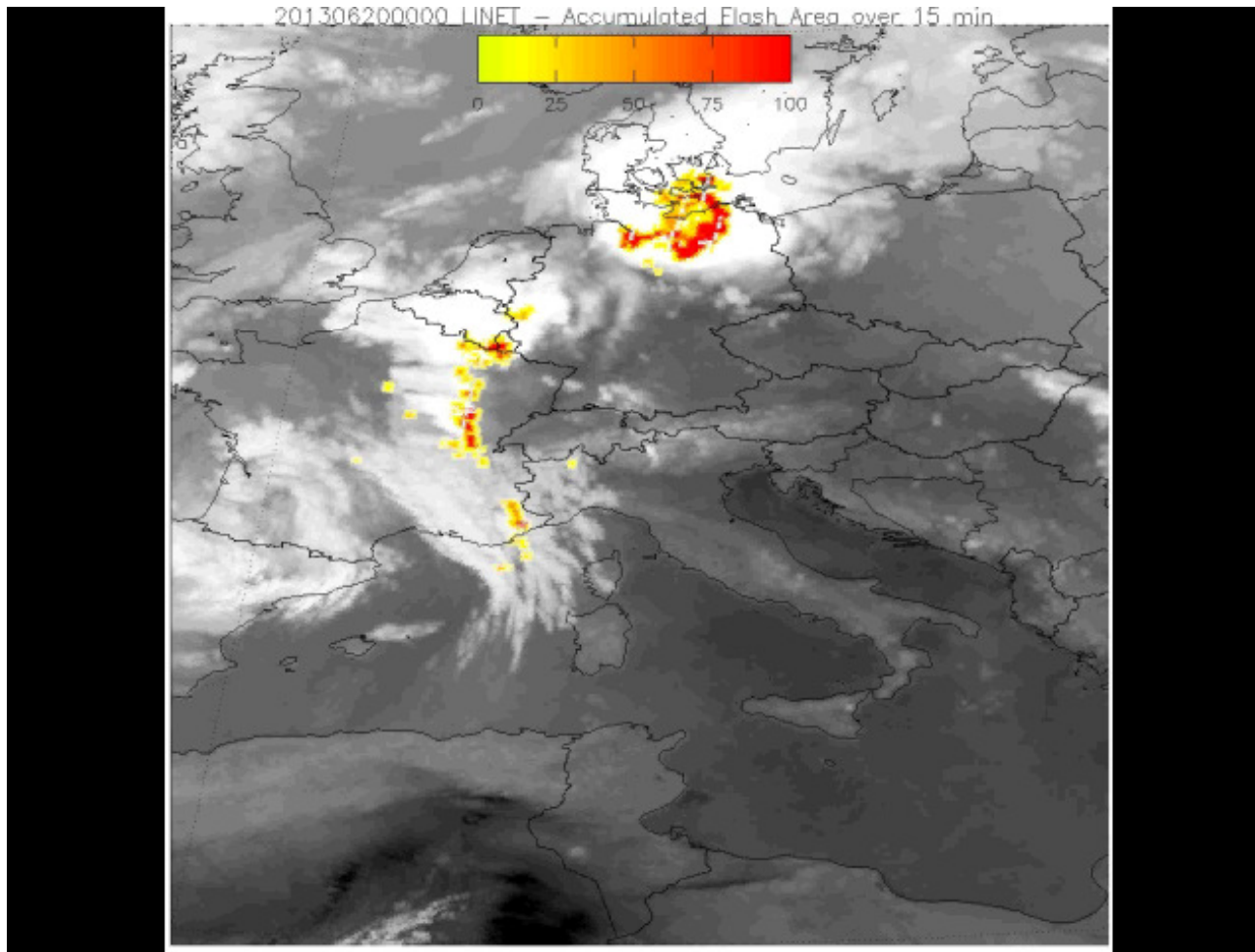
# How to get MTG LI test data? (1)

- What we do have:
    - TRMM LIS L2 statistics based on long-term observations
    - This is: Flashes/group/events long-term climatology
    - Ground based lightning detection network data; GLD360, ATDnet, LINET, etc.

- What we do **NOT** have:
    - **Optical pulse data** statistics!

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# How to get MTG LI test data? (2)

- Using data modified from ground-based Lightning Location System (LLS):

  1. Comparing LLS data with TRMM-LIS data in the case studies

  2. Using statistical model based on LLS observations for transforming the LLS stroke data into optical pulses

  3. Optical pulse statistics is used in creating proxy data for the reference processor, i.e. data as input for the instrument simulator

- **Challenge:** LLS observes RF signals when LI observes optical pulses of lightning
  - RF observations are sensitive to different parts of the lightning process than optical pulses

# How to get MTG LI test data? (3)

**Statistics of LIS L2 data:**
- 8 years of observations
- Flash/Groups/Events climatology

→

**Average flash rate statistics:**
- Global ±44 fl/s
- LI FOV ~26 fl/s

→

**Applied to ground-based data like GLD360, LINET or ATDnet**

→

**Simulated optical pulse data set**

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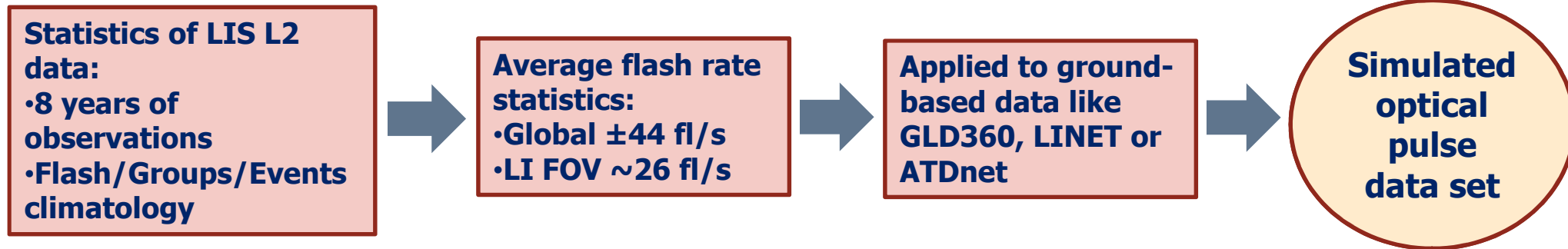
# MTG LI Test Data Example based on GLD360

- Currently we are working with Vaisala GLD360 ground-based data set for test data:
  - Covers the full disk
  - Is well validated
  - Is also partially sensitive to cloud-to-cloud lightning
- Added strokes around the original GLD360 stroke:



Red     original central GLD stroke
Blue     added strokes around central stroke
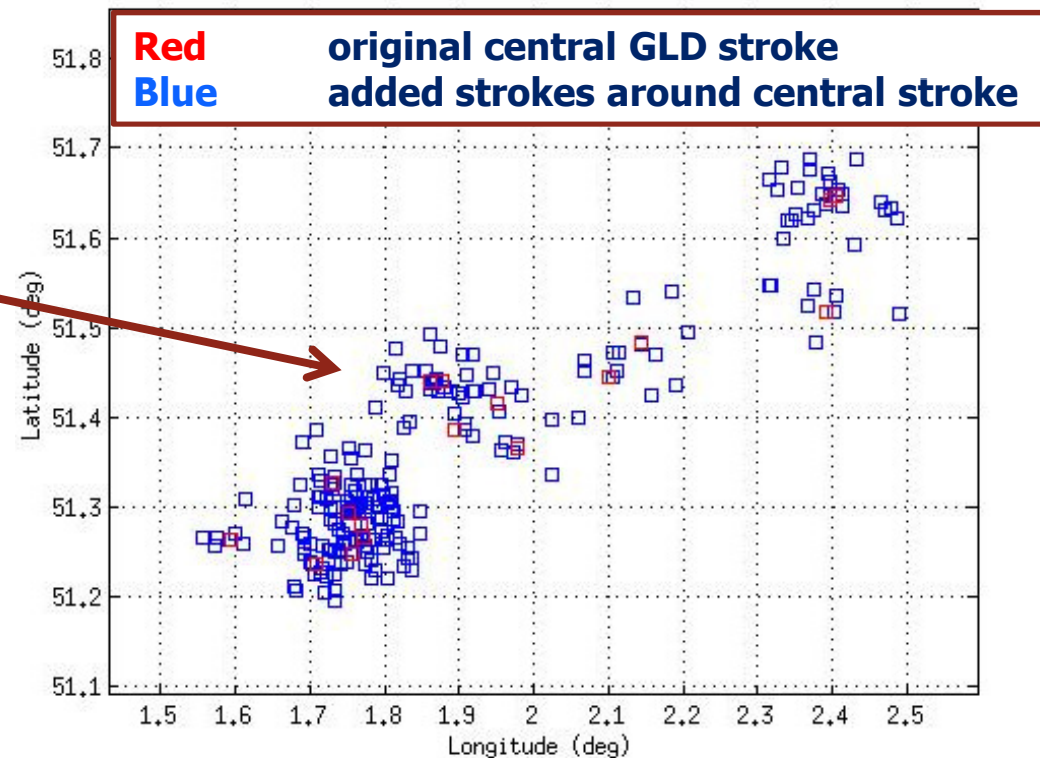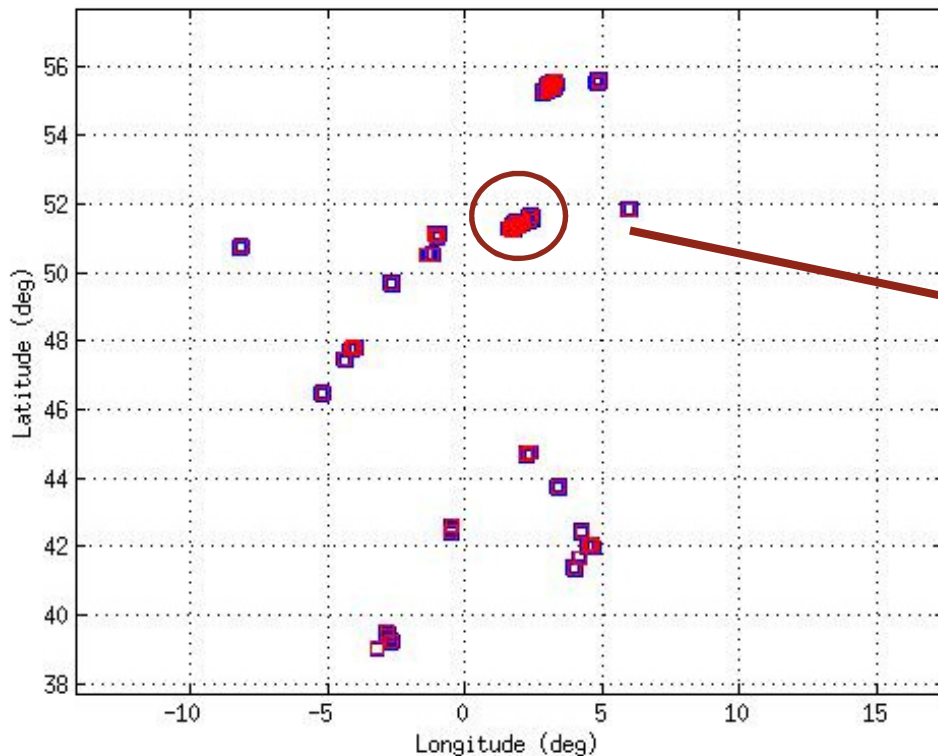
# Validation activities (Cal/Val)

- Cal/Val preparation is a critical part of the LI project
  - We must be ready for the validation of the LI products before the MTG launch 2020

- Ground based lightning detection systems play a key role in Cal/Val together with other space born systems like ISS-LIS, ASIM or TARANIS

- First feasibility studies for the Cal/Val data sets ongoing

- Cal/Val activities will be continued entire lifetime (~20 yrs) of MTG!

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# Summary

- The Lightning Imager is a new mission on Meteosat Third Generation, with no heritage in Europe (first GEO mission will be on GOES-R in Nov 2016)
  - Nearly full disk coverage (Europe) with 4 detectors
  - Homogeneous and continuous observations of lightning flashes with a timeliness of 30 seconds
  - To be launched in 2020

- User products consist of
  - Initial processing data (groups and flashes)
  - Accumulated product data

- For test data set a model was developed for transforming the LLS stroke data into optical emission ("pulses"), which mimics the LIS statistics

- LI Cal/Val activities will heavily relay on ground based LLS for entire MTG lifetime

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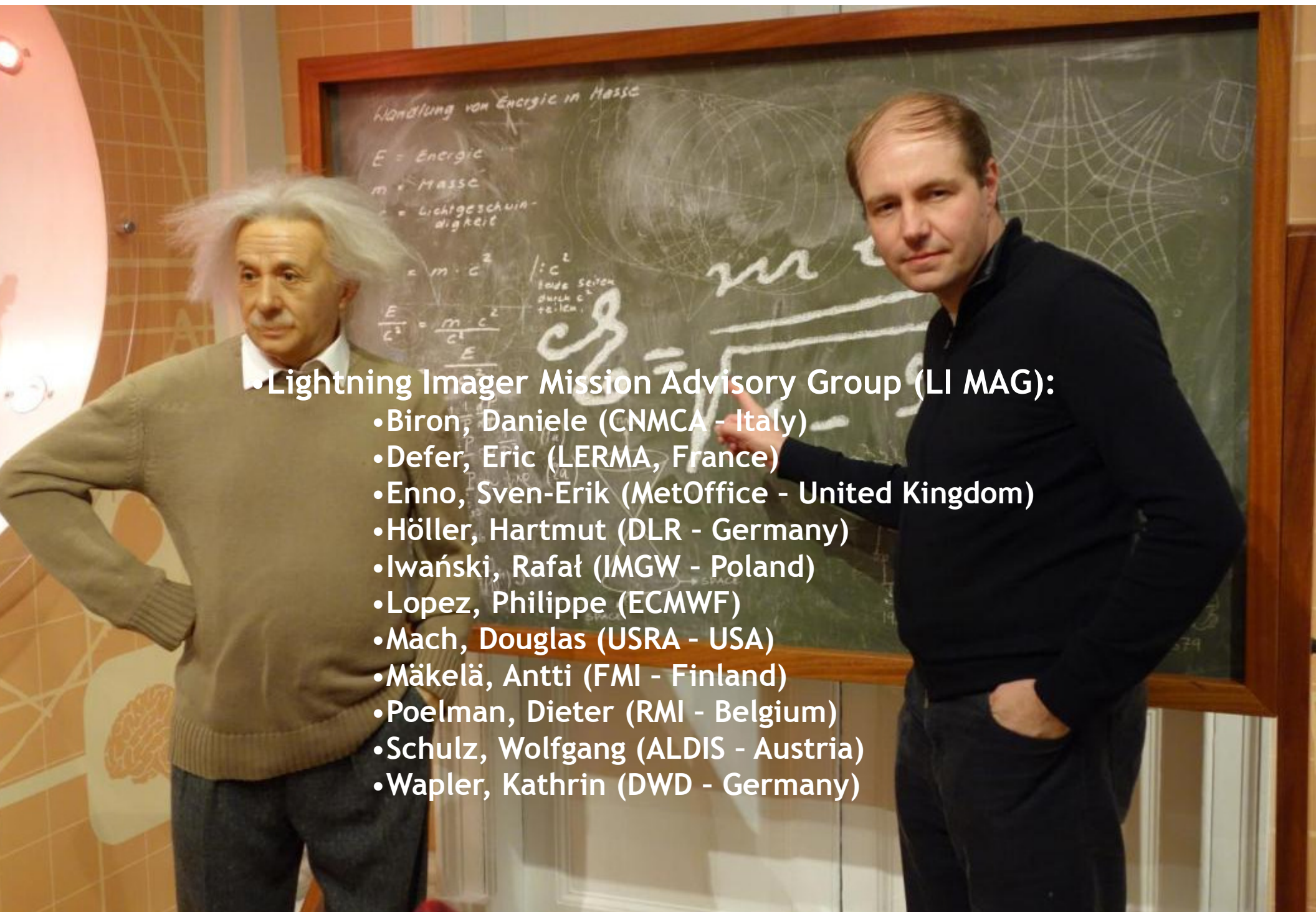
- **Lightning Imager Mission Advisory Group (LI MAG):**
  - Biron, Daniele (CNMCA – Italy)
  - Defer, Eric (LERMA, France)
  - Enno, Sven-Erik (MetOffice – United Kingdom)
  - Höller, Hartmut (DLR – Germany)
  - Iwański, Rafał (IMGW – Poland)
  - Lopez, Philippe (ECMWF)
  - Mach, Douglas (USRA – USA)
  - Mäkelä, Antti (FMI – Finland)
  - Poelman, Dieter (RMI – Belgium)
  - Schulz, Wolfgang (ALDIS – Austria)
  - Wapler, Kathrin (DWD – Germany)