Preliminary Results on the Study of the Lightning Activity and Cloud Properties Recorded During the SOP1-IOP6 (24 September 2012)

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1 – Objectives

Investigate the properties of lightning flashes and activity relatively to the dynamics and the microphysics of the parent thunderclouds

Document and understand the full lifecycle of the SOP1 IOP6 event

Investigate the relevance of total lightning activity as a convective precipitation proxy using high resolution HyMeX SOP1 measurements

2 – Instrumentation and Methodology

Instruments :

Lightning : HyLMA (NMT; IC + CG), EUCLID (CG)

Clouds/precipitation : RASTA (LATMOS, 95 GHz; airborne)
MXPOL (EPFL, 9.4 GHz Dpol; Monbrun)
X1 (LaMP, 9.3 GHz; La Bombine)
Op. Radars (Météo-France, C & S bands)

Methodology :
i) Merging of radar and lightning observations
ii) Temporal and spatial investigation at flash and storm scale

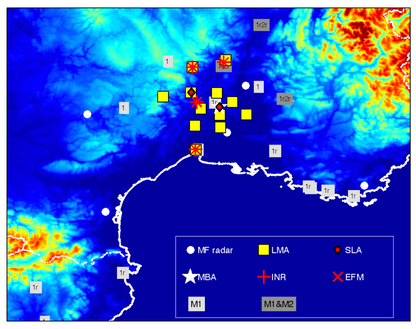

Fig-2.1. Locations of the different ST-Lightning research instruments over the SOP1-CV domain.

3 – Preliminary Results

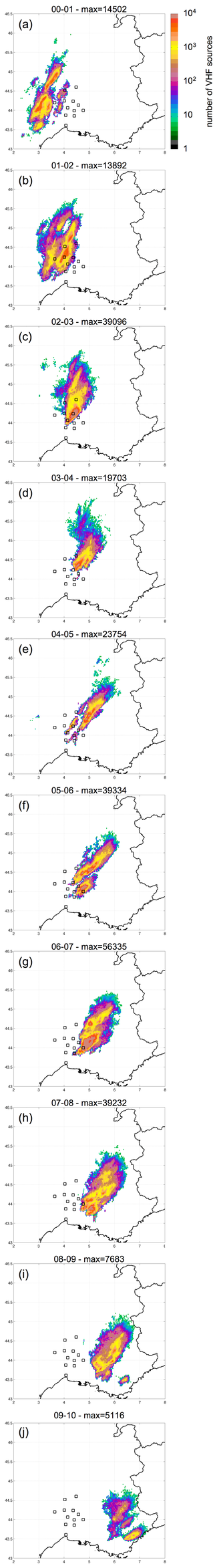

Fig-3.1. Density of VHF sources computed per 0.025°x 0.025° for every hour on the 24 September 2012 between 00 and 10 UTC.

Lightning and Precipitation

- HyLMA provides more information on the spatial distribution of lightning flashes than usual OLLSs to investigate the relationships between total lightning activity and precipitation at high resolution
- Lightning activity without precipitation can be explained by radar beam attenuation and/or lightning flashes in non precipitating cloud regions
- Total lightning activity seems located few km behind the intense precipitation for the studied case at the studied period
- Lightning flashes recorded over a large range of low level reflectivity according to the convection stage, the inner cloud structure and cloud charge regions
- *Next step :*
  - *Study at the scale of the convective cell with exclusion of attenuated radar beams*

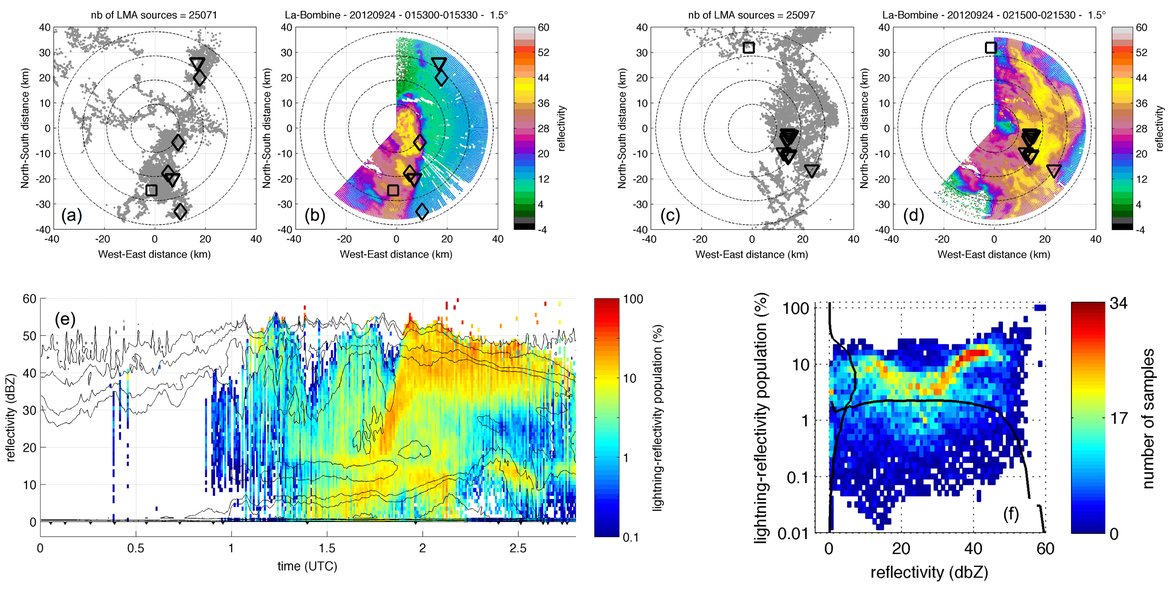

Fig-3.2. (a, b) : lightning activity (grey : HyLMA; dark symbols : EUCLID) and LaMP X-band radar reflectivity (1.5° elevation) between 01:53:00 and 01:53:30; (c, d) : same as (a, b) but at 02:15:00-02:15:30; (e) : time-reflectivity distribution with lightning expressed in % relative to the values of reflectivity measured during a given PPI scan (the lines map the total reflectivity distribution at the levels 10, 100, 500, 1000, 5000, 10000); (f) : distribution of the percentage of the reflectivity with lightning as a function of reflectivity compiled over the studied period (the solid lines show the histogram of the measurements expressed in % relative to the total number of samples as plotted according to the scales of the two axis).

Lightning, Kinematics and Microphysics

- Vertical extension of the lightning flashes consistent with the vertical structure of the parent clouds
- Upper lightning channels in deep convective areas often propagating just below the upper edge of the clouds
- Lightning intra-cloud discharges often located in convective regions with high reflectivity and high updraft whatever the altitude
- *Next steps :*
  - *Exploit radar-based microphysics retrievals to study flash structures relative to the cloud environment*
  - *Further investigate lightning properties in convective and stratiform cloud regions separately*

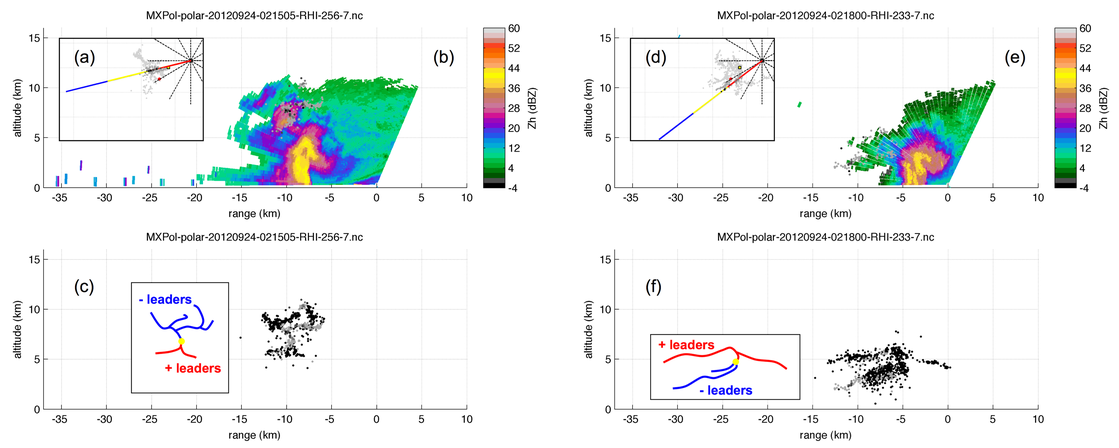

Fig-3.3. EPFL MXPOL RHI reflectivity scans and HyLMA lightning records along two different directions at two different times (02:15 and 02:18 UTC). (a) : ground projection of the studied lightning flash relatively to MXPOL location (red, yellow and blue segments are 10-km long); (b) : RHI reflectivity scan ending at 02:15:05; (c) : lightning flash recorded at 02:15:15 (colors are related to the azimuth range relative to MXPOL azimuth. (d), (e) and (f) same as (a), (b), (c) but for MXPOL RHI scan ending at 02:18:00 and for a lightning flash recorded at 02:17:15.

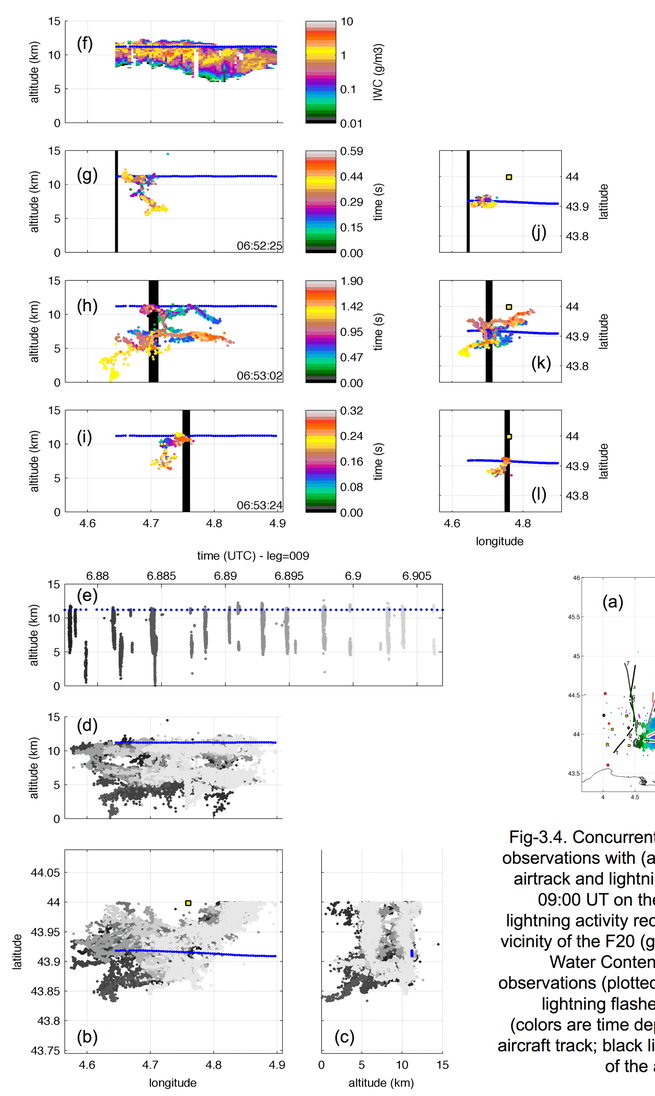

Fig-3.4. Concurrent LATMOS RASTA and HyLMA observations with (a) ground projections of the F20 airtrack and lightning activity for the period 06:30-09:00 UT on the 24 September 2012; (b,c,d,e) lightning activity recorded during the leg #09 in the vicinity of the F20 (grayscale is time related); (f) Ice Water Content curtain retrieved from RASTA observations (plotted in log scale); (g to l) individual lightning flashes recorded along the F20 track (colors are time dependent; blue lines indicate the aircraft track; black lines indicate the actual location of the aircraft at the time of the flash).

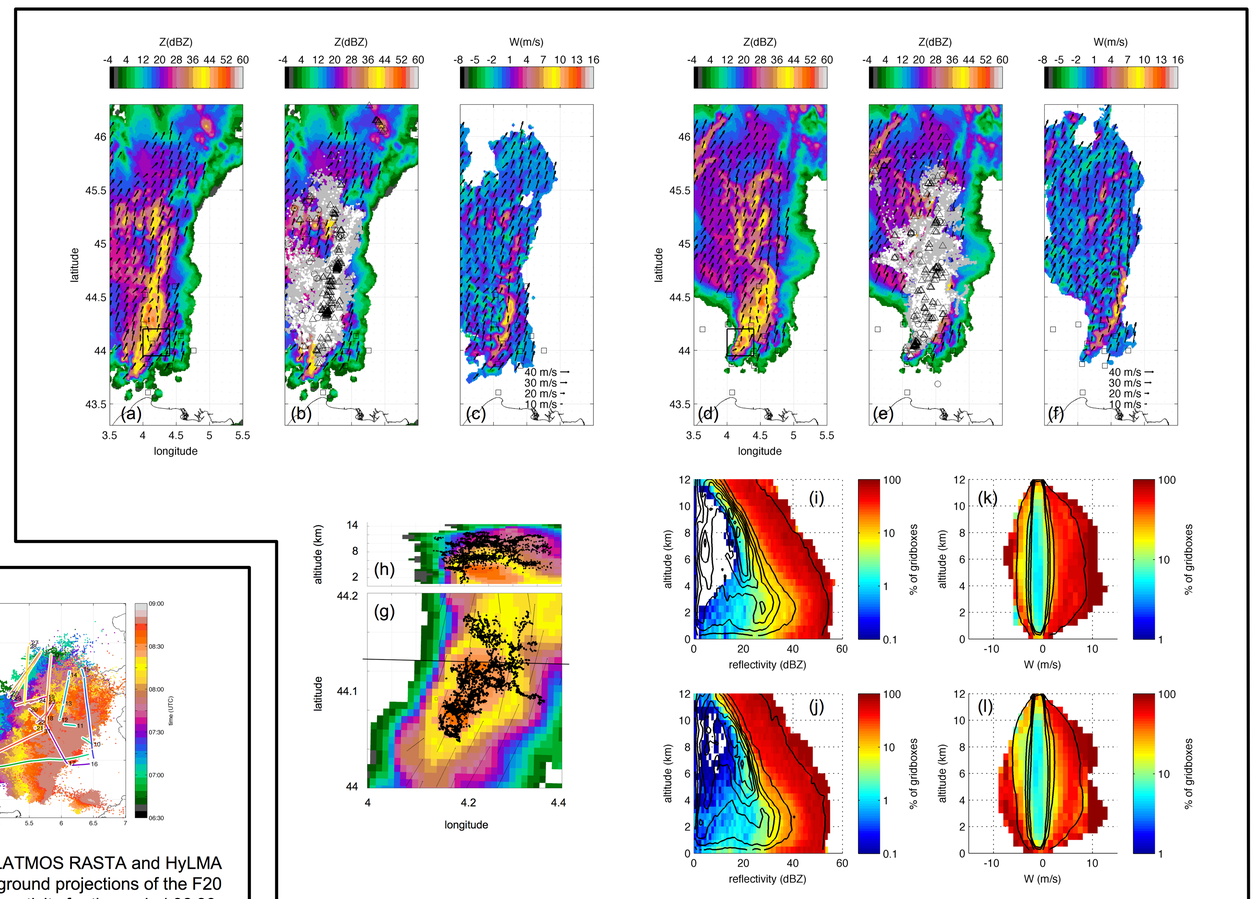

Fig-3.5. Météo-France operational radar observations and concurrent lightning activity with (a) reflectivity and horizontal wind at 5 km amsl from 3D Multiple-Doppler wind and reflectivity analysis at 02:00 UTC on 24 Sep 2012; (b) overlay of lightning activity as recorded by HyLMA (in grey along the depth of the 500m reflectivity layer; in white over the entire atmospheric column) and by EUCLID (-CG strokes as triangles; +CG strokes as circles) during 15 minutes; (c) vertical velocity; (d to f) same as (a to c) but at 02:30 UTC; (g) zoom in the domain drawn in (d) with lightning observations collected at 02:29:06-02:29:16 where 7 flashes were recorded by the HyLMA including one negative CG flash in the considered domain; (h) vertical distribution of the VHF sources along the black line in (d); (i,j) distribution of the reflectivity with 5-min lightning activity relative to the total number of reflectivity values per bins of 1 dBZ and 0.5 km (latitude ranging from 43.5°N and 45°N) at 02:00 and 02:15 UTC; (k,l) same as (i,j) but for radar-based retrieved updraft per bins of 1 m/s and 0.5 km. Black lines in (i-l) show the total number of the samples for the domain of interest.

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