Lightning observations during the GLM-CHUVA campaign and implications for MTG-LI proxy data generation

H. Höller\textsuperscript{1}, H.-D. Betz\textsuperscript{2,3}, C. Morales\textsuperscript{4}, R.J. Blakeslee\textsuperscript{5}, J.C. Bailey\textsuperscript{6}, R.I. Albrecht\textsuperscript{7}

\textsuperscript{1}DLR, Institut für Physik der Atmosphäre, Germany, \textsuperscript{2}Physics Department, University of Munich, Germany, \textsuperscript{3}nowcast GmbH, Munich, Germany, \textsuperscript{4}Universidade de São Paulo, Instituto de Astronomia, Geofísica e Ciências Atmosféricas, São Paulo, Brazil, \textsuperscript{5}NASA Marshall Space Flight Center, Huntsville, USA, \textsuperscript{6}University of Alabama, Huntsville, USA, \textsuperscript{7}Instituto Nacional de Pesquisas Espaciais (INPE), Cachoeira Paulista, Brazil

Lightning flashes, city lights, sunset, Aurora Australis, atmospheric glow and some stars, seen over Argentina on 4/23/2003 (Courtesy of NASA Johnson Space Center)
CHUVA

(Portuguese for RAIN)

Cloud processes of the main precipitation systems in Brazil:

A contribution to cloud resolving modeling and to the GPM (Global Precipitation Measurement)
Experimental area in Sao Paulo State
Lightning Detection Networks during GLM-CHUVA and related observations Oct 2011 – April 2012

**Deployed total lightning networks:**

- **12 LMA sites (VHF)**
  - NOAA/NASA
  - INPE

- **7 LINET sites (VLF-LF)**
  - DLR/nowcast
  - USP

- **5 TLS200 sites (LF-VHF)**
  - Vaisala

- **7 EN sites (ELF-LF)**
  - Earth Network

**Operational networks:**
- RINDAT (LF)
- STARNET (VLF)
- WWLLN (VLF)
- GLD360 (VLF)
- ATDnet (VLF)
- BrasilDAT (ELF-LF)

**Satellite Observations:**
- GOES-12
- MSG
- TRMM

**6 High Speed Video Cameras**

**8 Field-Mills**
CHUVA-GLM Vale do Paraíba
Sensor Sites

Sensor sites of the different lightning location systems
MSG on 27 March 2012
LIS overpass from 19:04 - 19:06 UTC
LIS view: 2012-087T18:53:01.0000 to 2012-087T20:27:11.0000
areas 37, flashes 239, groups 3190, events 14361
Max-cappi projection
18:18 – 20:00 UTC

Volume scans every 6 min

Cloud tops reach 20 km
LIS and LINET on 27 March 2012
One Second Frames
LIS and LMA on 27 March 2012
One Second Frames
Case Studies
27 March 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

[Diagram with labeled data points and markers]

LMA
LINET
LIS-Flash
LIS-Group
LIS-Event
Station
Case Studies
7 Feb 2012

Flash 01
Case Studies
7 Feb 2012

Flash 01
Case Studies
7 Feb 2012

Flash 01

LIS group radiance

LMA and LINET source height

No optical signal from low level part of flash
Modeling of MTG-LI Optical Signals
Strategy for Proxy Data Generation

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

- Model of cloud top optical emission
  - Simulation of the number of optical groups per stroke (depending on LINET detection efficiency (sensor baseline) in the area)
    
    If this number is ≥ 1:
    - Generation of one direct coincident optical group per LINET stroke
    - Random generation of additional optical groups per LINET stroke 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
Modeling of MTG-LI Optical Signals
Proxy Group Generation from LINET strokes

- Model of cloud top optical emission
  - Random generator for group radiance (and footprint)

Radiances: Statistics
Simulation (log-normal)
Modeling of MTG-LI Optical Signals
The Model Flash, Horizontal View

LIS events, groups (green), flash (black)
and LINET stroke (red)

15 July 2006
04:52:36 UTC
LIS Flash 367
LINET Flash 18957
TRMM VIRS Ch5

Simulation of circular shaped groups around LINET stroke (red)

15 July 2006
04:52:24.365 UTC
LIS Simulation
LINET Flash 18957
TRMM VIRS Ch5
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
MTG-LI Proxy Data for LIS Overpass
27 March 2012

Time of last event

Radiance of last event
before end of 1 s interval
Case Studies
Europe, 28 July 2006

Simulation of MTG LI events on 28 July 2006 at: 0 h 15 min

Movie generation by Jochen Grandell (EUMETSAT)
LINET Stroke Density
Europe 2006

All strokes

strokes > 10 kA
LINET Detection over Europe 2010
Smallest Detected Peak Current

Distribution of the smallest detected peak current during 2010

Depends on sensor baseline
Summary and Conclusions (1)

- All the different lightning detection system measure different parts of the lightning process with different resolution and efficiency, thus they are complementary to each other.
- 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.
- 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).
Summary and Conclusions (2)

- 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
- The next step of proxy data development will be the application to Europe, user readiness aspects, test bed demonstration
- ISS-LIS, proposed launch date late 2014 or early 2015, would enable observations over Europe
The End