Ground-based and space-borne lightning observations during CHUVA

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MTG and GOES-R
New Geostationary Satellite Systems

MTG-I; 4 satellites
Meteosat Third Generation
> 2018

MTG-S; 2 satellites

Geostationary Operational Environmental Satellite-R Series (GOES-R)
> 2015
TRMM (Tropical Rainfall Measuring Mission)
TRMM Instruments

- Visible and InfraRed Scanner (VIRS)
- TRMM Microwave Imager (TMI)
- Precipitation Radar (PR)
- Lightning Imaging Sensor (LIS)
Flash Types and Emissions
CG, IC and VLF/LF, VHF, Light

Intra-cloud (IC) and cloud-to-ground flashes emit VLF/LF, VHF and optical radiation

Long wavelength VLF/LF signals have one or several source points per flash arising from long channel segments

Short wavelength VHF signal have many source points per flash and allow for reconstructing short scale channel details
LINET (Lightning Detection Network)
System Characteristics

- Measurement of magnetic field
- TOA Method for lightning location
- IC - CG discrimination
- Height of IC events
LMA and LINET Sites
XPOL and operational radars

LMA and LINET configuration, XPOL and operational radars
LINET Sites
CHUVA, Sao Paulo
## LIS Overpasses

### Summary

<table>
<thead>
<tr>
<th>Date/Time UTC</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.10.2011 23:36</td>
<td>High</td>
</tr>
<tr>
<td>11.11.2011 16:24</td>
<td>Normal</td>
</tr>
<tr>
<td>7.12.2011 20:15</td>
<td>((Low))</td>
</tr>
<tr>
<td>10.12.2011 02:40</td>
<td>((lowest))</td>
</tr>
<tr>
<td>28.12.2011 17:11</td>
<td></td>
</tr>
</tbody>
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Case Studies
27 March 2012

CHUVA
2012-03-27
19:03:57-19:05:48 UTC
Case Studies
10 Feb 2012

CHUVA
2012-0210
19:01:37 -
19:03:22 UTC
Case Studies
10 Feb 2012
Case Studies
7 Feb 2012

XPOL Radar
20:10 UTC
Case Studies
7 Feb 2012

CHUVA
2012-02-07
20:10:25
20:11:43 UTC

Latitude
-23.7
-23.6
-23.5
-23.4
-23.3
-23.2

Longitude
-46.9
-46.8
-46.7
-46.6
-46.5
-46.4
Case Studies
7 Feb 2012
Case Studies
7 Feb 2012

Flash 01

CHUVA
07-February-2012
20:10:25 - 20:11:44
UTC
20120207_merge_01.txt
+:pos., -neg., 0:CG, o:IC
Case Studies
7 Feb 2012

Flash 01

LIS group radiance

LMA and LINET source height

No optical signal from low level part of flash
Case Studies
7 Feb 2012

Flash 06
Case Studies
7 Feb 2012

Flash 06
Case Studies
7 Feb 2012

20120207 Flash 6

- LIS Group
- LMA
- LINET

Flash 06

LIS group radiance

LMA and LINET source height

No optical signal from low level part of flash
Case Studies
08 Feb 2012

2012-Feb-08 LIS Flash 137

Radiance (µJ s⁻¹ m⁻² µm⁻¹)

Height (km)

Time of Day (s)
Case Studies
08 Feb 2012

LIS Flash 137

LIS group radiance

LMA and LINET source strengths correlate to some extent
Case Studies
19 Jan 2012

**Time differences of closest signals**

LMA followed by LINET and LIS
LINET and LIS correspond well

**Graphs**
- **LINET-LIS**
- **LMA-LIS**
- **LMA-LINET**
Modeling of MTG-LI Optical Signals

Model Strategy

Transformation of LINET RF stroke data into optical groups by a 2-step process:

- Model of cloud top optical emission
  - Number of optical flashes equals number of LINET flashes
  - One direct coincident optical group per LINET stroke
  - Distribution of additional optical groups per LINET flash according to a log-normal model for radiance, footprint and time

- Projection of group areas to optical plane of LI pixel matrix

Generation of optical events from RF stroke data
LIS Groups per LINET Stroke
Relation to Network Sensitivity

LIS groups per LINET stroke (GPS) from coincident flash observations for LIS overpasses in different areas

CHUVA data add additional information in the low peak current regime
Summary and Conclusions (1)

- 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 previous study, LINET strokes and LIS groups are often coincident
- LINET strokes map the flash branches similar to LMA (but with considerably less data points)
- An initial breakdown phase of vertically propagating sources can be often found in LINET and LMA data
Summary and Conclusions (2)

- Higher level LINET and LMA signals have higher probability to be optically detected
- Lower level LINET and LMA signals are optically detected from above in case of missing high level precipitation (e.g. from radar)
- XPOL radar helps in interpretation of 3D cloud structure important for scattering of light
- Improvement of proxy data generation
  - a small baseline (~30 km) LINET configuration provided a high DE network thus closing the gap in coverage at weak LINET strokes (flashes)
  - The number of LIS groups per LINET stroke should not be considered as constant but rather as dependent on minimum peak current