Results of the 2010-2011 lightning measurement campaigns in Spain

Oscar van der Velde¹

- Joan Montanyà¹, David Romero¹, Nicolau Pineda², Robert Rico¹, Ferran Fabró¹, Gloria Solà¹, Victor March¹, Serge Soula³
- 1. **Technical University of Catalonia**, Electrical Engineering Department, Lightning Research Group, Terrassa, Spain
- 2. Meteorological Service of Catalonia, Barcelona, Spain
- 3. Université de Toulouse, Laboratoire d'Aérologie, Observatoire Midi-Pyrenées, Toulouse, France



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Lightning research facilities in northeastern Spain



- Radar, LINET and LS8000 lightning detection networks
- x/gamma ray detectors
- High speed cameras
- Car with fisheye dome for chasing
- Instrumented tower (2500 m)
- High voltage laboratory
- Cameras for sprites, elves and (hopefully some day) jets
- Ebro 3D Lightning Mapping Array

Main Objectives

- Which processes in natural cloud-to-ground lightning strikes produce x-rays or gamma rays
- The spatial and temporal evolution of lightning processes and the subsequent production of sprites, elves and jets in much higher detail than before
- Summer/winter storm differences (e.g. why very powerful strikes occur primarily during the cold season)
- Lightning strikes to man-made structures
- Development of infrastructure used to supplement the Atmosphere-Space Interactions Monitor (ASIM) – an ESA project

Short Background

- Terrestrial Gamma-ray Flashes (TGFs) reported from spacecraft since 1993, linked to lightning, mostly tropical
- X-and gamma ray emissions from lightning have been reported from ground as well, either natural (e.g. Moore et al. 2001, Dwyer et al. 2005a, Howard et al. 2008), Or triggered by rockets (e.g. Dwyer et al. 2003, Howard et al. 2008).
- Emissions due to slowing down of relativistic electrons (bremsstrahlung), which can form in the strong electric field near lightning leaders



2009-2010: mobile lightning and x-ray recordings









2009-2010: mobile lightning and x-ray recordings

- Only once (in 2009) x-rays recorded
- Negative cloud-ground flash struck closer than 500 m away
- But, flash missed by highspeed camera (reason to use fisheye lens in 2010-)
- No other observations from flashes (typically several km away) – short propagation

99 pulses higher than 10 keV in 27 bursts 0.86 ms duration



2010: mobile lightning and x-ray recordings

- For example, no x-rays during this +CG flash striking a few kilometers away.
- (video)





Tower measurements of lightning





Tower measurements



No x-ray pulses related to the leader.

Tower measurements



Again no xray pulses related to the leader.

Ebro Lightning Mapping Array

- developed by New Mexico Tech
- 6 of 13 sensors currently installed
- Baselines 6-20 km
- 63-68 MHz (VHF)
- 12500 sources per second (80 μs)
- 3D time-of-arrival



Well located for warm and cold season storms + sprite observations

Ebro Lightning Mapping Array





LMA example + LINET





LMA detecting upward leaders from a windmill





Sprites in range of the LMA



3 LMA animations of very large flashes (~30-50 km)