

Features of lightning discharges observed by high speed cameras and VHF/VLF total lightning mapping systems at the Ebro Valley

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The paper presents the results of the campaigns conducted in the north-east of Spain where two high speed video cameras are available for recording of lightning together with a 2D VHF interferometer network, a 3D VLF network and a 3D lightning mapping array. Examples of the observations downward and upward cloud-to-ground (CG) flashes will be reviewed as well for the intra-cloud (IC) flashes.

1. General

Two main techniques have been used in order to investigate the processes related to the lightning phenomena: optical methods and electromagnetic detection. Thanks to the popularity of high speed digital video cameras at frame rates higher than 1000 fps, for the last ten years several researches precisely determined visible properties of lightning flashes. A big effort to record natural negative and positive cloud-to-ground lightning and detail their visible properties has been done [e.g. 1]. On the other hand, high speed videos have been used to identify and understand the processes with different lightning detection systems detect [e.g. 2].

In parallel, the total lightning systems using VHF [3] and VLF [4] have been become also popular in the scientific community. One of the main advantages of the VHF systems is the capability to map leaders (mainly negative) within the cloud where high speed camera cannot observe.

Since 2009, the Ebro Valley region (northeast of Spain) has been the target for lightning research in the frame of the ASIM mission. In this area some state-of-the-art facilities have been running in order to study the properties of lightning, transient luminous events (TLE) and high energy emissions from natural lightning.

2. Data

Two high speed video cameras have been used for lightning recordings. A 800 x 600 pixels (6,688 fps at full resolution) camera was arranged for mobile operation (figure 1). With this camera an image intensifier is attached for TLE observations.



Figure 1. High speed camera (at top) and instruments operating during 'storm chasing'.

The second camera was permanently installed at about 10 m of the Eagle Nest tower (2537 msl) during summer 2011 (figure 2). With this camera, two NaI(Tl) detectors and two electric field antennas (LF and VHF) provided high energy and electromagnetic fields related to the lightning flashes at the tower.



Figure 2. View of the instrument with the second high speed camera at the Eagle Nest tower (2537 msl).

For nine years a VHF interferometer network (XDDE) has provided 2D detections of VHF sources related to CG and IC flashes.

More recently, a VLF network (LINET) is also ranging the Ebro Valley region. This network provides detections of CG flashes and also detections of IC flashes. The altitudes of the emissions for the IC events are also estimated.

Since summer 2011 the Ebro Valley lightning mapping array (ELMA) system is operating at the Ebro Delta region. This network uses the time-of-arrival technique in VHF for providing 3D detections of sources emitted by leaders.

3. Summary of results

3.1 Cloud to ground lightning

Figure 3 shows three stacked video frames for three different types of CG flashes.

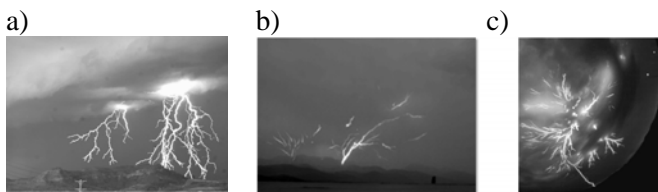


Figure 3. Stacked images: a) negative flash, b) upward negative flash and c) downward positive flash.

Figure 4 displays an example of a negative CG flash detected by the ELMA, the XDDE and LINET.

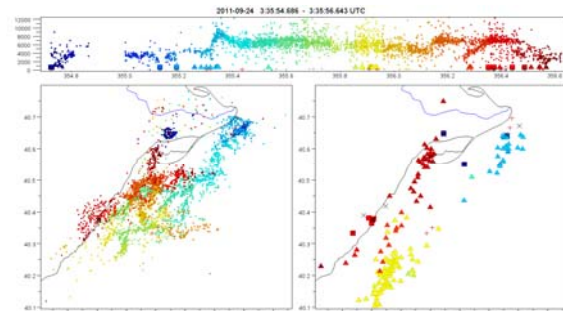


Figure 4. Negative cloud to ground flash detected with the ELMA, XDDE and LINET.

An example of a rare case corresponding to an upward positive flash is plotted in the figure 5.

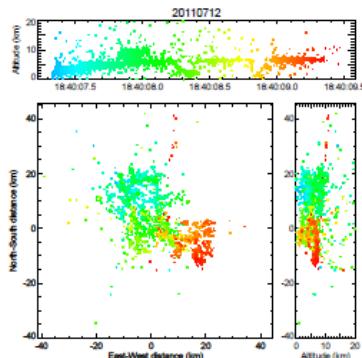


Figure 5. Example of an upward positive flash mapped by the ELMA.

An upward negative flash at the Eagle Nest tower with its corresponding electric field is depicted in figure 6.

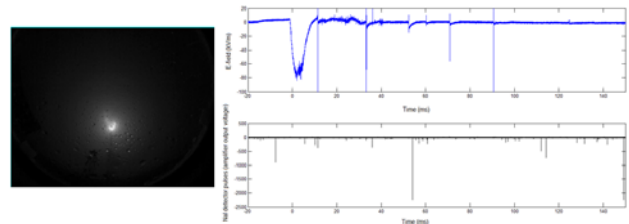


Figure 6. Left: Negative upward flash at the Eagle Nest tower. Right: Electric field (top) and high energy detections.

3.2 Intra cloud lightning

And an example of an IC flashes is presented in figure 7.

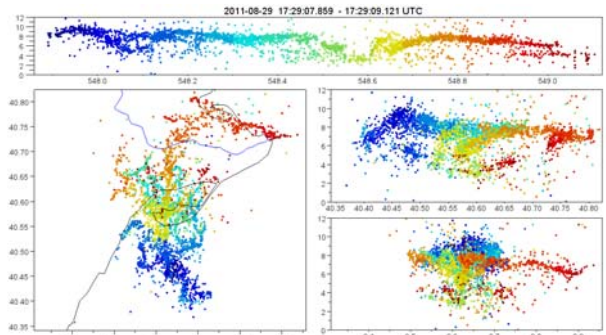


Figure 7. Example of an IC flash.

3. References

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