Convection and Lightning Activity from Ground-based and Multi-satellite Observations

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1 Scientific context

The cloud microphysical structure is of primary importance concerning rainfall studies either from numerical simulations, space-born passive microwave or ground-based radar measurements. Observational tools (polarimetric radar, satellite radiometry,...) can be used to assess cloud microphysical structures but they are not continuously available everywhere in Europe or over the Mediterranean Sea. For example polarimetric radars are not routinely operated while geostationnary infrared/visible radiometry scans only the upper layer of the clouds and sensors onboard low-orbit satellites suffer of a poor temporal sampling of storms. In thunderclouds, lightning flashes occur in highly electrified areas. Microphysical processes responsible for the cloud electrification occur in specific environnements. Basically, cloud-water and ice mixing ratios as well as updraft control the electrification rate and implicitely the occurence of lightning flashes. In many cases, the lightning flash activity in terms of rate and density can be compared to convection intensity and significant rainfall. Our **goals** are:

- to gain further insight in the understanding of the interactions between cloud microphysics, cloud dynamics, cloud electrification and occurence of lightning flashes in continental and maritime storms;
- to assess the potential improvement of rainfall retrieval gained in using lightning flash measurements in conjunction with more classical observations/products for operational applications in weather and hydrological nowcasting.

The newly-operational Lightning Network (LINET) monitors continuously the total (intracloud and cloud-to-ground) lightning activity since May 2006. It can also provide a 3D mapping of the flashes both at high temporal and spatial resolutions for a network configuration relatively compact ($<$ 200 km). The deployment of LINET sensors in special observing zones should provide more accurate observations in terms of location accuracy and detection efficiency than any lightning sensor available in Europe. Our mid-term perspective is to compare the lightning flash activity as sensed by LINET to the simulated one using mesoscale electrified thundercloud simulations along with passive microwave observations.

2 Multi-sensor observation of the 6-9 September 2005 South-of-France Flood Event

- **Rainfall** Significant rain recorded over the region of Arles.

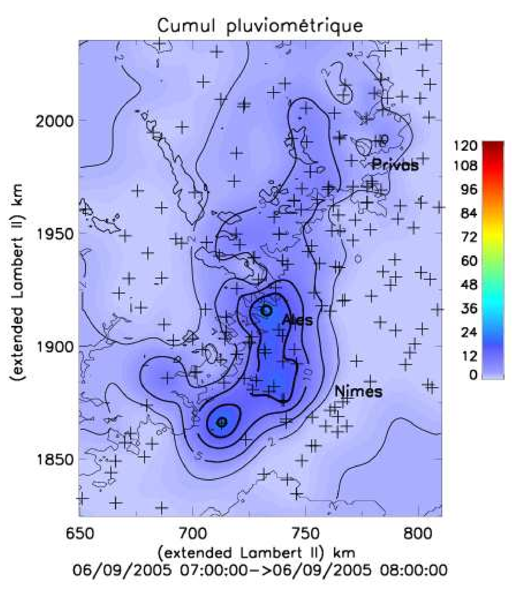

Figure 1: 1-hour rain accumulation on the 6th September 2005.

- **Meteosat Second Generation** Significant convection with successive close developments.

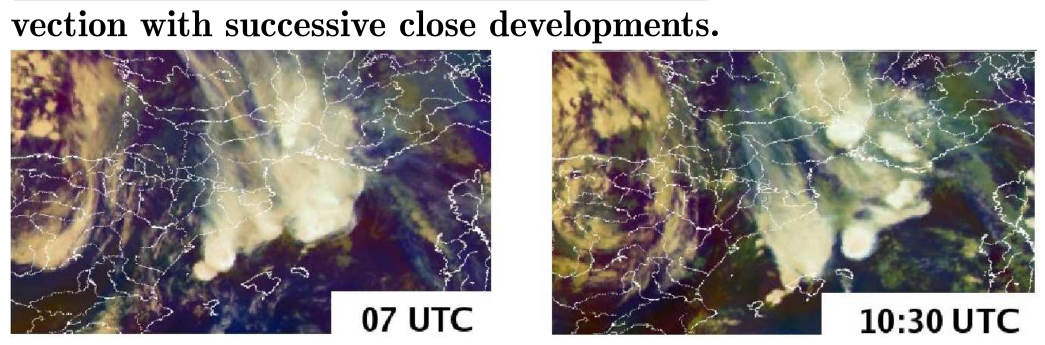

Figure 2: MSG composites images on the 6th September 2005.

- **Microwave SSMI** Relatively cold SSMI 85 GHz brightness temperature.

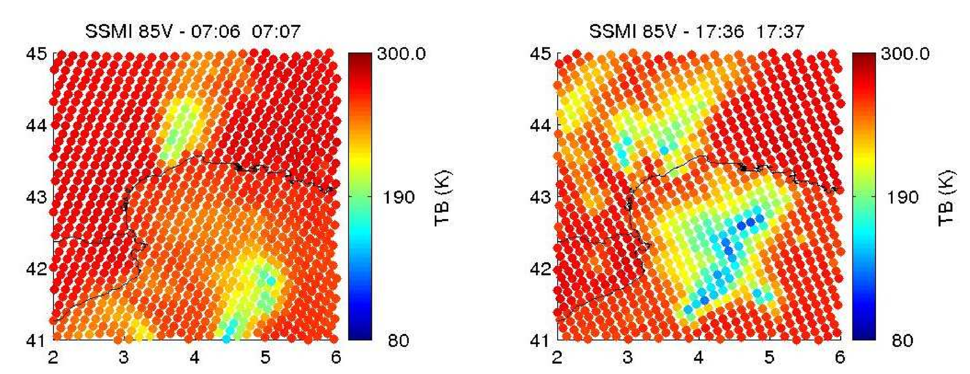

Figure 3: SSMI 85GHz, on the 6th September 2005.

- **Lightning activity** Significant lightning activity sensed all-day long in the entire region.

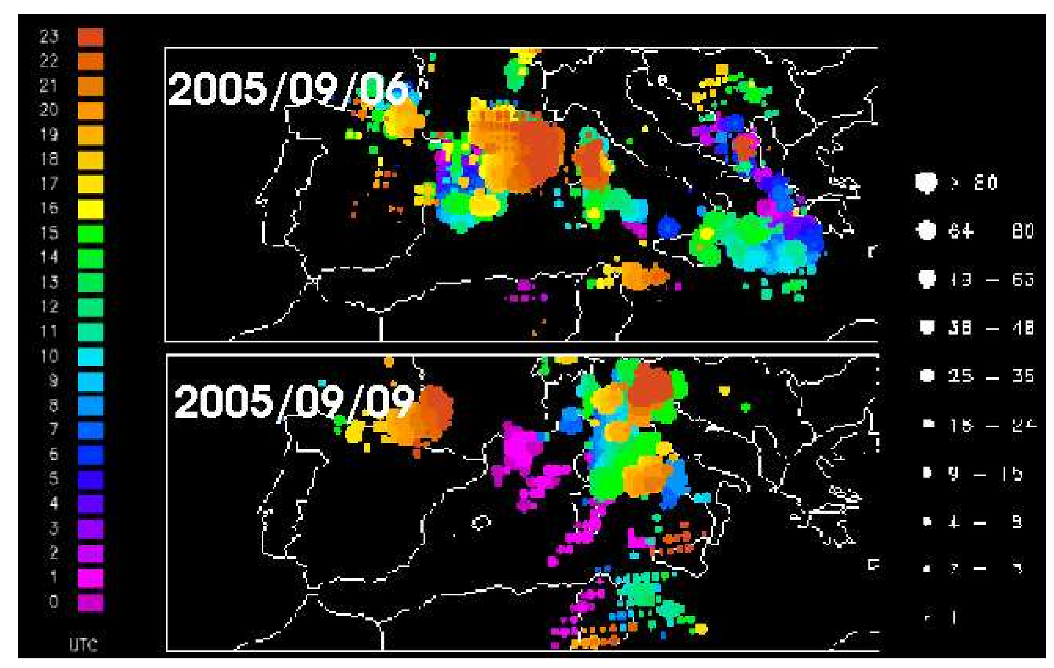

Figure 4: Lightning activity recorded by the UK Met Office ATD lightning network in Europe (www.torro.org.uk/sfinfo.htm).

3 LINET: 3D IC + CG

- **Features**
  - VLF/LF, TOA, real-time
  - Total lightning capability with equal detection efficiency for cloud-to-ground (CG) and intra-cloud (IC) lightning.
  - High efficiency for low amplitudes (currents >2kA)
  - Continuous sampling, no loss of signals (up to 250/s)
  - Optimized statistical location accuracy
    - ∗ location accuracy 200 m (rms TOA error 0.2s)
    - ∗ compact storm cells, few bad locations
  - DLR-LINET deployed in Brazil, Australia, Africa

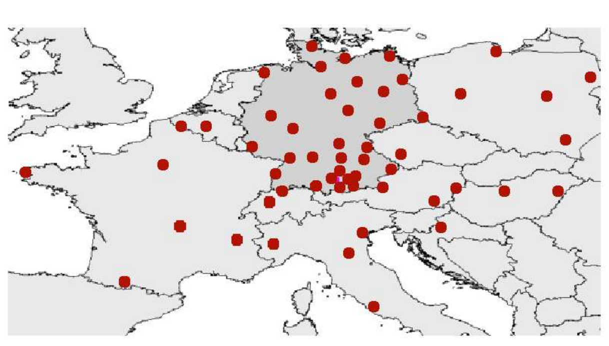

Figure 5: Current LINET network.

- **Example of observation**

LINET sensor detected signal ≡ **FIX**

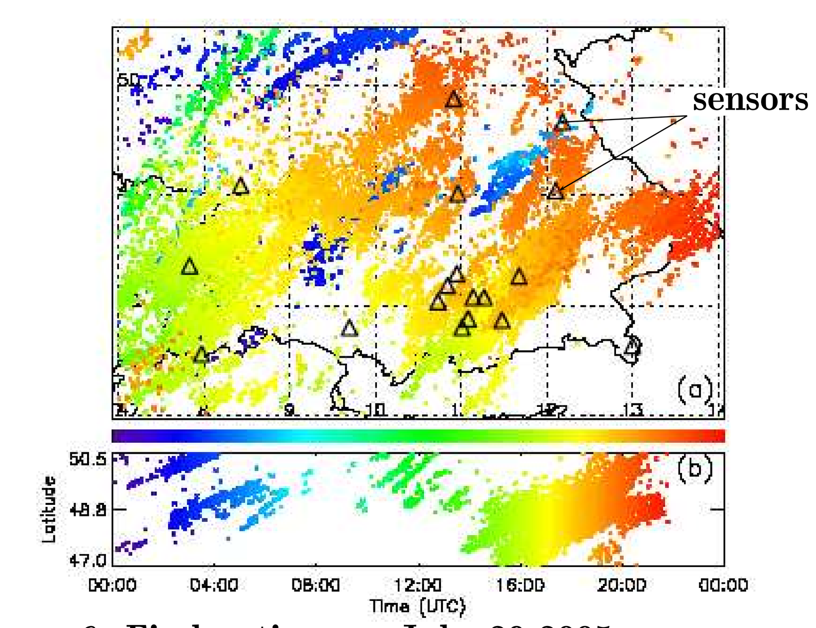

Figure 6: Fix locations on July, 29 2005.

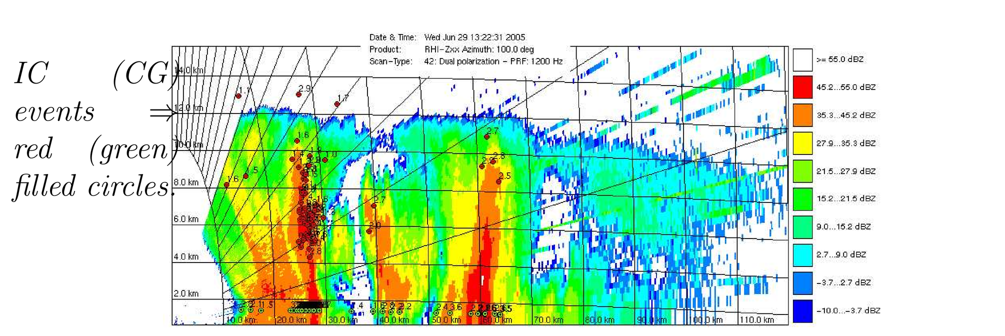

Figure 7: PPI Radar reflectivity + Fixes on June, 29 2005.

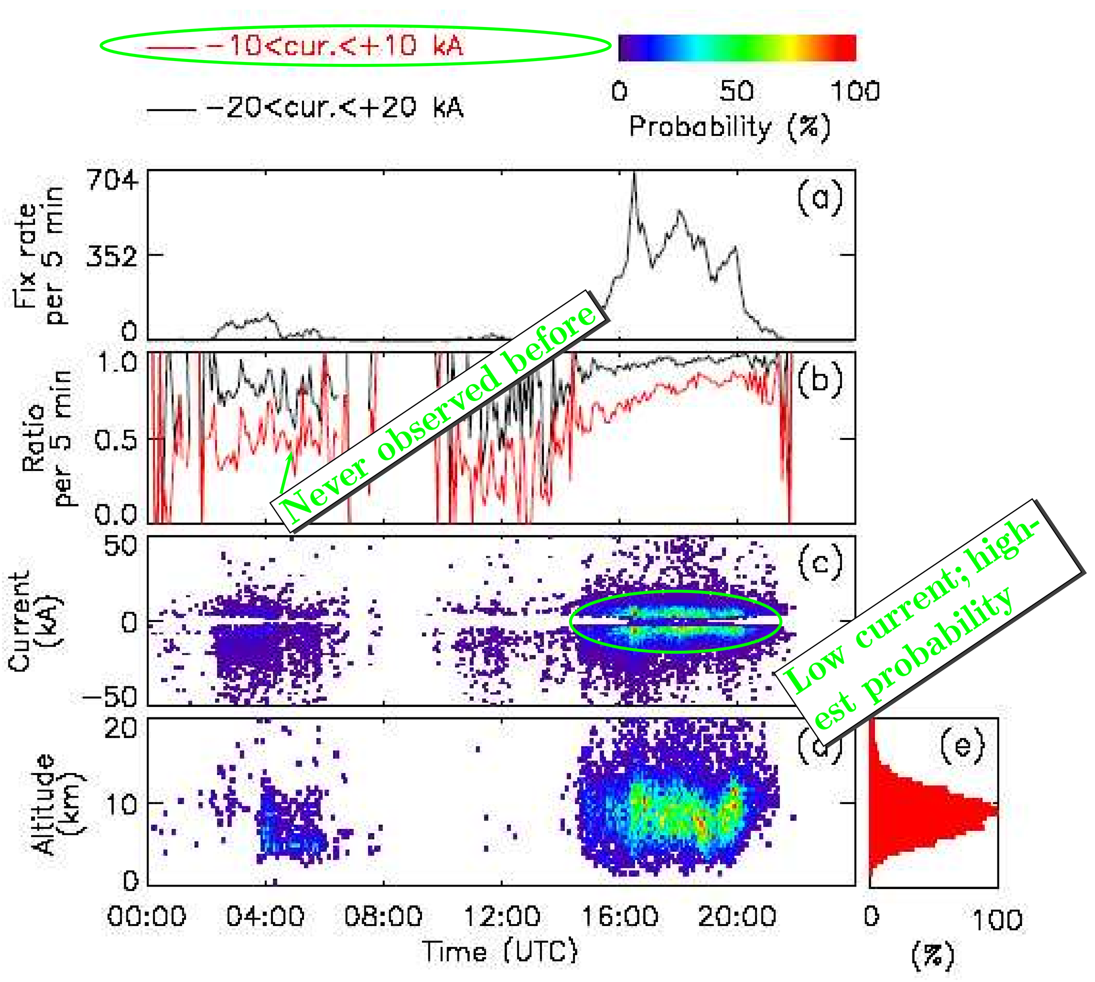

Figure 8: LINET data analysis.

4 Numerical simulations

- Cloud electrification and lightning flash parameterizations implemented in MesoNH
  - A stochastic lightning flash scheme for the purposes of :
    - ∗ simulations of lightning flashes featuring branches;
    - ∗ γ-mesoscale thundercloud life-cycle simulations.
  - Cloud electrification due to elastic collisions of ice particles ⇒ cloud charge pockets ∼1 C.km^{-3} ⇒ electric stress.
  - Need to relax cloud electric stress: A stochastic lightning flash scheme is implemented.

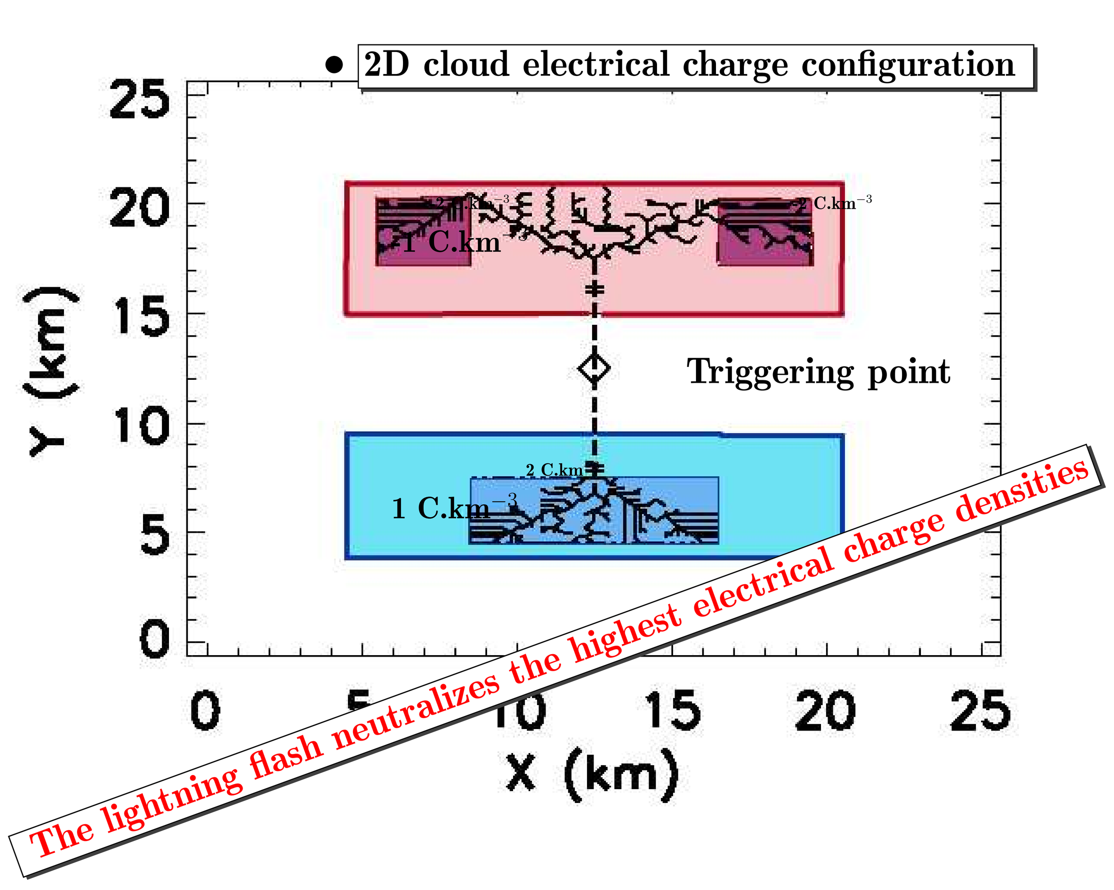

Figure 9: 2D test of the lightning flash scheme

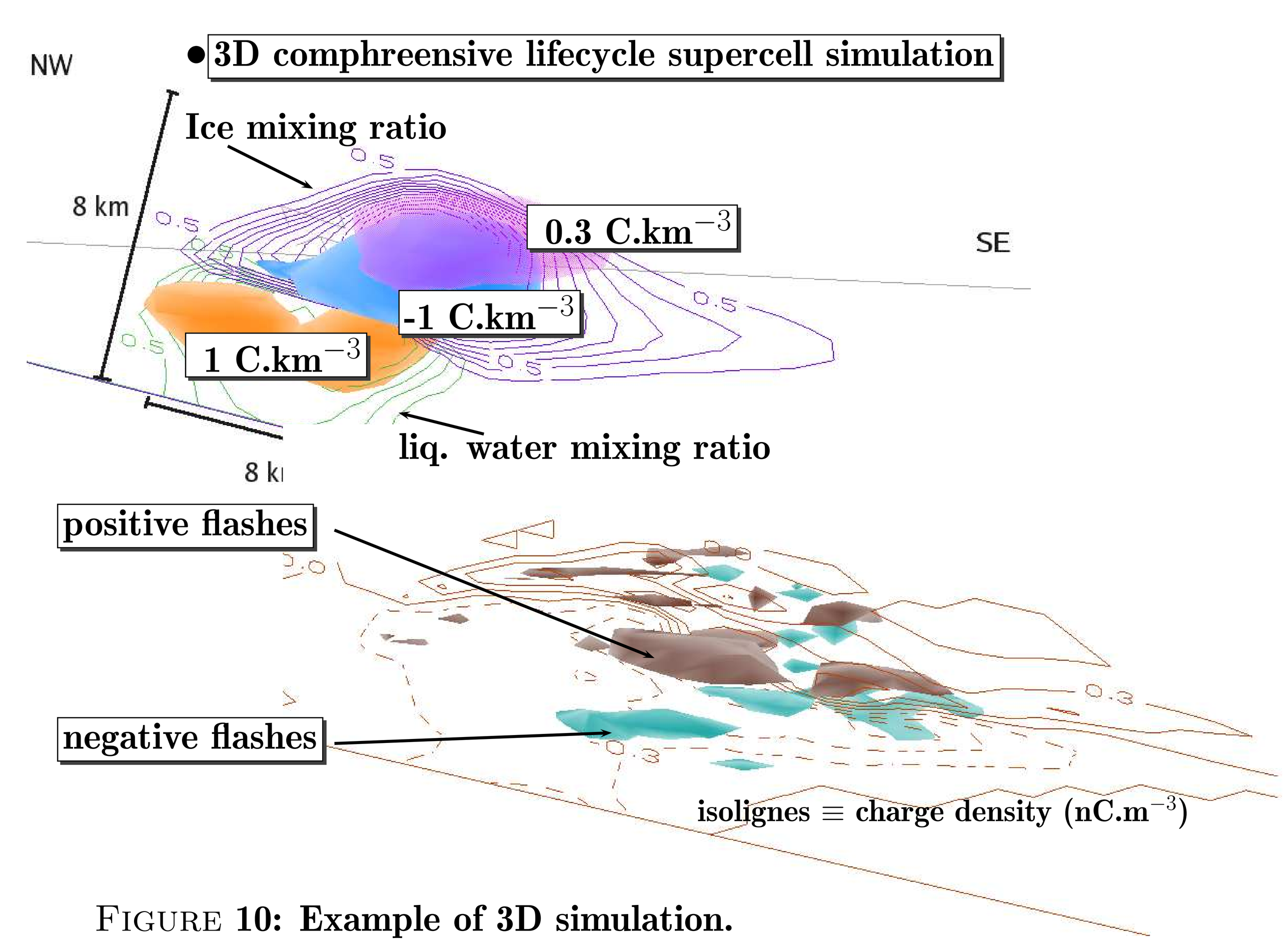

Figure 10: Example of 3D simulation.