



Lightning activity associated to Amazonian coastal squall lines: a case study

**Laure Madeleine Dentel¹, Brigida Ramati Pereira da Rocha¹⁻³, Ricardo
Santos de Souza², Ronald L. Holle⁴, Jaci Maria Bilhalva Saraiva³**

¹ UFPA Universidade Federal do Pará, Faculdade de Engenharia Elétrica, Belém-PA

² UFPA Universidade Federal do Pará, Faculdade de Meteorologia, Belém-PA

³ SIPAM – Sistema de Proteção da Amazônia, CTO/BE, Belém-PA

⁴ Vaisala Inc.



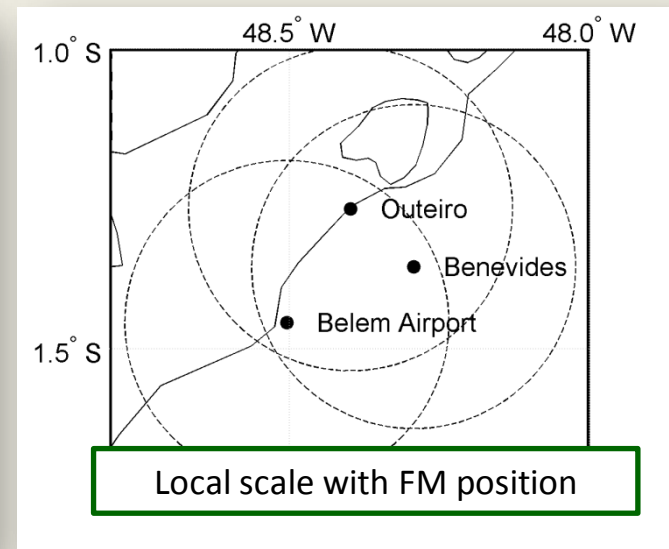
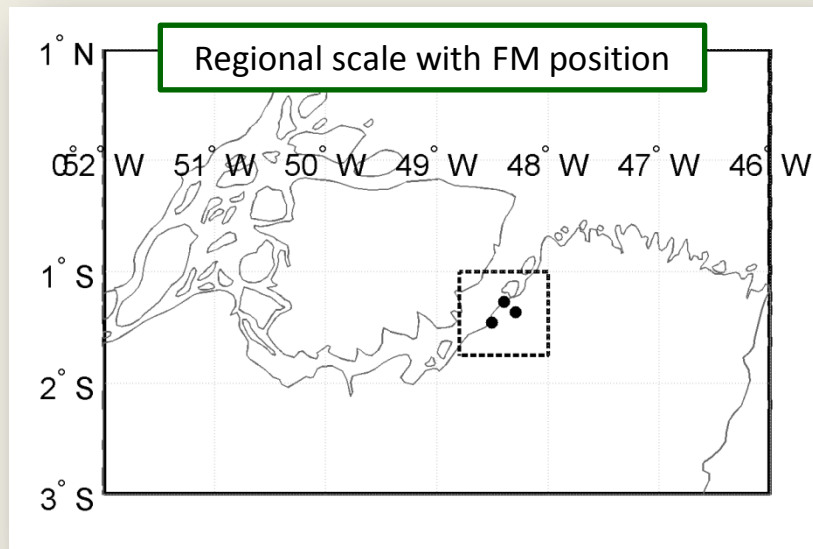
Introduction

- The goal of this study is to analyze the **electrical activity** embedded to the **coastal Amazon Squall Lines (ASL)**,
- observed and measured the **23rd June of 2011** over the region of Belém.
- The electrical activity was measured by different types of systems:
 - **3** Electric **Field Mills** (EFM);
 - and **2** **VLF** Lightning Detecting Network (LDN) the **STARNET** and the **Vaisala GLD360**.



Methods

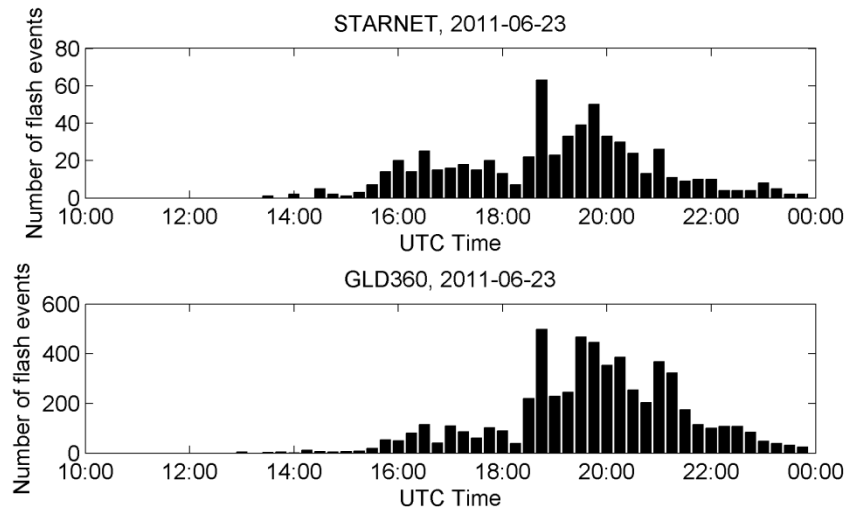
- The electrical activity produced by the ASL was studied for **two spatial scales**:
 - a **regional scale** following the lightning flashes detected by the VLF systems during the ASL life cycle;
 - and a **local scale** studying the vertical electric fields measured by EFMs when the ASL shift over Belém city.



Results and discussion: Regional scale

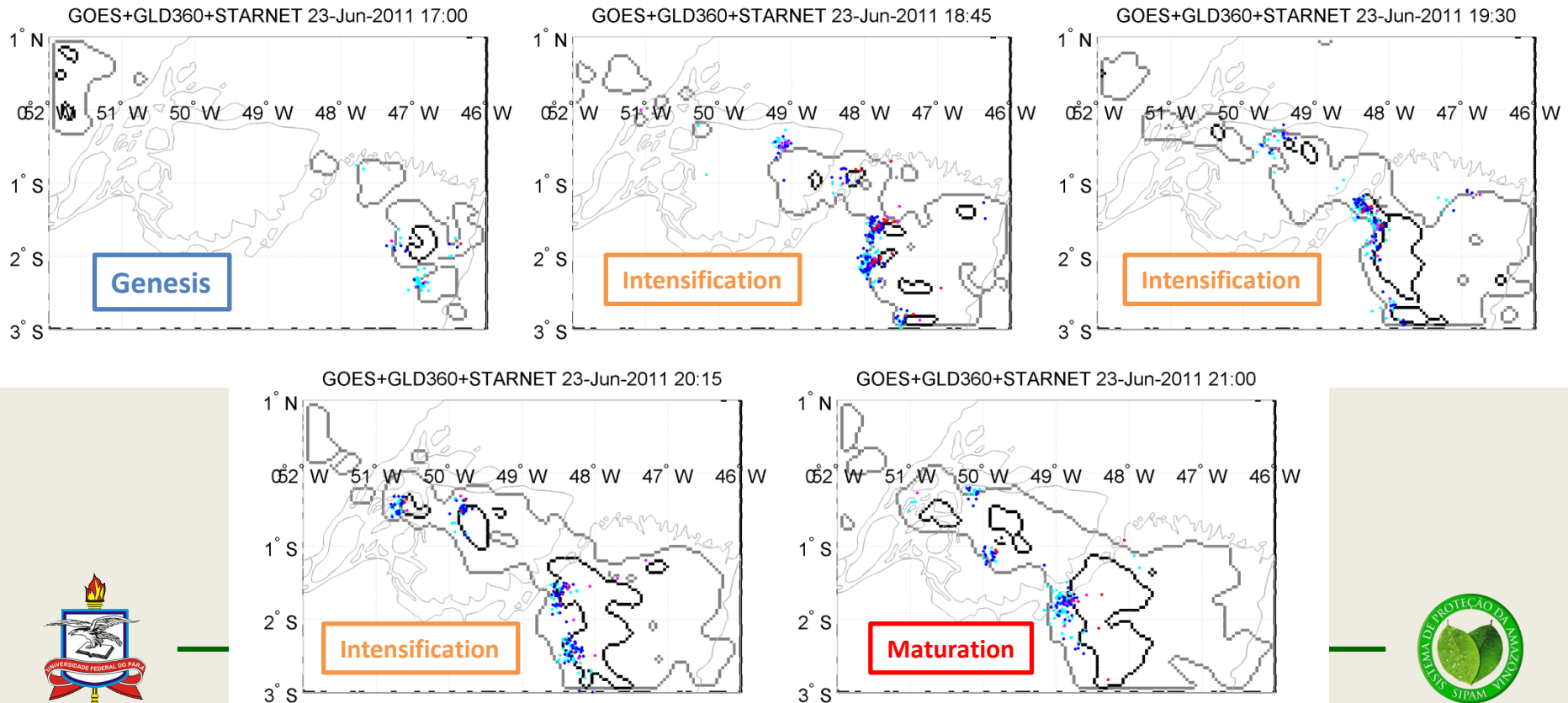
- The **number of flash events** collected by the **GLD360** during the ASL is about **10.9 times** the number of flash events collected by the **STARNET**
- Indeed, the GLD360 detects **more IC** flashes and **more low peak** current flashes than the STARNET.
 - The **STARNET** receivers are **focused on GC** detection (Chronis and Anagnostou 2006);
 - while the **GLD360** does **not distinguish** between ground and cloud flashes (Said et al. 2011);
 - Moreover the **GLD360** could **detect Sferics from low peak current** discharges at large distances (Said et al. 2011).

GLD360 and STARNET, time distribution of flash events, limited by -3°S , 1°N and -52°W , -46°W .



Results and discussion: Regional scale

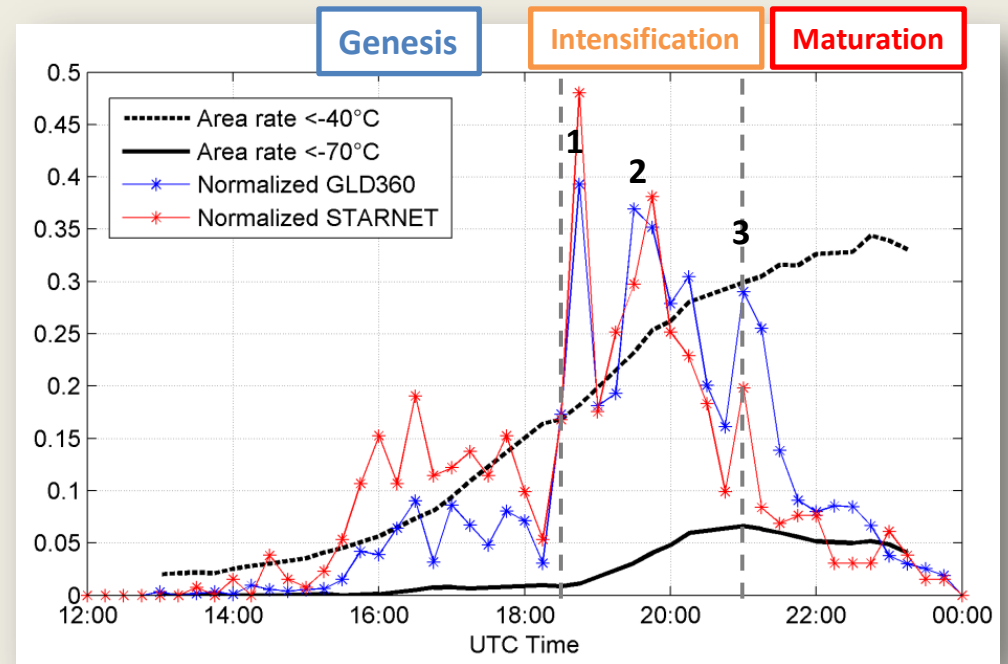
- The lightning events detected by the VLF networks **STARNET**(overlaid as magenta dots) and **GLD3060** (overlaid as blue dots) are mapped and compared to the isolines of cloud top temperature calculated from the pixel color of enhanced infrared (IR) satellite images, GOES-12 (INPE/CPTEC/DSA) : **-40°C gray line** and **-70°C black line**



Results and discussion: Regional scale

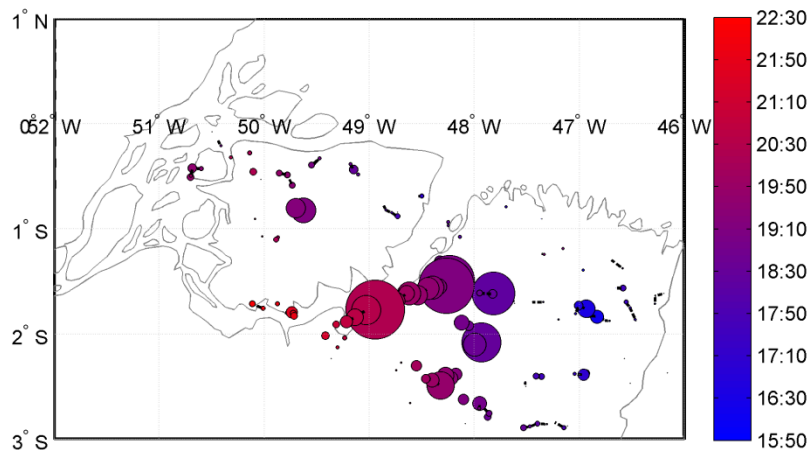
The **intensification** phase of the ASL is embedded to **3 strong peaks** of lightning flash:

- 1) **at the beginning of the intensification** phase when the growth rate of the area covered by cloud top temperature $<70^{\circ}\text{C}$ was maximum (**first convective burst**);
- 2) In the middle of the intensification phase;
- 3) at the end of the intensification phase, marking the ASL maturation.

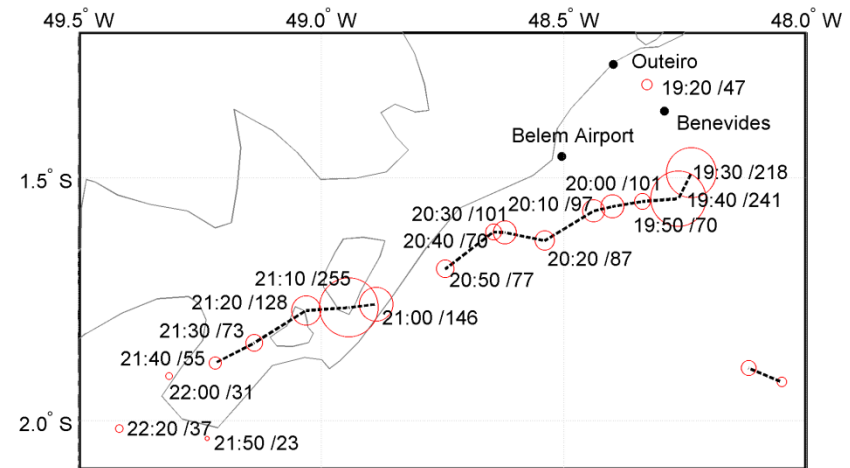


Results and discussion: Lightning clusters

- By tracking the main **lightning clusters** in time, it was observed that:
 - the ASL was mainly **expanded towards the west**, until the middle of the intensification phase, when the core of the dominant cell storm **reached the Amazon River**.
 - Subsequently, the dominant cell of the ASL **changed its drift direction**, close to the experimental sites of Outeiro and Benevides.
 - Next, the ASL was **mainly expanded towards the Southwest** and the core of the dominant cell storm seemed to **follow the Amazon River side**.
- The cell storm direction and intensification from Outeiro suggest an **influence of the river-breeze**.



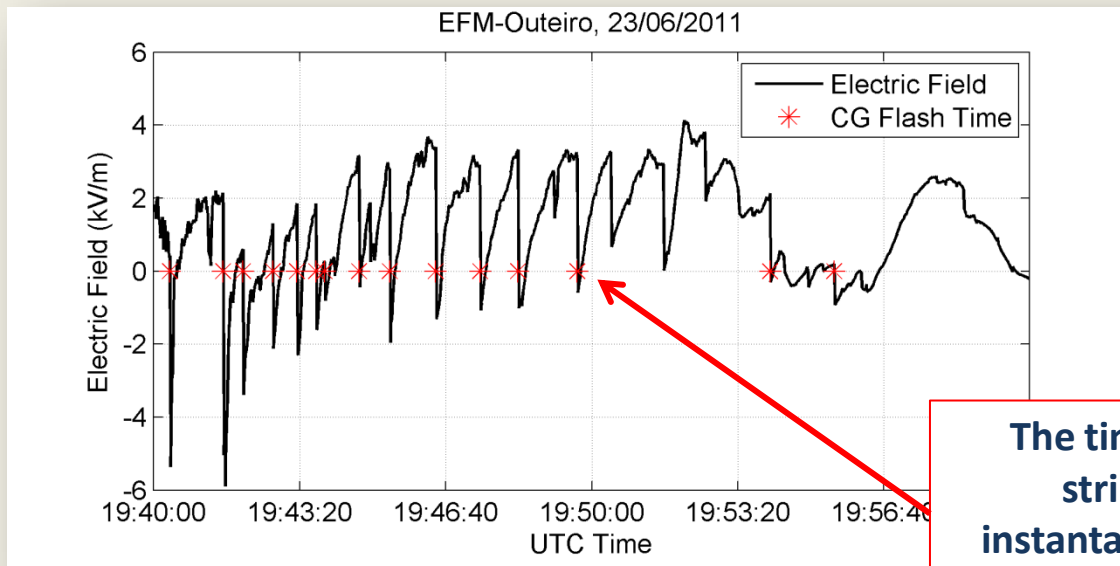
Lightning clusters from GLD360 as a function of weight and time (UTC)



Lightning clusters from GLD360 embedded with time / number of lightning

Results and discussion: Regional scale

- The fine-weather electric field is about 100 V/m
- the thunderstorm electric field can reach 20 kV/m
- The effective detection range of an EFM varies from a few km to perhaps as much as 20 km
- Localization impossible due to the **time sample of 1s**

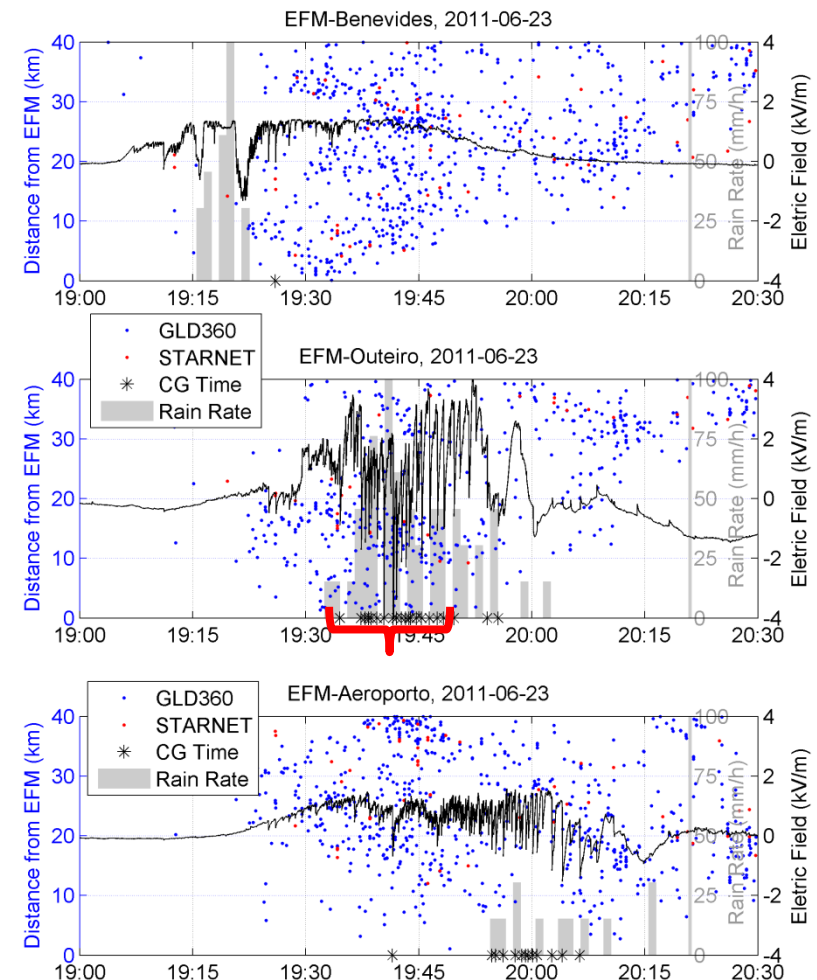


The time of Cloud-to-Ground (CG) strikes was calculating as an instantaneous reversal of the electric field with a magnitude drop >1 kV/m

Results and discussion: Regional scale

- Outeiro: the electric activity was intense (until 4000 V/m).
- This activity may result from the **convergence between the main cell storm with the river-breeze** which **intensified the deep convection over Outeiro** and increase the cloud charge.

EFM signal with the identified CG flash time, compared to the lightning events of the VLF networks plotted in function of flash distance from each experimental base and to the rain rate



References

- Chronis T. G. e E. N. Anagnostou, “Evaluation of a Long-Range Lightning Detection Network With Receivers in Europe and Africa,” IEEE Geoscience and Remote Sensing Society, vol. 44, n. 6, pp. 1504-1510, 2006.
- Said R. K., M. J. Murphy, N. W. S. Demetriades, K. L. Cummins e U. S. Inan, “Methodology and Performance Estimates of the GLD360 Lightning Detection Network,” em XIV International Conference on Atmospheric Electricity, Rio de Janeiro, Brazil, 2011. .

