Lightning activity in relation to thermodynamics, dynamics and microphysics in storms over Paris region

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1. Introduction

Lightning activity produced by storms is related to their thermodynamics, dynamics and microphysics. PEACH (Projet d'Electricité Atmosphérique pour la Campagne HyMeX) proposes to investigate this issue as part of the global HyMeX project. One of the goals is to contribute to heavy precipitation forecast and/or to develop tools to help in rainfall estimation, by using the lightning activity. The purpose of the study we are currently carrying out on the Paris region (region chosen for the diversity of available data), is to build analysis methods to highlight links between lightning, thermodynamics, microphysics and heavy precipitation.

We focus on two events of 2009 (24/08/09 and 7/10/09) which presented some interest in a sustained lightning activity and during which some experimental data on intra cloud (IC) sources activity (from LS 8000 system) were available.

2. Data

Herein, the example of the 24/08/2009 is presented. This event exhibits several small cells which merged leading to a convective system between 11:00 and 22:00 UTC in which 2309 CG occurred with about 20 % of +CG. To realize this study, we use several kinds of data :

- *lightning data (CG)* : Meteorage Network – LF Detection
- *radar (reflectivity and wind)* : Météo France – French Doppler radar network ARAMIS, resolution: 2.5 × 2.5 km. Each specified time corresponds to the previous quarter-hour.
- *satellite (cloud top temperature)* : Meteosat – MSG, IR channel [10.5 - 12.5] µm, resolution : 0.046 × 0.046 °. Each specified time corresponds to the next quarter-hour.

From this data set, we realized some comparisons to try to observe some links.

3. Observation of Cloud-to-Ground (CG) lightning activity and Cloud Top Temperature

Fig. 1 : 24/08/2009 – CG lightning activity between 10h45 and 22h UTC (colors correspond to the temporal evolution)

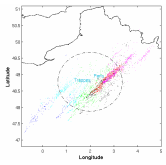


Fig. 2 : 24/082009 - Cloud Top Temperature at 18h30 UTC (interpolate on a grid of 5×5 km, hour corresponding to radar data)

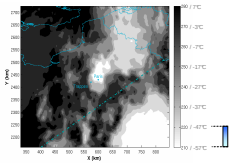
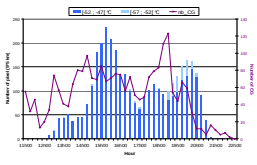


Fig. 3 : 24/08/2009 - Temporal evolution of CG lightning activity and of surface covered by the coldest range of cloud top temperature (between -57 and -47 °C (ie. 210 and 220 K) by rang e of 5°C)



- CG lightning activity precedes the development of the surfaces of the coldest cloud top temperature for this event (Fig.3).
- The merger of new cells seems to reactive the CG lightning activity in a first time (for example between 17h15 and 18h30), and intensifies the updrafts, which carry more ice particles that can spread out in upper layers in a second time.

4. Observation of Cloud-to-Ground (CG) lightning activity and Reflectivity

Fig. 4 : 24/08/2009 - Radar reflectivities at 2500 m and CG (pink circles) at : a) 18h30 and b) 11h45

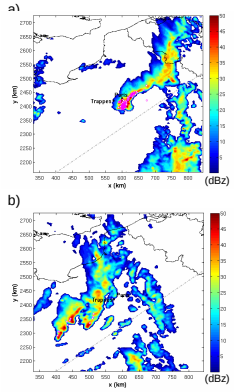


Fig. 5 : 24/08/2009 : Temporal evolution of CG lightning activity and of surface at 2500 m covered by : a) all the reflectivities, b) reflectivities higher than 40 dBz

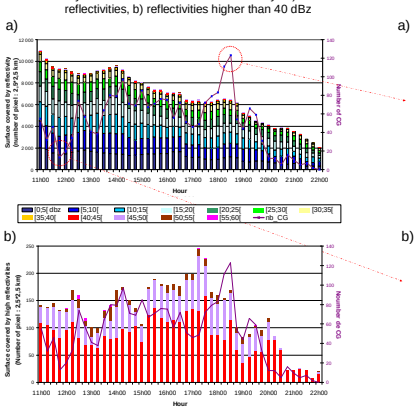


Fig. 6 : 24/08/2009 : Vertical profile of the surface covered by the high reflectivities (> 40 dBz) and of their fraction (in percentage) against the whole surface at : a) 18h30 and b) 11h45

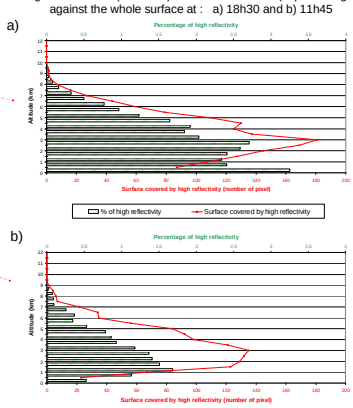
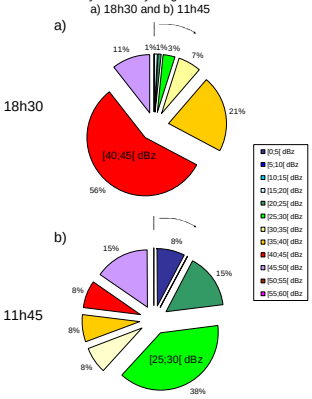


Fig. 7 : 24/08/2009 : Repartition of percentage of CG by reflectivity range at 3000 m at a) 18h30 and b) 11h45



- Surface covered by the whole reflectivity field tends to decrease while the mean CG lightning activity tends to increase (Fig.5. a).
- More concordance between variation of CG lightning activity and of surface covered by high reflectivities (>40 dBz) can be observed (Fig.5. b).
- **2 specific moments** can be observed :

11h45

- Relatively high surface of reflectivities / weak lightning activity (9343 pixels / 13 CG) (Fig.5.a)
- Maximum of high reflectivities surface (3000 m, under the isotherm 0°C which is around 3600 m) is not much extended contrary to weaker reflectivities (below 40 dBz) (Fig.6).
- Fraction represented by high values of reflectivity is very weak and mainly placed between 1000 and 3000 m (Fig.6).
- **About 77 % of CG are linked with low reflectivity values** (only 23 % of CG are associated with reflectivities higher than 40 dBz) (Fig.7).

18h30

- Weaker surface of reflectivity / very higher lightning activity (6532 pixels / 123 CG) (Fig.5.a).
- Maximum of high reflectivities surface (3000 m, under the isotherm 0°C) is more extended (mainly due to the surface covered by reflectivity values between 40 and 45 dBz) (Fig.6).
- High reflectivity values are more present at any level including near the ground (Fig.6).
- **About 67 % of CG are linked with high reflectivities** (more than 55 % are associated with the reflectivity values between 40 and 45 dBz) (Fig.7).

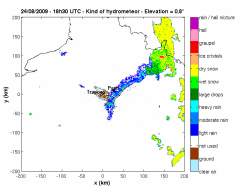
Possible explanation : the weak spreading out of the convective cores at 18h30 can promote a sustain electrification or different microphysical contents that can be more favorable to the CG production. On the other hand, the first comparison with vertical velocity (3D restitution issued from the French Doppler radar network ARAMIS) gave no additional explanation (no evident temporal correlation between the development of the stronger updrafts or downdrafts and the CG lightning activity).

5. In prospect …

A. In progress :

- Repeat this study for the **7/10/09** on the same region
- Comparison with **microphysics**

Fig. 8 : 24/082009 – 18h30 : Microphysics for an elevation of 0.8°
Data : from dual polarimetric C-band Doppler radar of Trappes



B. To come :

- Comparison with **IC sources**
- Extend this study to the **southeast region of France** (in anticipation of HyMex Campaign)
- Numerical simulation of some events with Meso-NH model

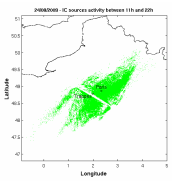


Fig. 9 : 24/08/2009 – Global IC sources activity between 11h and 22h
Data : from an interferometer system (LS 8000 developed by Vaisala, only 2 stations available)

All these data will be available during HyMeX campaign and will allow analyzing the storms in Mediterranean region with methods presently developed on Paris region to highlight links between lightning activity and others processes related to different kinds of storms.