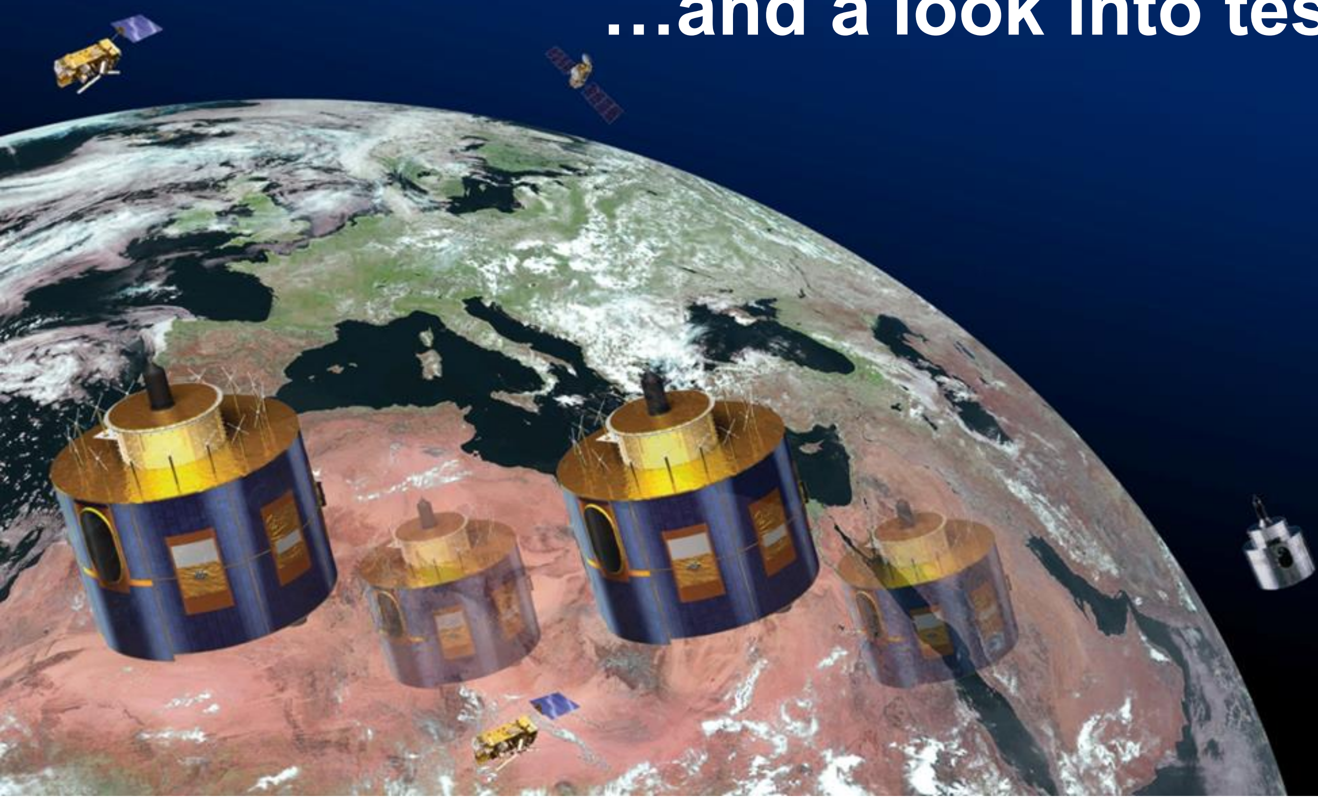
MTG Lightning Imager status update …and a look into test data development

Jochen Grandell



Topics

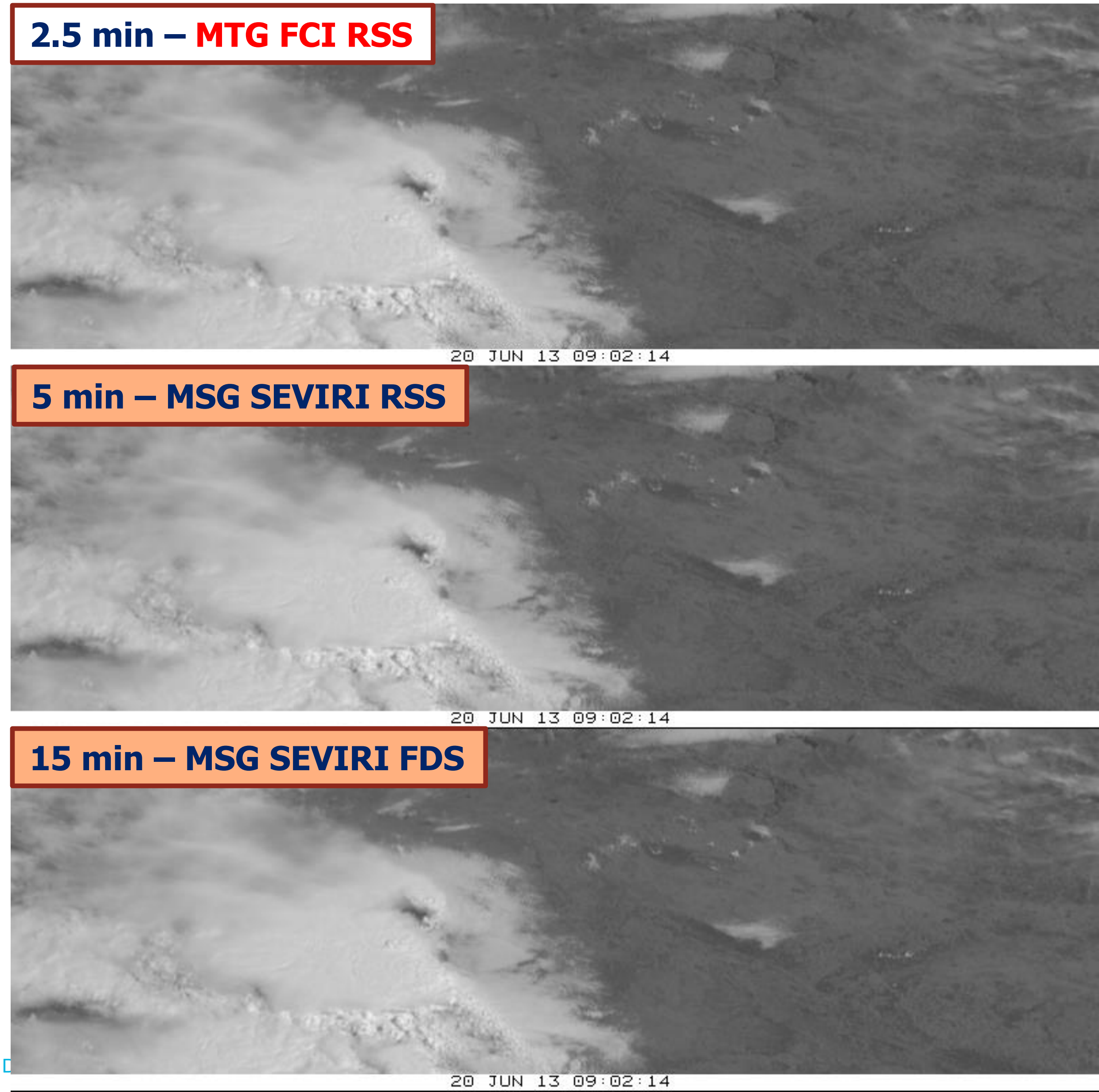
- MTG Lightning Imager (MTG-LI)
  - Quick recap of basic concepts
  - Products at L2
- MTG-LI test/proxy data development

Linking also to other enhanced capability of MTG

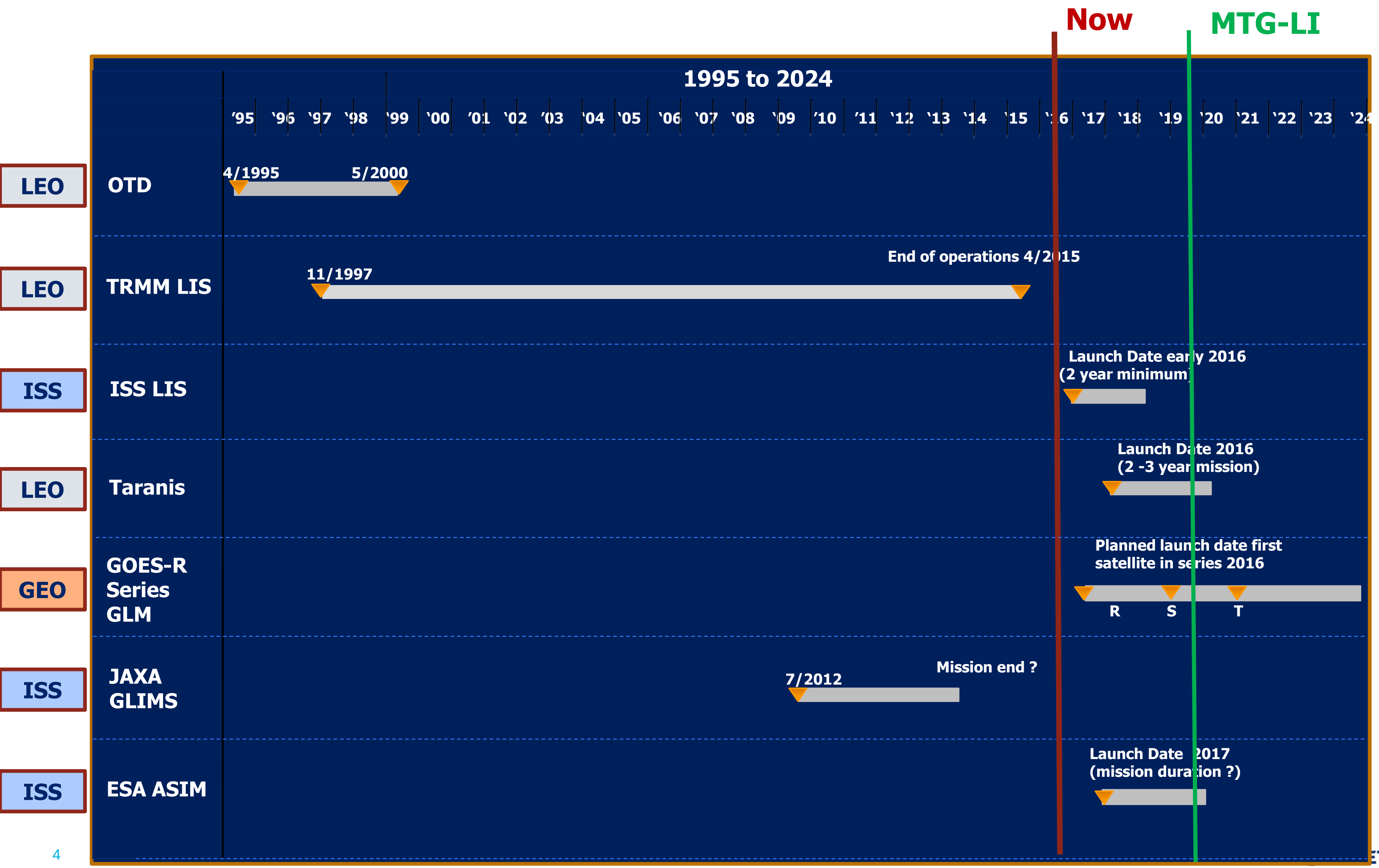
- 2.5 min rapid scanning provided by the MTG Flexible Combined imager (MTG-FCI)

Allows a combination of:

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



Other lightning related space missions



Modified from Blakeslee et al.

Joint MTG-LI and GOES-R GLM workshop

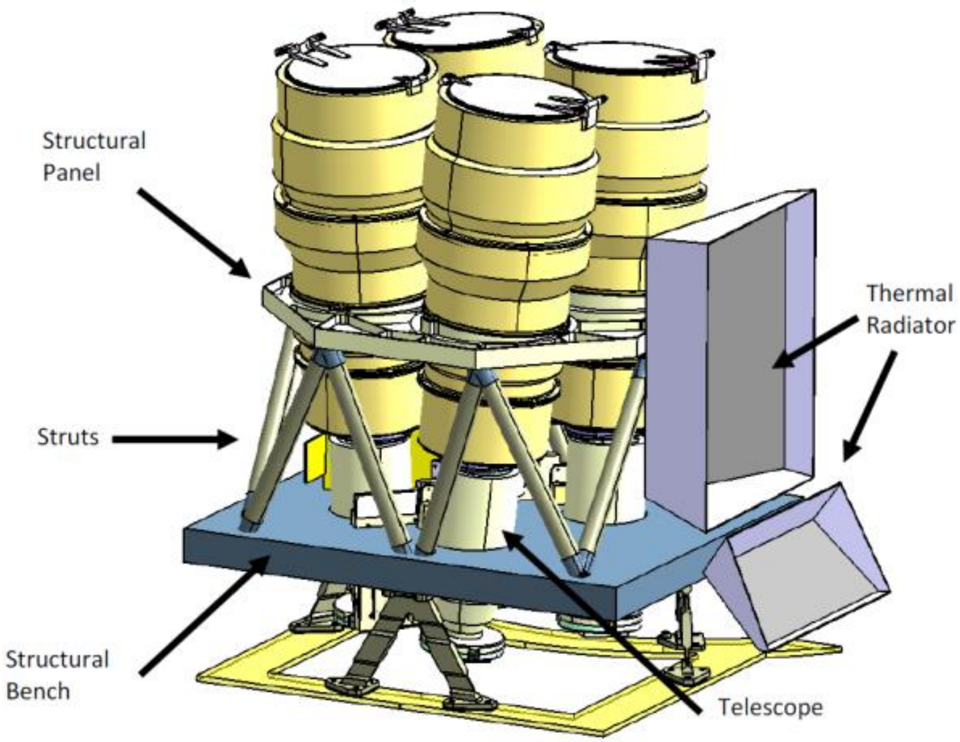
- **Organised as a joint effort by EUMETSAT and NOAA, and hosted by the Italian Met Service (CNMCA)**
- **Co-chaired by J. Grandell (EUMETSAT) and S. Goodman (NOAA).**

- The main objectives of the meeting was to:
  - **Facilitate a discussion between the LI, GLM, and other lightning mission teams on all levels**
  - **Including also ground-based LLS data providers in these discussions (e.g. on Cal/Val)**

Lightning Imager (LI) – Main Characteristics

- **LI main characteristics:**
  - **Measurements at 777.4 nm**
  - **Coverage close to visible disc**
  - **Observing total lightning (CG + CC/IC), with no separation**
  - **Continuous measurements of (lightning) triggered events**
  - **Ground sample distance at sub-satellite point ~4.5 km**
  - **Integration time per frame 1 ms (baseline)**
  - **Background subtraction and event detection in on-board electronics**

Lightning Imager (LI) design

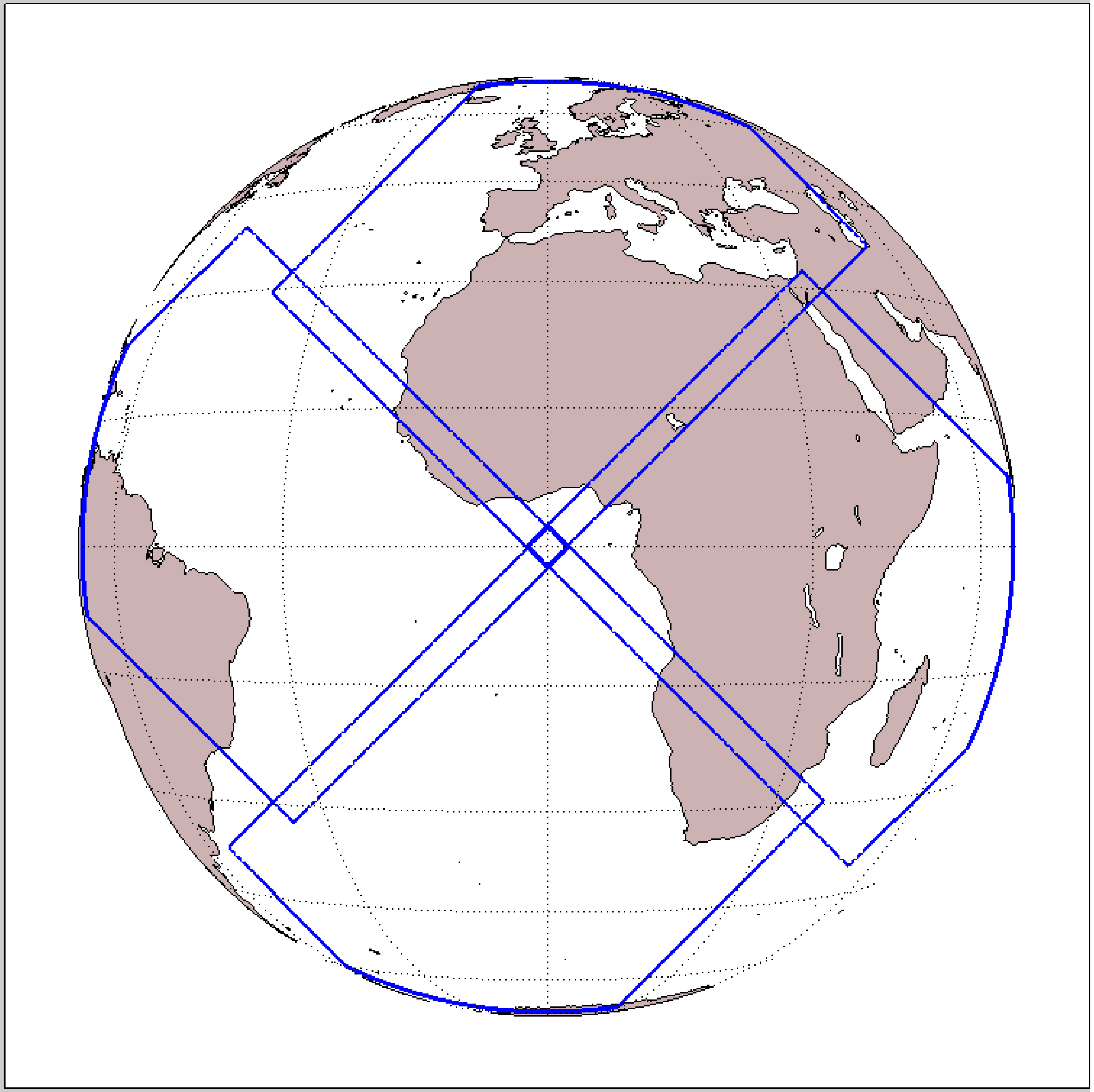


CMOS Back-thinned backside illuminated detectors with integrated ADCs

The baseline for the LI is a 4-camera solution

1170 x 1000 pixels per camera

LI coverage – full disk view

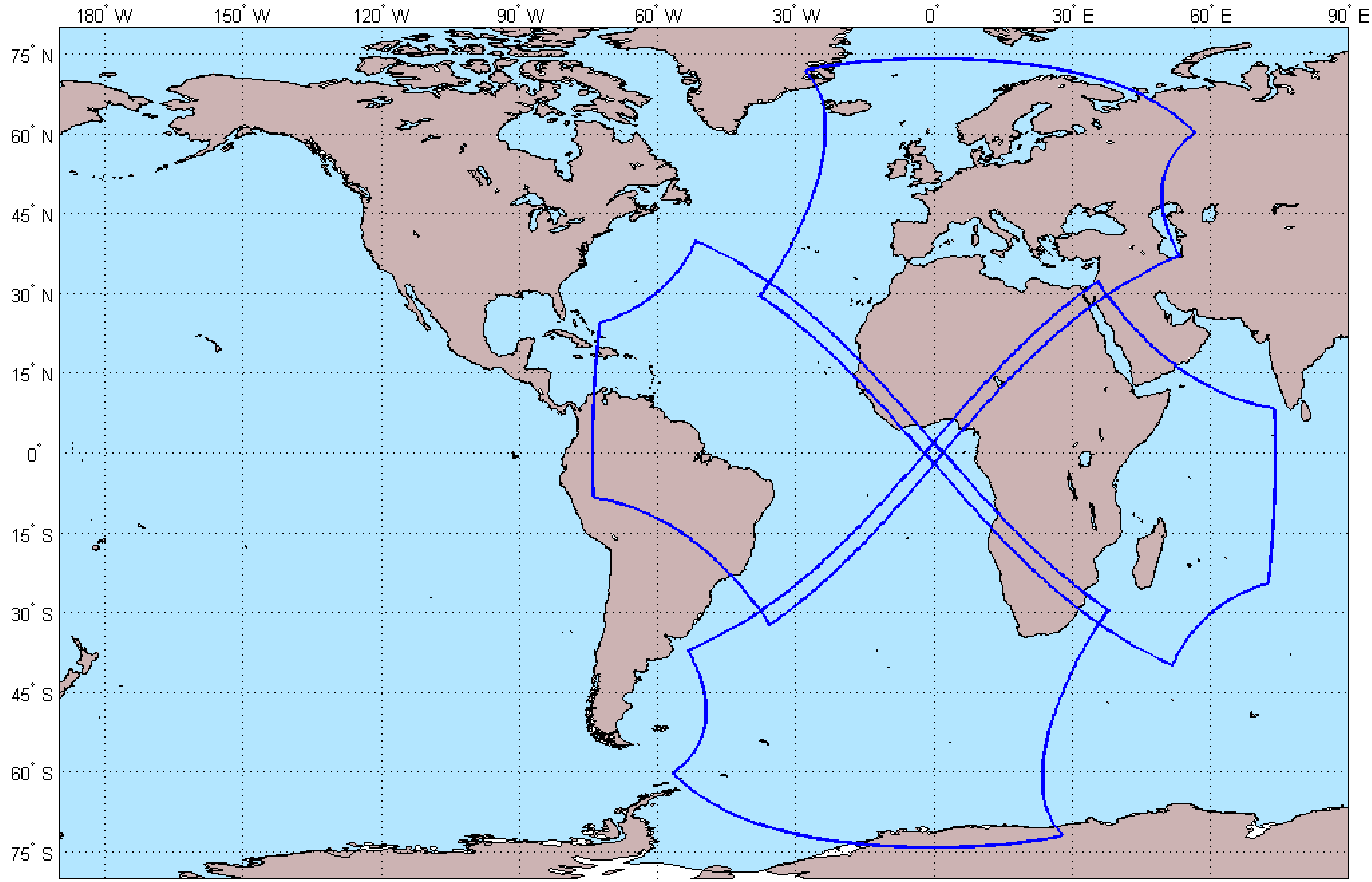


Four identical detectors with small overlaps

End-users (Level 2) will not see the "detector structure"

However, data contains information on from which detector(s) the observation is origination from

LI coverage – another projection



Instrument procurement status (1)

- **Preliminary Design Review (PDR) closed**
- **Instrument hardware is being built**
- **Challenging technology:**
  - **Large diameter (12 cm) spectral filters**
  - **CMOS detectors**
  - **On-board computer for data reduction/processing**
- **Calibration approach/methods/equipment for on ground and in orbit under development**
- **On-board data processing algorithms for distinguishing between real lightning and false triggered events under development. This is to avoid system saturation from events**
  - **Significant on-ground processing for false event filtering is nevertheless needed**

Instrument procurement status (2)

- **0-1b data processing software under development for the following level-1b data products:**
  - **Triggered Events: false events and lightning events.**
  - **Background radiance images.**
  - **Calibration product.**

- **Performance challenge:**
  - **Obtain an as high as possible lightning detection efficiency in combination with an as low as possible false event detection probability**

- **L2 processing facility developed as a separate contract:**
  - **Clustering of events to groups and flashes, accumulated products**
  - **Filtering of false events (also during the group/flash clustering process)**

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

Lightning Imager (LI) – User Products

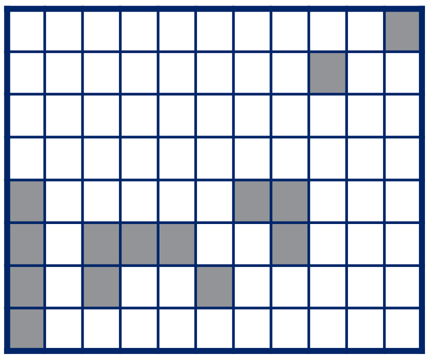
- **LI Initial Processing => point data**
  - **Groups (~strokes) & Flashes with geographical coordinates**
- **Accumulated products => gridded data**
  - **Product density shown in the fixed MTG-FCI (*) imager grid (same grid as for the FCI IR channels in the 2 km FDHSI resolution)**

(*) FCI = Flexible Combined Imager on MTG

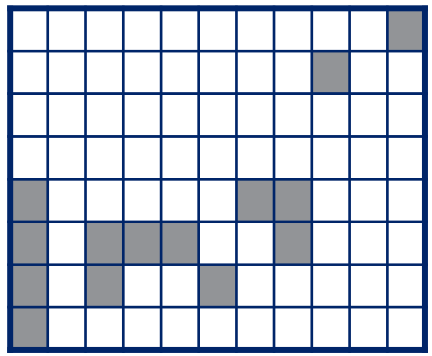
Groups and Flashes

Example/Conceptual representation of a L2 processing sequence:

LI grid of 4.5 km at SSP



LI grid of 4.5 km at SSP



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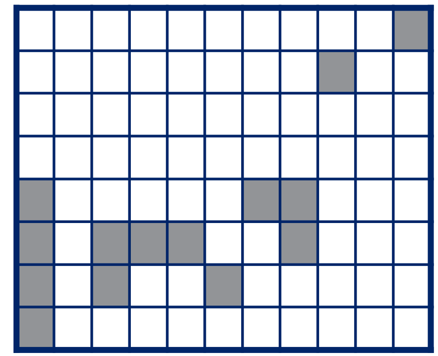

SSP = Sub-Satellite Point

Groups and Flashes

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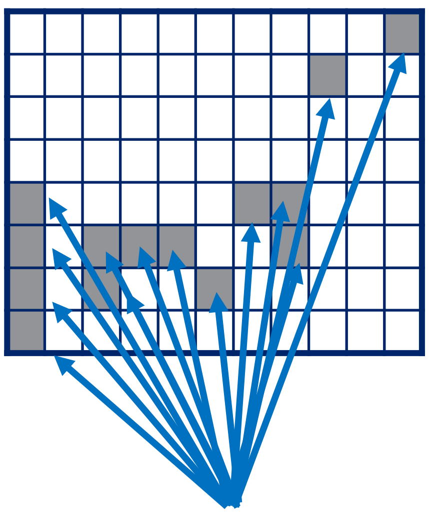

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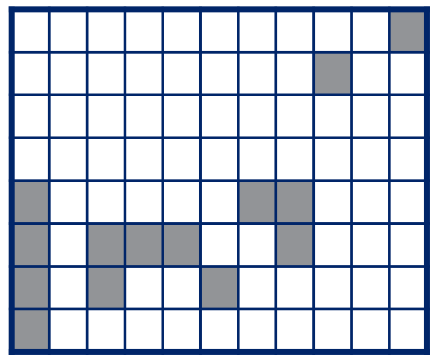
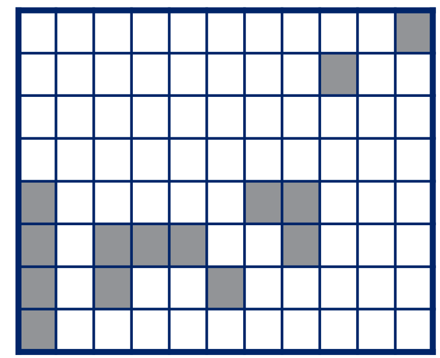


LI grid of 4.5 km at SSP



"Events"

SSP = Sub-Satellite Point

Groups and Flashes

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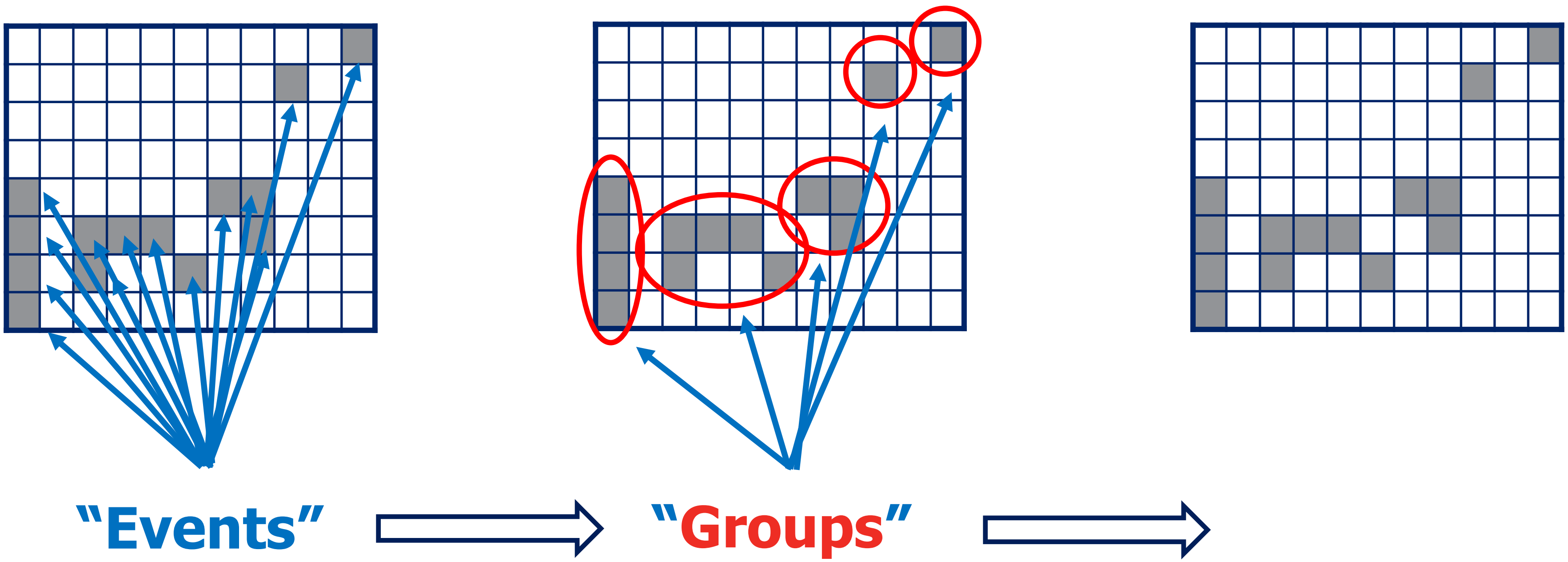

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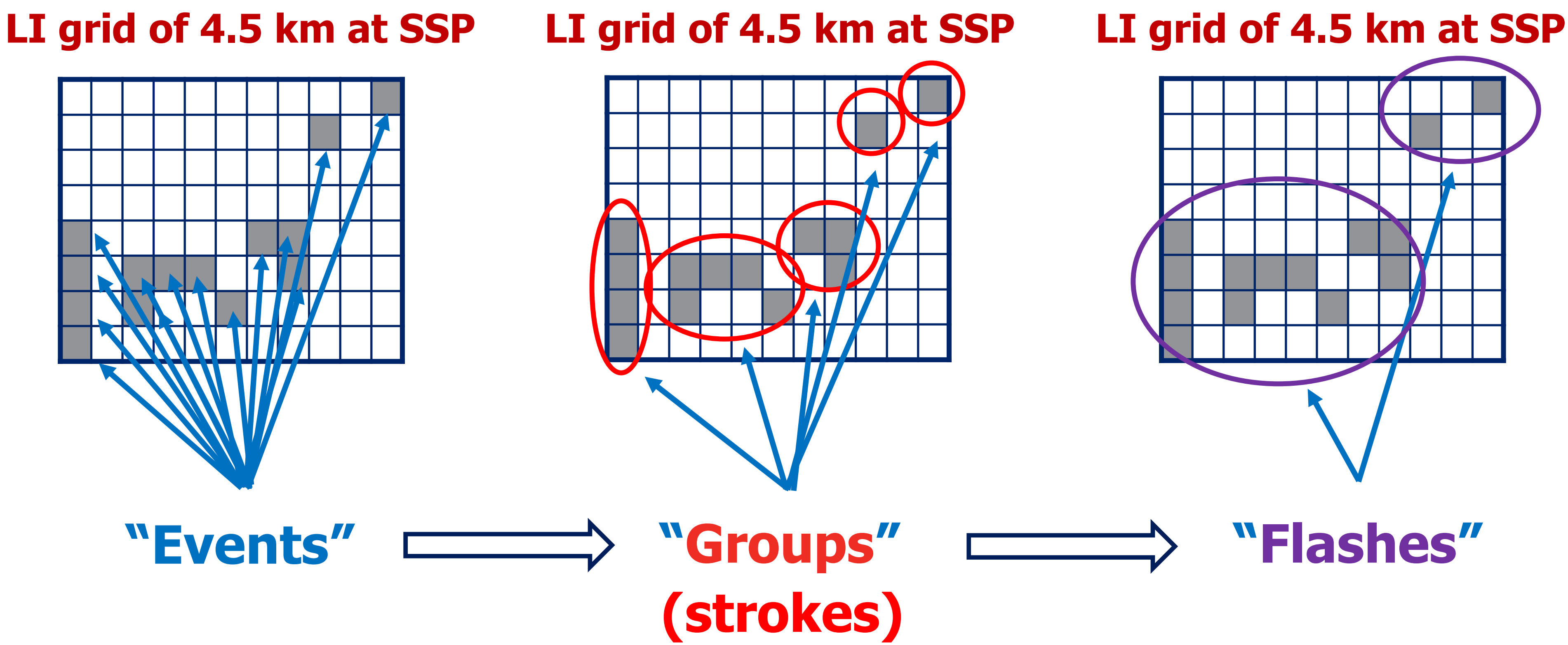
Groups and Flashes

Example/Conceptual representation of a L2 processing sequence:



SSP = Sub-Satellite Point

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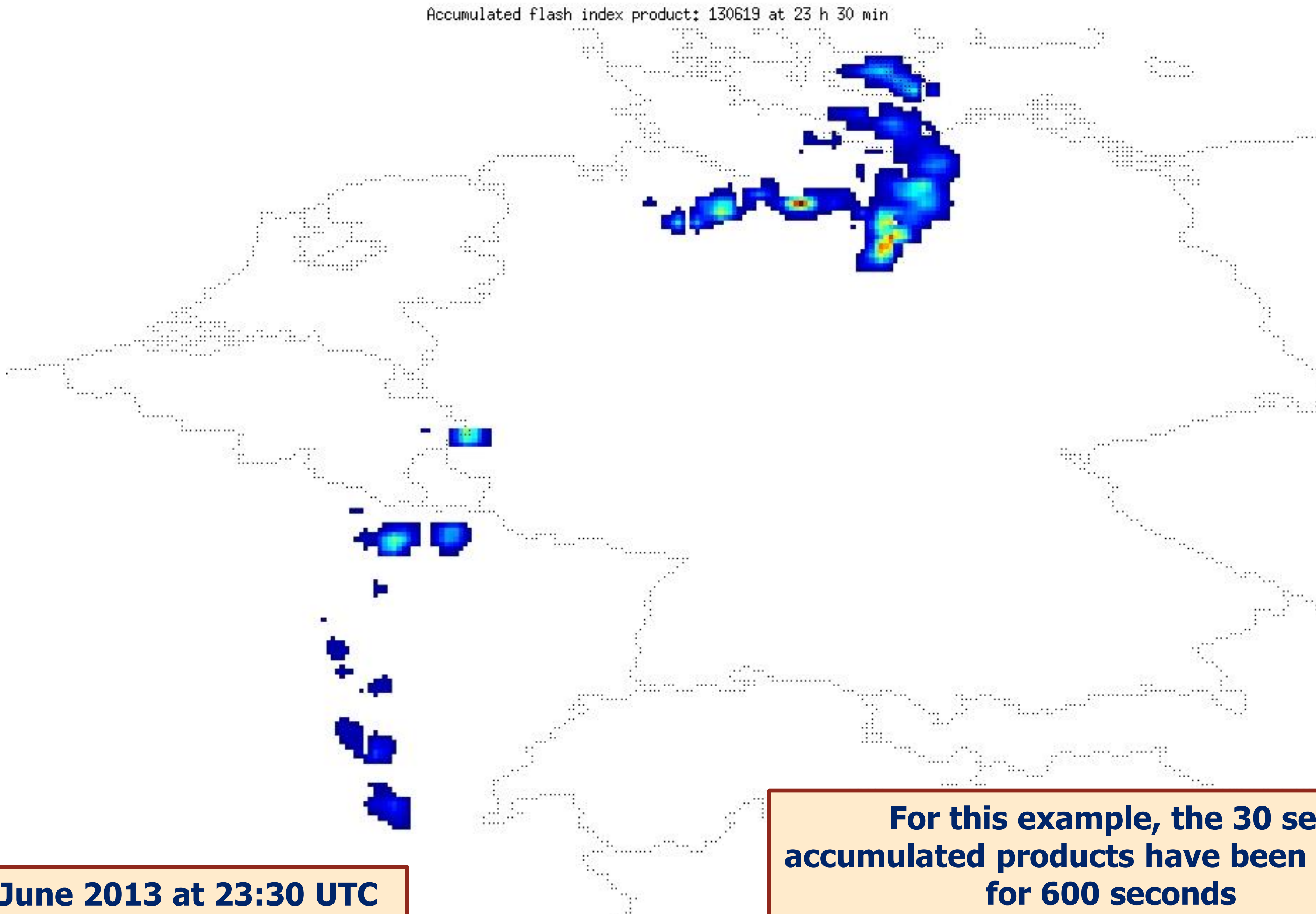
Introduction to Accumulated Products

- The **accumulated products** allow users to get in one look **information on the flashes/groups/strokes** and the extent of lightning activity in a given time period

- This is especially **useful for real-time users (forecasters)** who use the lightning as added information to other data sources available to them

- The periodicity of the **accumulated product** is such that it **can be stacked** for users’ personal preference (from 30 seconds upwards)

Example accumulated product – test data example



19 June 2013 at 23:30 UTC

For this example, the 30 sec accumulated products have been stacked for 600 seconds

Summary – part I

- 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 2016)
    - **(almost) Full disk coverage with 4 different detectors**
    - **Homogeneous and continuous observations of lightning flashes with a timeliness of 30 seconds**
    - **To be launched in 2019**

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

Test data development

MTG LI Test Data – various options available

1. Data modified from ground-based LLS data:

- Use of ground-based Lightning Location System (LLS) data as input not straightforward, as they are based on RF observations of lightning and are sensitive to different parts of the lightning process than optical pulses
- By **comparing LLS data in case studies with TRMM-LIS data, a model** for transforming the LLS stroke data into optical emission (“pulses”) **has been developed** that can be adapted to different LLS observations

2. Simulated data:

- Simulated data based on LIS statistical properties

3. “Direct” use of data:

- **GLM** – from L0 to L2 data, with possible re-gridding etc. (**from 2016 onwards**)

Issues regarding option #1 (use of LLS data) (1)

- **What we do have:**
  - LIS L2 statistics based on long-term observations
  - This is: Flashes/group/events, long-term climatology

- **What we do NOT have:**
  - **Optical Pulse** statistics!

- **What we want to get:**
  - Pulse statistics to be used in creating proxy data for the reference processor, i.e. **data as input for the instrument simulator => this is the “right” way of using test data**

Issues regarding option #1 (use of LLS data) (2)

- **How to get there:**
  - From LIS (and other climatology) we get average statistics about flash rates (global ±44 fl/s, LI FOV ~26 fl/s)
  - Assumptions like groups ~ strokes ~ pulses are in the right direction, but contain many inaccuracies
  - If starting from ground-based data we can create a "starter set" of optical pulse data
  - This "starter set" would need to be cross-referenced with LIS statistics after L2 processing (optimally by running the full reference processor)

Issues regarding option #1 (use of LLS data) (3)

- Initial work done with LINET data, which has been successfully used over Europe

- Currently working with Vaisala GLD360 data set as a new starter set for test data:
  - **Covers the full disk**
  - **Is well validated**
  - **Is also partially sensitive to cloud-to-cloud lightning**

Feedback loop

Optical pulse data set: V1…V*n*

Full-chain reference processor

(With "LIS-like" settings)

L2 event, group & flash statistics

Do these L2 statistics compare well with LIS statistics?

No

Create a new Optical pulse data set V2…V*n*

Yes

Continue with the pulse data set for further analysis e.g. with different reference processor settings

Roadmap from GLD360 to pulses – assumptions

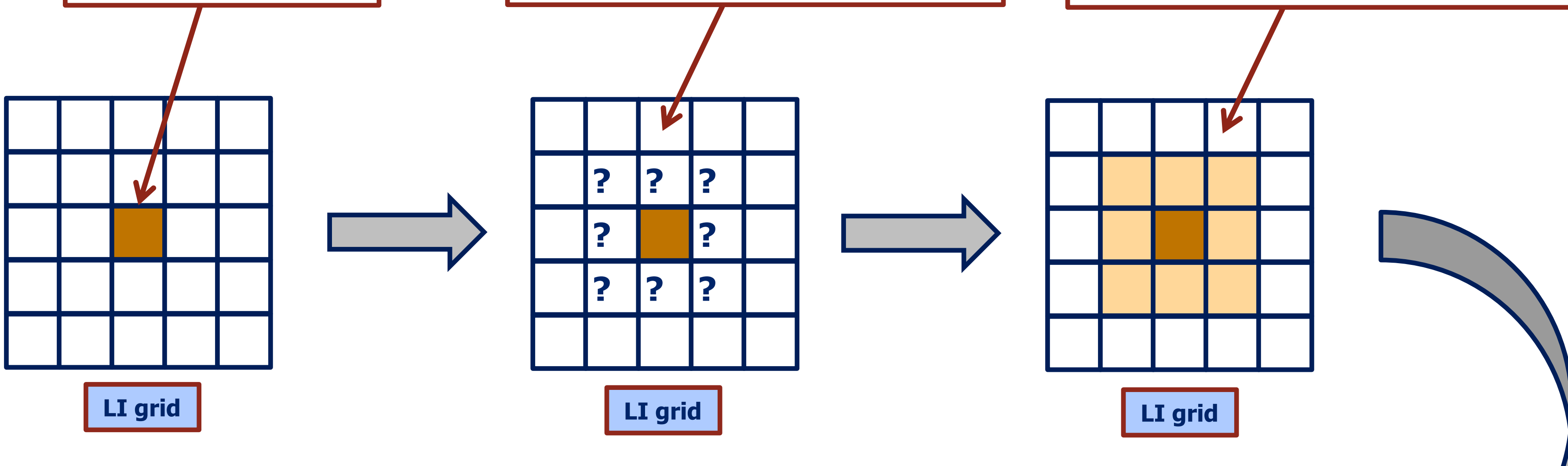
- The GLD360 strokes are close or equal to pulses
- However, if used directly at the input of a L2 processor, we would make the assumption that **these strokes are in fact L1b events. This would lead to a group/event ratio of = 1**
- Therefore the 1st step of using GLD360 data is to create additional events surrounding the original GLD360 stroke
- In the end **we can go backwards** and create a pulse file, as we now know the size of the GLD360 based "pulses" => and based on the L2 outcome, can decide on where/how to create additional pulses, **taking also into account the known GLD360 detection efficiency maps**

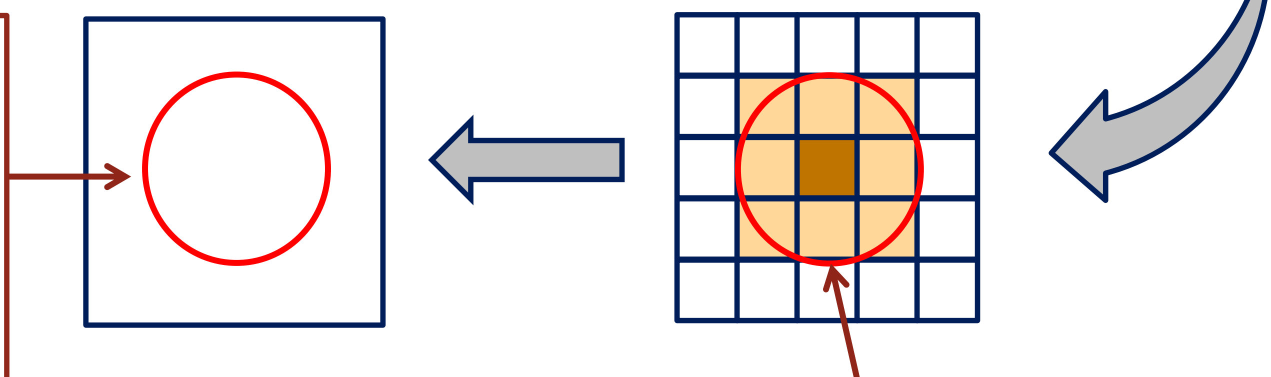
From GLD360 strokes => pulses

GLD360 stroke interpreted as a L1b event at the L2 processor input

Possible neighbouring events triggered by a pulse (this is one example – shapes can vary and also go beyond the first neighbour

New triggered events around the original GLD360 stroke-event. In the "baseline", 8 additional events would lead to a 1:9 group/event ratio





Circular pulse defined based on how the neighbouring new events are located (in this case: simple baseline)

Now we get pulses with:

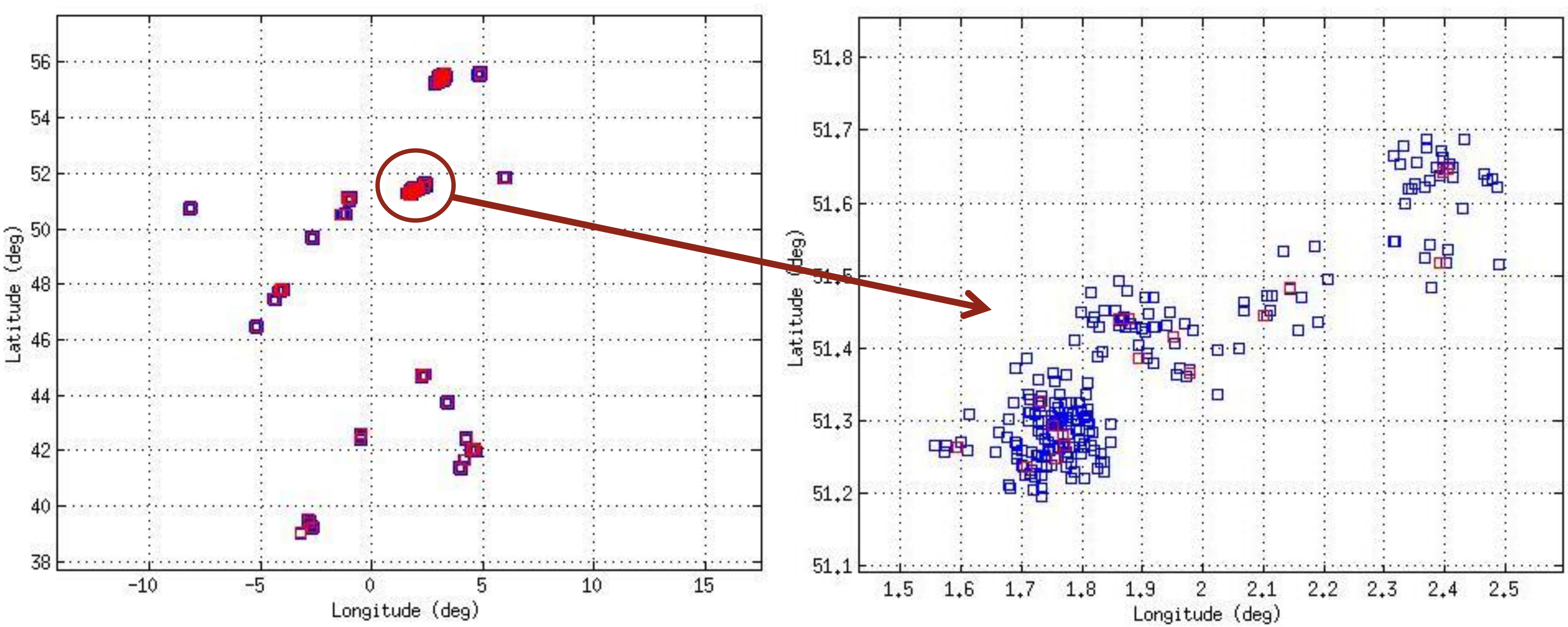
- Lat/lon (not in a grid)
- Size (defined by events created in previous steps)
- Shape circular
- Strength (related to GLD360 central stroke peak current or a distribution based)

How to do the “Monte Carlo” in a nutshell

- **To repeat:** the idea is to trim the pulse statistics by using the L2 output, comparing to LIS statistics, and looking back
- **If event-to-group ratio is too low/high**:
  - Trim the number of events added around “GLD360 central events”
- **If group-to-flash ratio is too low/high**:
  - Trim the number of artificially created new pulses centred around the GLD360 strokes
- **If flash rates are too low/high**:
  - Add/remove pulses which close to each other (so that they would cluster as new flashes)
- Also flash/group/event ratio **distributions** need to checked and compared to LIS

Added strokes around central stroke: example

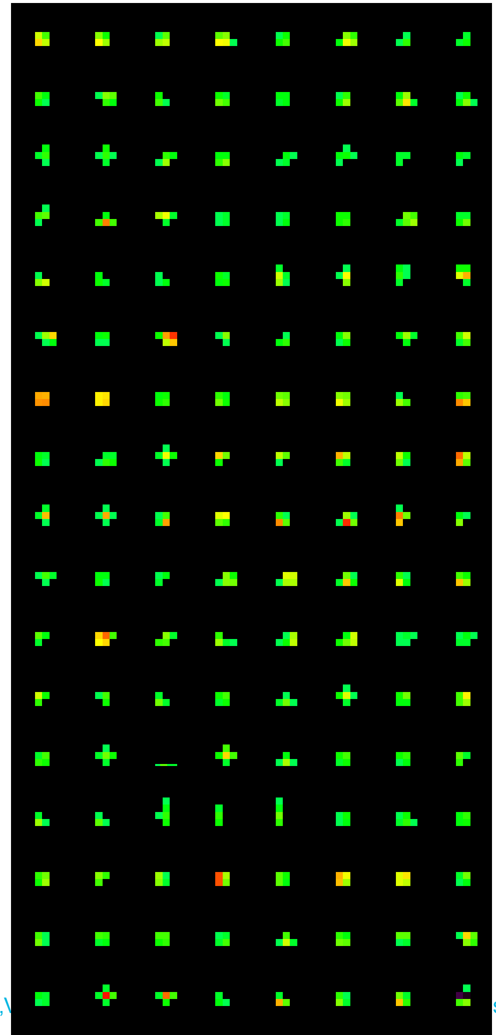
Red	original central GLD stroke
Blue	added strokes around central stroke



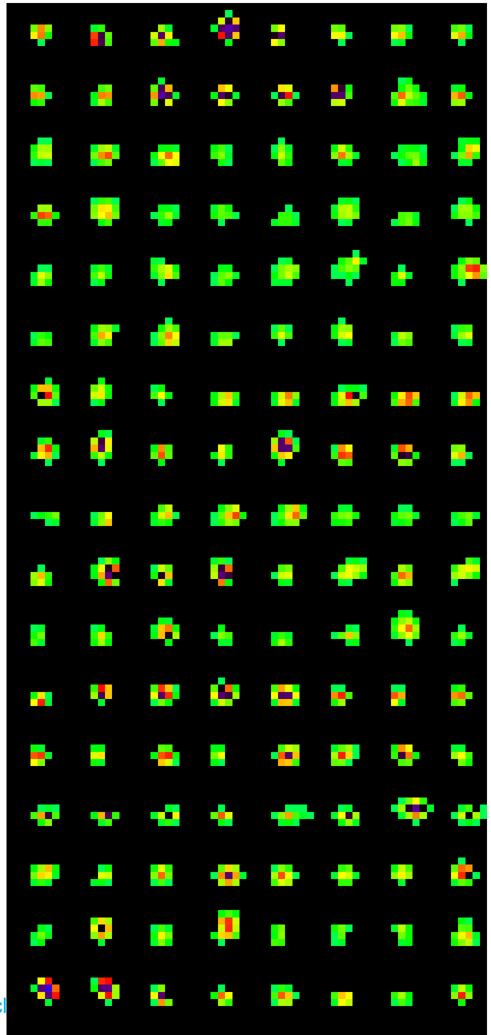
Additional strokes: number of events created around central stroke (2)

True LIS groups with contributing events

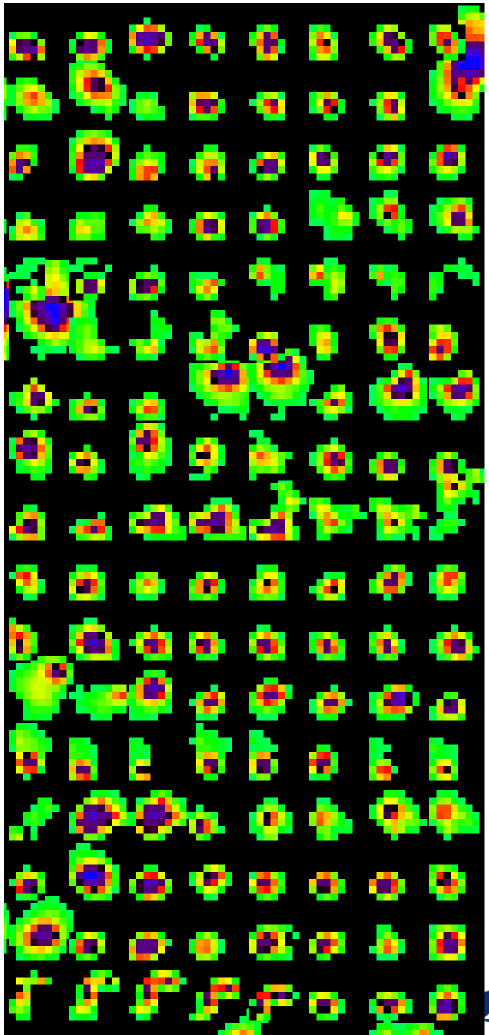
2-5 events



6-15 events



>15 events



Additional strokes: number of events created around central stroke (3)

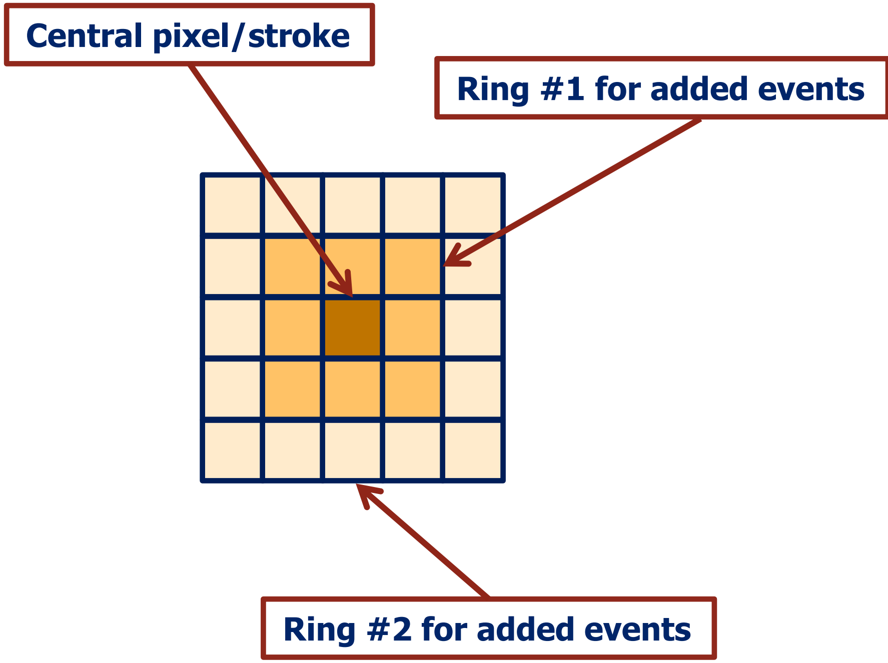
- **Number of events created around central stroke (to form a group)**

  - Implementing the spatial patterns

  - New events placed randomly on “rings” around the central pixel/stroke

  - However such that in case the total number of events to add is:

    - < 8: all events are on ring #1
    - 8...24: ring #1 is filled and the remaining are placed randomly on ring #2
    - > 24: we assume a total of 24 events and fill both rings #1 & #2 (based on the distribution, cases with > 24 are very rare and we do not consider them)



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Last step: from beefed up GLD-events file to pulses

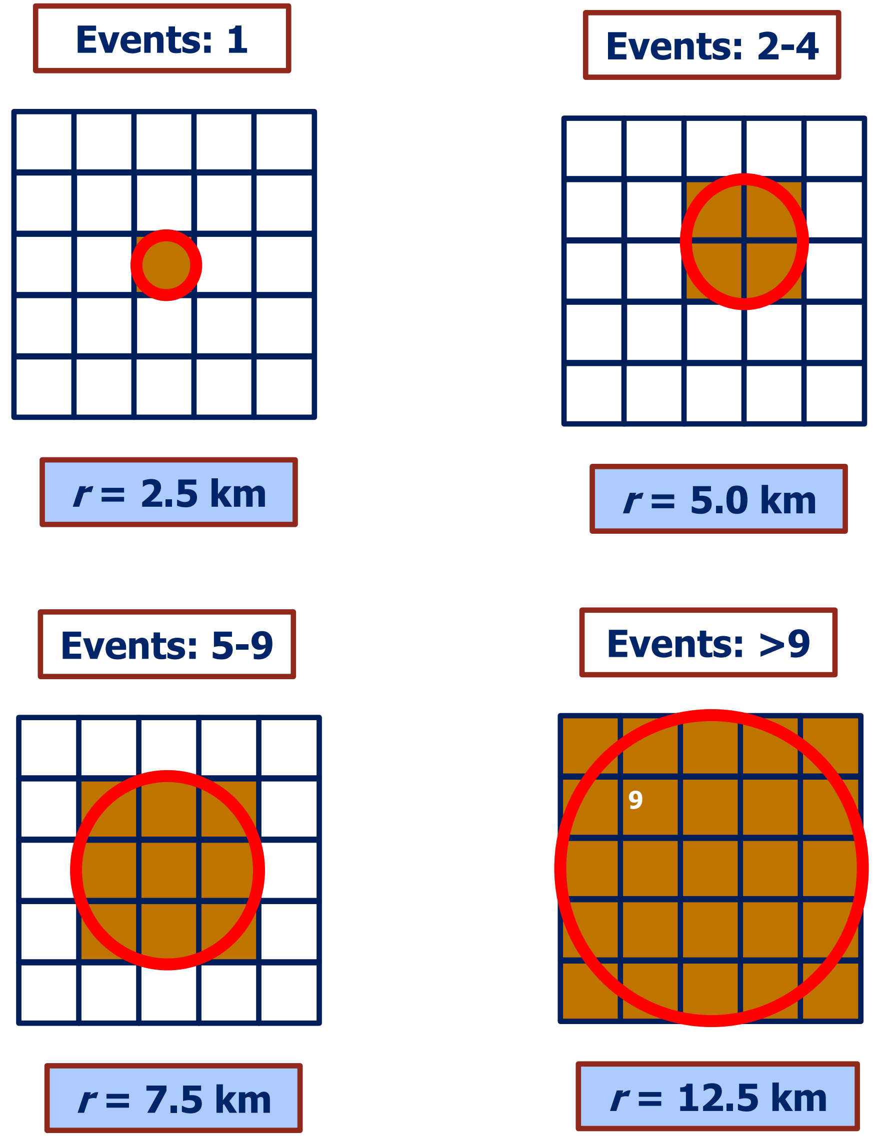
Need to get a pulse file to be fed to LIDEFAS (full prototype processor L0-L2)

The previous steps have given us an event file with added events to the original GLD file (at L1b)

This is processed in a stand-alone L2 processor to get groups

These groups are then converted to pulses by giving each group characteristics of a pulse (radiance, pulse radius)

Depending on the number of events in the group, the pulse radius is given in 4 categories



Results – case of 3 Nov 2014 – trimming input data

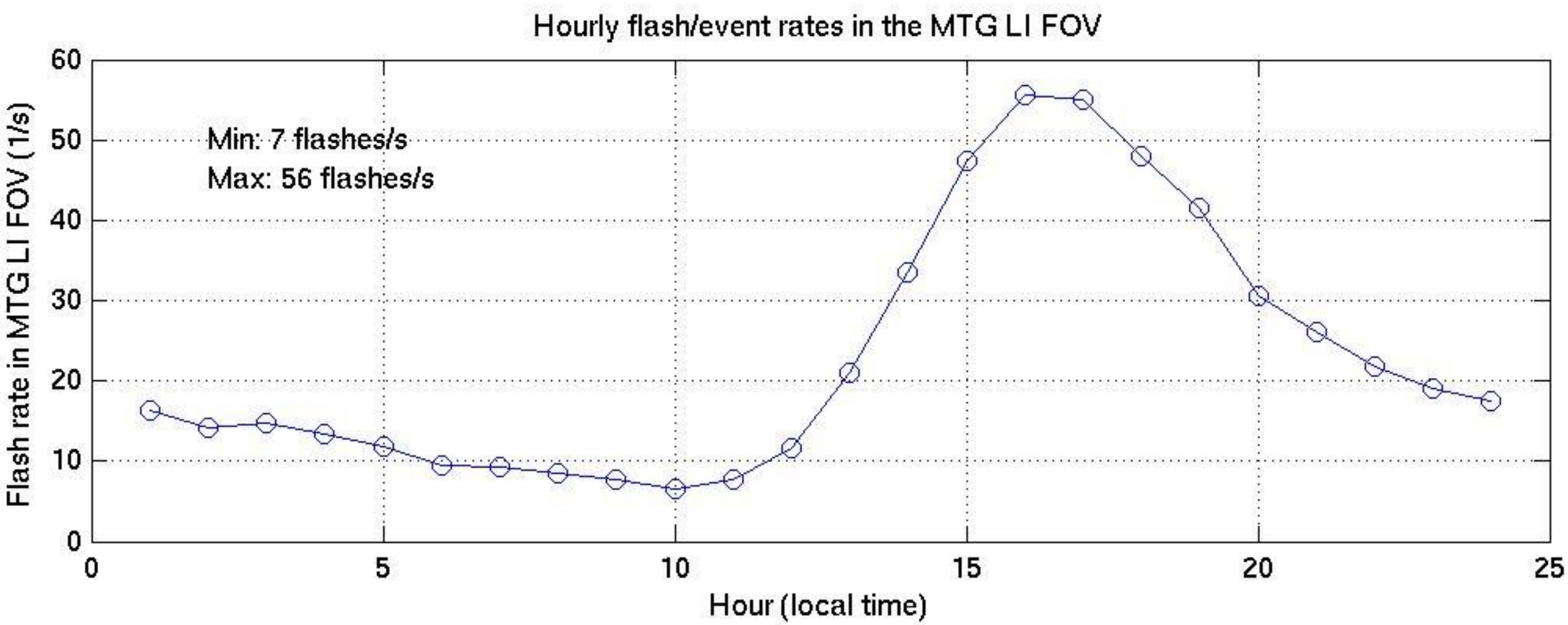
00:00 UTC

- Simulation length: 2 min
- Frame length: 2 ms [LIS case]
- Flash clustering parameters: 330 ms, 5.5 km [LIS case]

	Matlab L2 simulator output		Matlab L2 simulator output		Matlab L2 simulator output	
	Group distance 5 km Stroke hand tuning 2.0 Event hand tuning 1.0		Group distance 5 km Stroke hand tuning 2.0 Event hand tuning 0.8		Group distance 5 km Stroke hand tuning 2.0 Event hand tuning 0.6	
	Total	Ratio	Total	Ratio	Total	Ratio
Flashes	1782	1	1799	1	1859	1
Groups	17962	10.1	17995	10.0	18012	9.7
Events	130791	73.4	105962	58.9	82013	44.1
fl/s in full disk area	14.9		15.0		15.5	

- *Notes:*
  - ***"Group distance"*** *variable causes the number of flashes to increase as new strokes are placed too far to be clustered all in the same flash*
  - ***"Stroke hand tuning"*** *variable modifies the added strokes distribution to fit better in the LIS results after running L2 prototype processor. It adds strokes (and therefore events) but does not directly impact the number of flashes.*
  - ***"Event hand tuning"*** *variable modifies similarly as above the event distributions (how many events per group)*

Estimated average MTG LI FOV flash rates (from LIS/OTD long-term climatology)



Summary – part II

- Various methods for creating test/proxy data exist, with pros and cons

- Latest development is a Vaisala GLD360 based test data set model/simulator, which mimics very well the LIS statistics

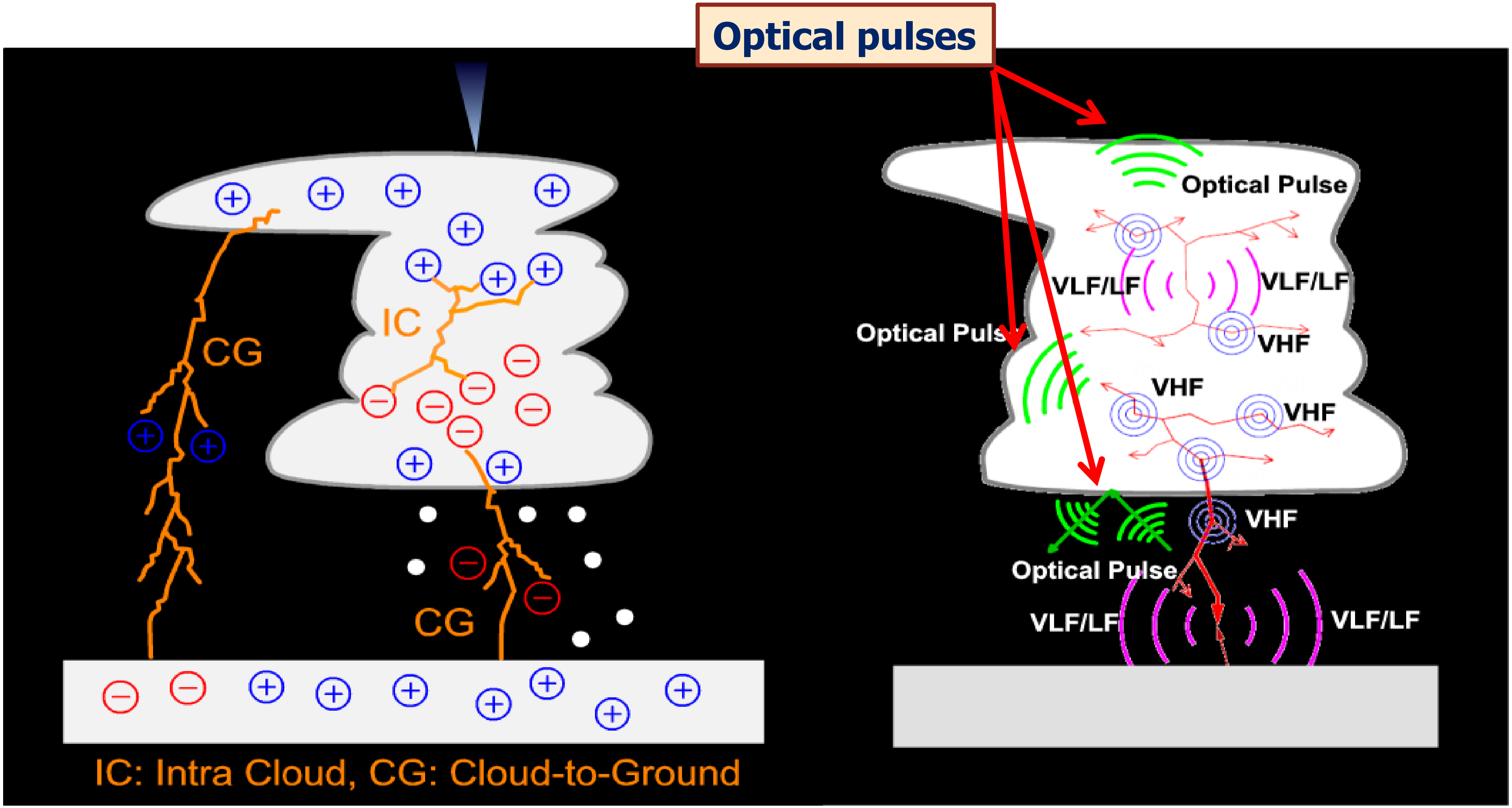
- When fed into the LI reference processor as input optical pulses, the statistics will no longer be LIS statistics, so trimming/tuning is done outside of the LI reference processor

- **Good progress on test data...**

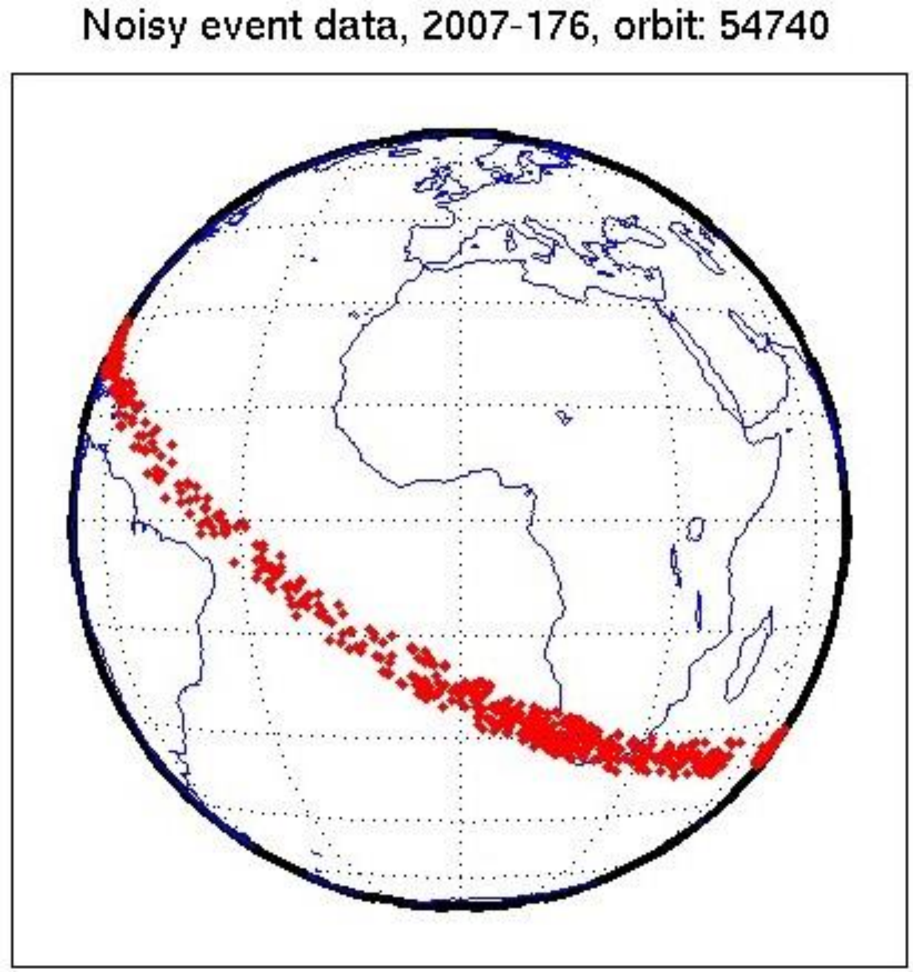
Back-up slides

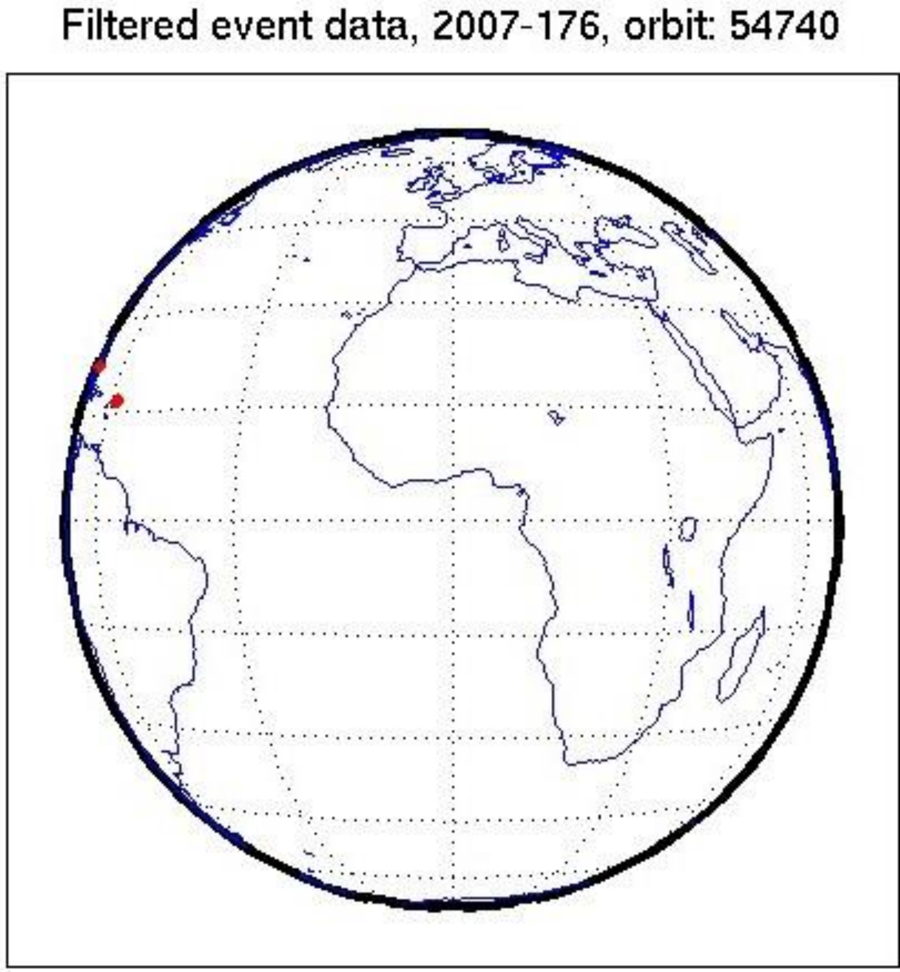
Thunderstorm Electrification

Lightning and its Emissions



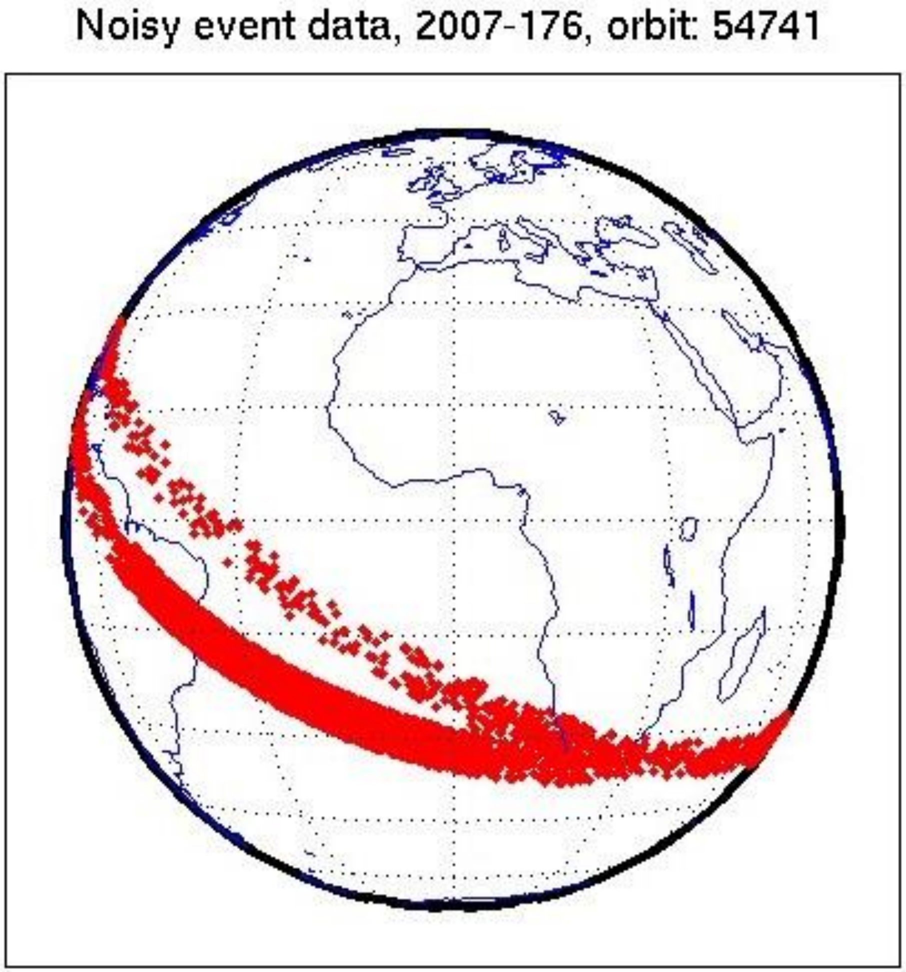
- VHF – Very High Frequency, (V)LF – (Very) Low Frequency

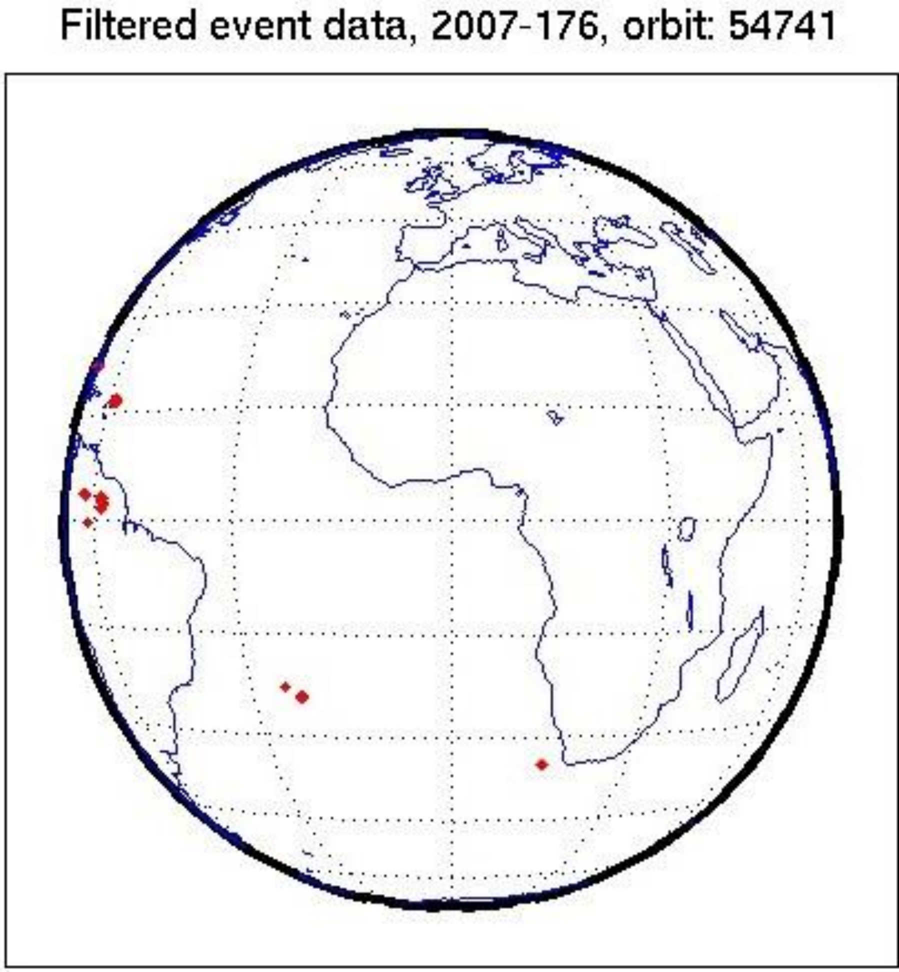




TRMM LIS events with false transients

TRMM LIS events with filtered L2 events





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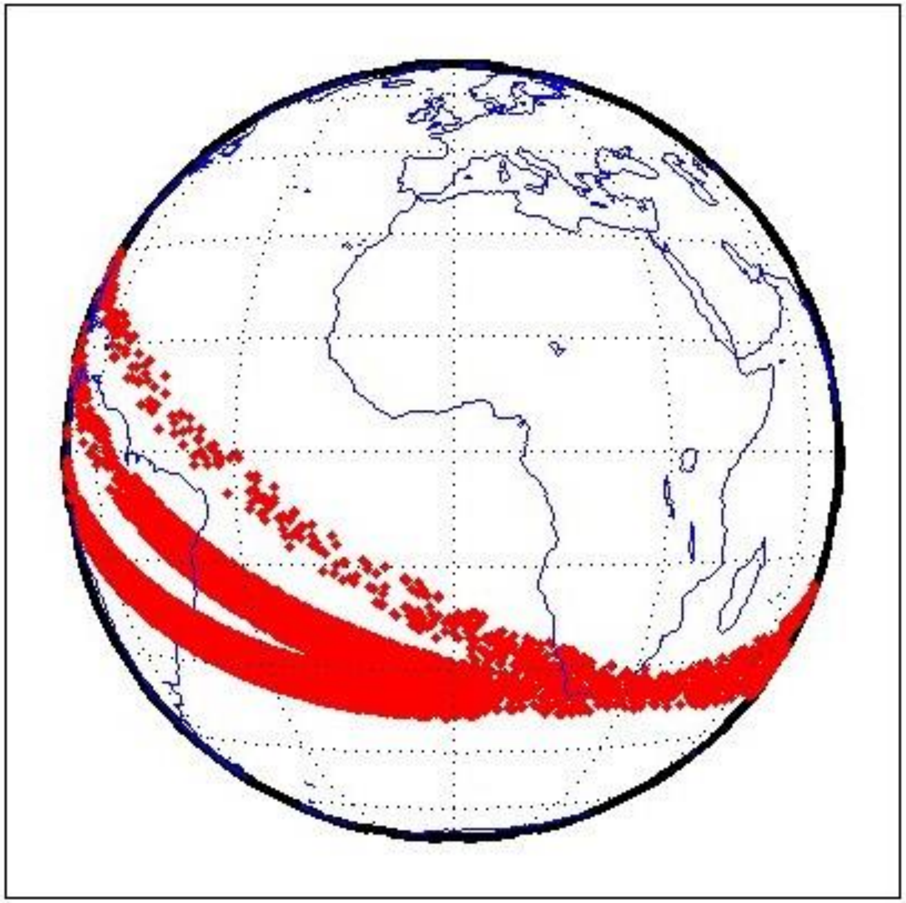

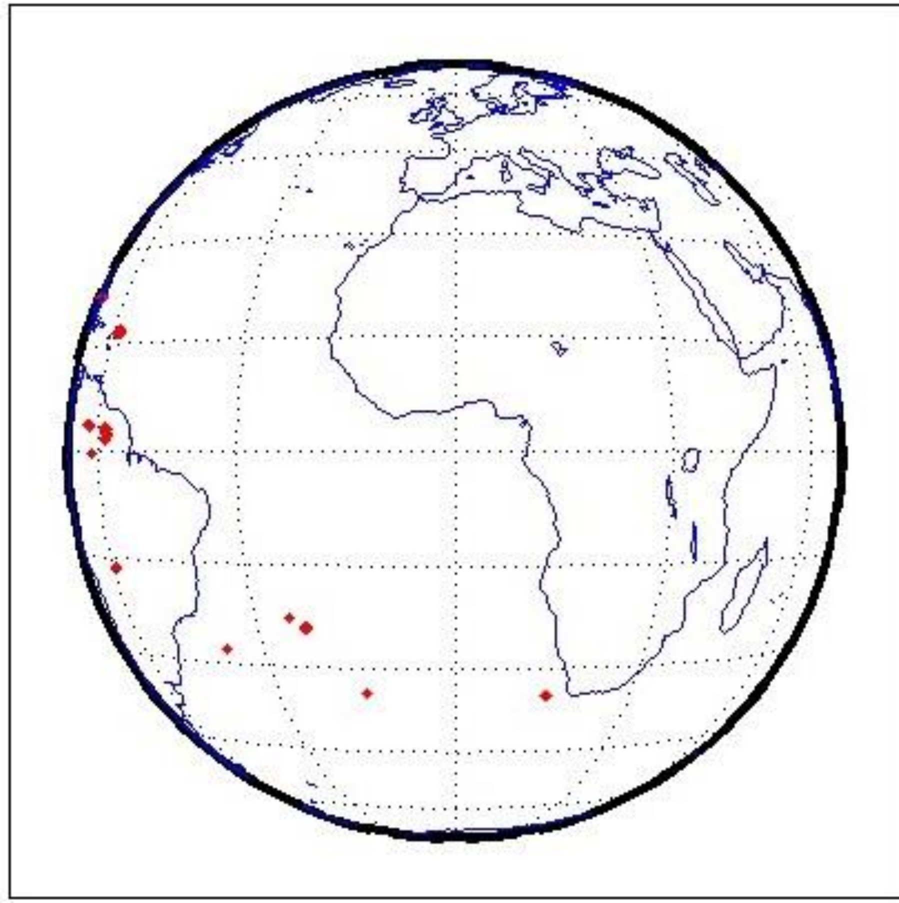

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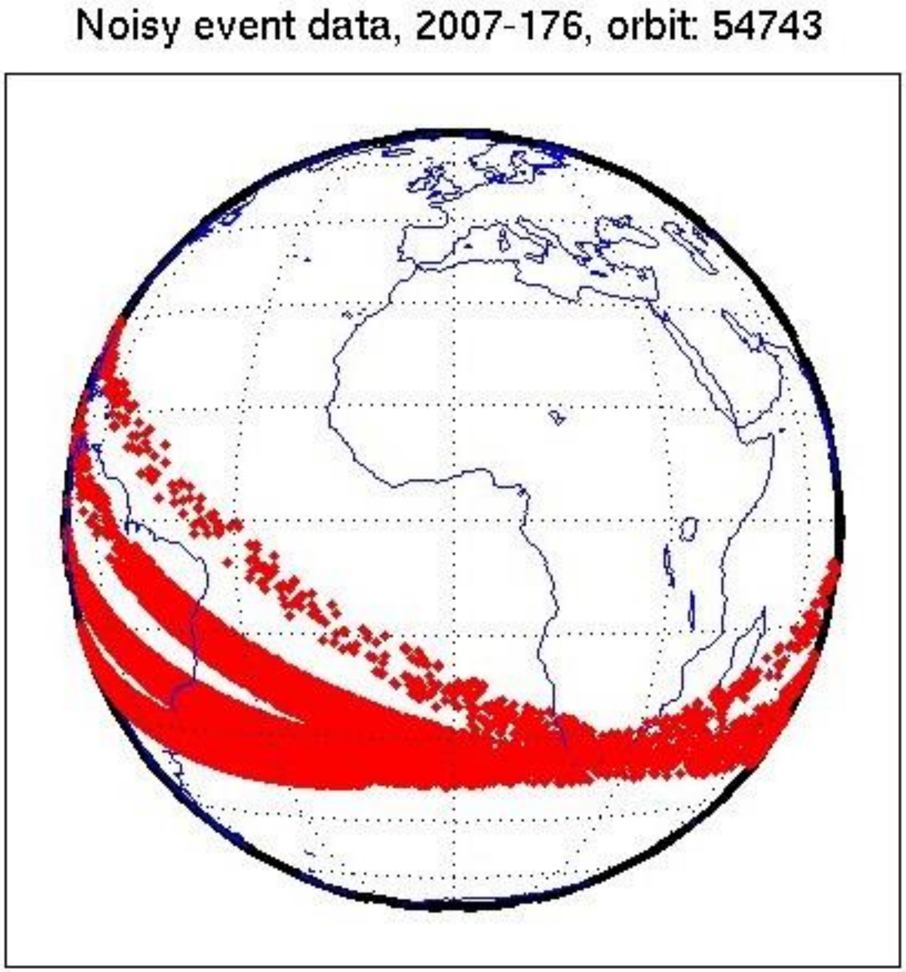

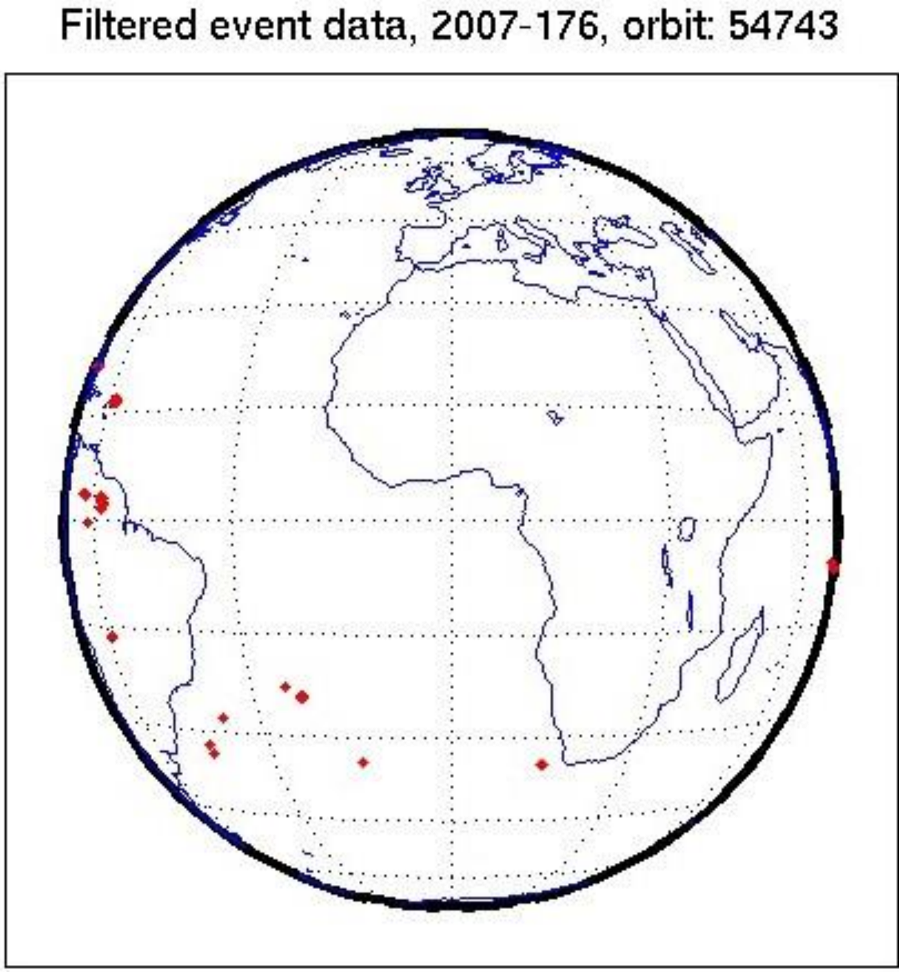

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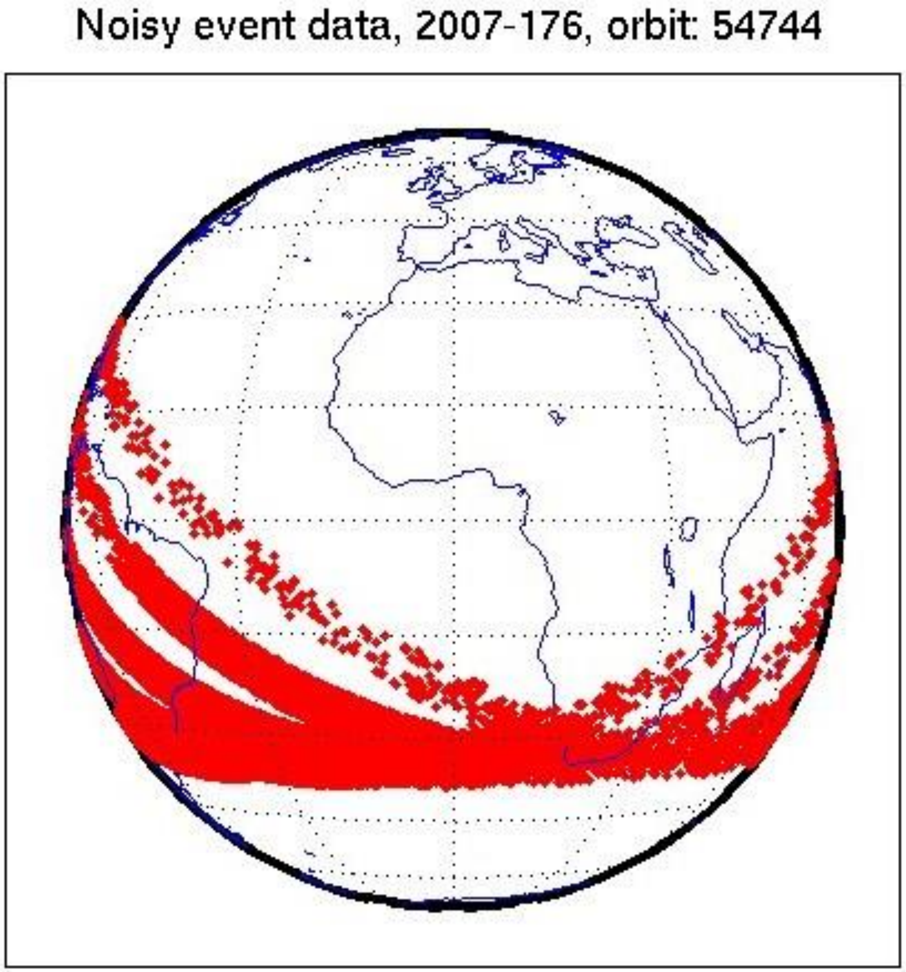
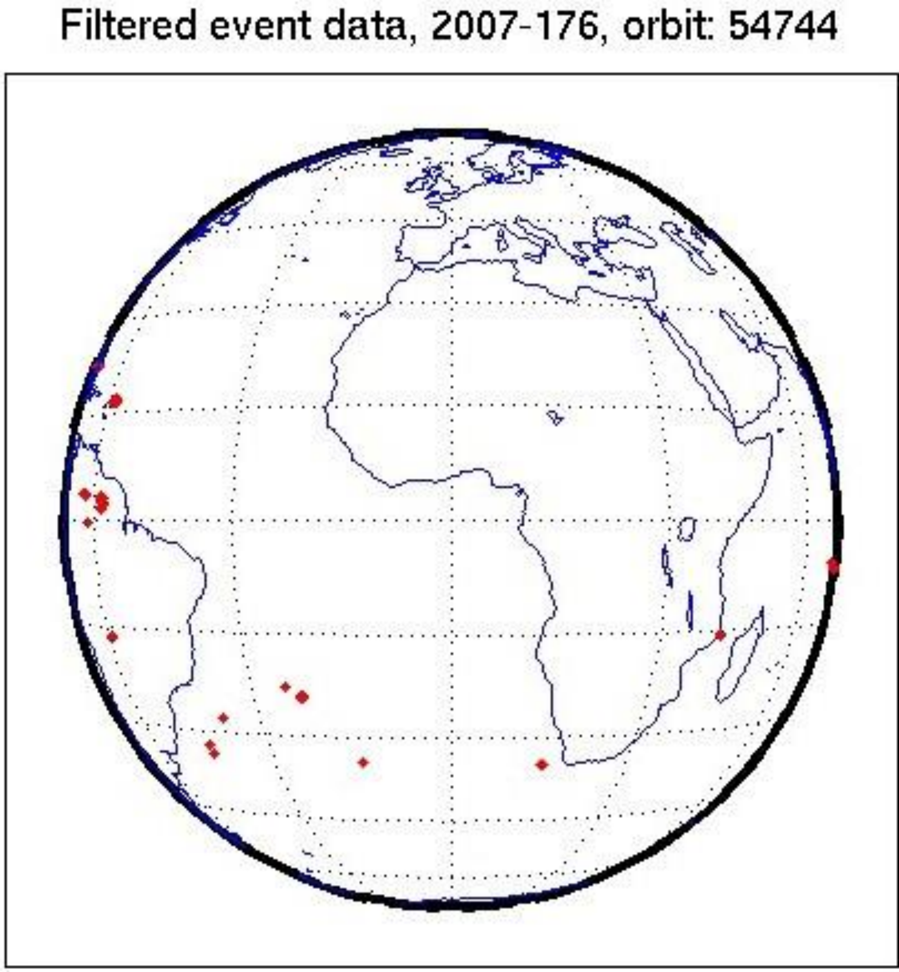
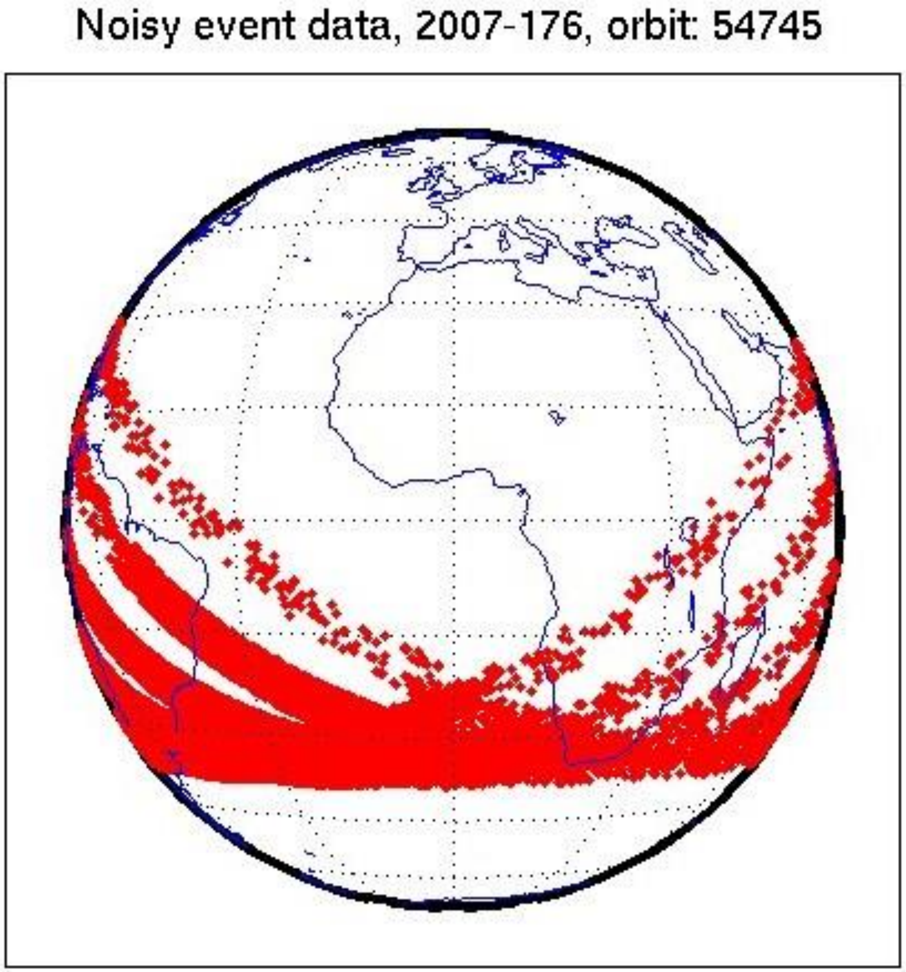
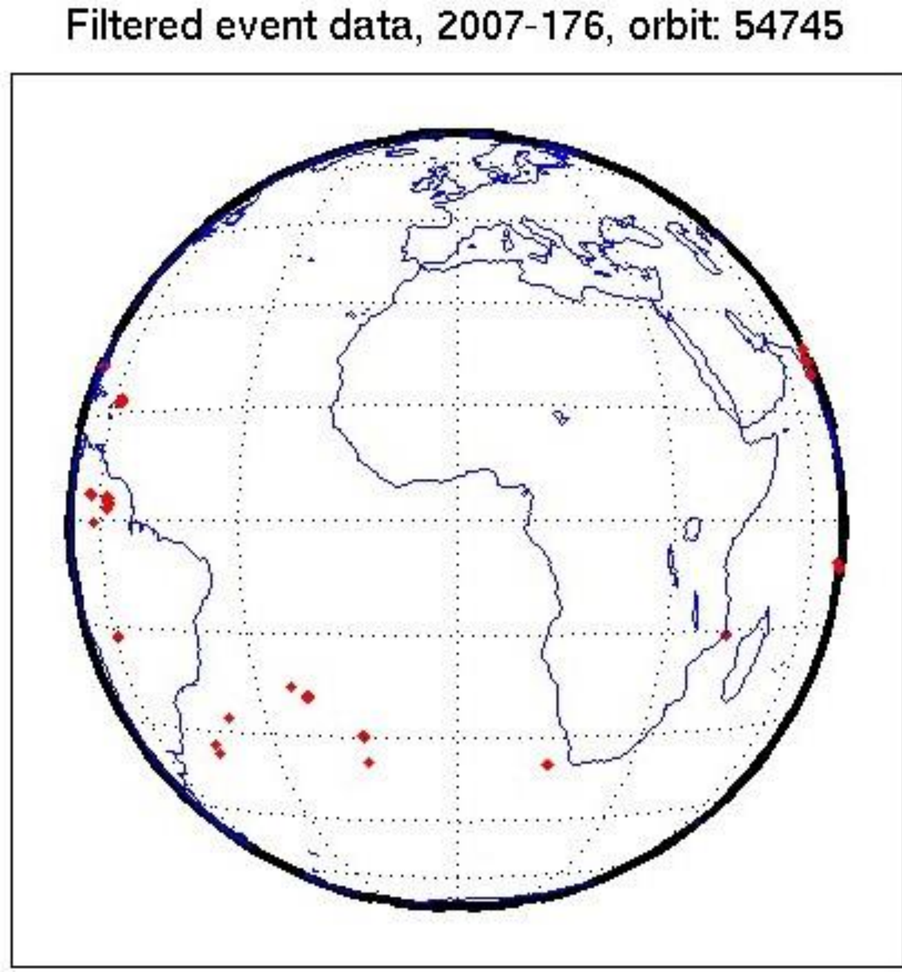




TRMM LIS events with false transients

TRMM LIS events with filtered L2 events





TRMM LIS events with false transients

TRMM LIS events with filtered L2 events

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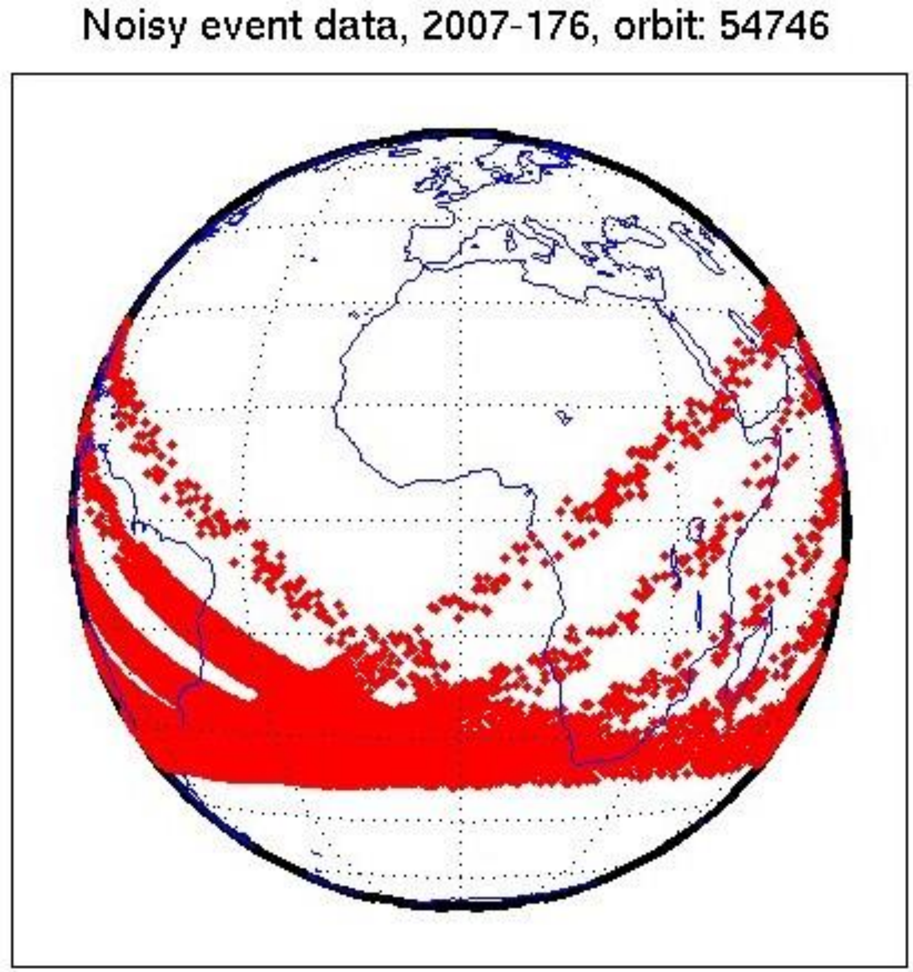
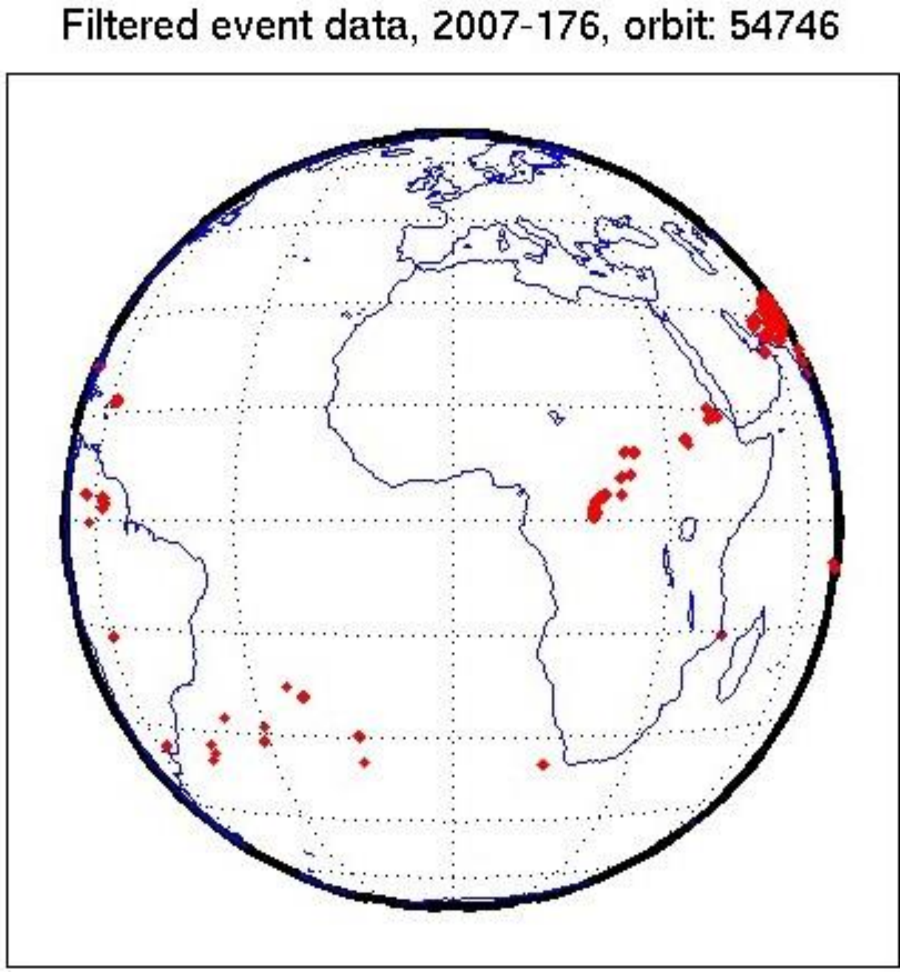
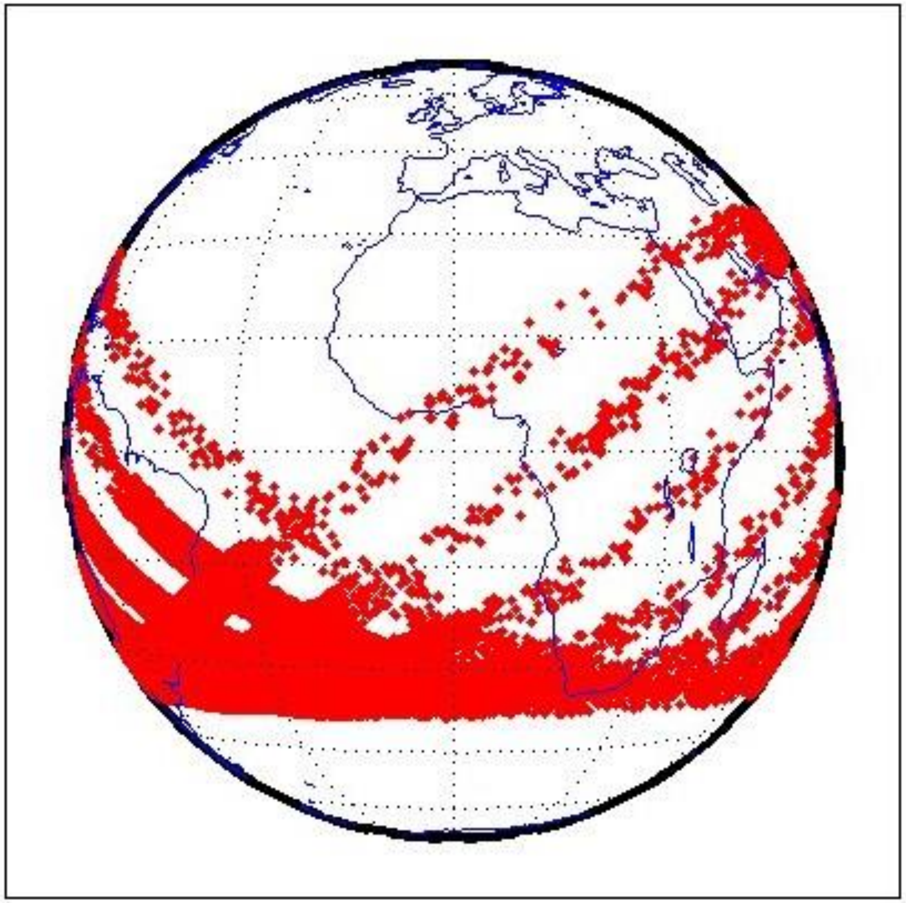




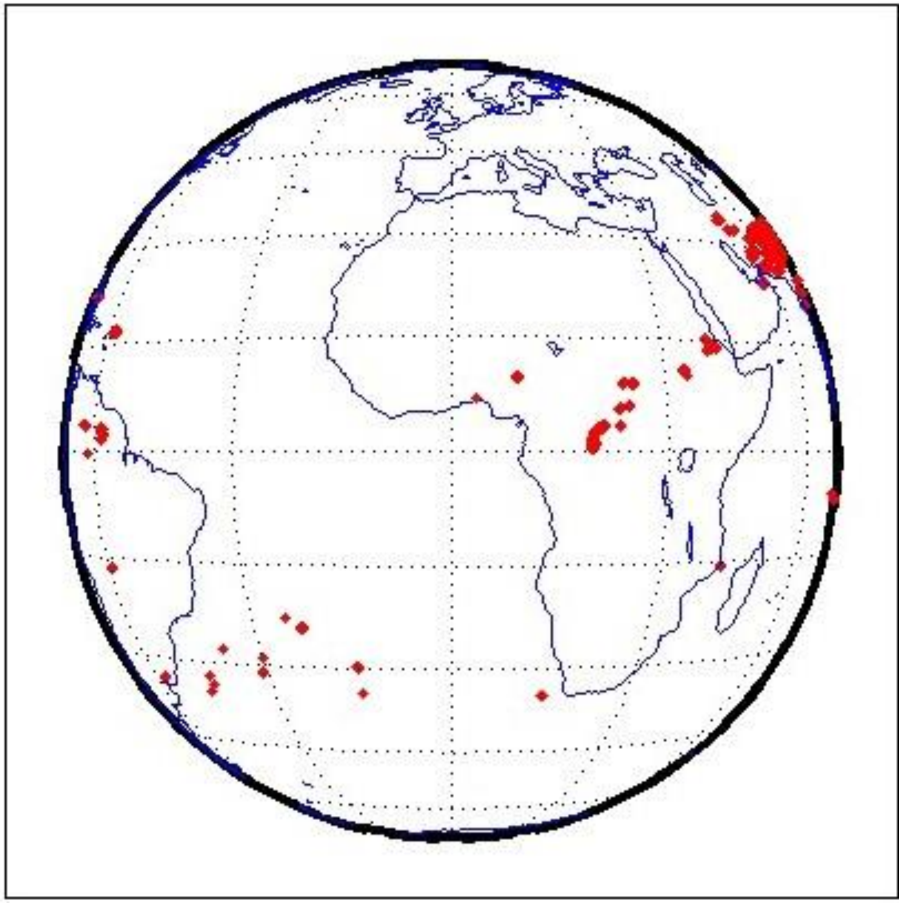
TRMM LIS events with false transients

TRMM LIS events with filtered L2 events

Noisy event data, 2007-176, orbit: 54747



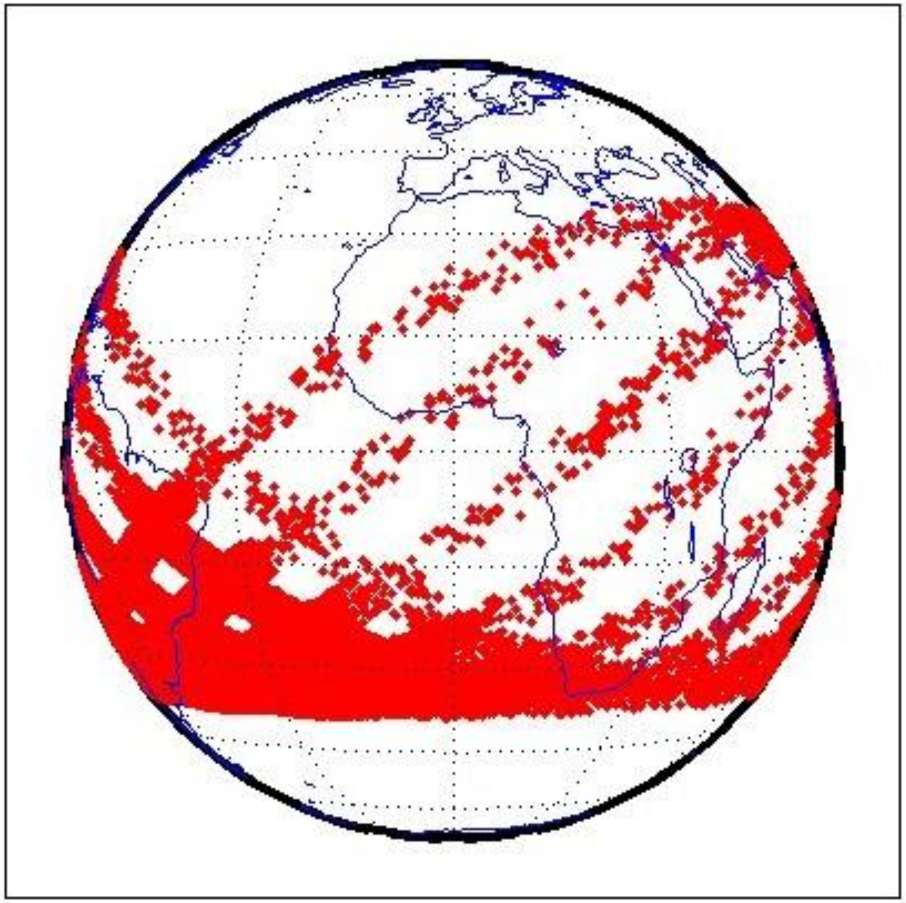
Filtered event data, 2007-176, orbit: 54747



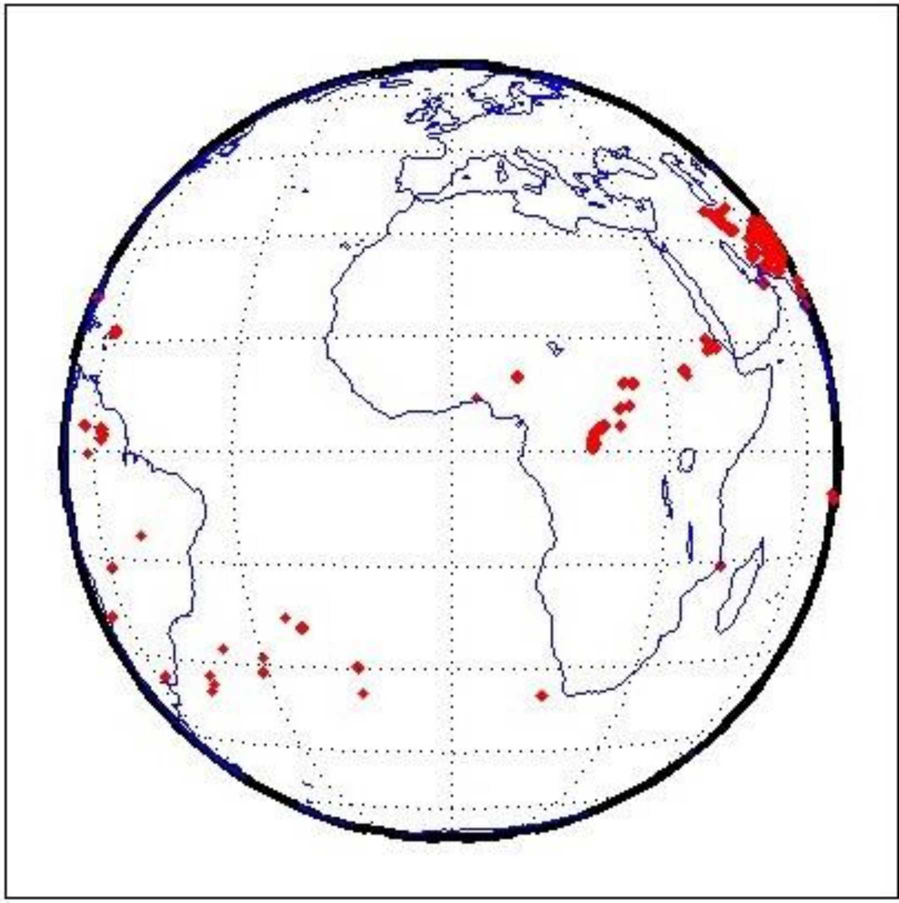
TRMM LIS events with false transients

TRMM LIS events with filtered L2 events

Noisy event data, 2007-176, orbit: 54748

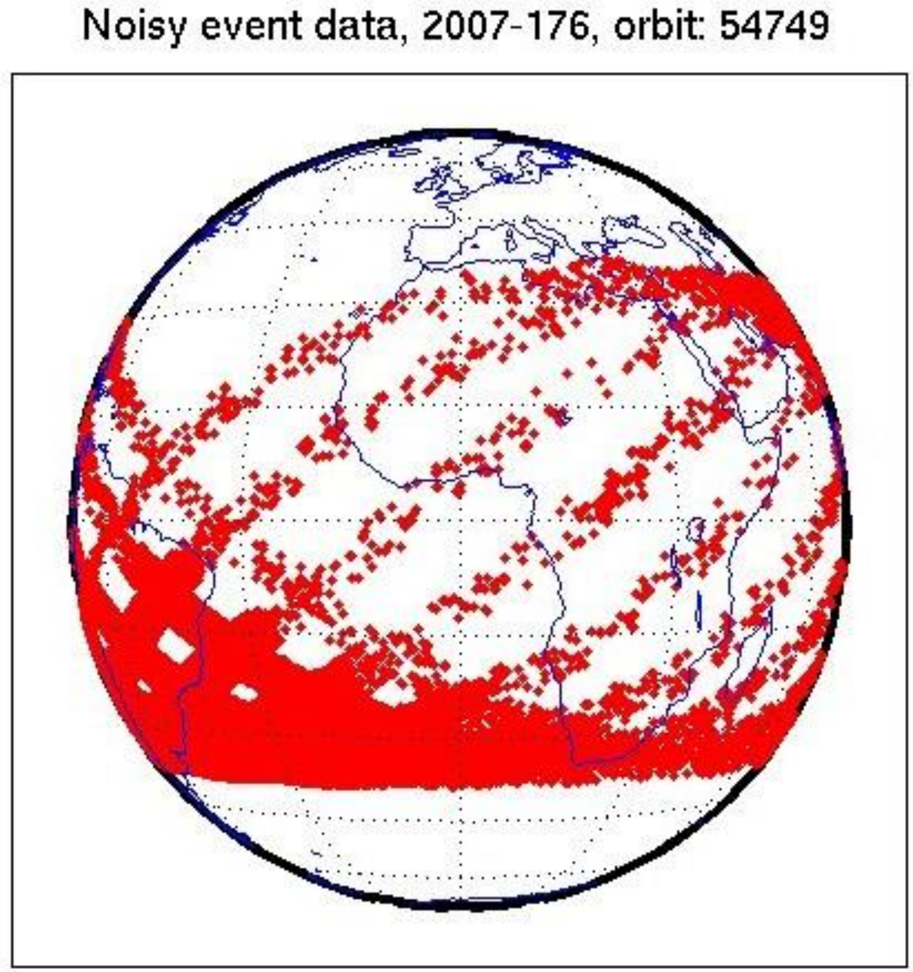


Filtered event data, 2007-176, orbit: 54748

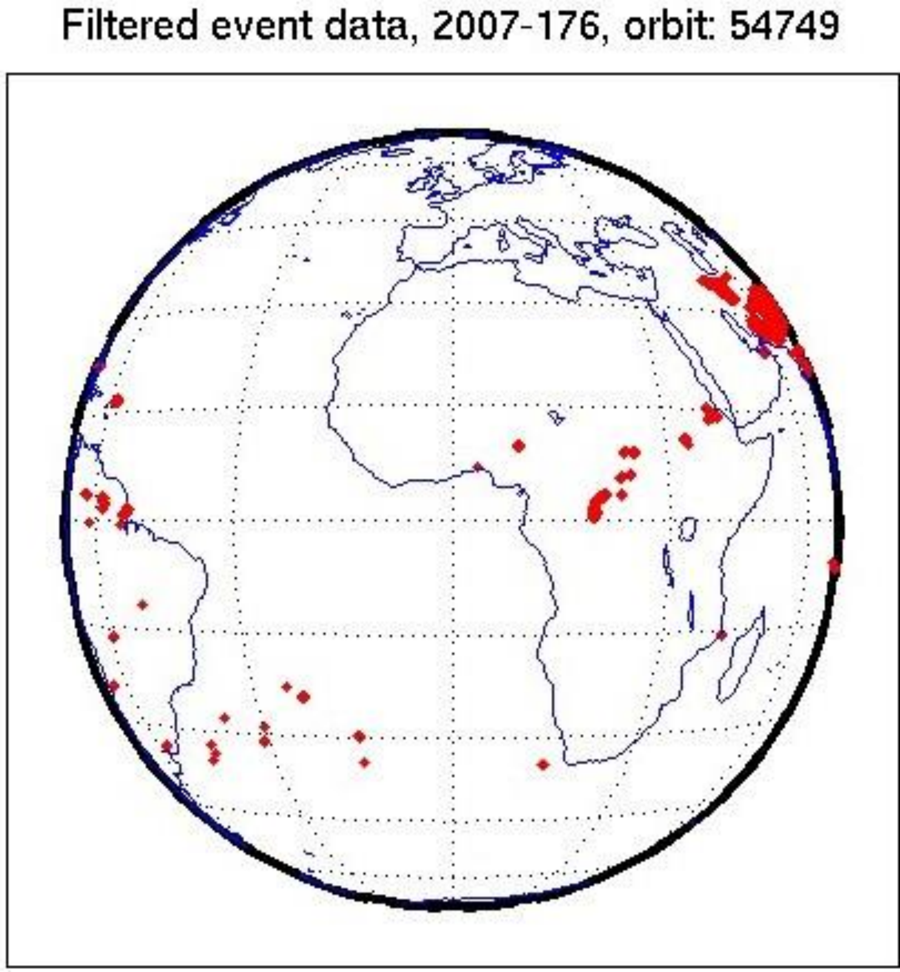


TRMM LIS events with false transients

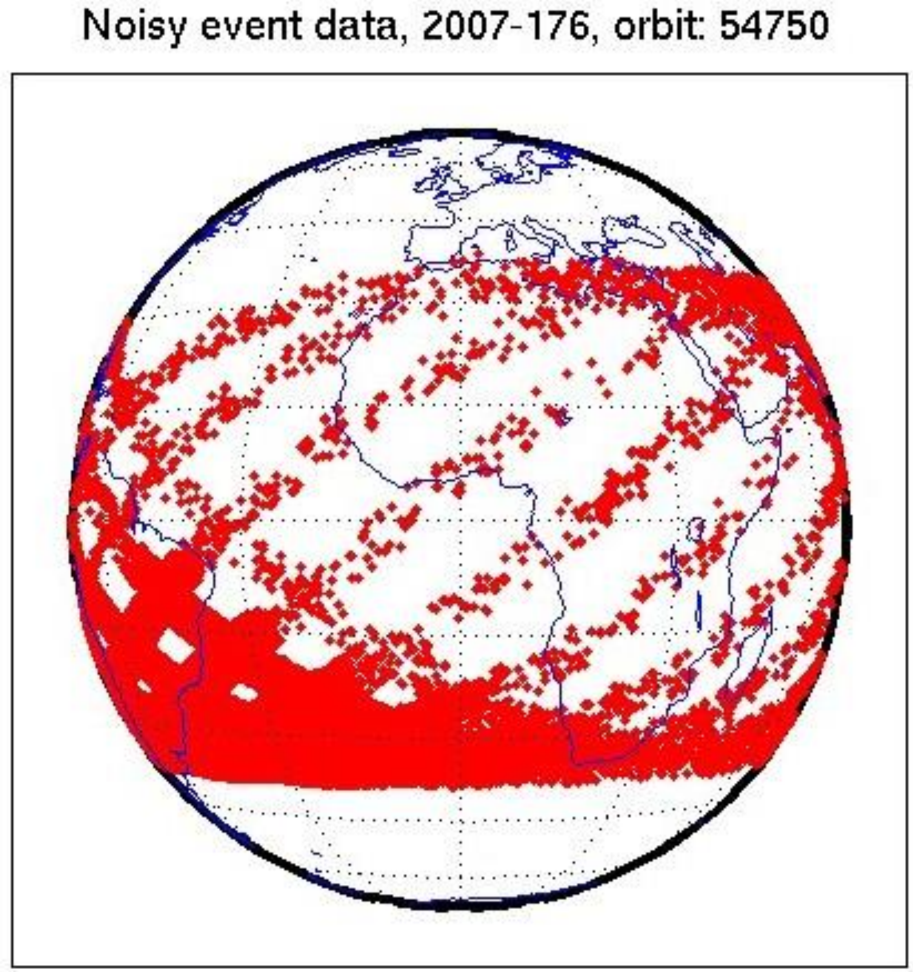
TRMM LIS events with filtered L2 events

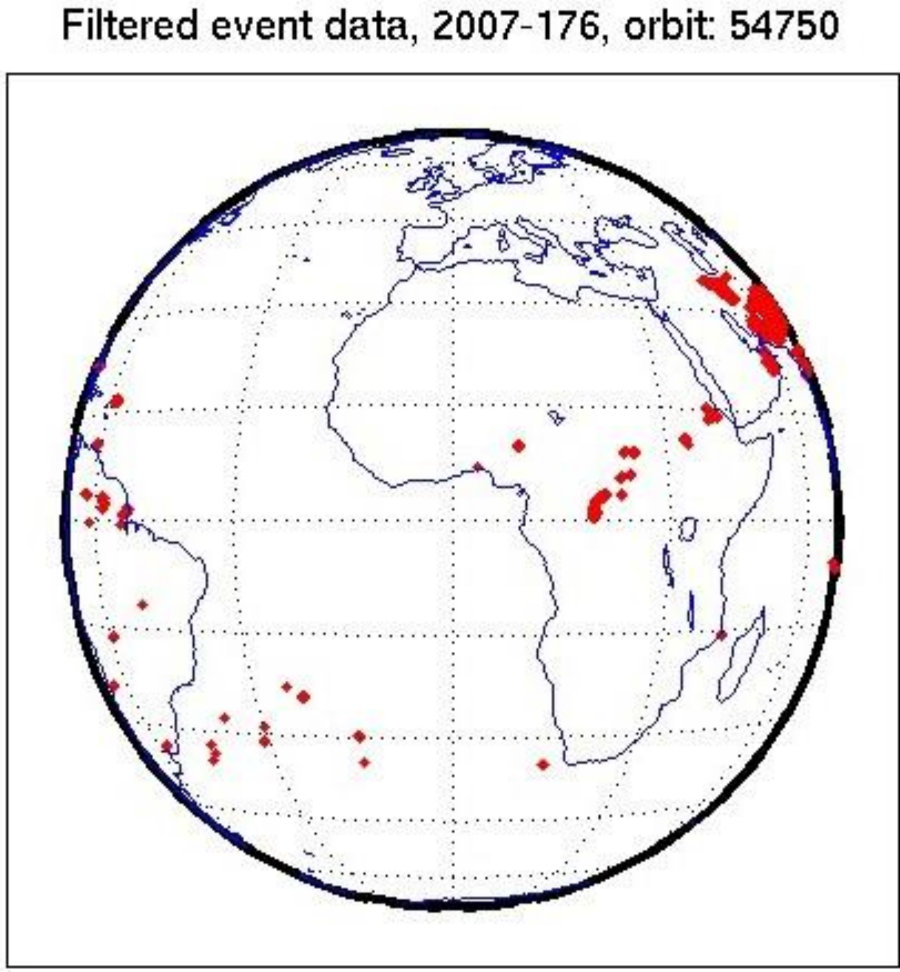


TRMM LIS events with false transients



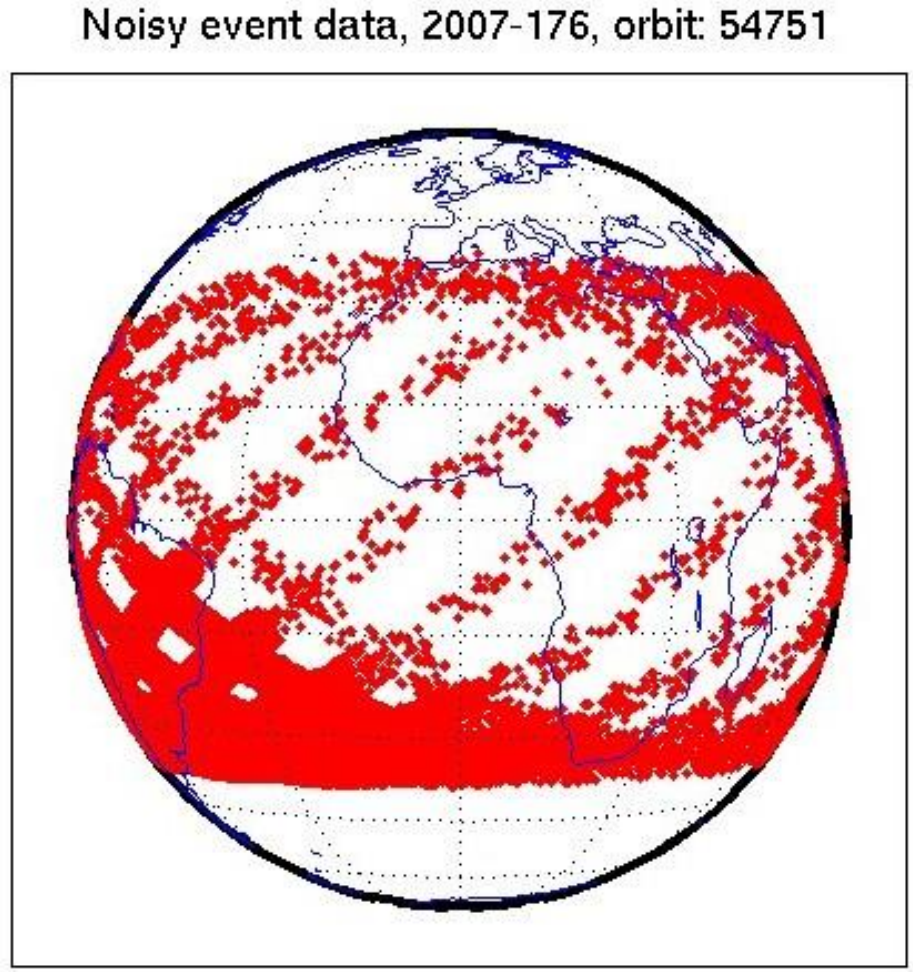
TRMM LIS events with filtered L2 events

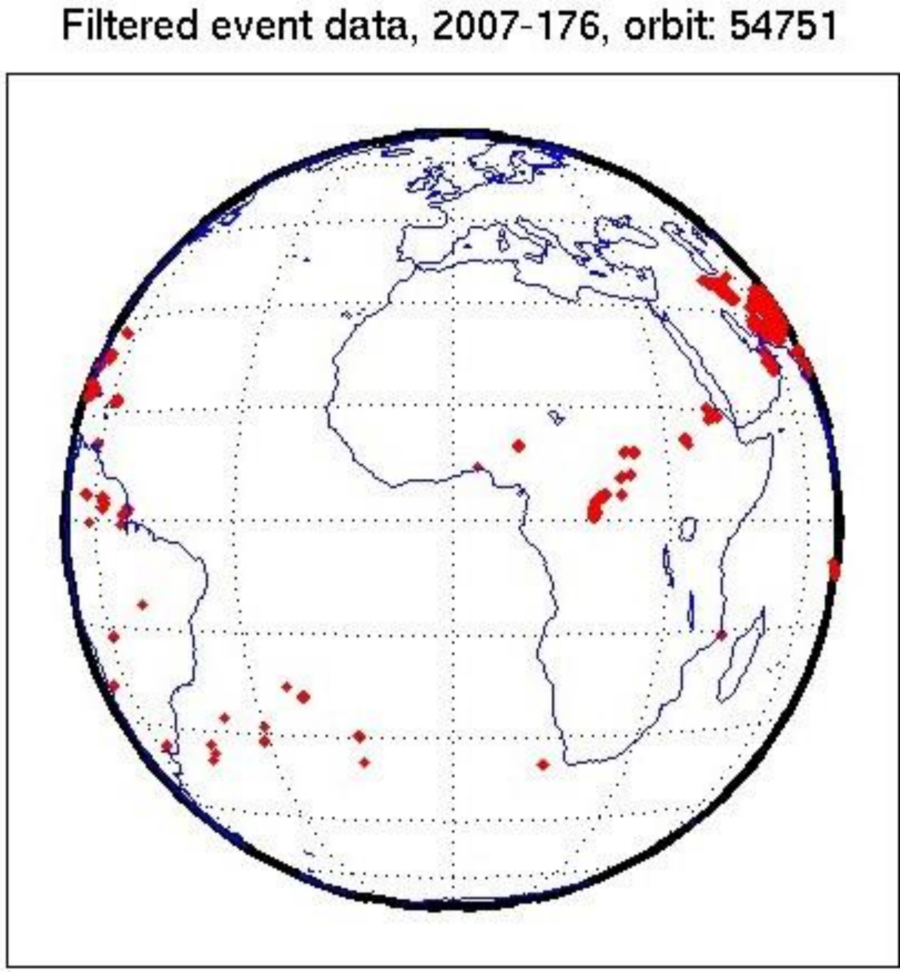




TRMM LIS events with false transients

TRMM LIS events with filtered L2 events

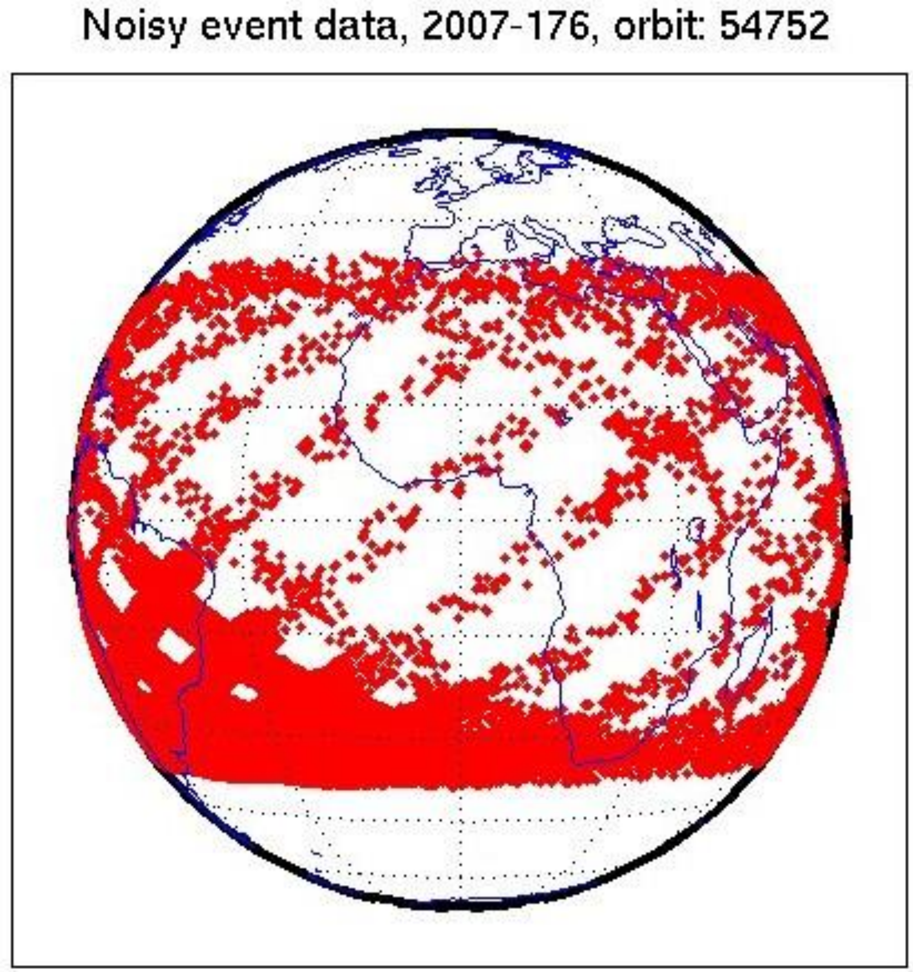


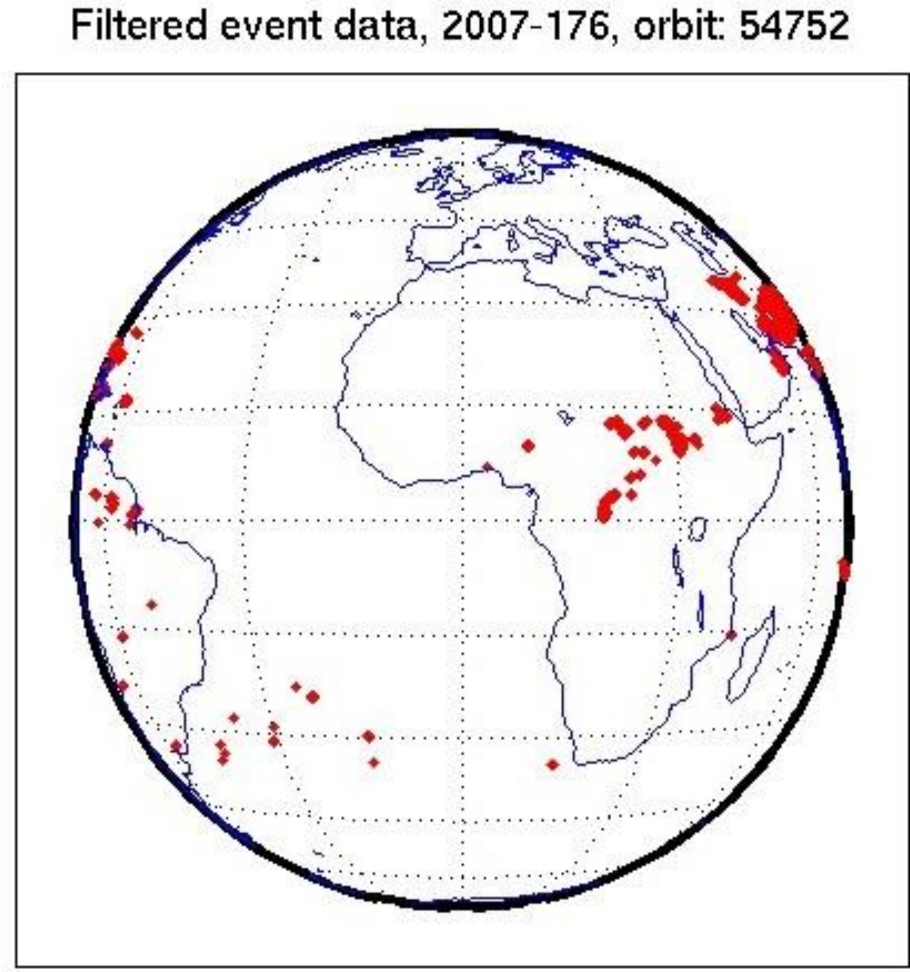


TRMM LIS events with false transients

TRMM LIS events with filtered L2 events

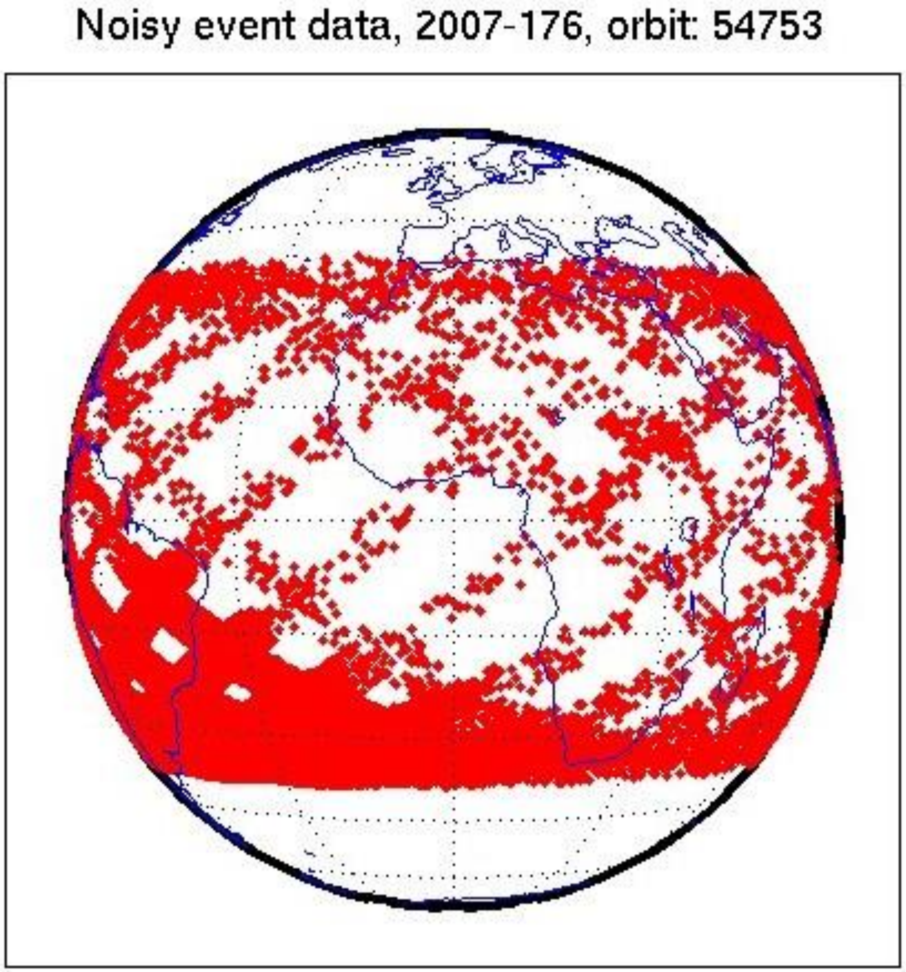
EUMETSAT

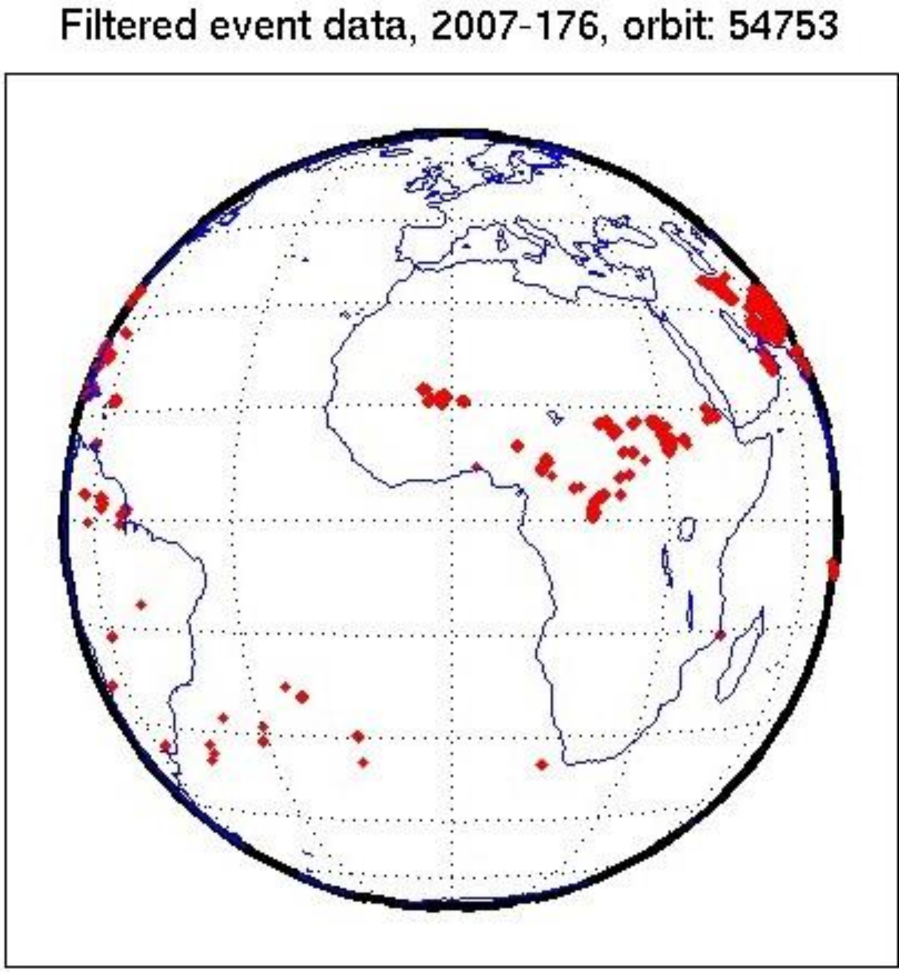




TRMM LIS events with false transients

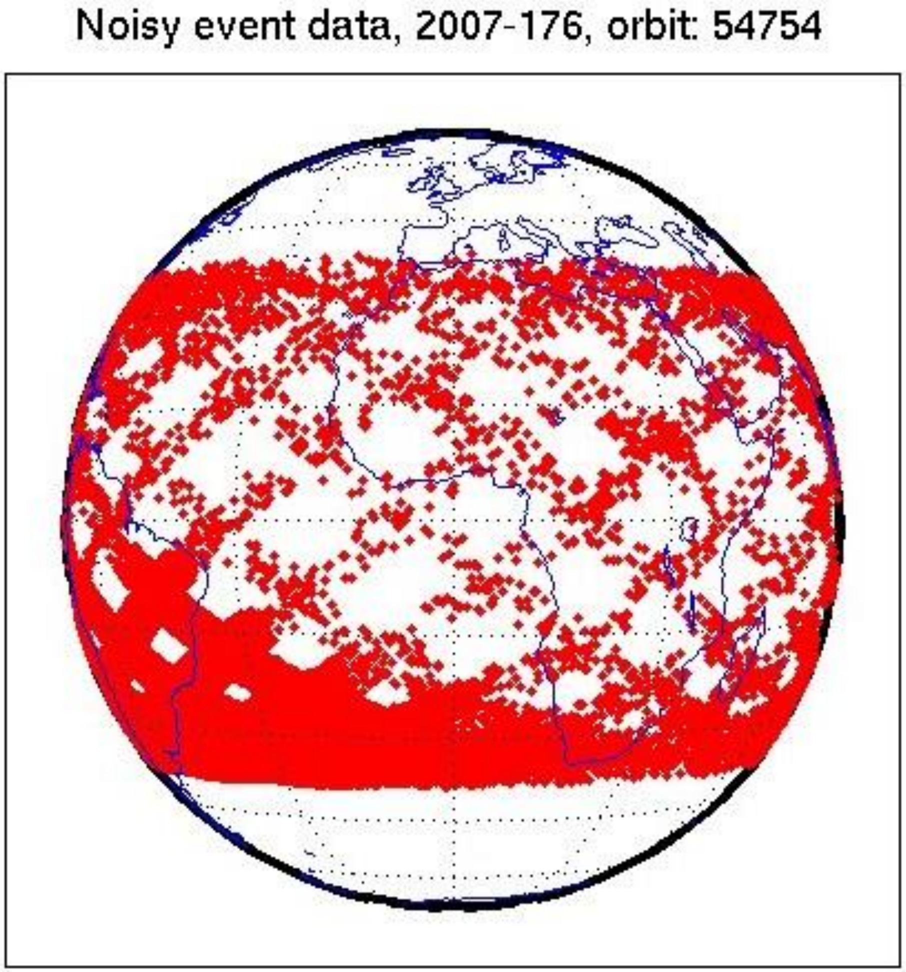
TRMM LIS events with filtered L2 events



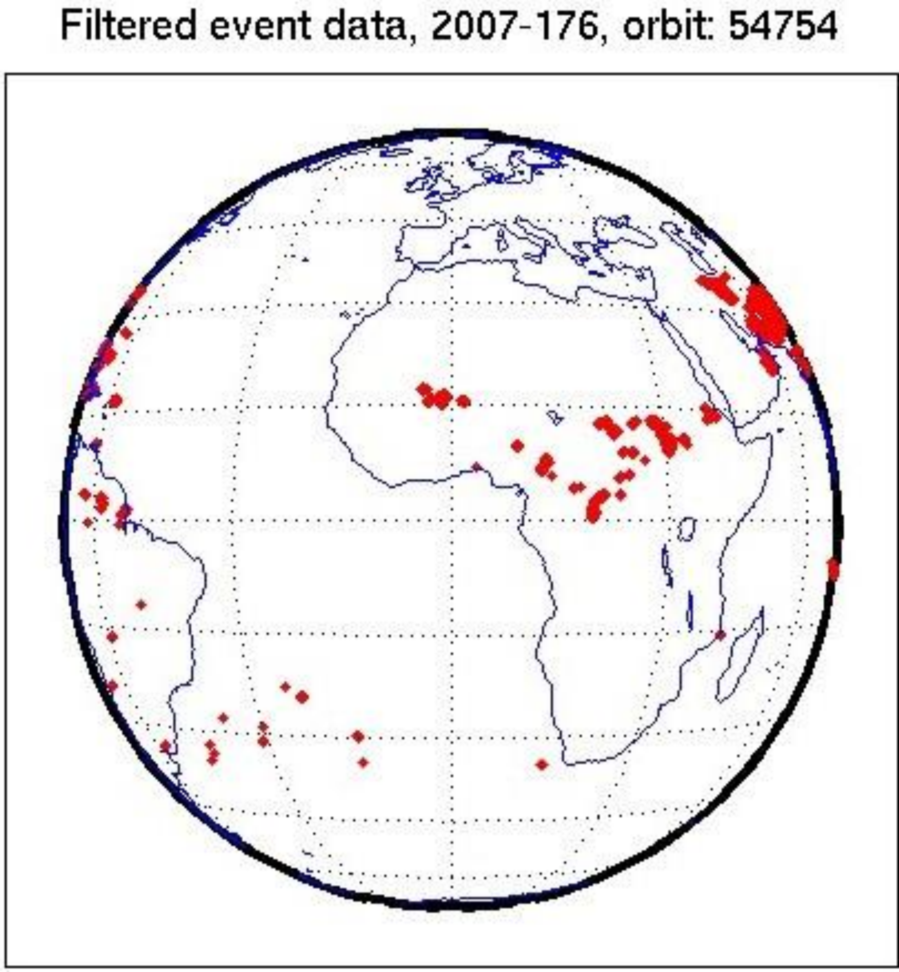


TRMM LIS events with false transients

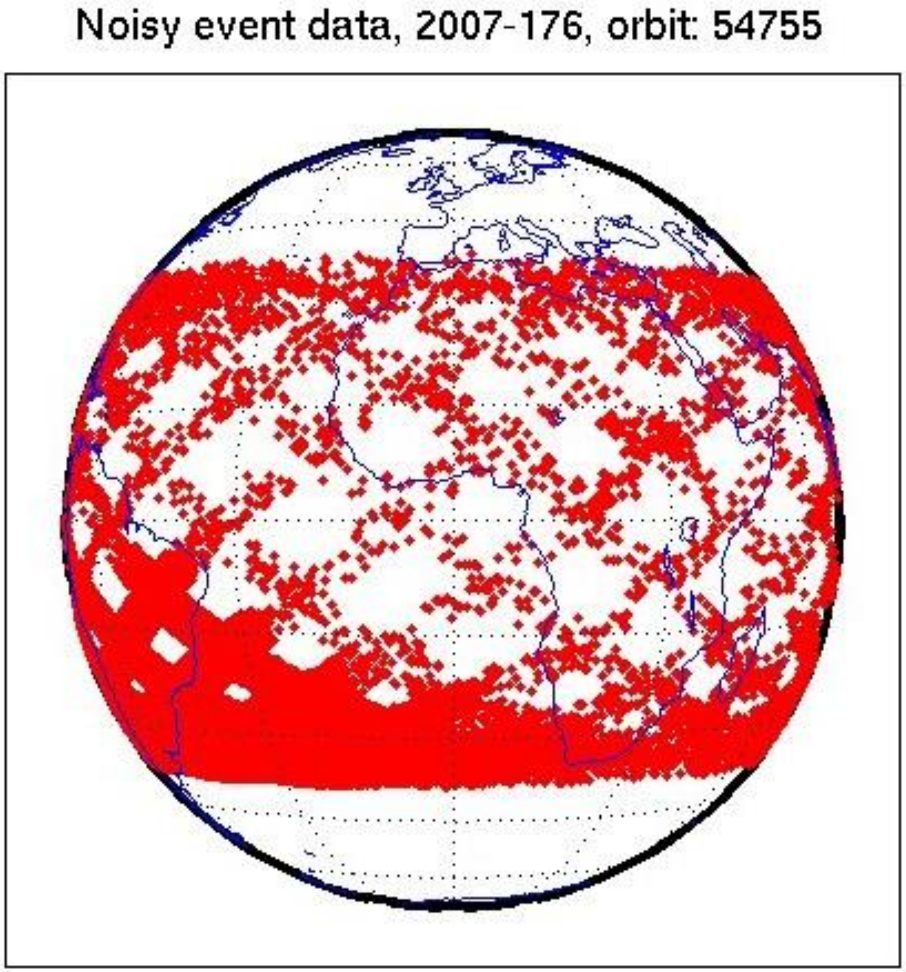
TRMM LIS events with filtered L2 events

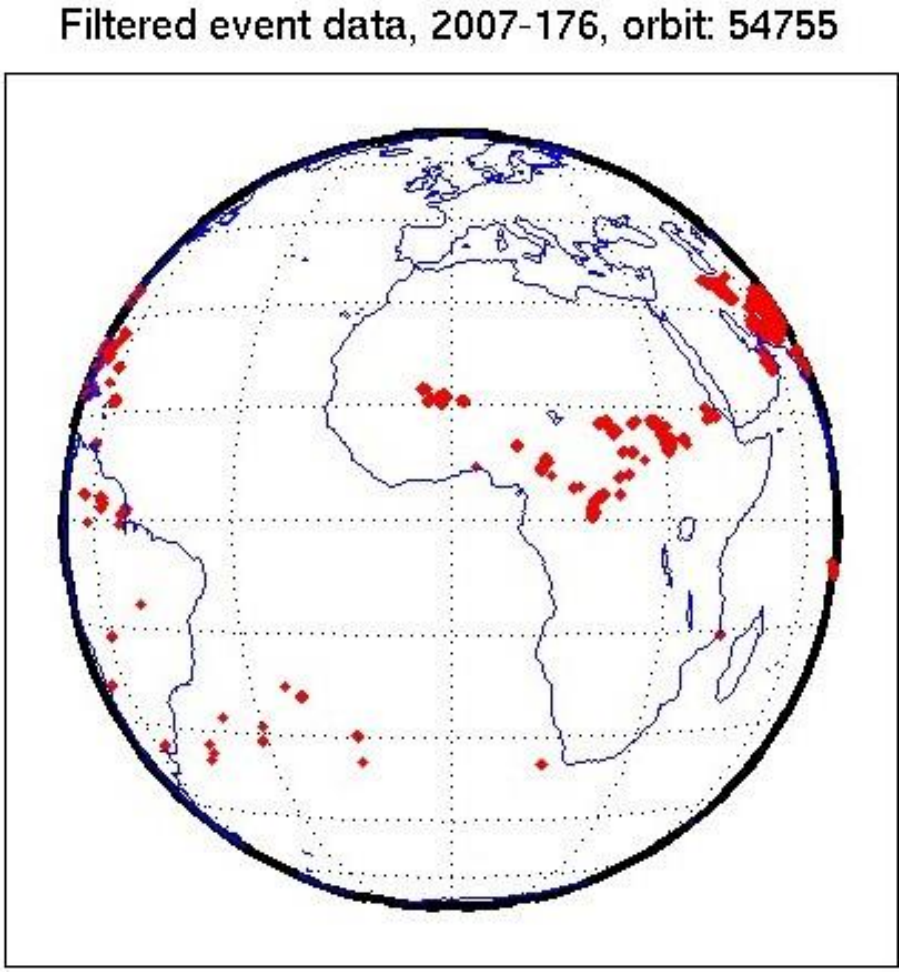


TRMM LIS events with false transients



TRMM LIS events with filtered L2 events





TRMM LIS events with false transients

TRMM LIS events with filtered L2 events

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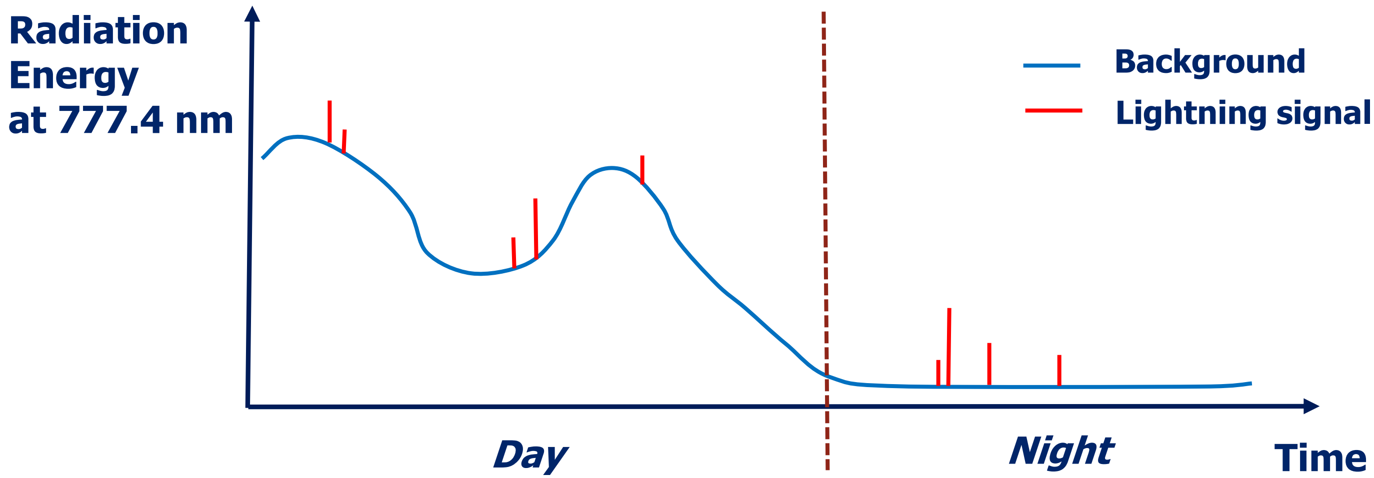
Detection of a Lightning Optical Signal

- Lightning with a background signal (bright clouds) changing with time:



- Lightning is **not recognized by its bright radiance alone, but by its transient short pulse character** (also against a bright background)

- Variable adapting threshold has to be used for each pixel which takes into account the change in the background radiance

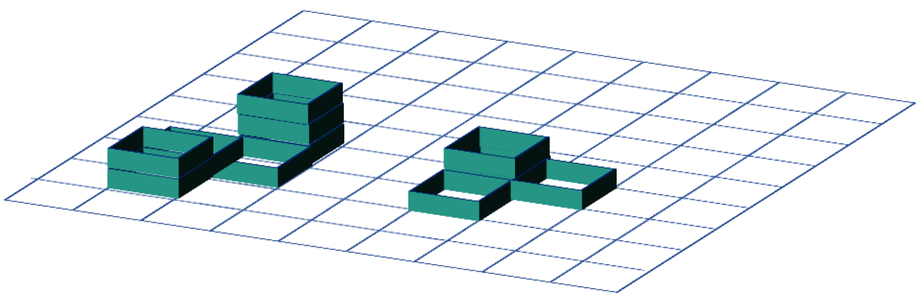
L2 Accumulated Products

- **Accumulated products:**
  - **Collecting samples from a 30 second buffer**
  - **Presented in the same 2-km grid as the imager IR channel data for easier combining with imager information**
  - **Events define the extent in the products**
  - **Flashes define the values in the products**

  - **For a longer temporal accumulation, the 30 second products can be stacked according to users' preferences**

Accumulation status at *t* = 10s

 = Events in Flash #1



Event count in density buffer (and density grid)

		3			2	1		
	1	1			1			
	2							

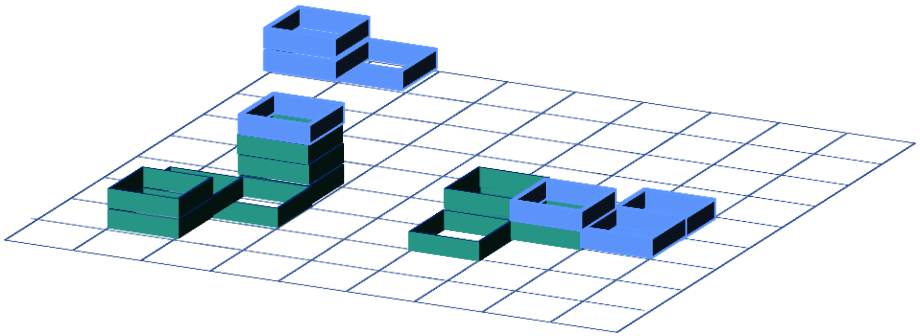
Flash count in density buffer (and density grid)

		1			1	1		
	1	1			1			
	1							

Accumulation status at *t* = 20s

= Events in Flash #1

= Events in Flash #2



Event count in density buffer (and density grid)

2	1							
							1	
		4			2	2	1	
	1	1			1			
	2							

Flash count in density buffer (and density grid)

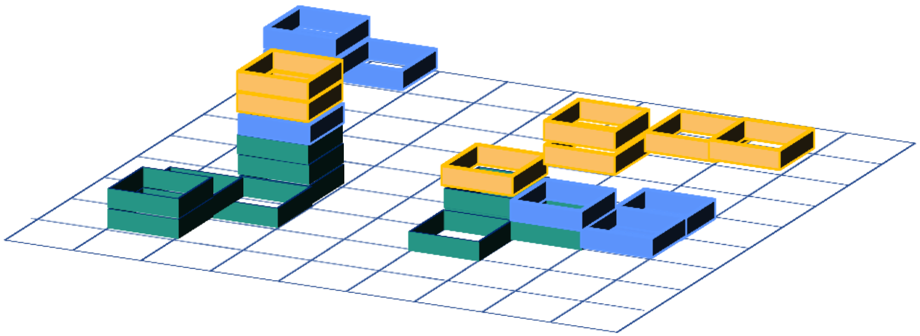
1	1							
							1	
		2			1	2	1	
	1	1			1			
	1							

Accumulation status at *t* = 30s

 **= Events in Flash #1**

 **= Events in Flash #2**

 **= Events in Flash #3**



Event count in density buffer (and density grid)

2	1							
						1	1	
					2			
							1	
		6			3	2	1	
	1	1			1			
	2							

Flash count in density buffer (and density grid)

1	1							
						1	1	
					1			
							1	
		3			2	2	1	
	1	1			1			
	1							

Accumulated product stacking

The original 30 sec product stacked into several longer time periods depending on application

Original 30 second product

Accumulated flash area product

stacking 5 products

Accumulated flash area product

2.5 min (= FCI Rapid Scanning Service FDC/4)

stacking 10 products

Accumulated flash area product

5 min (= FCI Rapid Scanning Service FDC/2)

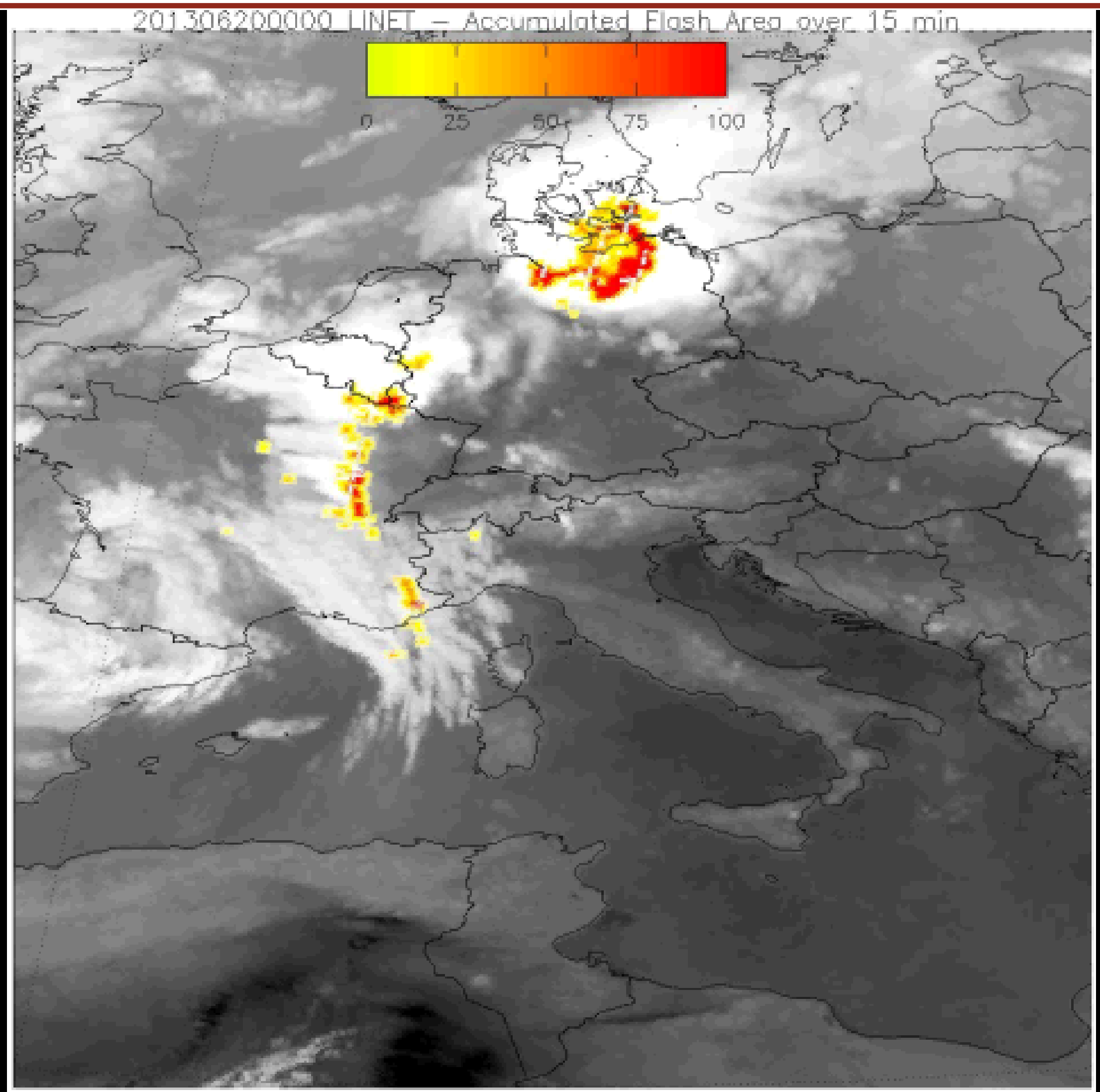
stacking 20 products

Accumulated flash area product

10 min (= FCI Full Disk Scanning Service FDC)

2nd look at the example shown in the beginning

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



EUMETSAT

MTG LI Test Data – available before launch

- MTG LI is without heritage in GEO orbit, and the closest comparable instruments are the optical lightning imagers on LEO orbits:
  - **OTD (1995-2000)**
  - **TRMM-LIS (1997-2015)**
  - **ISS-LIS (2016 -)**
- However, observations from a LEO orbit can only monitor storms for minutes instead of a continuous coverage like from GEO
- **First GEO observations to become available with the launch of GOES-R GLM in late 2016.**
- A combination of methods/data sources is needed to make the best use of test data possibilities while preparing for the LI

MTG LI test data for user familiarisation

- Based on the existing test data used for algorithm development, a **user familiarisation data set** is in development
- This will be in the **netCDF-4 format**, according to the LI L2 format specification
- Will include test data sample(s), but mainly intended for testing interfaces etc

Further information on the EUMETSAT web-pages

- MTG in general:
  - http://www.eumetsat.int/website/home/Satellites/FutureSatellites/MeteosatThirdGeneration/index.html
- MTG Lightning Imager L2 ATBD:
  - http://www.eumetsat.int/website/home/Data/TechnicalDocuments/index.html
  - There: Meteosat services $\Rightarrow$ Meteosat Third Generation (MTG) $\Rightarrow$ ATBD

Some notes on previous slide:

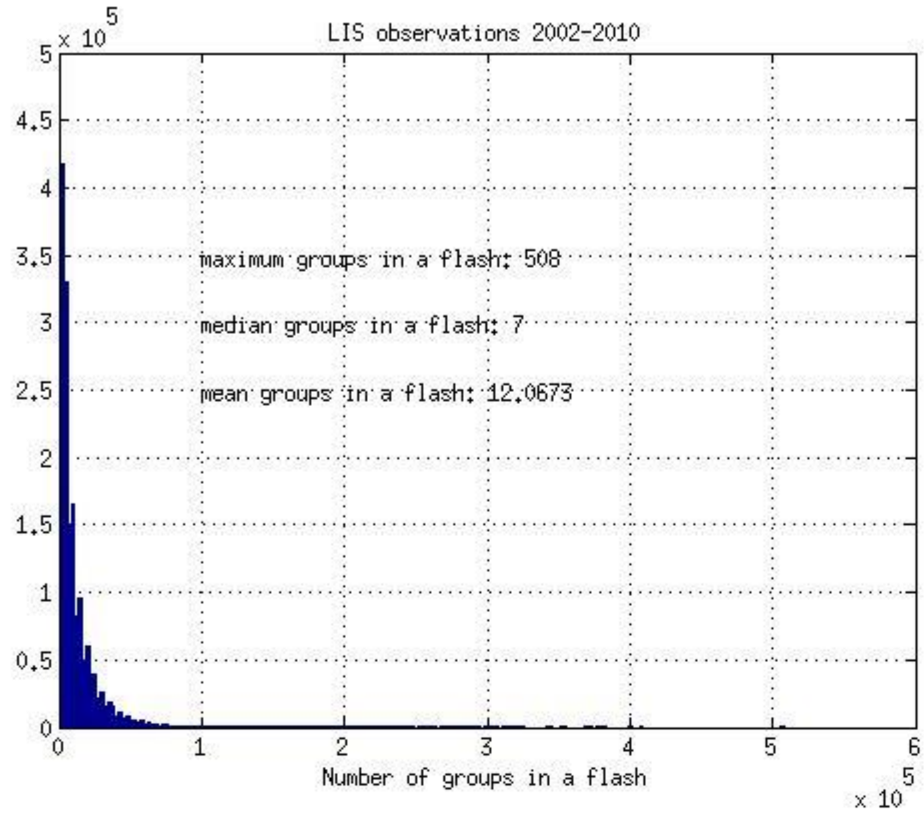
- Pulse size is based on events created around the initial GLD360 “central event”
  - **the addition of events can be a complex or a simple procedure depending on how realistic we want to get in simulating cloud scattering processes**

- Strength can either be loosely based on peak current of the “central event”, or then fully LIS distribution based

- If adding events around central pixel is done with the same procedure across the FOR, this alone would add the needed variety in pulse sizes due to viewing geometry
  - **geographical distribution is not then realistic**

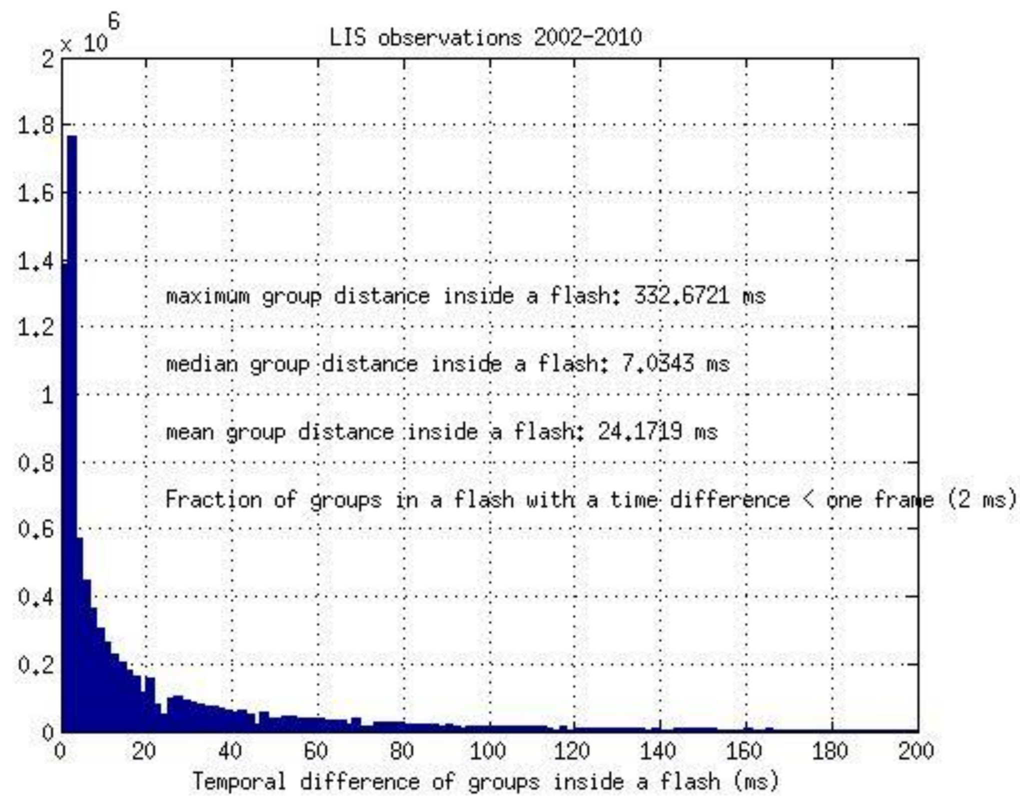
Additional strokes: number of strokes to add

- **Number of strokes to add:**
  - LIS statistics: distribution of groups per flash used
  - Exponential distribution modelled in matlab
  - Random function selects for each central stroke a number of additional strokes to add based on this modelled probability



Additional strokes: temporal distance to central stroke

- **Temporal distance to central stroke:**
  - LIS statistics: distribution of group time difference inside a flash used
  - Exponential distribution modelled in matlab
  - Random function selects for new stroke a temporal distance to the central stroke based on this modelled probability
  - The original LIS data does not have a "central stroke", so this is not a perfect solution

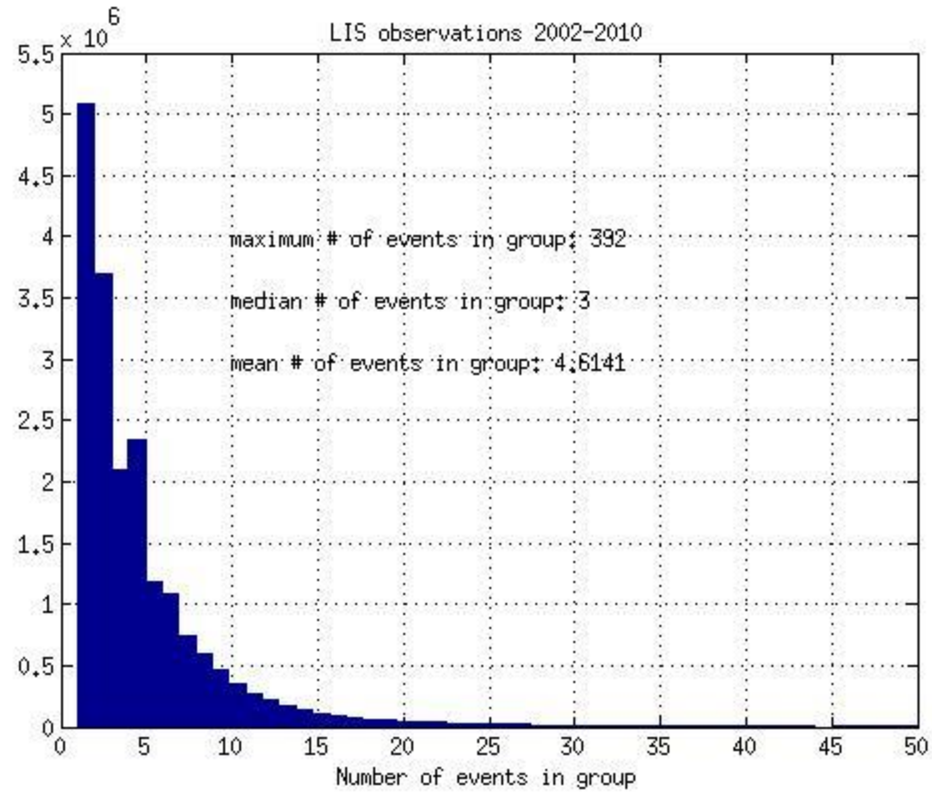


Additional strokes: spatial distance to central stroke

- **Spatial distance to central stroke:**
  - LIS statistics: no direct reference yet available (would need to be analysed)
  - Even when existing, the original LIS data does not have a “central stroke”, so this is not a perfect solution
  - Now using a simplified solution
    - random distance [0...X km] from the central stroke
    - Random azimuth direction [0...360 deg] from the central stroke
  - Random function selects for new stroke a temporal distance to the central stroke based on this modelled probability

Additional strokes: number of events created around central stroke (1)

- **Number of events created around central stroke (to form a group)**
  - LIS statistics: distribution of events in a group
  - Exponential distribution modelled in matlab
  - Random function selects how many events each stroke (“central” and “new”) should be given based on this modelled probability
  - Spatial patterns in principle random (see next slide), but all connected to central pixel/stroke either directly or through other pixels



Results – case of 3 Nov 2014 – trimming input data

30 YEARS 1986-2016

- Simulation length: 2 min
- Frame length: 2 ms [LIS case]
- Flash clustering parameters: 330 ms, 5.5 km [LIS case]

00:00 UTC

	Matlab L2 simulator output		Matlab L2 simulator output		Matlab L2 simulator output	
	Group distance 20 km hand tuning 1.2		Group distance 10 km hand tuning 1.2		Group distance 5 km hand tuning 1.2	
	Total	Ratio	Total	Ratio	Total	Ratio
Flashes	5261	1	2603	1	1835	1
Groups	13509	2.6	13344	5.1	13103	7.1
Events	78312	14.9	84628	32.5	84628	46.1
fl/s in full disk area	43.8		21.7		15.3	

- *Notes:*
  - *As number of added strokes/events in the process is a distribution based random process, variations in stroke/event numbers do occur in otherwise identical cases*
  - ***"Group distance"** variable causes the number of flashes to increase as new strokes are placed too far to be clustered all in the same flash*
  - ***"hand tuning"** variable modifies the added_strokes distribution to fit better in the LIS results after running L2 prototype processor. It adds strokes (and therefore events) but does not directly impact the number of flashes.*

Results – case of 3 Nov 2014 – trimming input data

- Simulation length: 2 min
- Frame length: 2 ms [LIS case]
- Flash clustering parameters: 330 ms, 5.5 km [LIS case]

17:00 UTC

	Matlab L2 simulator output		Matlab L2 simulator output		Matlab L2 simulator output	
	Group distance 20 km hand tuning 1.2		Group distance 10 km hand tuning 1.2		Group distance 5 km hand tuning 1.2	
	Total	Ratio	Total	Ratio	Total	Ratio
Flashes	17588	1	8296	1	5200	1
Groups	46653	2.7	42933	5.2	43186	8.3
Events	263943	15.0	260302	31.4	270546	52.0
fl/s in full disk area	146.6		69.1		43.3	

- *Notes:*
  - *As number of added strokes/events in the process is a distribution based random process, variations in stroke/event numbers do occur in otherwise identical cases*
  - ***"Group distance"** variable causes the number of flashes to increase as new strokes are placed too far to be clustered all in the same flash*
  - ***"hand tuning"** variable modifies the added_strokes distribution to fit better in the LIS results after running L2 prototype processor. It adds strokes (and therefore events) but does not directly impact the number of flashes.*

Results – case of 3 Nov 2014 – LIS reference

- Simulation length: 10 min
- Frame length: 2 ms [LIS case]
- Flash clustering parameters: 330 ms, 5.5 km [LIS case]

LIS reference

	LIS true output (full 24 hours) (*)	
	Total	Ratio
Flashes	4847	1
Groups	54001	11
Events	229144	47
fl/s in full disk area	(not possible to compute as LIS is sampling only)	

- *(*) NOTE: the LIS statistics for the same day are just given for reference – they are for the full 24 hours (not for 10 min like the simulated data) and due to LEO sampling are not comparable in any way except in a broad statistical sense*

Results – case of 3 Nov 2014 – trimming input data

- Simulation length: 2 min
- Frame length: 2 ms [LIS case]
- Flash clustering parameters: 330 ms, 5.5 km [LIS case]

00:00 UTC

	Matlab L2 simulator output		Matlab L2 simulator output		Matlab L2 simulator output	
	Group distance 10 km Stroke hand tuning 1.2		Group distance 10 km Stroke hand tuning 1.4		Group distance 10 km Stoke hand tuning 2.0	
	Total	Ratio	Total	Ratio	Total	Ratio
Flashes	2603	1	2763	1	2696	1
Groups	13344	5.1	14393	5.2	18251	6.8
Events	84628	32.5	91530	33.1	128375	47.6
fl/s in full disk area	21.7		23.0		22.5	

- *Notes:*
  - *As number of added strokes/events in the process is a distribution based random process, variations in stroke/event numbers do occur in otherwise identical cases*
  - ***"Group distance"** variable causes the number of flashes to increase as new strokes are placed too far to be clustered all in the same flash*
  - ***"Stroke hand tuning"** variable modifies the added strokes distribution to fit better in the LIS results after running L2 prototype processor. It adds strokes (and therefore events) but does not directly impact the number of flashes.*

Results – case of 3 Nov 2014 – trimming input data

- Simulation length: 2 min
- Frame length: 2 ms [LIS case]
- Flash clustering parameters: 330 ms, 5.5 km [LIS case]

00:00 UTC

	Matlab L2 simulator output		Matlab L2 simulator output		Matlab L2 simulator output	
	Group distance 7.5 km Stroke hand tuning 1.2		Group distance 7.5 km Stroke hand tuning 1.4		Group distance 7.5 km Stroke hand tuning 2.0	
	Total	Ratio	Total	Ratio	Total	Ratio
Flashes	2162	1	2201	1	2282	1
Groups	12828	5.9	14953	6.8	17911	7.8
Events	79221	36.6	97867	44.5	128634	56.4
fl/s in full disk area	18.0		18.3		19.0	

- *Notes:*
  - *As number of added strokes/events in the process is a distribution based random process, variations in stroke/event numbers do occur in otherwise identical cases*
  - ***"Group distance"** variable causes the number of flashes to increase as new strokes are placed too far to be clustered all in the same flash*
  - ***"stroke hand tuning"** variable modifies the added strokes distribution to fit better in the LIS results after running L2 prototype processor. It adds strokes (and therefore events) but does not directly impact the number of flashes.*

Results – case of 3 Nov 2014 – trimming input data

- Simulation length: 2 min
- Frame length: 2 ms [LIS case]
- Flash clustering parameters: 330 ms, 5.5 km [LIS case]

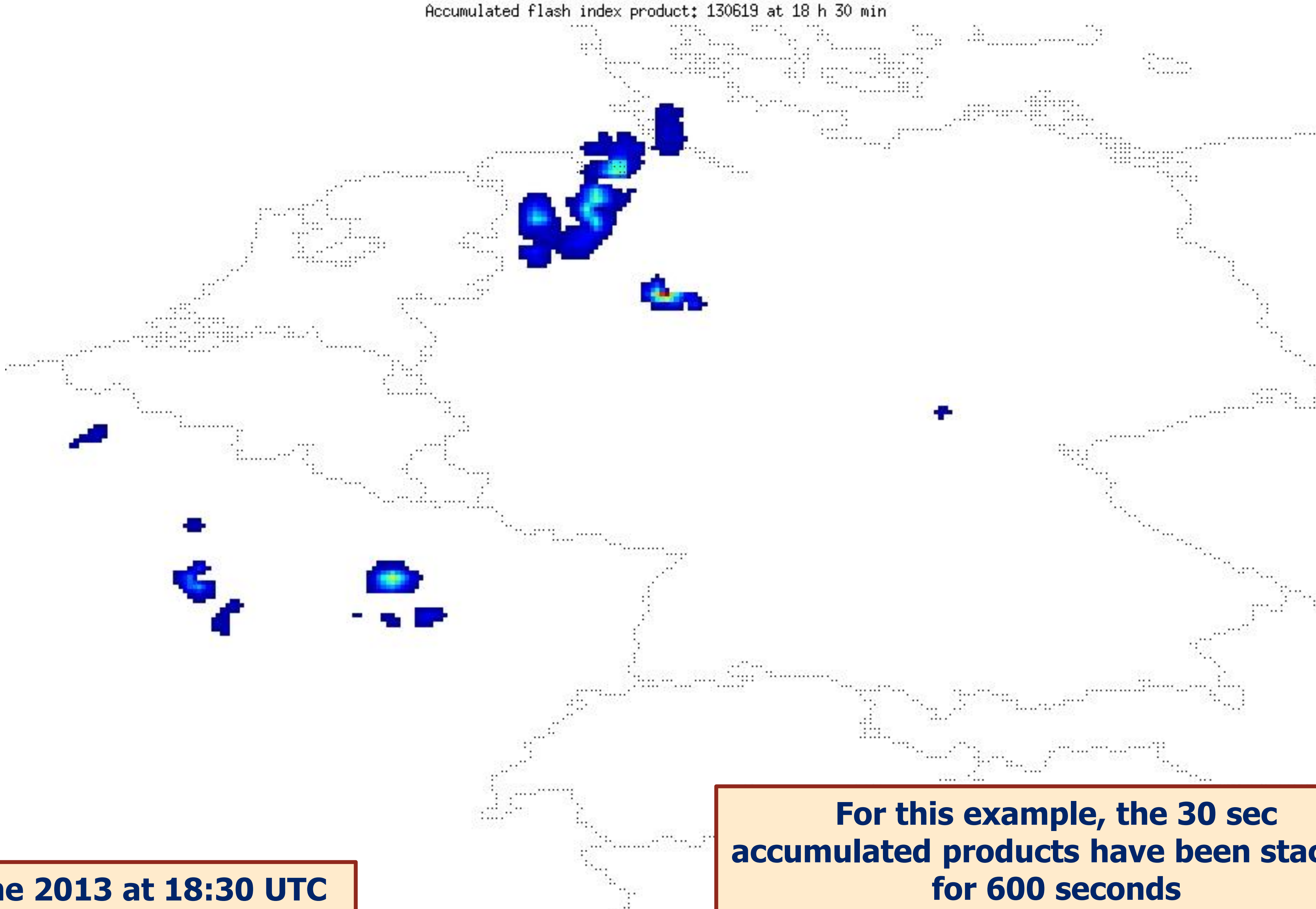
00:00 UTC

	Matlab L2 simulator output		Matlab L2 simulator output		Matlab L2 simulator output	
	Group distance 5 km Stroke hand tuning 1.2		Group distance 5 km Stroke hand tuning 1.4		Group distance 5 km Stroke hand tuning 2.0	
	Total	Ratio	Total	Ratio	Total	Ratio
Flashes	1793	1	1797	1	1782	1
Groups	12137	6.8	14803	8.2	17962	10.1
Events	76373	42.6	98902	55.0	130791	73.4
fl/s in full disk area	14.9		15.0		14.9	

- *Notes:*
  - *As number of added strokes/events in the process is a distribution based random process, variations in stroke/event numbers do occur in otherwise identical cases*
  - ***"Group distance"** variable causes the number of flashes to increase as new strokes are placed too far to be clustered all in the same flash*
  - ***"Stroke hand tuning"** variable modifies the added strokes distribution to fit better in the LIS results after running L2 prototype processor. It adds strokes (and therefore events) but does not directly impact the number of flashes.*

Example accumulated product – test data example (1)

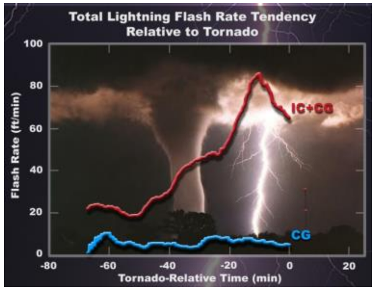
YEARS 1986-2016



19 June 2013 at 18:30 UTC

For this example, the 30 sec accumulated products have been stacked for 600 seconds

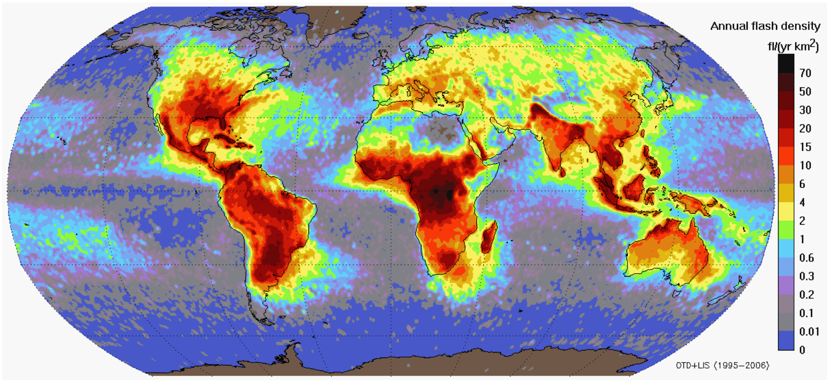
Lightning – Why do we observe it?



Lightning is a precursor of severe weather – where total lightning is the parameter to observe

Severe weather and lightning strikes are a big threat to public (and not only aviation)

One method of assessing the impact of climate change on thunderstorm activity is to globally monitor and analyse the long-term lightning characteristics.

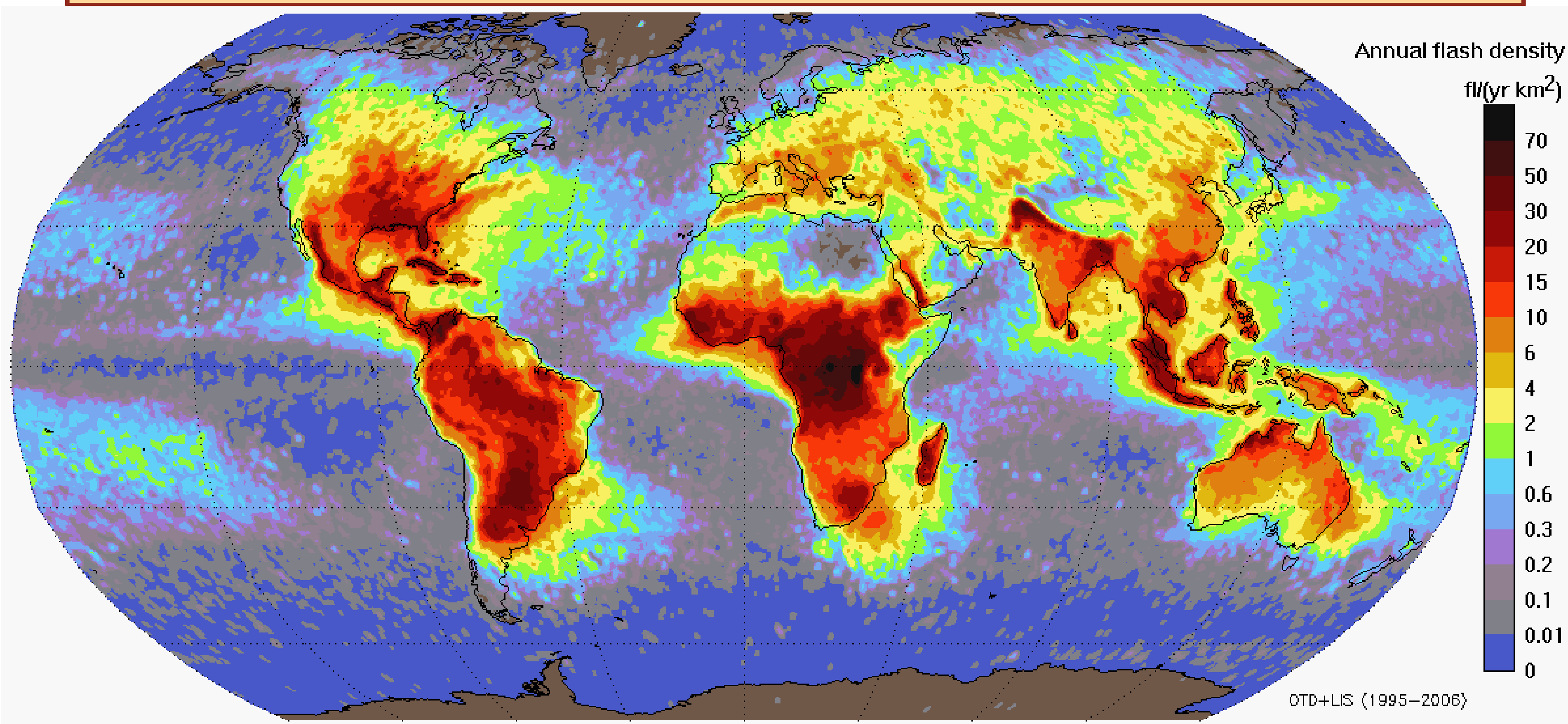


EUMETSAT

Lightning Detection from Space – from LEO to GEO

Lightning detection from space by optical sensors from the Optical Transient Detector (OTD) and Lightning Imaging Sensor (LIS)

1995-2015 !!



Results from LIS/OTD: Global lightning distribution - Annual flash density

Issues to consider: FALSE events...

- The LI observes the rapid changes wrt background (transient short pulse character)

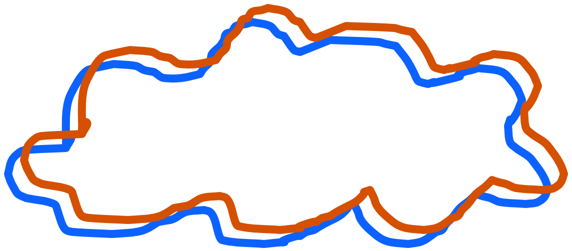
- This leads to:
  - Triggered events caused by lightning
  - Triggered events caused by something else

- The ratio of False/True events can be up to 99% / 1%

- Filtering steps needed for making data useful

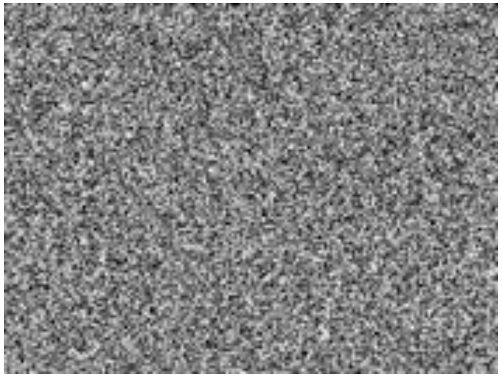
False transients are mainly caused by:

- Microvibrations affecting e.g. cloud edges



- Charged particles

- Electronics noise



International collaboration

- Strong & active interest for collaboration between the various lightning related missions
    - **MTG LI**
    - **GOES-R GLM**
    - **ISS-LIS**
    - **ESA ASIM**
    - **TARANIS**
    - **...**

- For MTG LI, the main forum for interaction is through the LI Mission Advisory Group (LI MAG)