Meteosat Third Generation Lightning Imager (MTG LI)

Status Update

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GLM Science Team

19-21 September 2012

(through Webex)

Topics of Presentation

- Quick introduction to Meteosat Third Generation (MTG)
- MTG LI instrument status update
- Lightning Imager Science Team (LIST)
- Examples of LIST studies supporting LI L1/L2 processor development
  - **EUMETSAT contribution to the CHUVA campaign (LINET measurements)**
  - **LIProxy – tool for proxy data development and LI simulation**
- Summary

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Short Introduction to the MTG Programme

MTG-I; 4 satellites

MTG-S; 2 satellites

Courtesy of

ThalesAlenia Space
A Thales / Finmeccanica Company

EUM/MTG/VWG/12/0865
GLM Science team meeting
19-21 Sep 2012, Huntsville, Alabama

EUMETSAT

MTG to Secure Continuity and Evolution of EUMETSAT Services

1977 — 2002 — 2017 and 2019

MOP/MTP

MOP/MTP

MSG

MSG

MTG-I and MTG-S

Observation mission:
- **MVIRI: 3 channels**

Spinning satellite
Class 800 kg

Observation missions:
- **SEVIRI: 12 channels**
- **GERB**

Spinning satellite
Class 2-ton

Observation missions:
- **Flex.Comb. Imager: 16 channels**
- **Infra-Red Sounder**
- **Lightning Imager**
- **UVN**

3-axis stabilised satellites
Twin Sat configuration
Class 3.6-ton

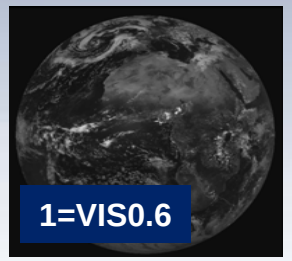
Implementation of the EUMETSAT Mandate for the Geostationary Programme

Atmospheric Chemistry Mission (UVN-S4): via GMES Sentinel 4
(Ultraviolet Visible Near-infrared spectrometer)

MTG Space Segment Configuration

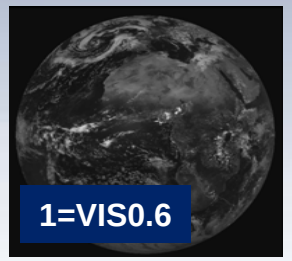
- Twin Satellite Concept, based on 3-axis platforms
  - 4 Imaging Satellites (MTG-I) (20 years of operational services)
  - 2 Sounding Satellites (MTG-S) (15.5 years of operational services)
- Payload complement of the MTG-I satellites
  - The Flexible Combined Imager (FCI)
  - The Lightning Imager (LI)
  - The Data Collection System (DCS) and Search and Rescue (GEOSAR)
- Payload complement of the MTG-S satellites
  - The Infrared Sounder (IRS)
  - The Ultra-violet, Visible and Near-infrared Sounder (UVN)

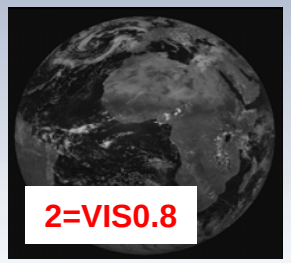
From MVIRI through SEVIRI to FCI on MTG 1977

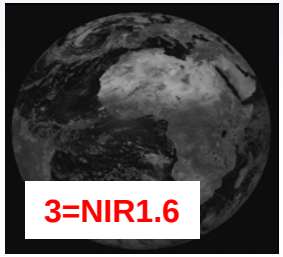


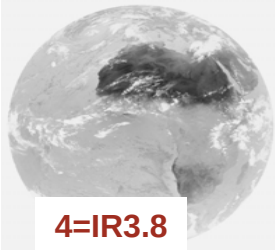
12=HRV

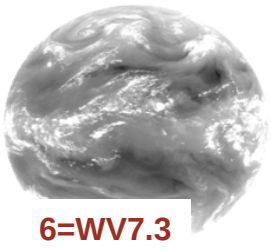
From MVIRI through SEVIRI to FCI on MTG
1977 -> 2002

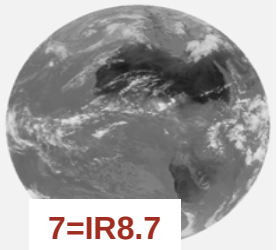


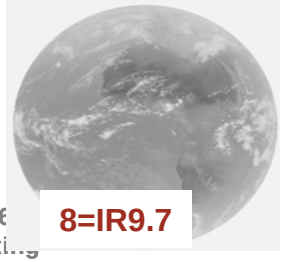


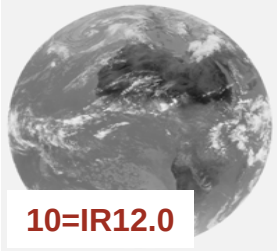




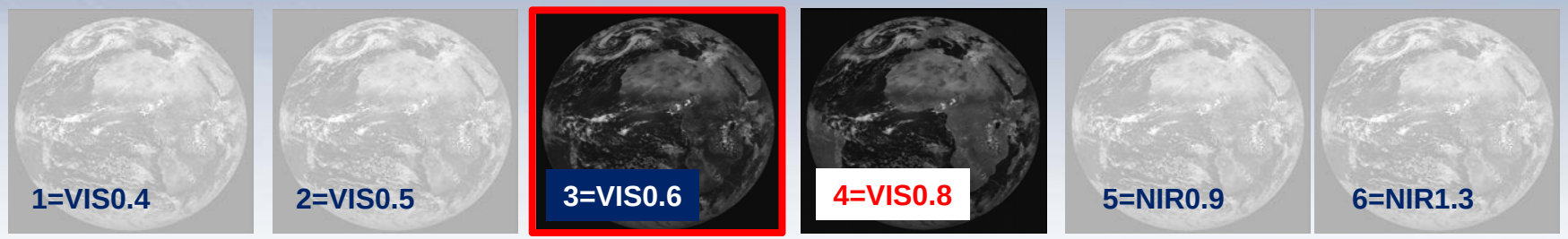




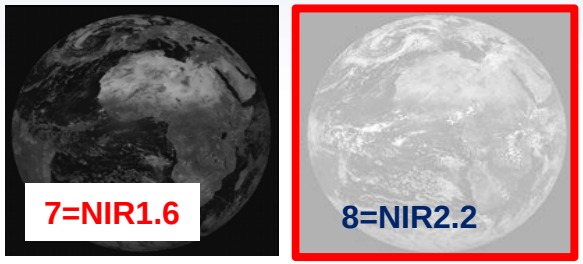




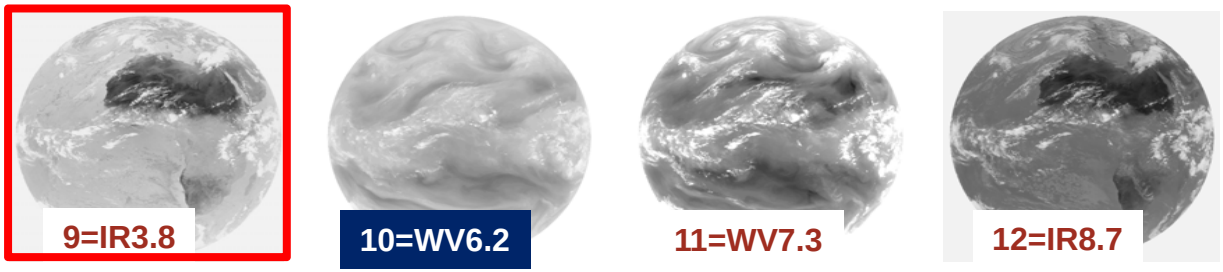
From MVIRI through SEVIRI to FCI on MTG
1977 -> 2002 -> 2018

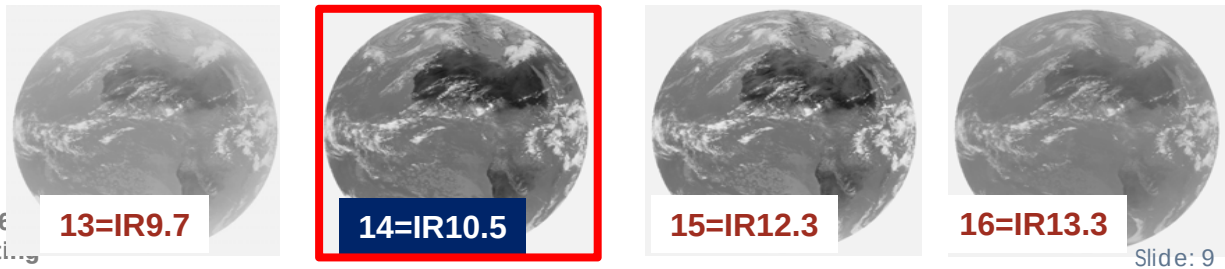


FCI-FDSS:
8 solar channels at 1km
8 thermal channels at 2km



FCI-RSS:
2 solar/thermal channels
at
0.5 km/1.0 km





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Lightning Imager (LI) Status Update (1)

- The MTG satellite PDR (Preliminary Design Review) was held in May 2012.
  - The LI instrument was not part of this review, only MTG-LI interface requirement documents were reviewed.

- LI industrial consortium consolidated via ITT, concluded by April 2012.
- LI instrument prime contractor is Selex Galileo in Italy.
- LI mission prime activities are still to be allocated.
  - This includes the 0-1b data processing software.
  - These activities will most likely be allocated to either Thales (MTG prime contractor) or to Selex Galileo (TBC).

Lightning Imager (LI) Status Update (2)

- **MTG LI Phase B2 has been kicked off:**
  - **beginning of July 2012**
- **Selex Galileo are preparing for SRR (System Requirements Review):**
  - **end October 2012**
- **LI instrument PDR (Preliminary Design Review)**
  - **not before October 2013.**

Lightning Imager (LI) main characteristics

LI main characteristics:

- Coverage about equal to visible disc (instantaneous view).
- Continuous measurements of triggered events / lightning triggered events.
- Continuous measurements of background images, typically one every minute.
- Data rate <30 Mbps; Mass < 110Kg; Power < 320W.
- Ground pixel size required < 10 km at 45 degrees latitude
- Measurements at 777.4 nm with 1.5-2.0 nm spectral bandpass filter.

Challenge for processing: “False Events” (noise)

- Noise can be (instrument) internal or external depending on the mechanism

- **“Internal” noise:**
  - Electronic noise
  - Thermo-mechanical noise
  - Stray light noise
  - Ghost noise?

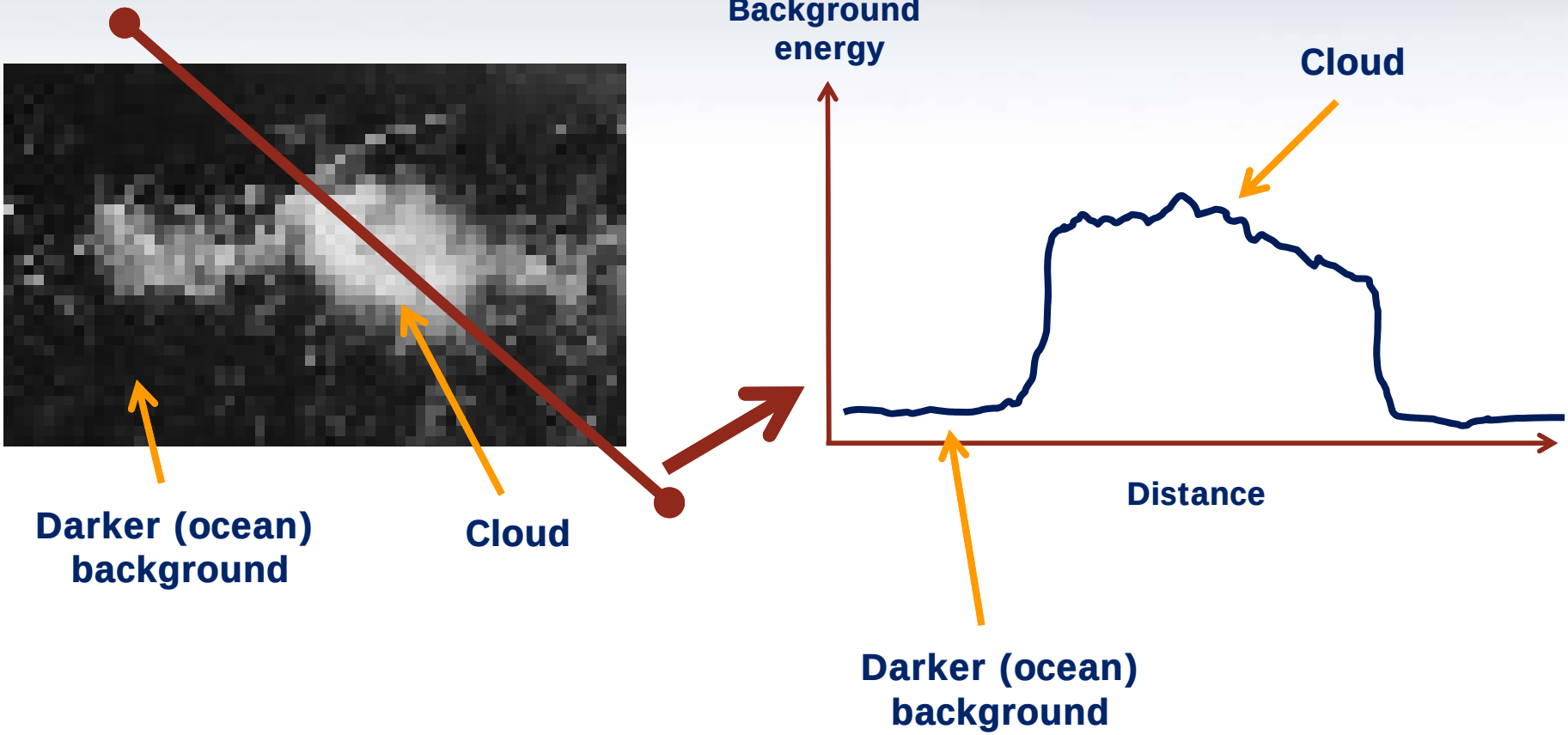
- **“External” noise:**
  - Jitter (spacecraft motion)
  - Cloud radiation (background in general)
  - Sun glint
  - Particles flux

Rough order of severity (based on GLM analysis):

Spacecraft motion, Photon/electronics noise, Sun glint, Radiation

Effect of Microvibrations ("jitter") on Lightning Detection

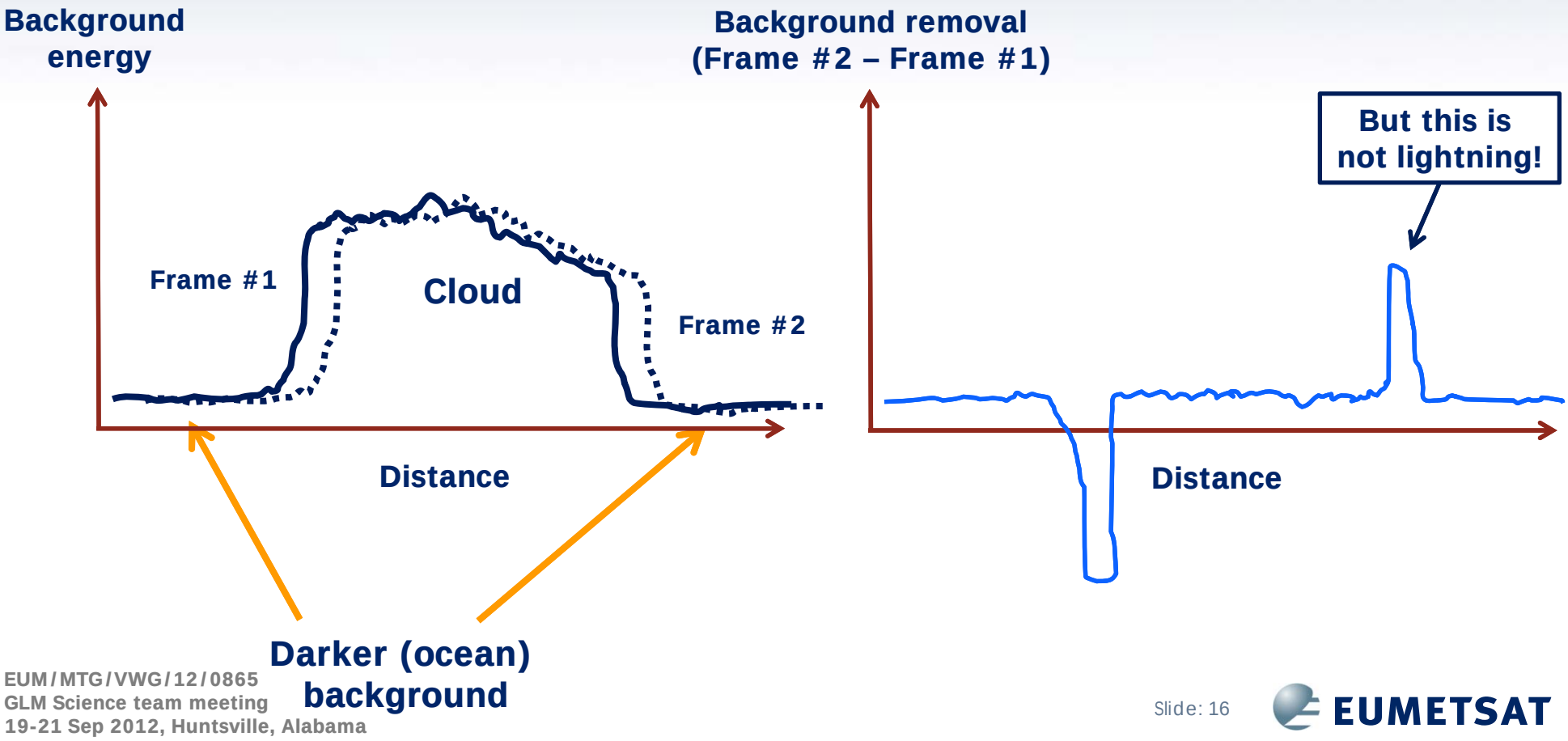
Assuming that this is what the Lightning Imager is looking at...



EUMETSAT

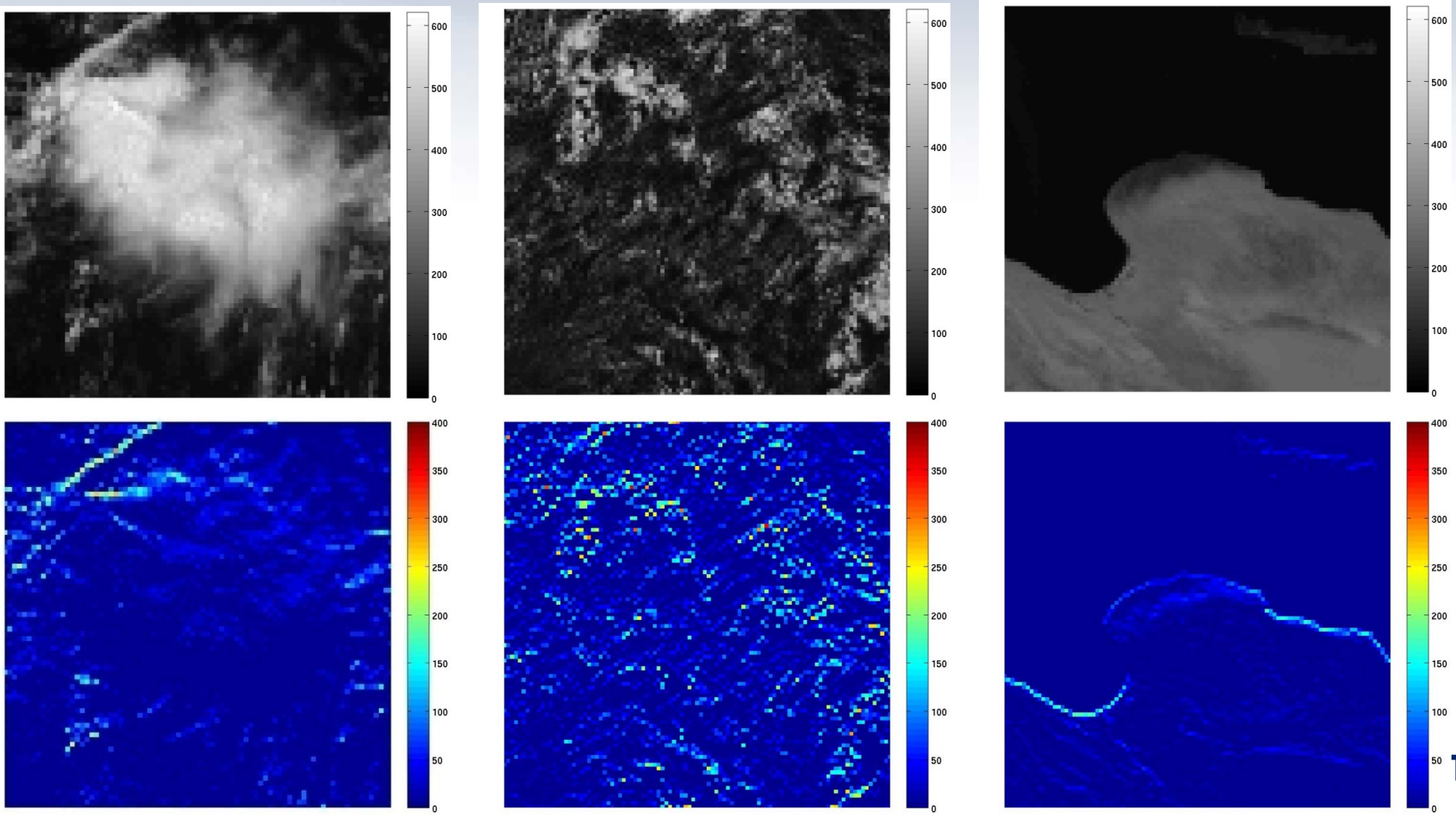
Effect of Microvibrations ("jitter") on Lightning Detection

What if the instrument (satellite) moves slightly between integration frames...?

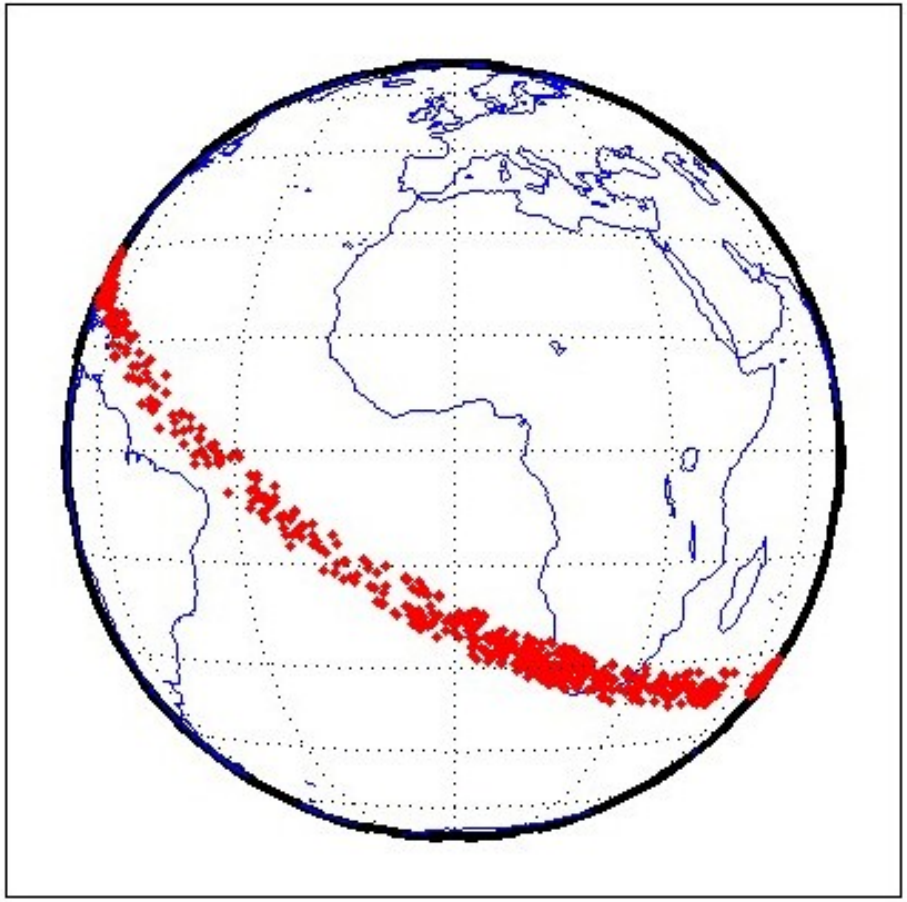


Close-up of jitter cases – full 6 km pixel movement (corresponding to 168 µrad !! – illustration only)

Cloud #1 | **Cloud #1** | **Coastline**



Noisy event data, 2007-176, orbit: 54740



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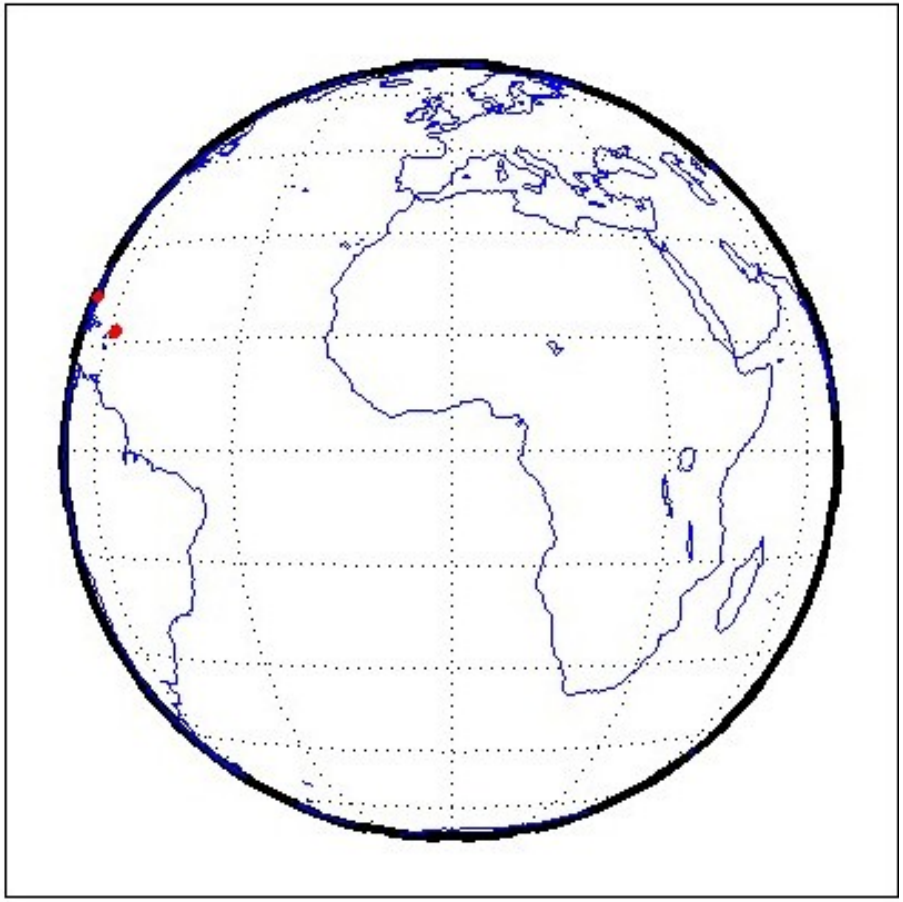


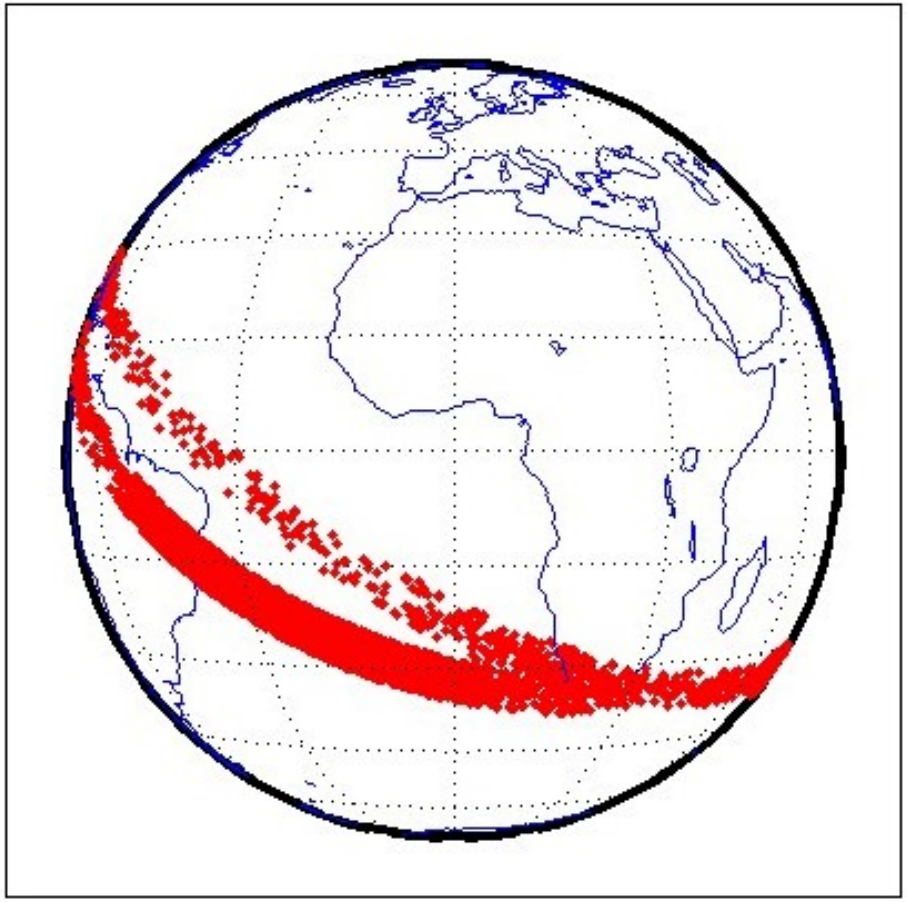
Geolocated events but with all filters switched off
(data provided by Dennis Buechler / Doug Mach)

**Effect of filtering => **

L2 events where all filters have been applied

Overall rejection rate for this data set ~80 %

Noisy event data, 2007-176, orbit: 54741



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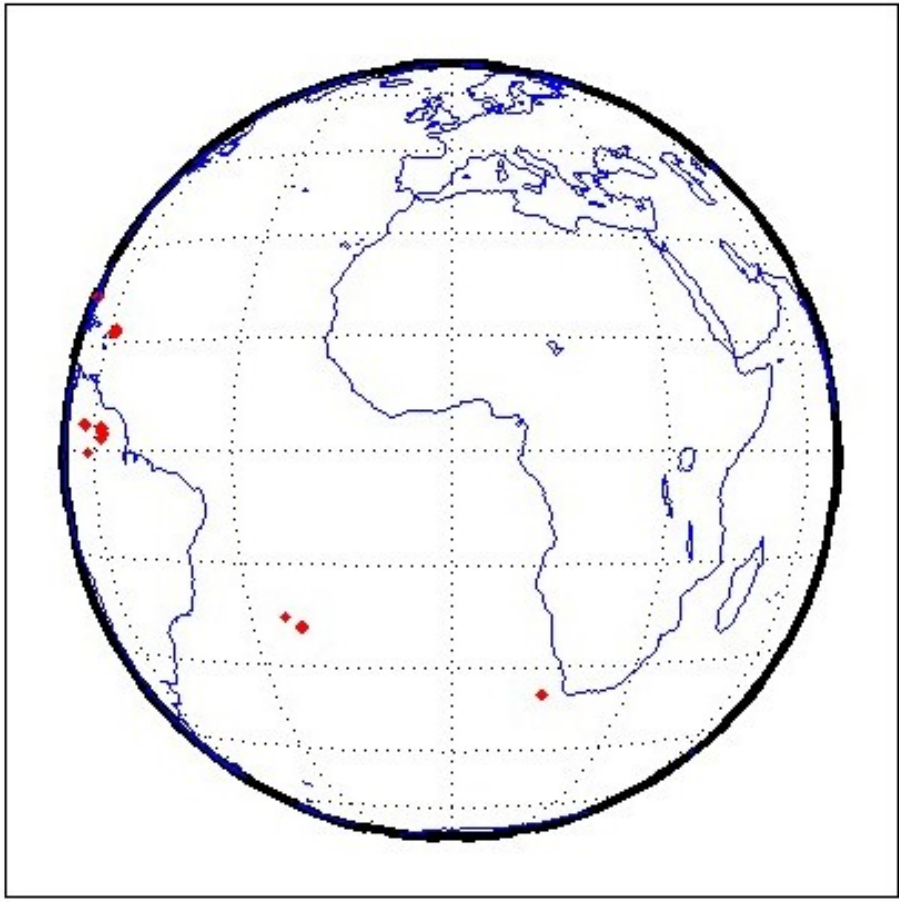

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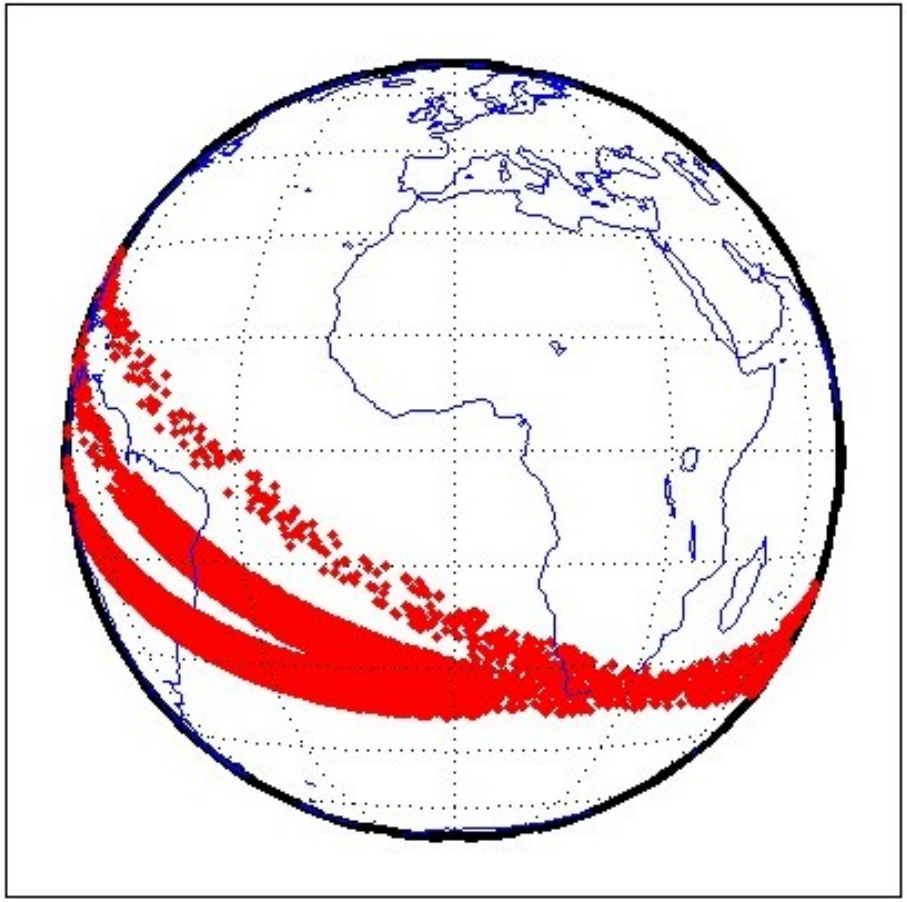

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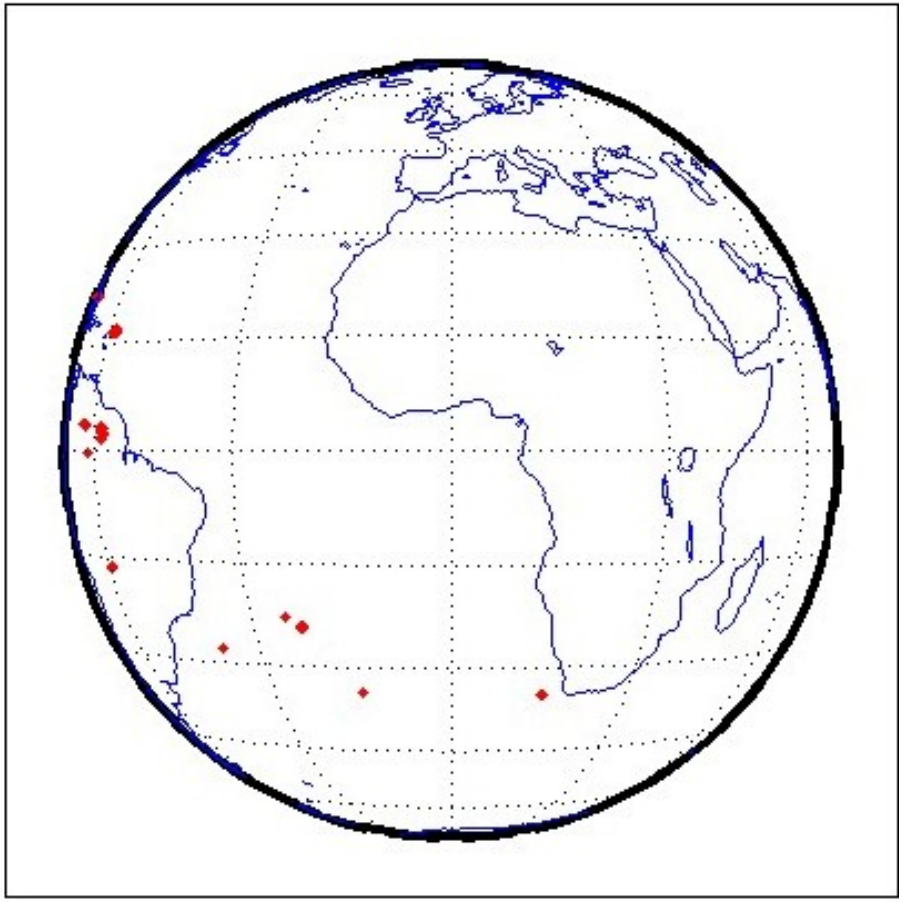

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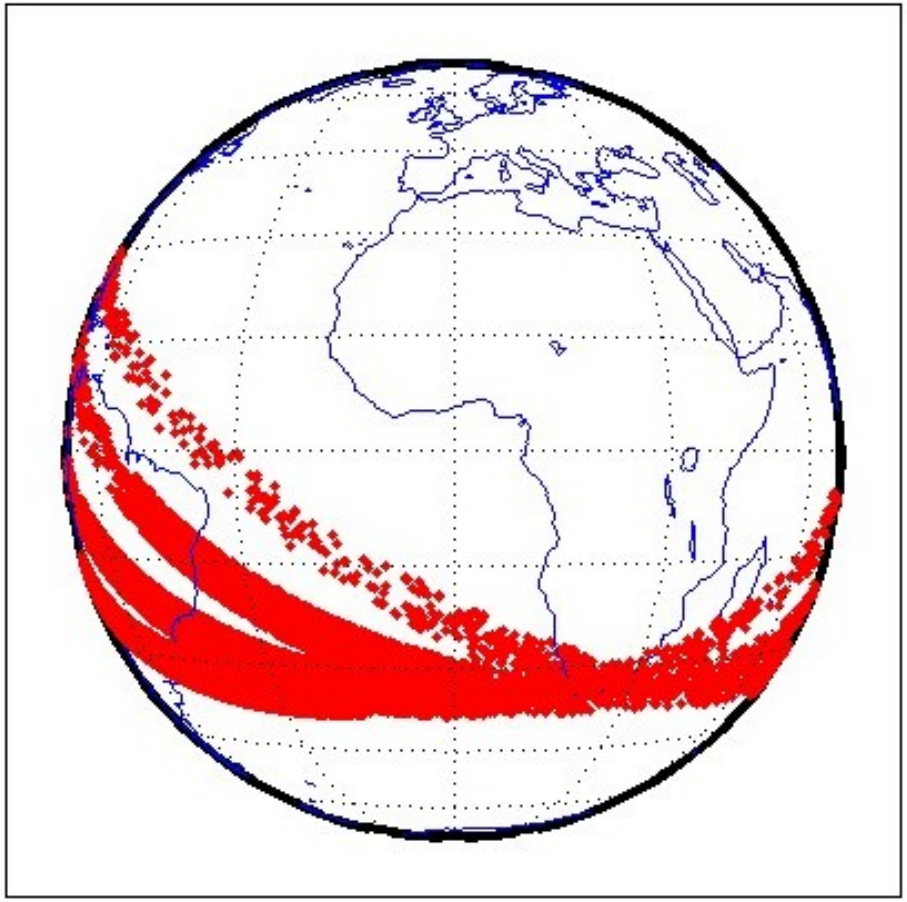

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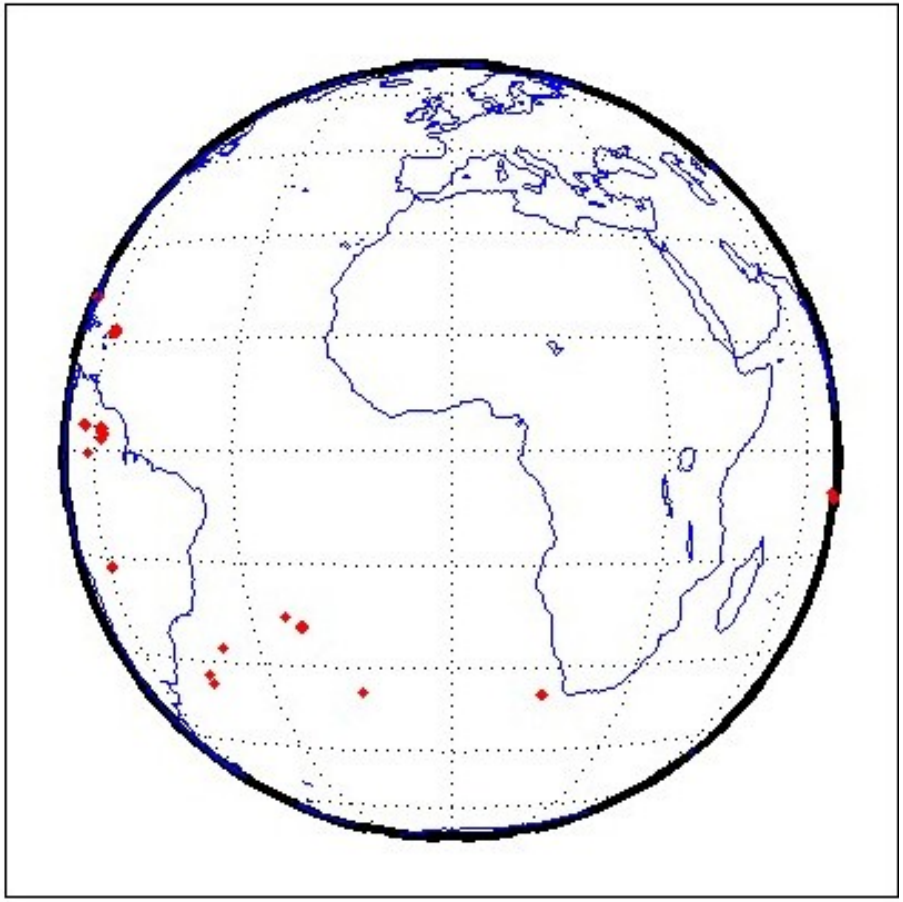

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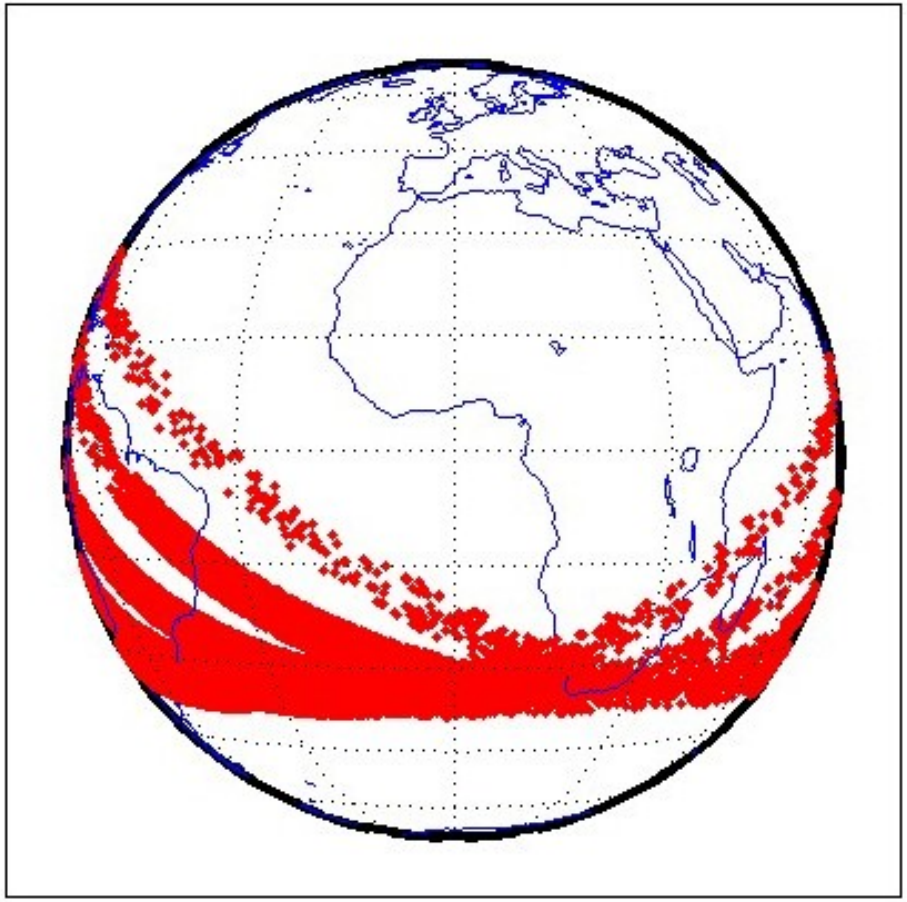

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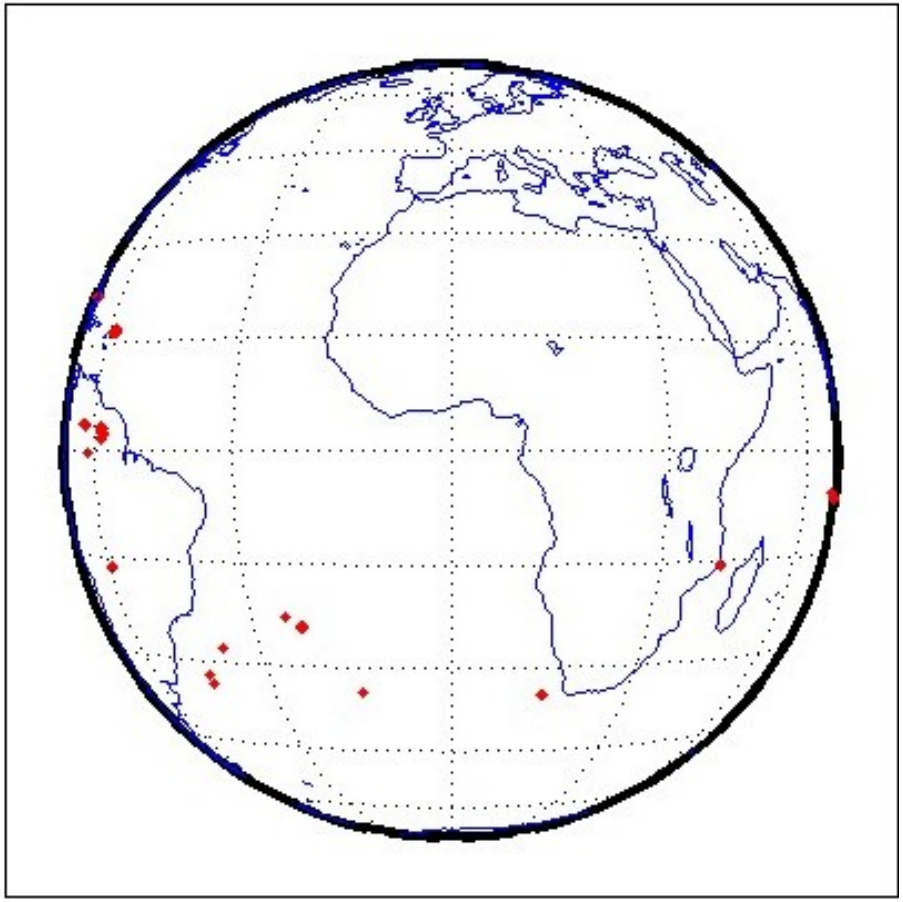

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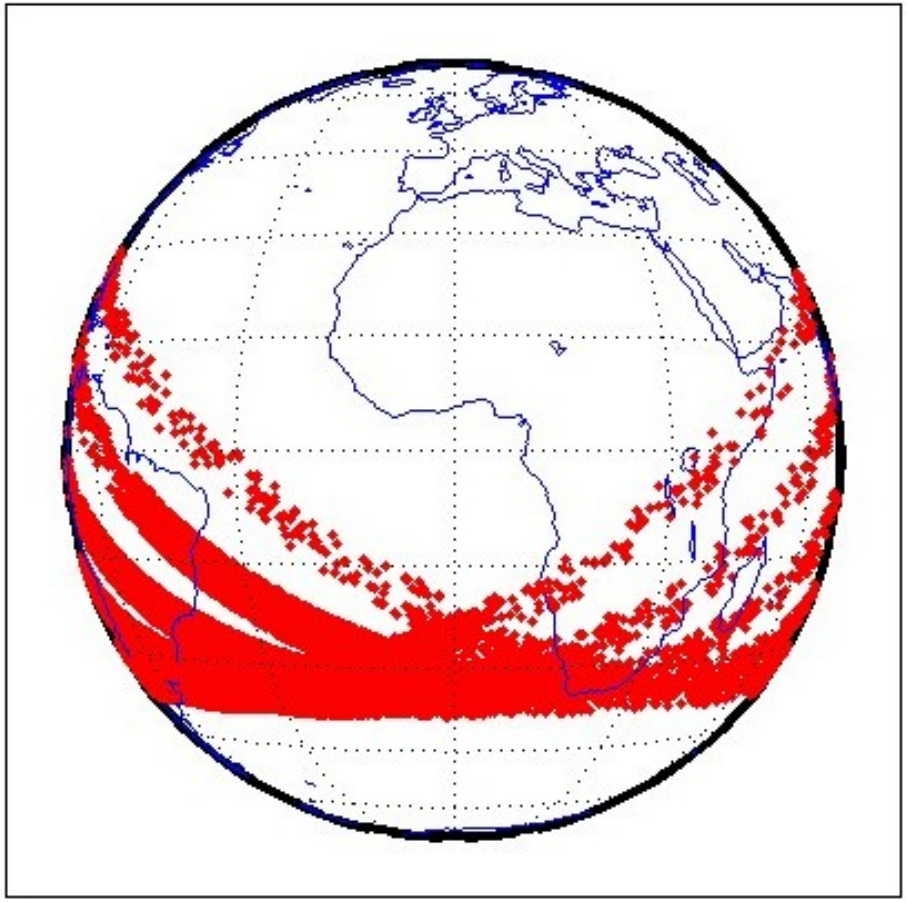

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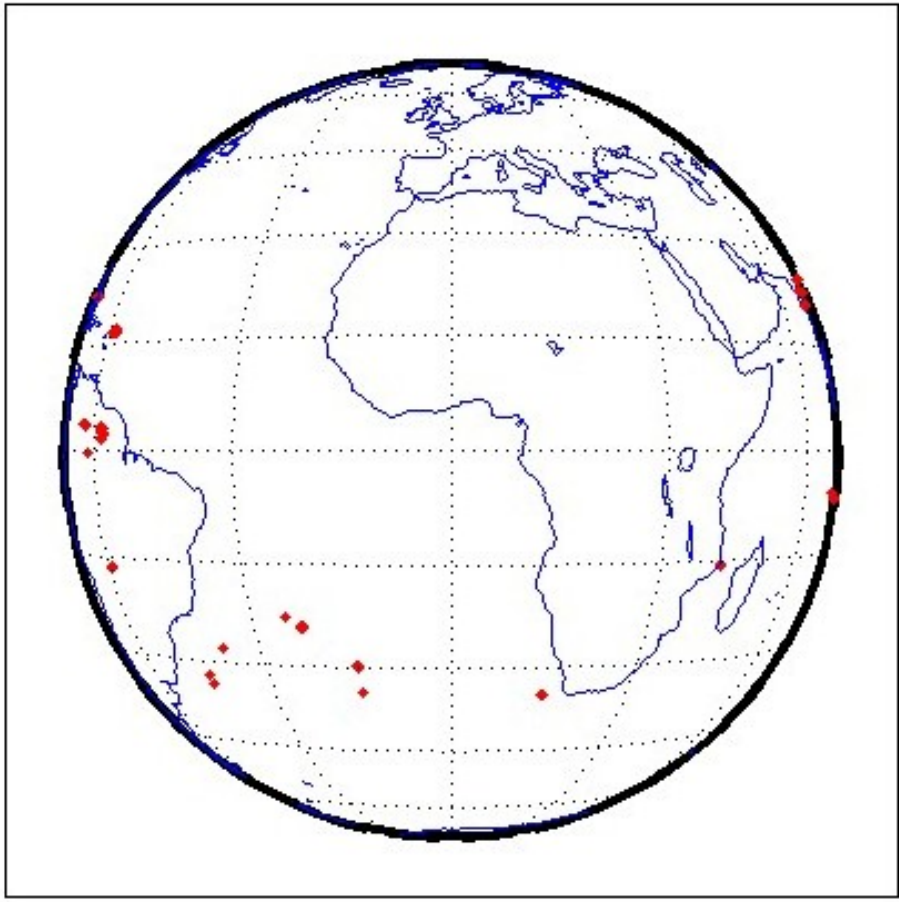

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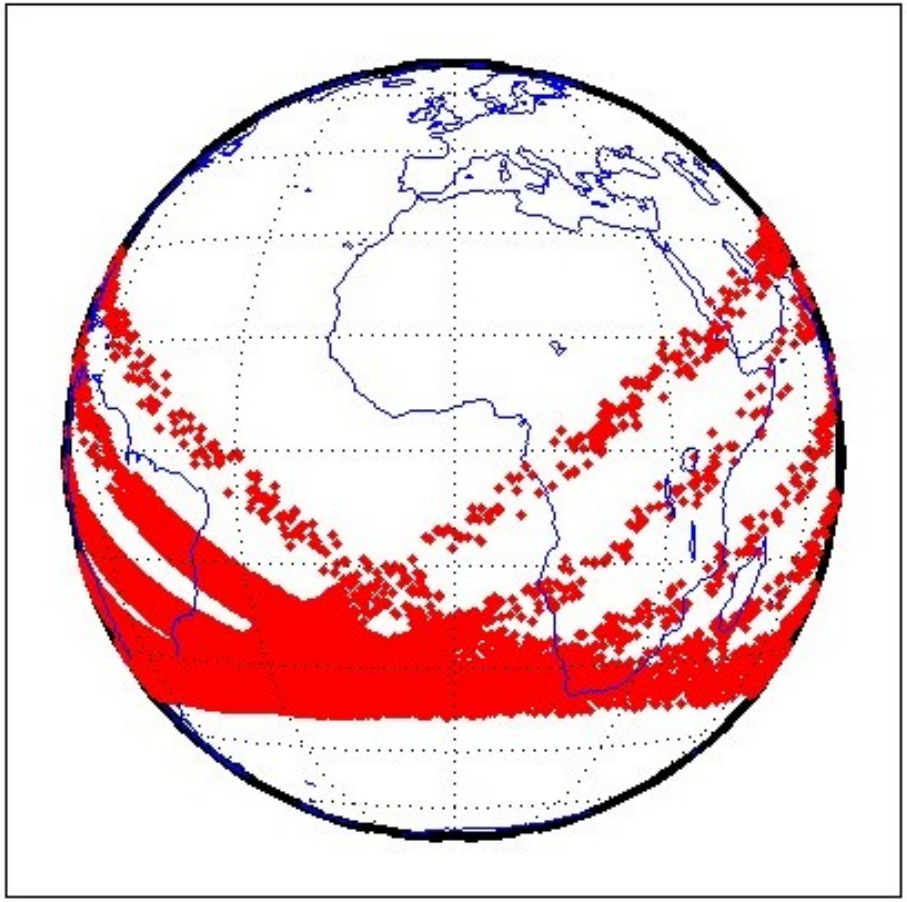

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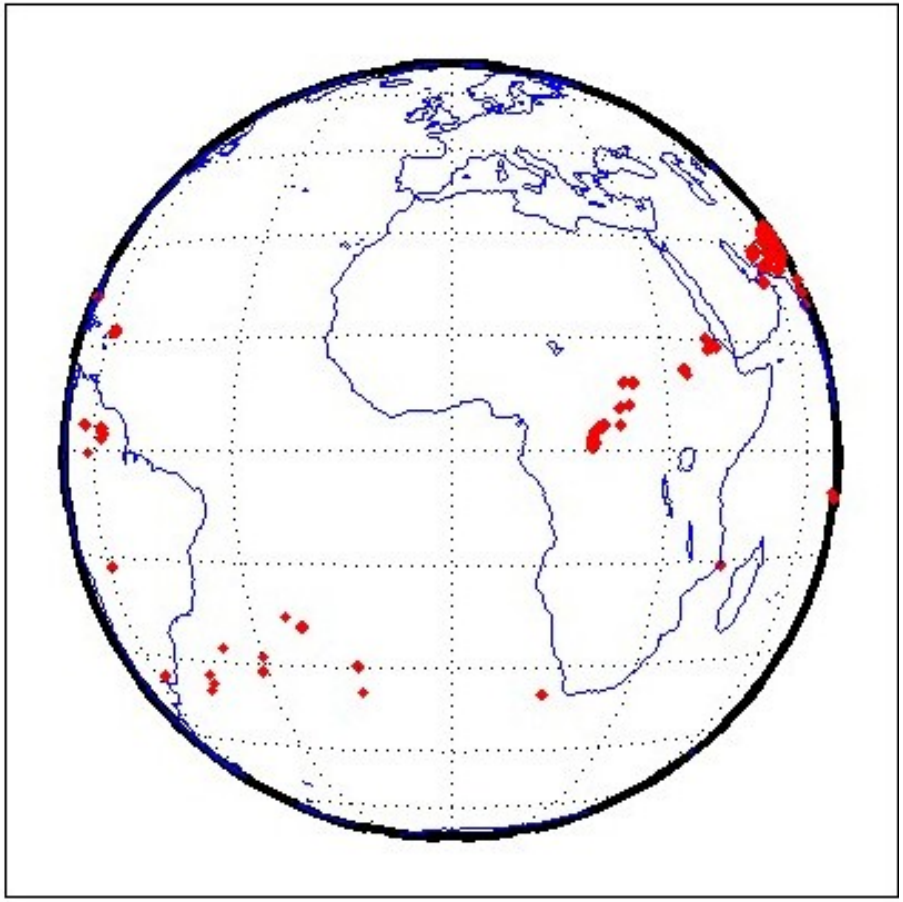

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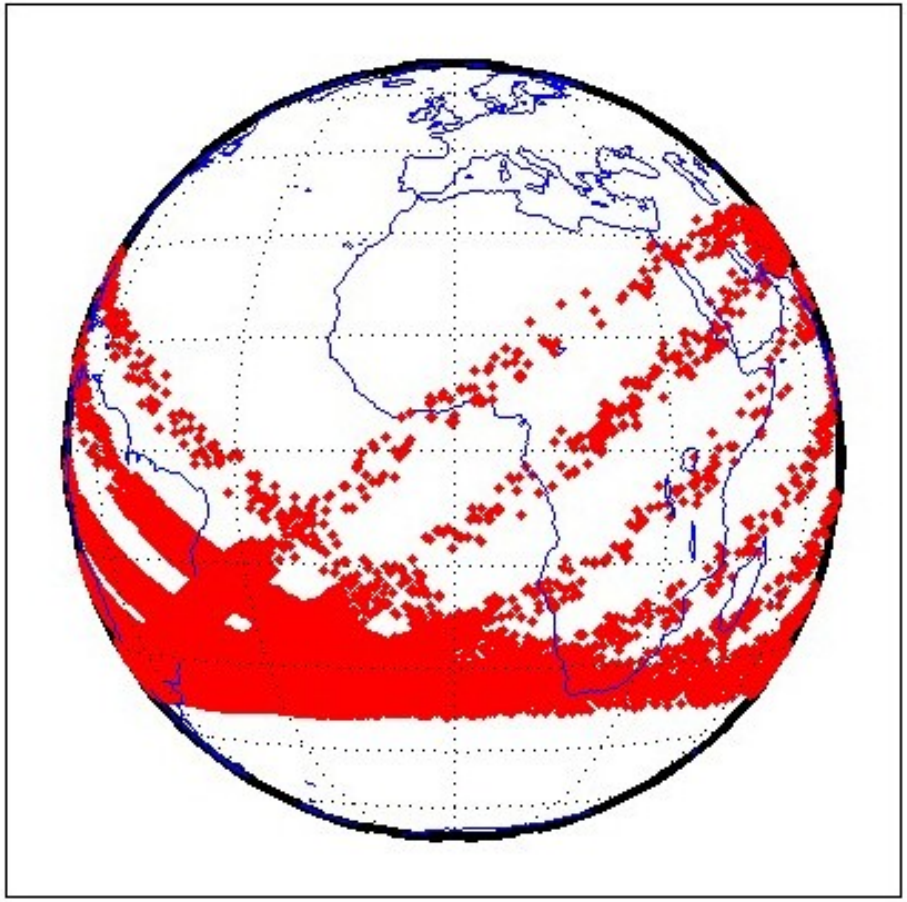

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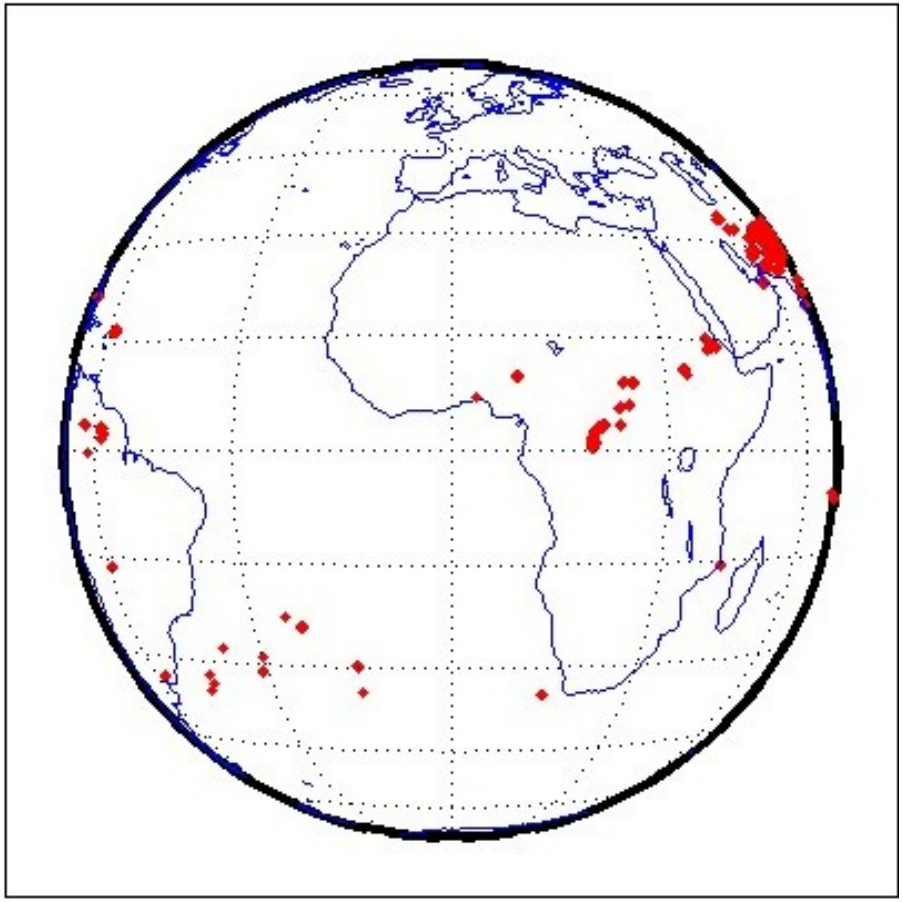

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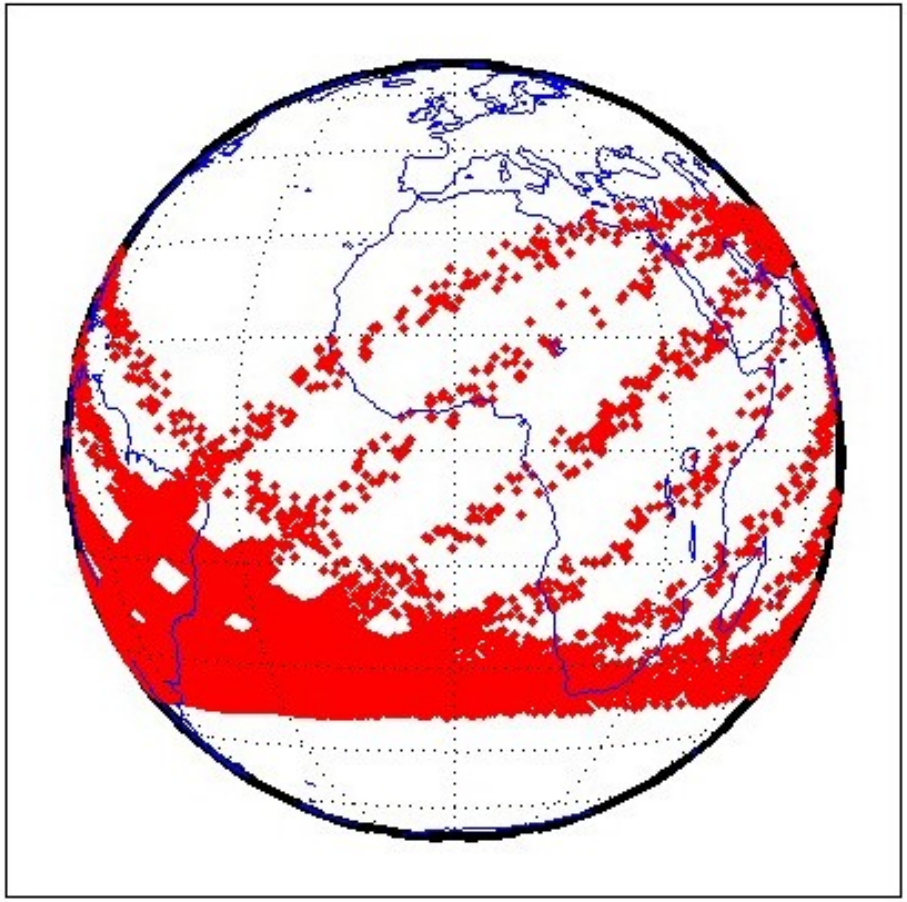

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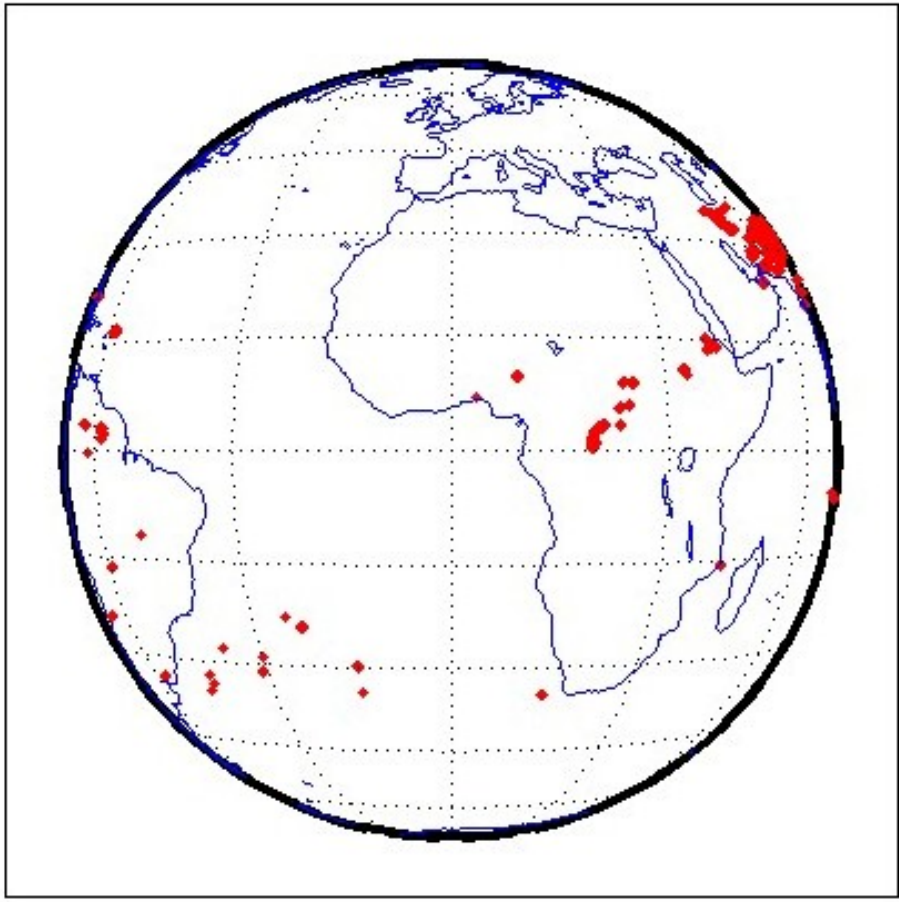

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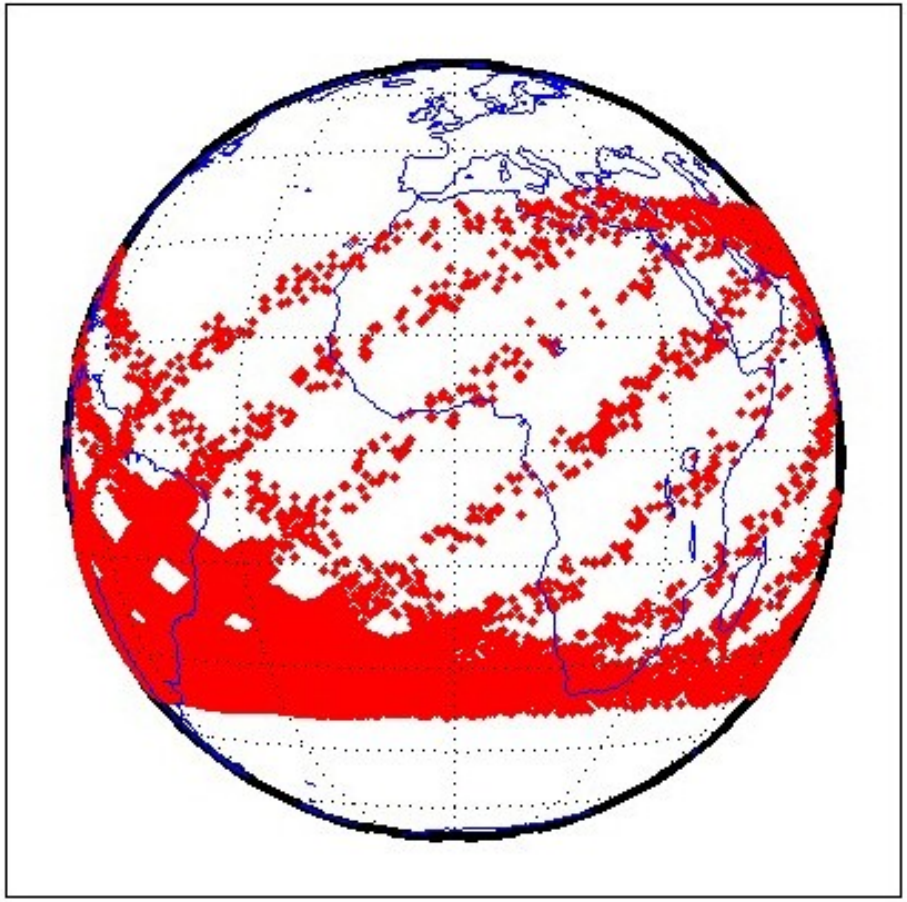
Noisy event data, 2007-176, orbit: 54749



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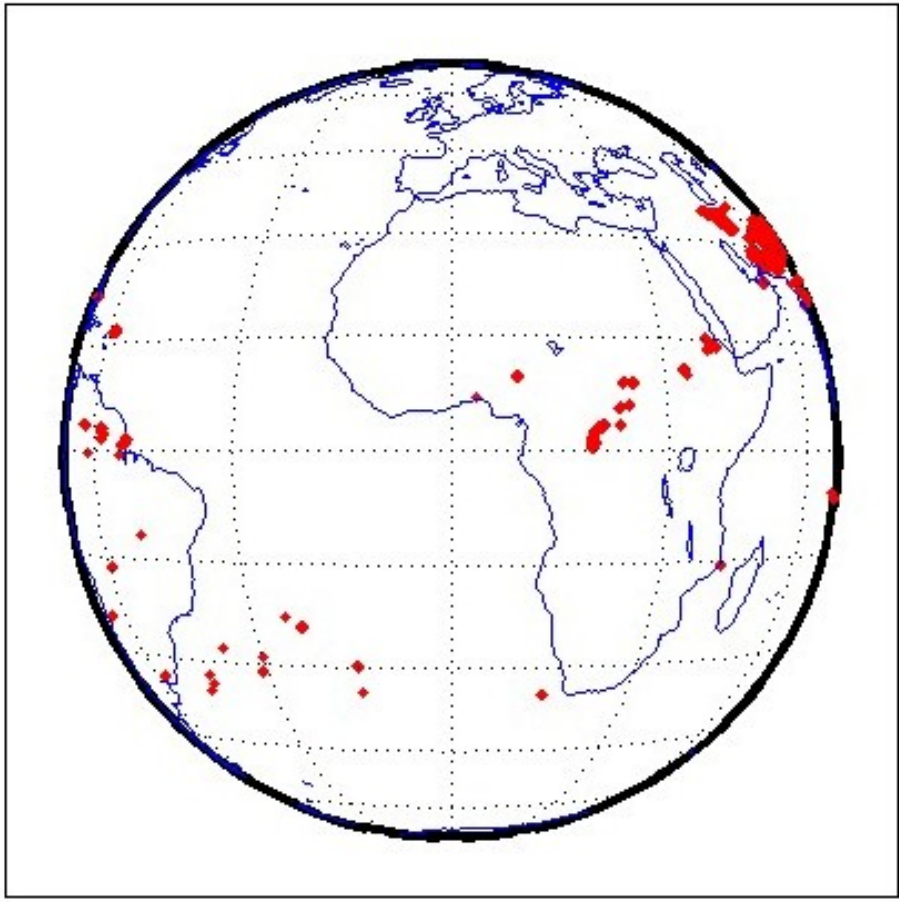

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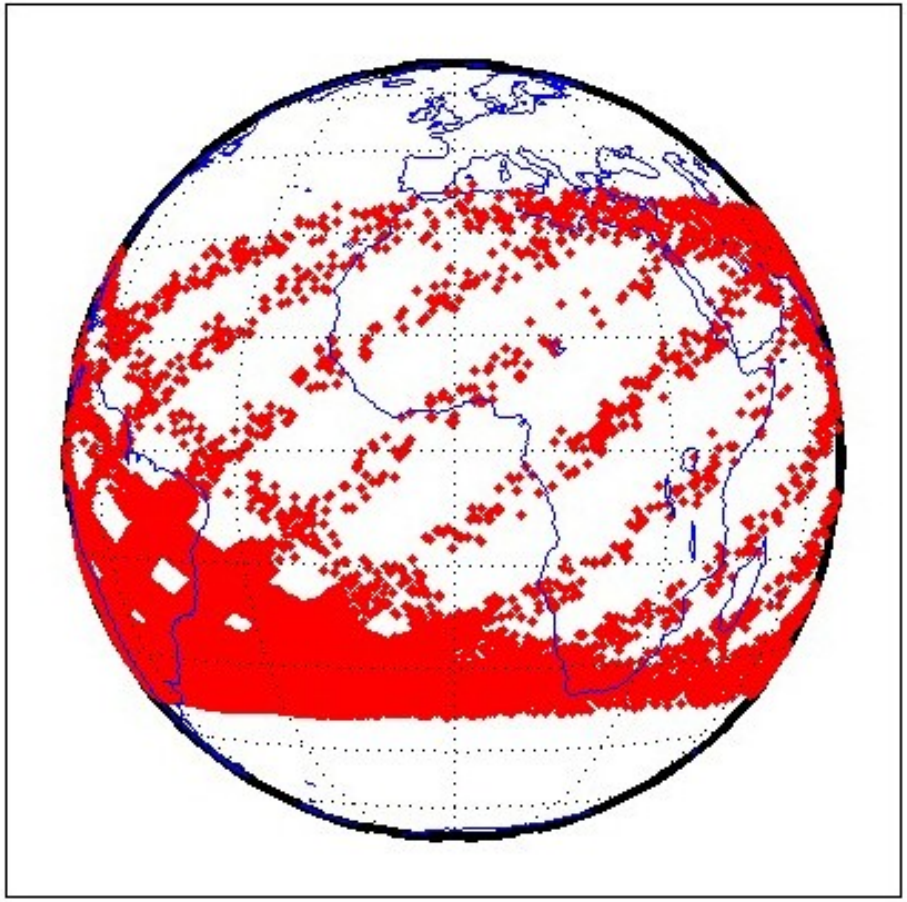
Noisy event data, 2007-176, orbit: 54750



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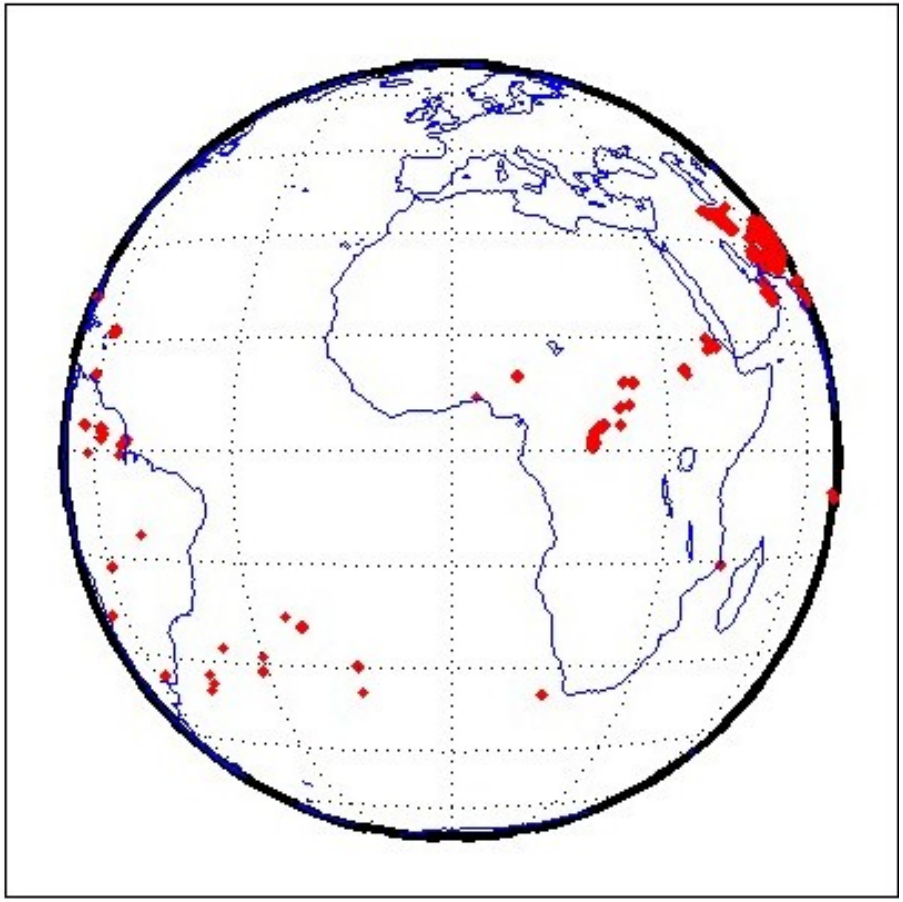

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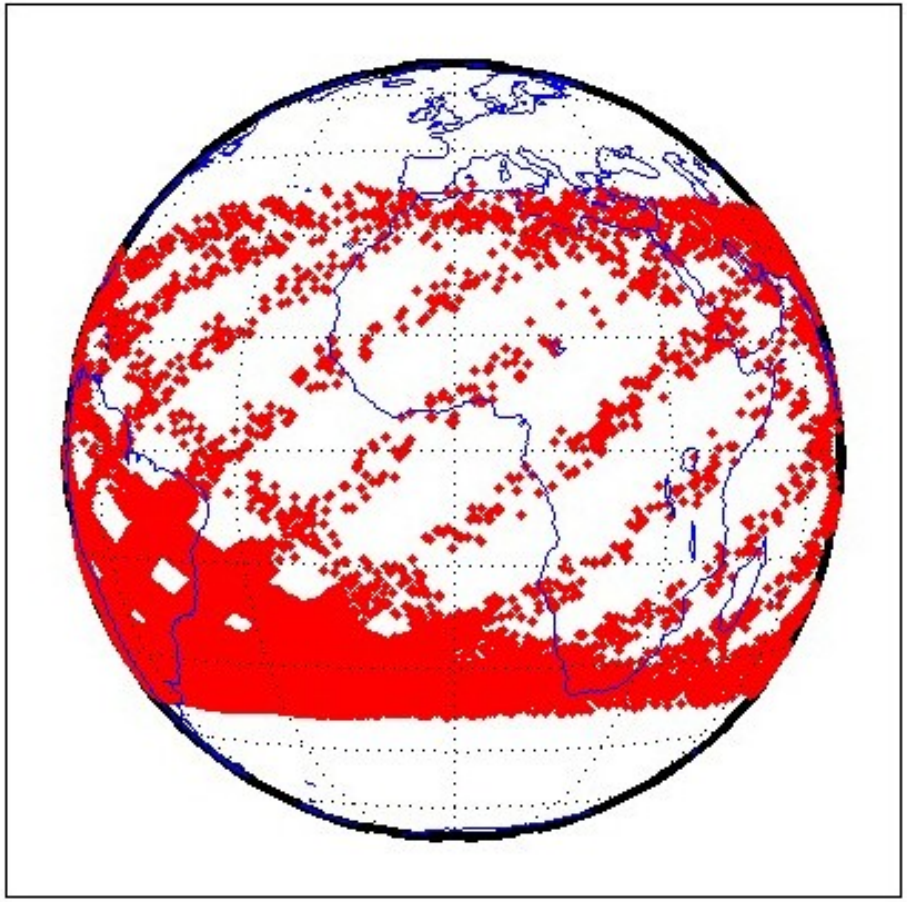
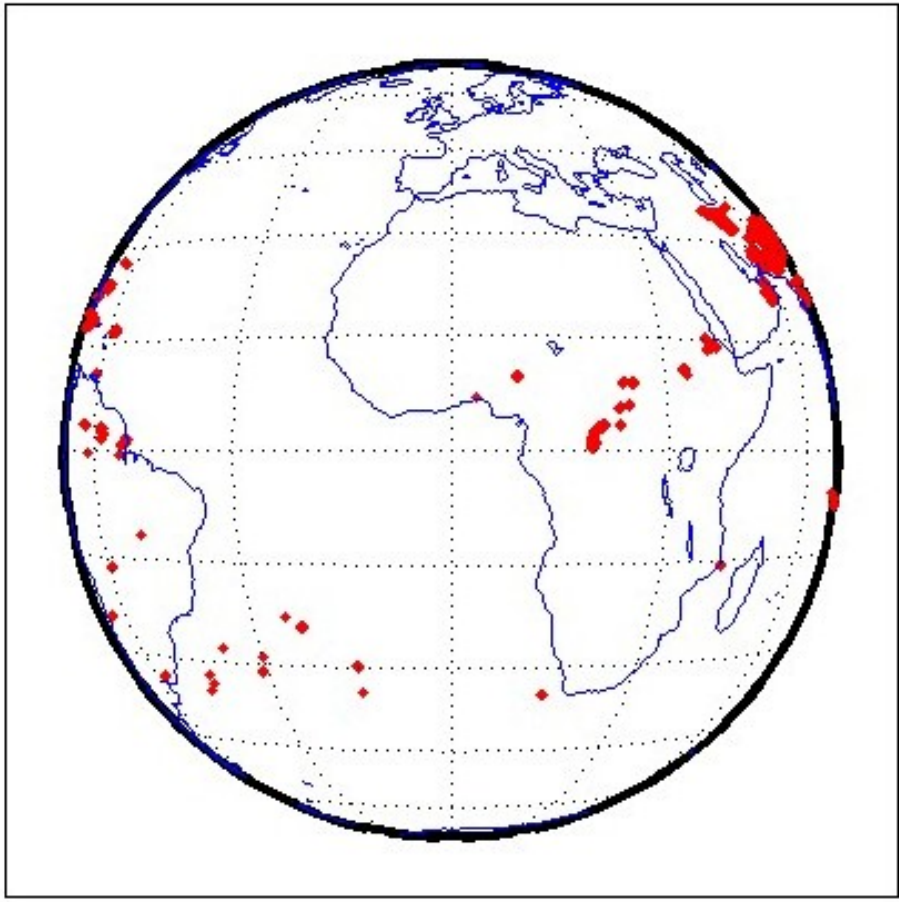


Filtered event data, 2007-176, orbit: 54751



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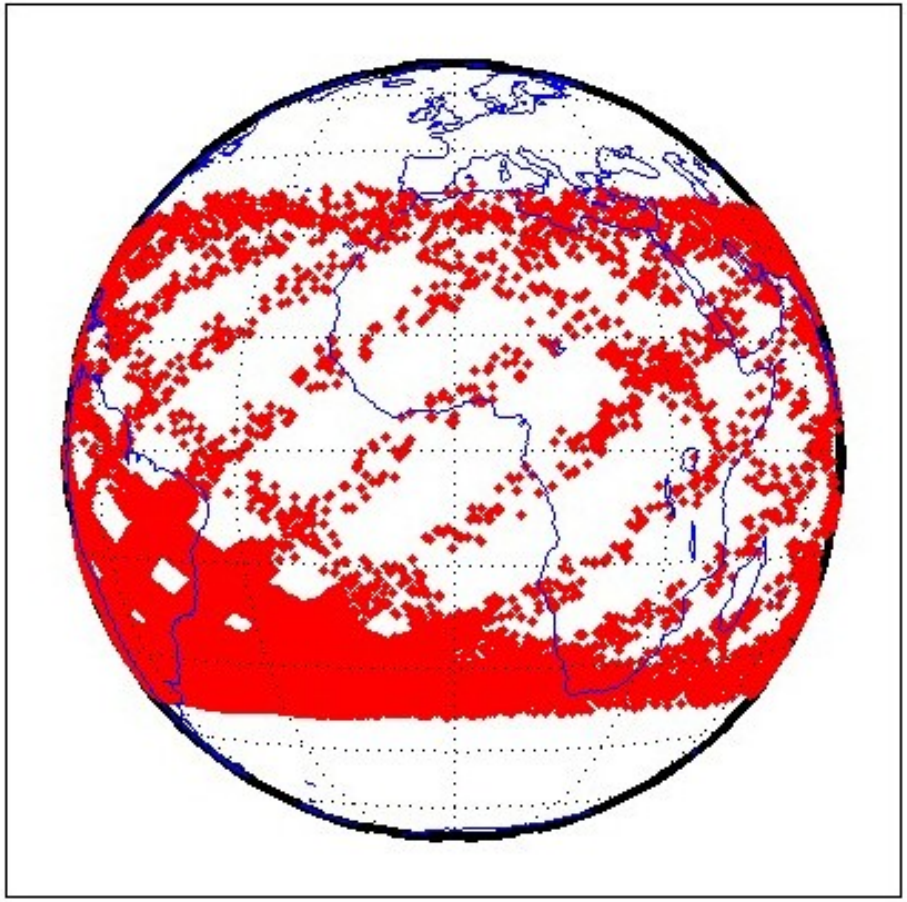
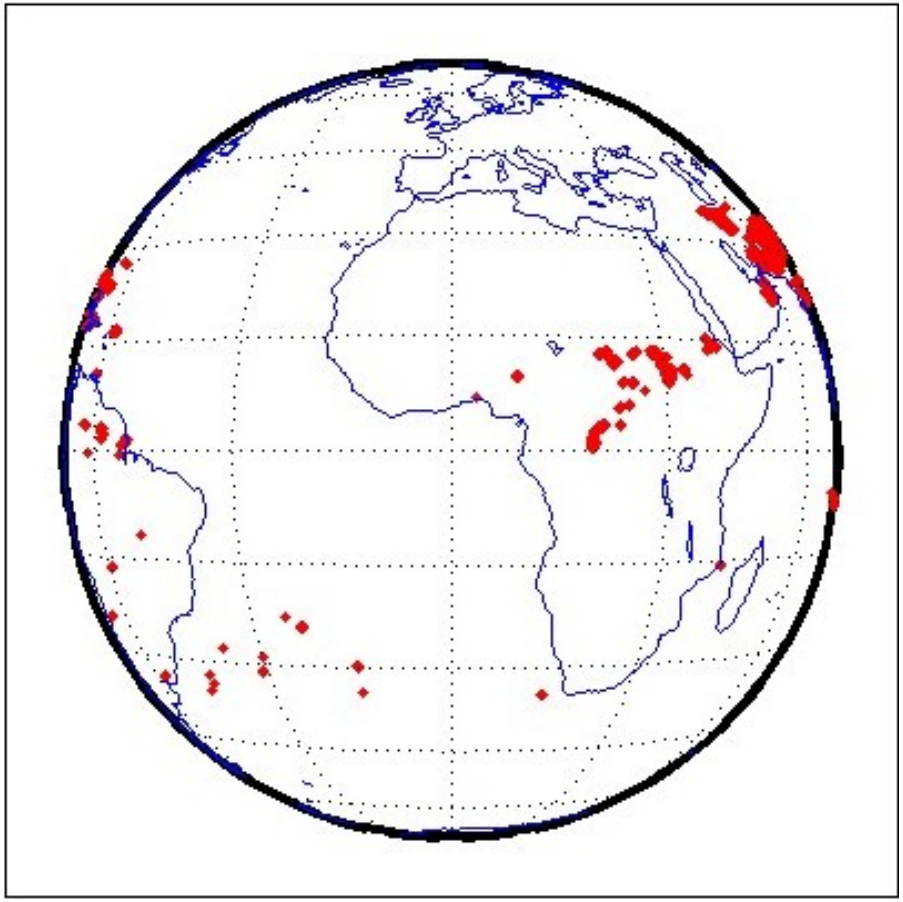


Filtered event data, 2007-176, orbit: 54752



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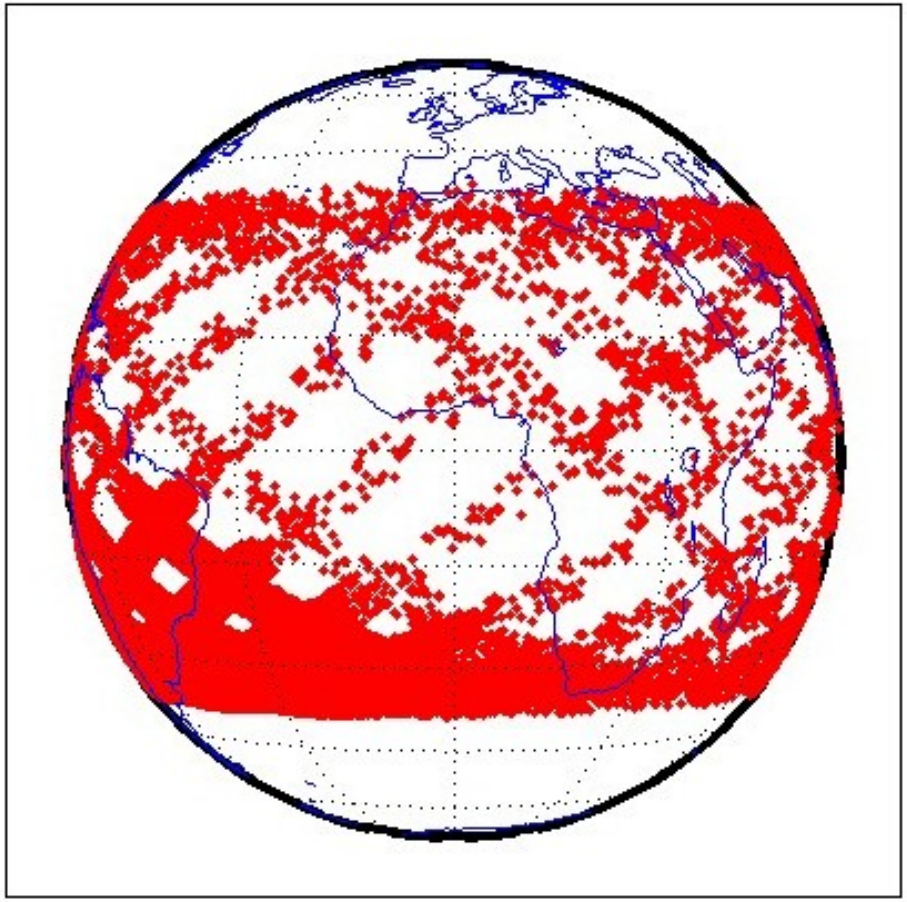
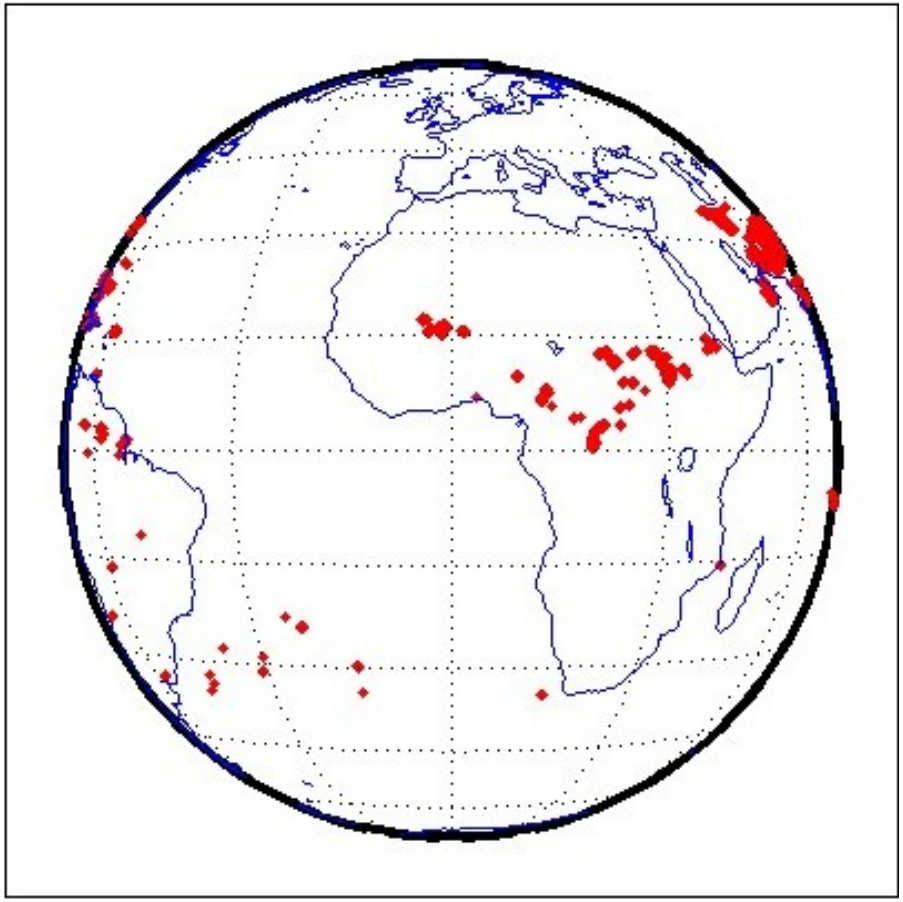
Overall rejection rate for this data set ~80 %

Noisy event data, 2007-176, orbit: 54753



Filtered event data, 2007-176, orbit: 54753



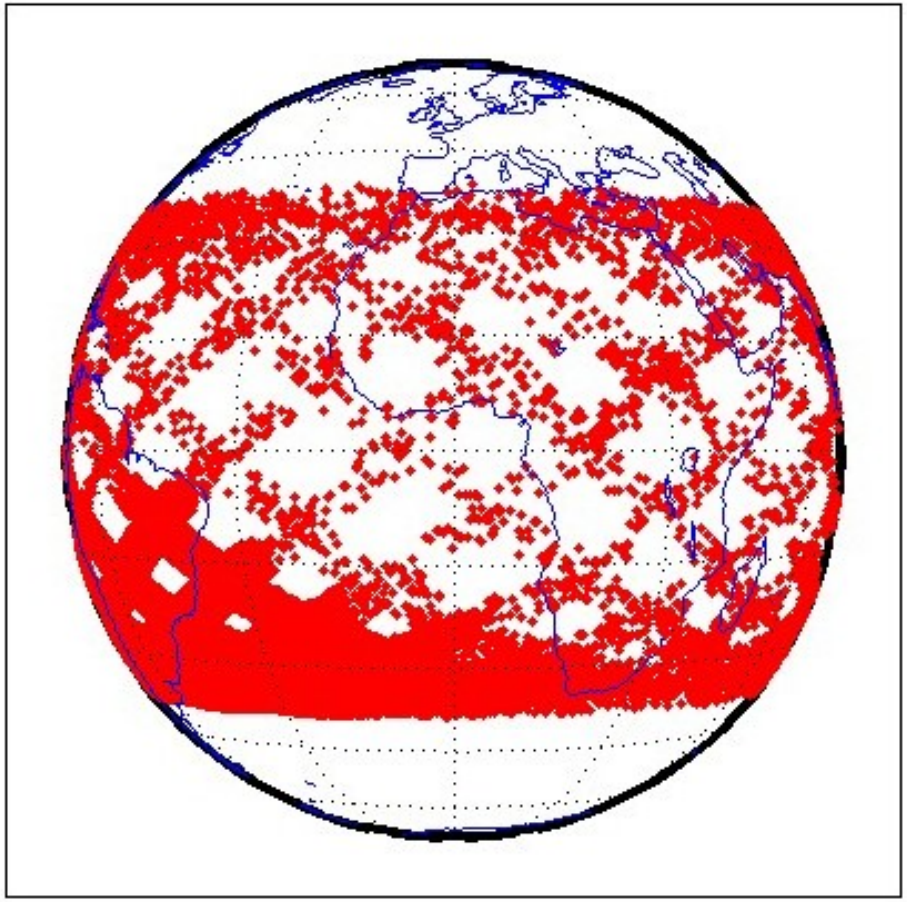
Geolocated events but with all filters switched off
(data provided by Dennis Buechler / Doug Mach)

**Effect of filtering => **

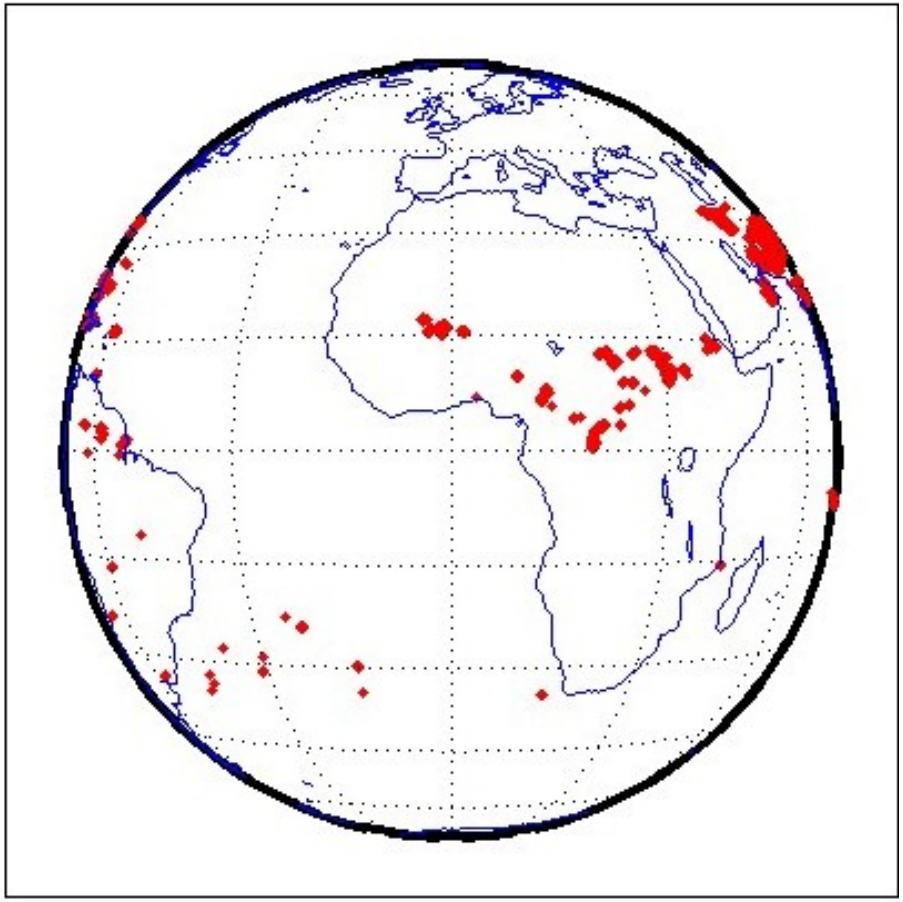
L2 events where all filters have been applied

Overall rejection rate for this data set ~80 %

Noisy event data, 2007-176, orbit: 54754



Filtered event data, 2007-176, orbit: 54754



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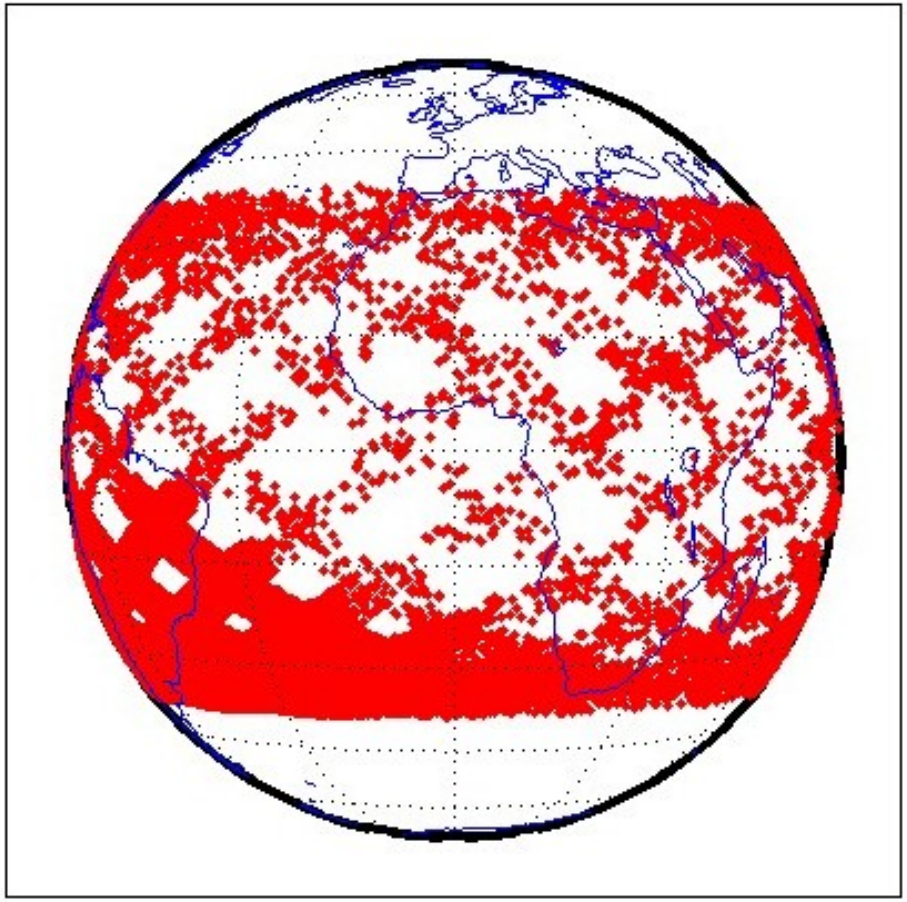
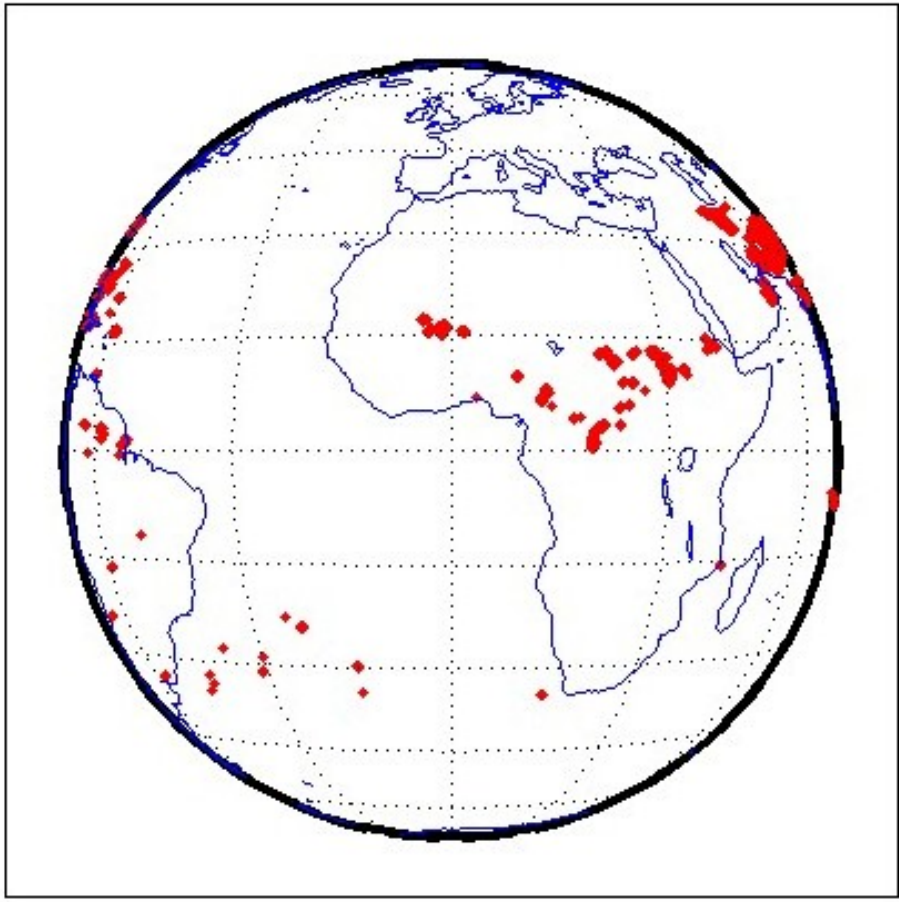


Filtered event data, 2007-176, orbit: 54755



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(data provided by Dennis Buechler / Doug Mach)

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L2 events where all filters have been applied

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Topics of Presentation

- Quick introduction to Meteosat Third Generation (MTG)
- MTG LI instrument status update
- Lightning Imager Science Team (LIST)
- Examples of LIST studies supporting LI L1/L2 processor development
  - **EUMETSAT contribution to the CHUVA campaign (LINET measurements)**
  - **LIProxy – tool for proxy data development and LI simulation**
- Summary

MTG Lightning Imager Science Team (LIST)

- In order to support activities for establishing a scientific baseline for the operational Lightning Imager (LI) L2 processor, a MTG LI Science Team was set up in 2009.
- The main objectives of this (external) team is to:
  - **Assist EUMETSAT with the implementation of the MTG LI L2 scientific baseline processor.**
  - **Prepare an *Algorithm Theoretical Basis Document* (ATBD). It includes also a description of the proxy dataset, to be used for algorithm development and processor development.**

- The ATBD **V1** was subject for review at the Preliminary Design Review (PDR) concluding the MTG system Phase B activities in May-June 2011
- LIST continues to support EUMESTAT for L2 processor development and ATBD updates

MTG Lightning Imager Science Team (LIST)

- The MTG LI Science Team, led by EUMETSAT, currently consists of the following members:
  - **Graeme Anderson (MetOffice – United Kingdom)**
  - **Daniele Biron (USAM – Italy)**
  - **Eric Defer (LERMA – France)**
  - **Ullrich Finke (U. Hannover – Germany)**
  - **Hartmut Höller (DLR – Germany)**
  - **Philippe Lopez (ECMWF)**
  - **Douglas Mach (NASA – USA)**
  - **Antti Mäkelä (FMI – Finland)**
  - **Dieter Poelman (RMI – Belgium)**
  - **Serge Soula (Laboratoire d'Aerologie – France)**
- **In addition, invited experts are contributing to individual meetings.**

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LIST study: EUMETSAT contribution to the CHUVA field campaign

- A study was initiated to provide the EUMETSAT contribution (LINET measurements) to the CHUVA Field Campaign which took place (IOP) in the Sao Paulo area in Brazil from December 2011 to April 2012.
- The aim of the study was:
  - **to generate a very comprehensive data set of lightning observations (surface based VHF/LF/VLF observations, surface & space based optical observations from the polar orbit and MSG SEVIRI imagery)**
  - **to enhance the generation of geostationary lightning imager proxy data,**
  - **to support the development of verification and validation strategies for these novel instruments (MTG-LI and GOES-R GLM),**
  - **to enable development of strategies for a complementary use of surface based VLF lightning location systems and space-based optical systems such as MTG-LI, and**
  - **to foster the user readiness for the future MTG-LI mission.**

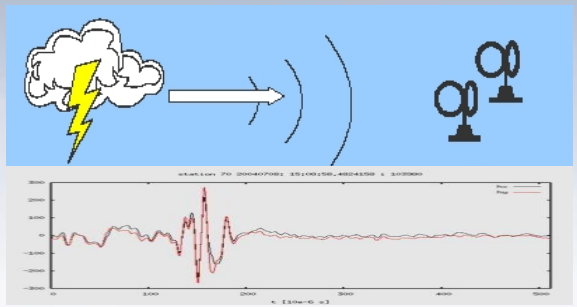
LIST study: EUMETSAT contribution to the CHUVA field campaign

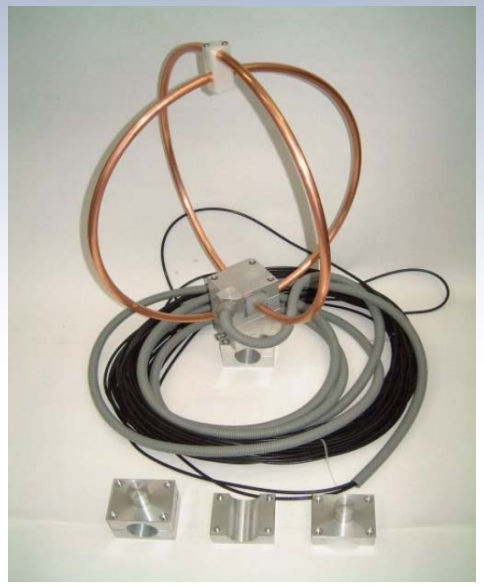
- Within the study the portable LINET system, owned and operated by DLR, was deployed in Brazil.
    - **Measurements were taken continuously from December 2011 to April 2012 and could also be monitored in real-time via a link provided by Nowcast on the web.**

- A second part of the study (Oct 2012 - April 2013) **will concentrate on the creation of an enhanced proxy data method**, based on LINET data as in input source and the findings of the data comparisons especially between LINET and LMA
    - **This LINET-based proxy data V2 will be available after the study closure (April 2013), with a coverage of almost all of Europe.**
    - **A Real-time processing of the LINET proxy data is also being planned => <u>user readiness application</u>**

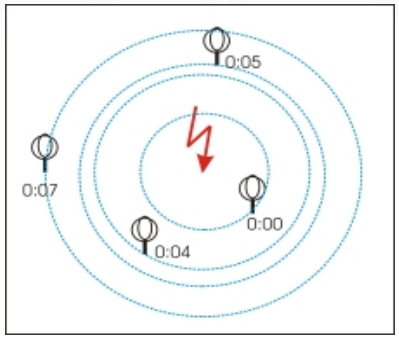
LINET (Lightning Detection Network in VLF/LF)
System Characteristics

Measurement of magnetic field



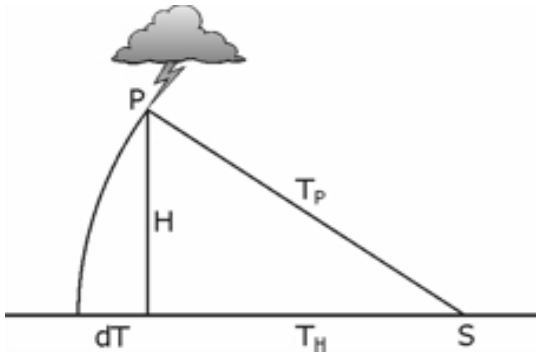


TOA Method for lightning location



IC - CG discrimination

Height of IC events



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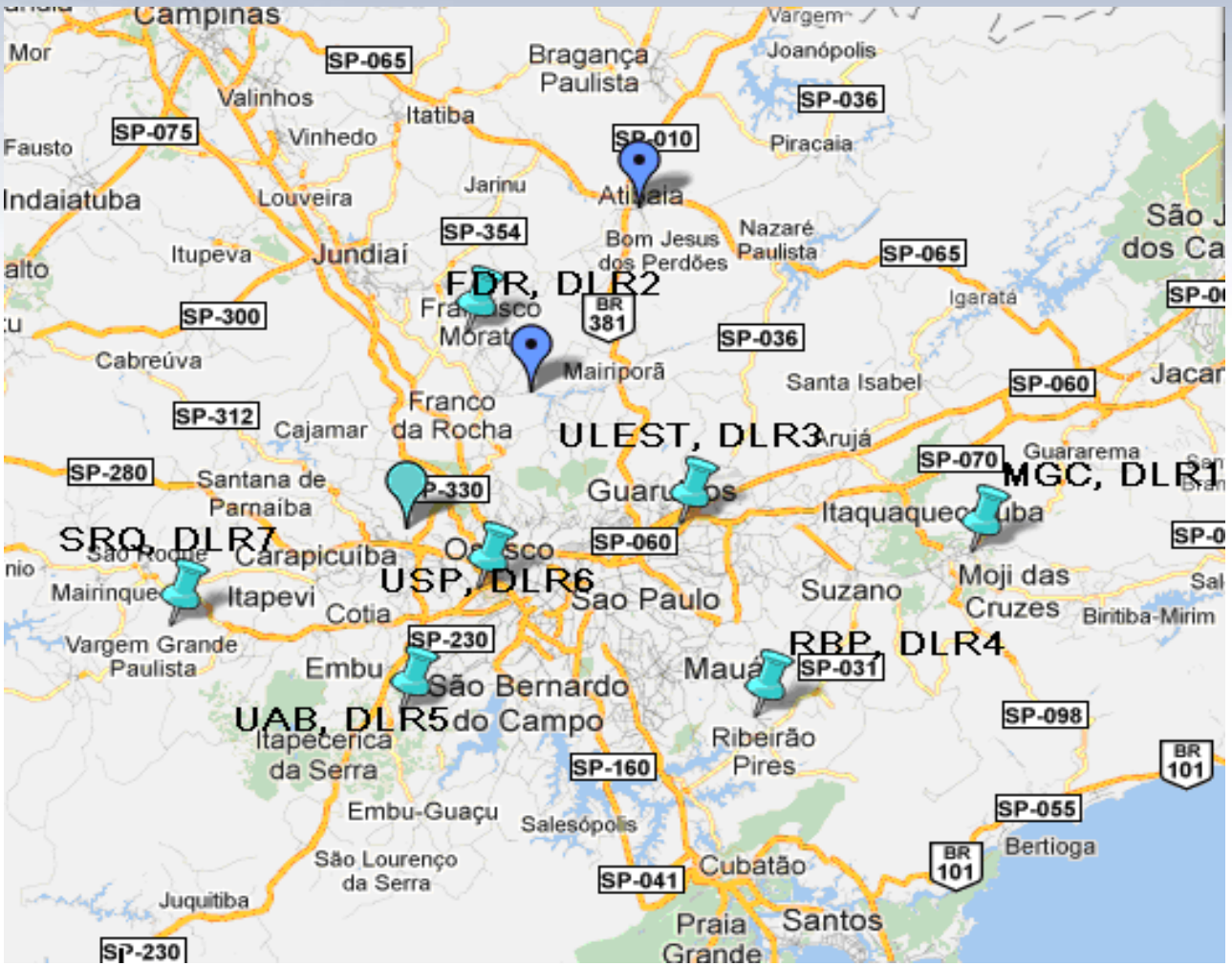
LINET sites in the CHUVA campaign (Sao Paulo area)



Baselines in the order of ~20-40 km

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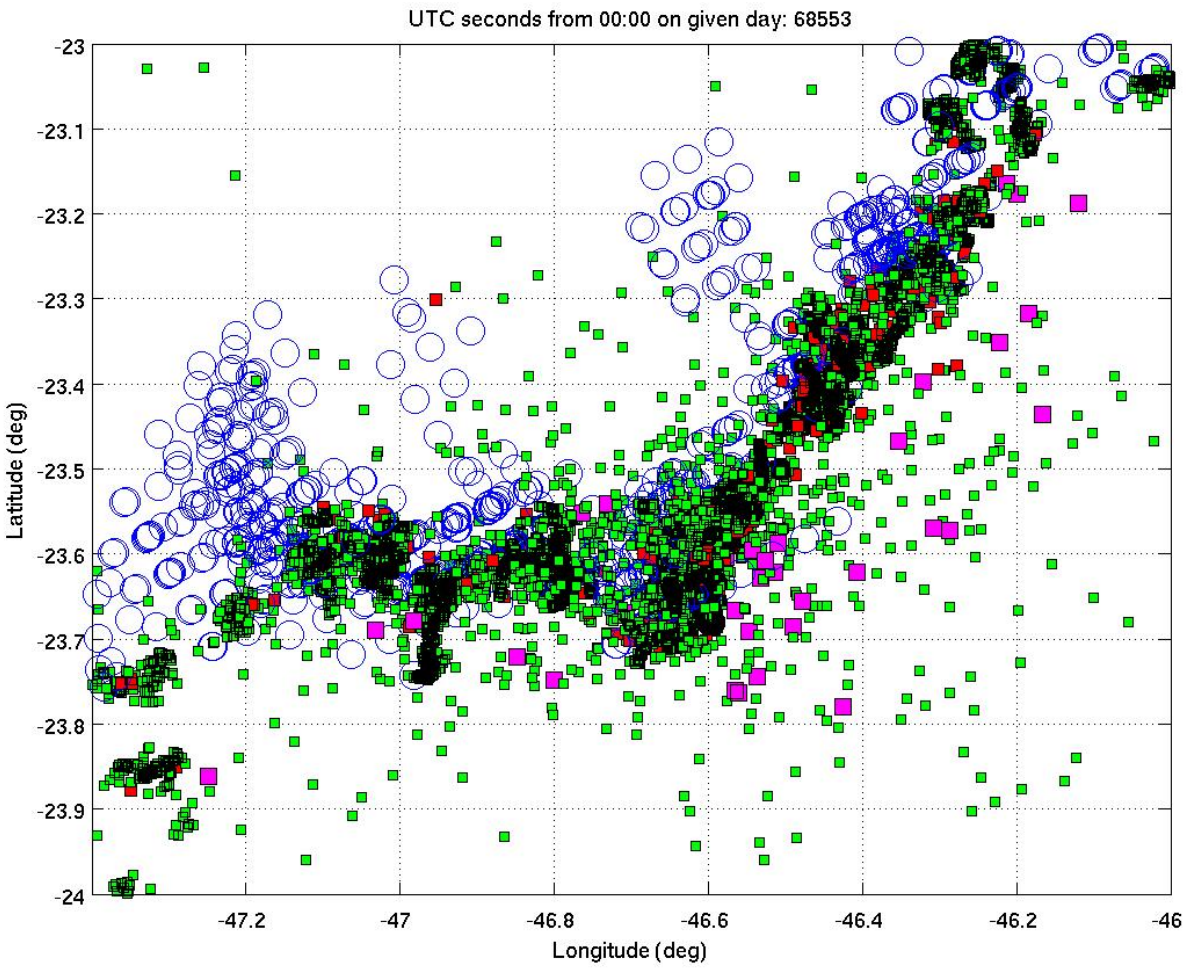
Example: Full LIS overpass on 10 Feb 2012 (60 seconds of data)

60 seconds contains already loads of data – need to look much closer

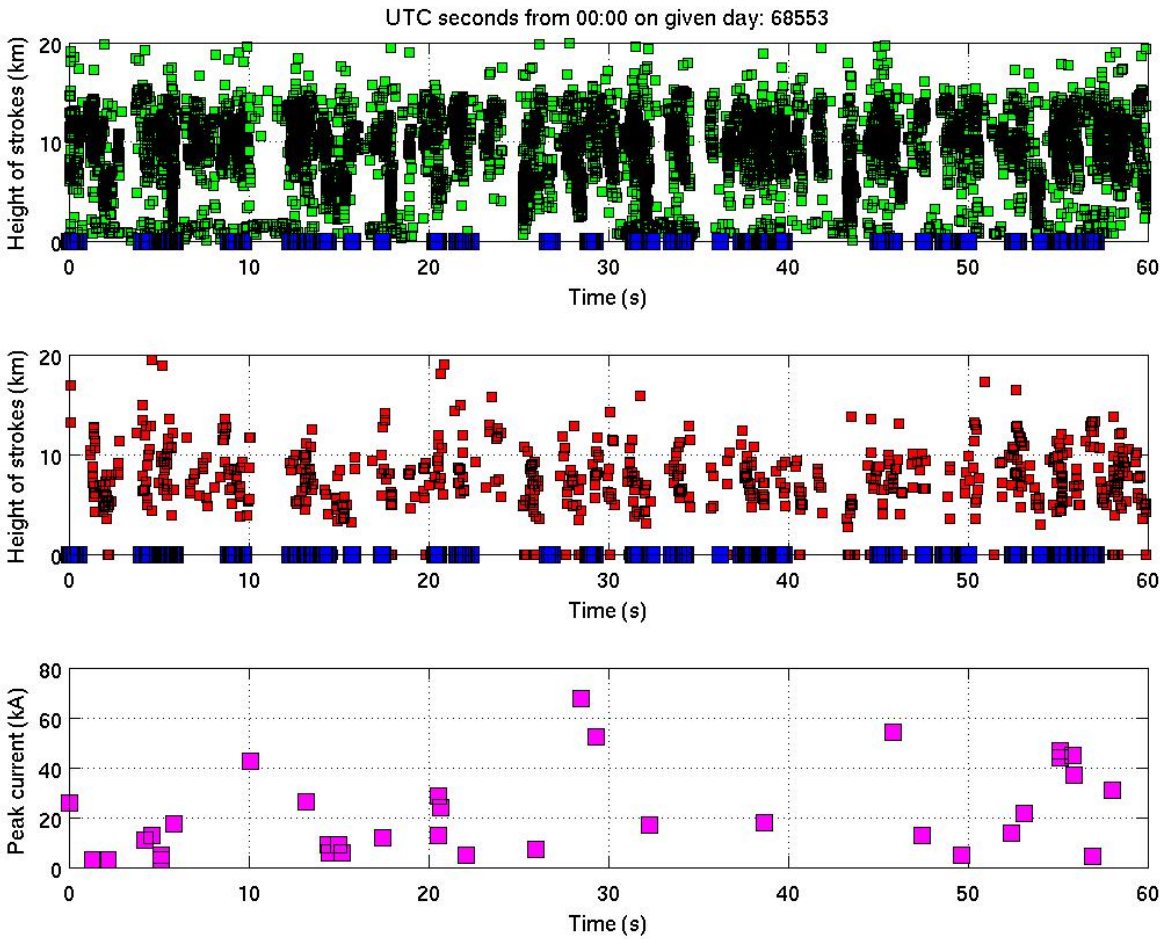


- LIS event (~5 km footprint)
- LIS event (in the temporal axis view)
- STARNET stroke
- LMA source (part of channel formation)
- LINET stroke

EUMETSAT

Example: Full LIS overpass on 10 Feb 2012 (60 seconds of data)

In temporal view (X-axis shows time of LIS overpass):



- LIS event (in the temporal axis view)
- STARNET stroke
- LMA source (part of channel formation)
- LINET stroke

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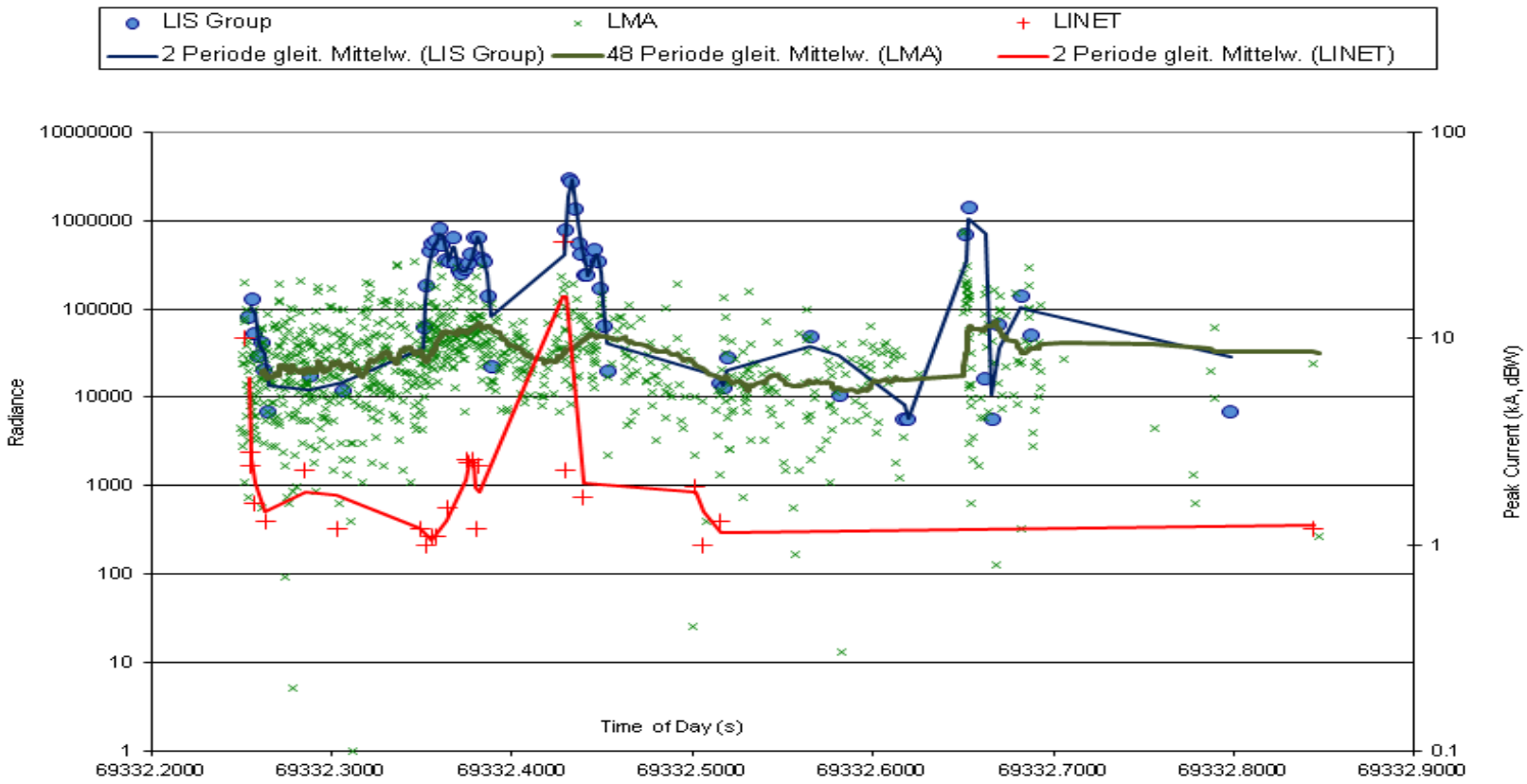
Case Studies
8 Feb 2012



- LIS group radiance, LINET peak current (absolute value) and LMA source power on 8 Feb 2012

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Conclusions
Preliminary Summary

- **CHUVA lightning campaign was very successful with respect to the objectives**
- **7 months (Oct 2011 – April 2012) of lightning data available for analysis complemented by XPOL radar data**
- **4-6 good cases with LIS overpasses of the inner network area (more than 20 cases in a wider area)**
- **As found in a previous study done by DLR (funded by EUMETSAT), LINET strokes and LIS groups are well correlating**
- **XPOL radar helps in interpretation of 3D cloud structure important for scattering of light**

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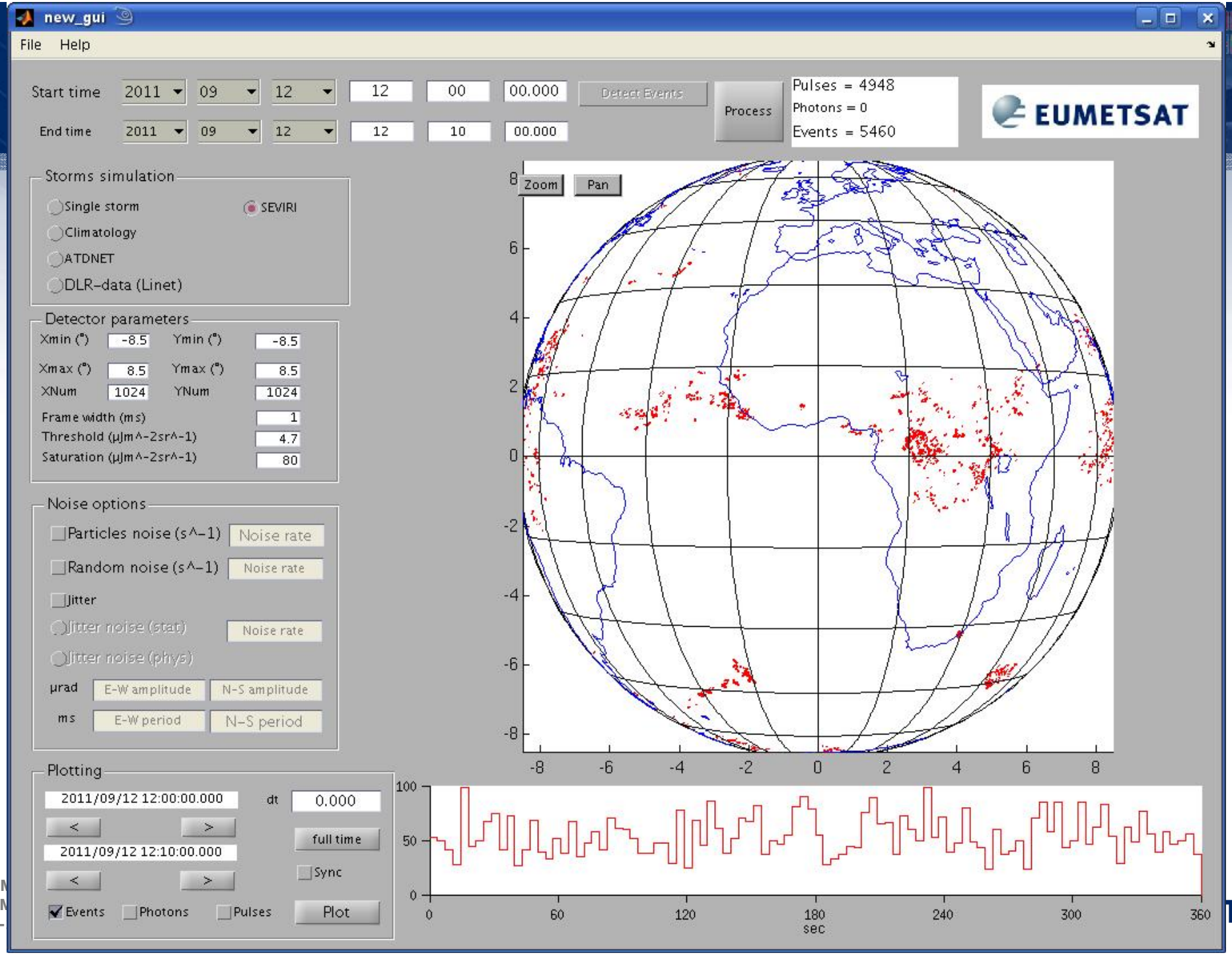
LIST study: LIProxy tool for generating MTG-LI proxy data

- LIproxy is a Matlab-based computational tool that simulates the expected LI operational data
  - **The development of the tool was started in 2010 as a LIST activity.**
  - **First version of the tool was created by Prof. Ulli Finke, and later further developed by CNMCA (Italian Meteorological Service) on EUMETSAT contracts**
- The tool simulates **lightning pulses** with “photons” which are a tool-internal unit to describe the pulse.
- The location/density of the pulses can be generated based on conceptual models or from external data such as ground-based networks (ATDnet or LINET) – this also allows realistic storm conditions to be simulated
- Event detection is then based on given parameters for threshold, saturation,...

LIST study: LIProxy tool for generating MTG-LI proxy data

- Recent updates to the tool include:
  - **Introduction of modules for noise simulation in LIProxy tool in order to enable the use of LIProxy for the full chain (L1b+L2) processor development**
    - **Random noise (simple statistical noise to investigate saturation)**
    - **1st version of spacecraft motion generated noise**
  - **Fully reworked GUI**
- Currently ongoing work:
  - **Implementing a background module for SEVIRI images**
  - **Noise modules for particle noise and Sun glint**
- Future plans:
  - **Implementation of an "instrument model" once the LI design is available**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End time
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Process
Pulses = 4948
Photons = 0
Events = 5460
EUMETSAT
Storms simulation
Single storm
SEVIRI
Climatology
ATDNET
DLR-data (Linet)
Detector parameters
Xmin (°) -8.5
Ymin (°) -8.5
Xmax (°) 8.5
Ymax (°) 8.5
XNum 1024
YNum 1024
Frame width (ms) 1
Threshold (µJm^-2sr^-1) 4.7
Saturation (µJm^-2sr^-1) 80
Noise options
Particles noise (s^-1)
Noise rate
Random noise (s^-1)
Noise rate
Jitter
Jitter noise (stat)
Noise rate
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Summary

- Meteosat Third Generation (MTG) will secure continuity and evolution of EUMETSAT geostationary services from 2018 onwards
  - **One of the new instruments on MTG is the Lightning Imager (LI) providing continuous lightning observation (CG+CC) over almost the full disk (at 0 deg).**
- Instrument prime was selected (Selex Galileo), with kickoff in July 2012 – System Requirements Review (SRR) to take place in October 2012.
- MTG Lightning Imager Science Team (LIST) supporting activities for defining a baseline L2 ATBD and prototype processor development
  - **Main achievements so far: ATBD V1, Proxy data, LIProxy tool, support to CHUVA campaign, …**

Thank you!

Further information and contact:

Jochen.Grandell@eumetsat.int

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