Examples of ST-Lightning Observations During SOP1 at Flash and Storm Scales

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1 – ST-Lightning Objectives

Provide HyMeX community record and analysis of the lightning activity as reported by research and operational lightning locating systems (LLSs) over SOP, EOP and LOP.

Multi-scale and multiple-year lightning detection for observational- and modeling-based multi-disciplinary investigations in the frame of HyMeX with emphasis on

- > Links between kinematics, microphysics, electrification, aerosols and lightning occurrence and characteristics,
- > Electrification processes and charge structures inside clouds over sea and land, and during sea-to-land and land-to-sea transitions,
- > Climatology of the lightning activity over the Mediterranean Basin,
- > Comparison of lightning observations from different LLSs,
- > Use of lightning detection in assimilation and nowcasting.

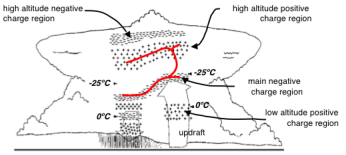


Fig-1.1. Vertical distribution of charge regions in a thunderstorm as derived from in situ measurements (adapted from Stolzenburg *et al.*, JGR, 1998).

2 – ST-Lightning Instrumentation

Four operational LLSs : - ATDnet (UKMO)
- EUCLID
- LINET (LMU)
- ZEUS (NOA)

One research LLS : - LMA (NMT)

Auxiliary ground sensors : - Induction rings (LA)
- Electric field mills (LA)
- Barometer array (CEA)
- Video- and FM-system (OVE)

Cloud resolved mesoscale models : - MESONH (LA)
- WRF (NOA)

3 – ST-Lightning Instrumentation Deployment and Data Available

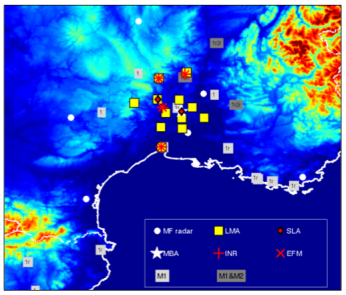
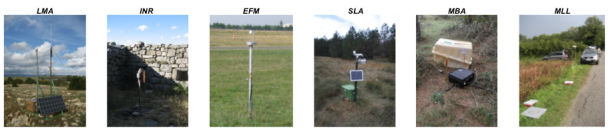
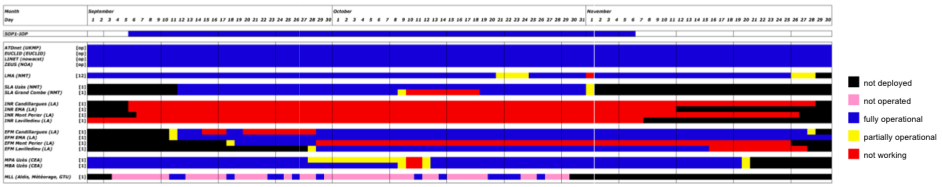


Fig-3.1. Left : locations of the different TTO1h research instruments (MLL locations are indicated by M1 markers while M2 markers indicate the few locations where a second video camera was operated); Right : pictures of the instruments with LMA station at Mont Aigoual, induction ring (INR) at Mont Perier, electric field mill (EFM) at Candillargues, slow antenna (SLA) at Uzès airfield, micro-barometers (MBA) at Uzès airfield, and MLL deployment on 26 September 2012 with M1 and M2 measurements); bottom : data as available on HyMeX database.





4 – ST-Lightning Concurrent Observations

Concurrent observations at the flash scale

- Comprehensive description of flashes from different instruments sensitive to different processes occurring during the flash life
  - Material to study these different processes,
  - Material to actually understand the concurrent records of the different LLSs.

- Example : a negative Cloud-to-Ground (CG) flash on Sept. 24th at 01:43:17
  - 1.1-s duration CG flash with 10 negative ground strokes according to SLA & MLL field records (Fig-4.1) about 25 km away from MLL,
  - Rather accurate stroke locations from the operational LLSs relative to LMA records (Fig-4.1),
  - First ground stroke not seen by any LLS but by the camera and MLL field records (Fig-4.1 and Fig-4.2).

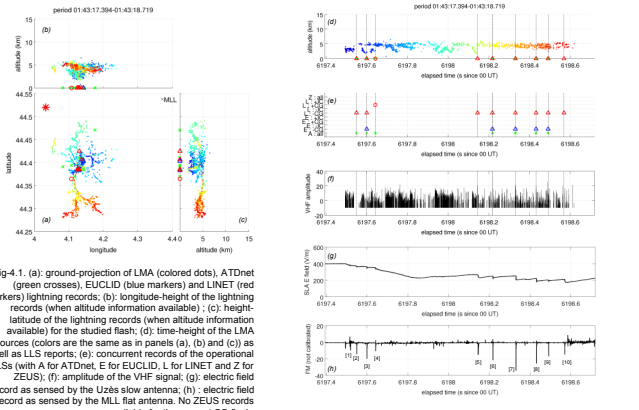


Fig-4.1. (a): ground-projection of LMA (colored dots), ATDnet (green crosses), EUCLID (blue markers) and LINET (red markers) lightning records; (b): longitude-height of the lightning records (when altitude information available) ; (c): height-latitude of the lightning records (when altitude information available) for the studied flash; (d): time-height of the LMA sources (colors are the same as in panels (a), (b) and (c)) as well as LLS reports; (e): concurrent records of the operational LLSs (with A for ATDnet, E for EUCLID, L for LINET and Z for ZEUS); (f): amplitude of the VHF signal; (g): electric field record as sensed by the Uzès slow antenna; (h) : electric field record as sensed by the MLL flat antenna. No ZEUS records were available for the present CG flash.

Fig-4.2. Some frames of the video recorded during the CG flash. The time resolution of the video camera is 5 ms. The location of the video camera is indicated as "MLL" in Fig-4.1. The contrast of the images was enhanced. Time of the frames is indicated above each image.

Concurrent observations at the storm scale

- Comprehensive description of lightning activity and electrical state of the parent thunderclouds from different instruments sensitive to different geophysical and atmospheric parameters
  - Material to study these different parameters through the storm lifecycle,
  - Material to investigate links between dynamics, microphysics, electrification and lightning occurrence.

- Example : the 24th September 2012 case
  - Synergetic use of operational LLS records to pinpoint properties of CG activity relatively to Intra-Cloud (IC) activity in conjunction with the storm structure and dynamics as deduced from radar observations (Fig-4.3),
  - Study of the acoustic signal radiated by flashes relatively to flash properties (Fig-4.4).

- **Different storm-scale investigations underway using TTO1h records**

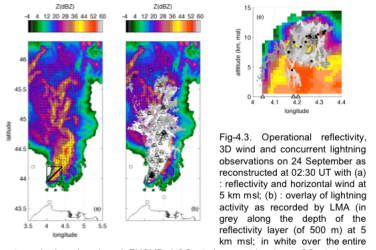


Fig-4.3. Operational reflectivity, 3D wind and concurrent lightning observations on 24 September as reconstructed at 02:30 UT with (a) : reflectivity and horizontal wind at 5 km msl; (b) : overlay of lightning activity as recorded by LMA (in grey along the depth of the reflectivity layer (of 500 m) at 5 km msl; in white over the entire atmospheric column) and EUCLID (+CG strokes as triangles; +CG strokes as circles) during the period 02:25-02:35; (c) : vertical distribution of the VHF sources (02:29:30-02:30:30) overlaid on the reflectivity curtain along the segment plotted in (a). Dark dots [hexagrams] in panel (c) show the locations of the [short-duration] flash triggering. The radar data was provided by Olivier Bousquet (Météo France).

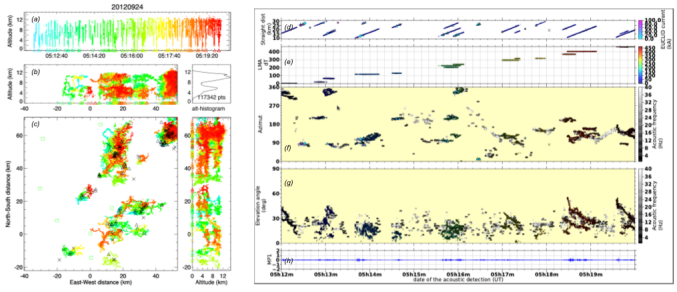


Fig-4.4. Lightning and acoustic activities as sensed by LMA, EUCLID and MPA on September 24th between 05:12 and 05:20. (a) : time series of the altitude of the LMA sources; (b) : longitude-height of the lightning activity; (c) : ground projection of the lightning activity; (d) : straight distance of the LMA discharges, plotted in relation to their time of arrival at the acoustic array; (e) : elapsed time (in s) between the different LMA sources in reference to the first considered LMA source of the studied period; (f) : azimuth of the LMA sources (in colors) and azimuth of the acoustic signal as derived from the MPA records (grey squares); (g) : elevation of the LMA discharges (colors) in straight distance and elevation of the acoustic wavefronts at MPA location (grey squares); (h) : acoustic signal recorded at one microphone at MPA location.

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