Relationships between lightning activity and microphysics in thunderclouds:

The 6-7-8 sept. 2010 event observed by S and C-band radars in the Southeast of France (HyMeX SOP area)

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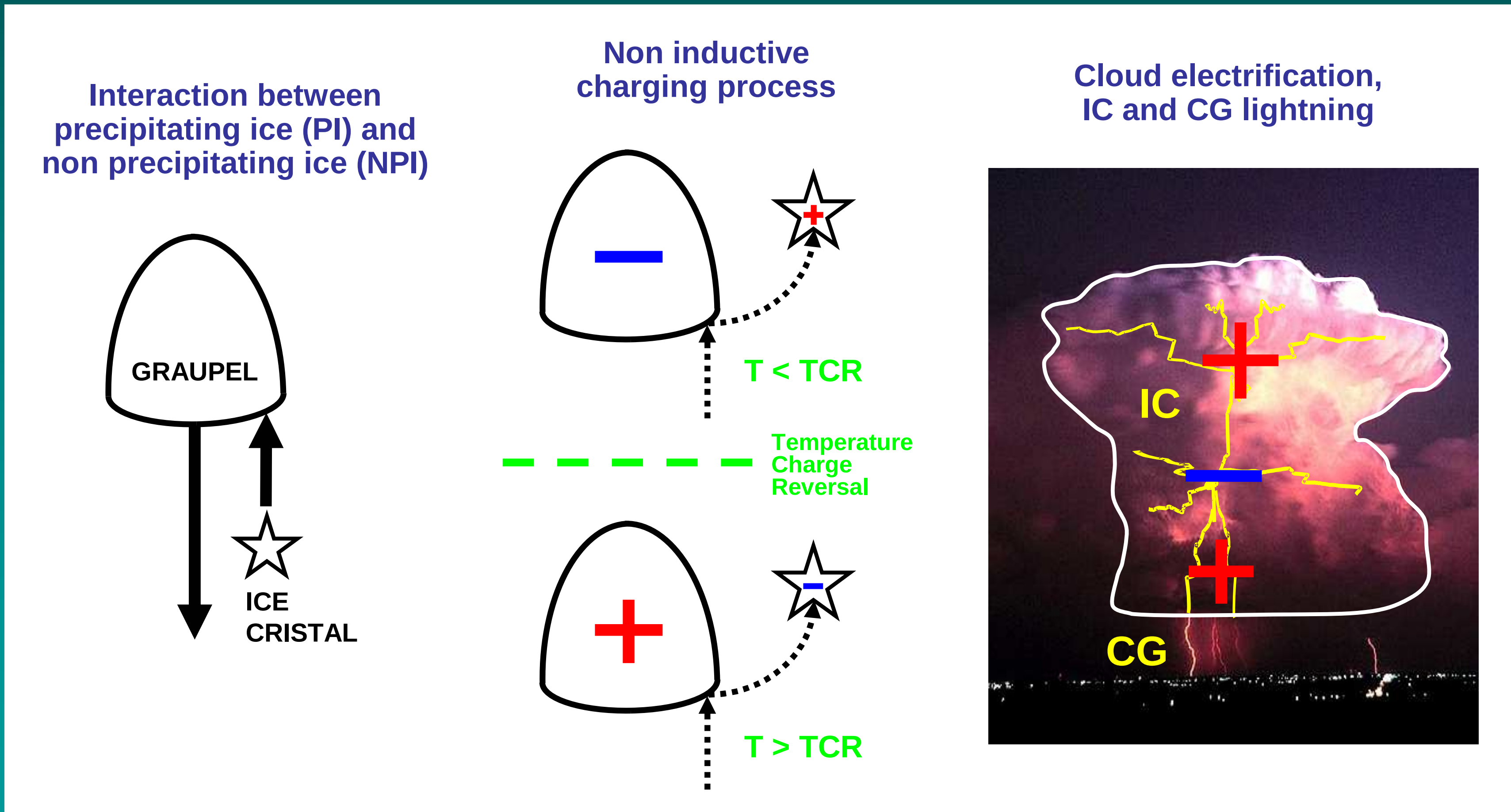
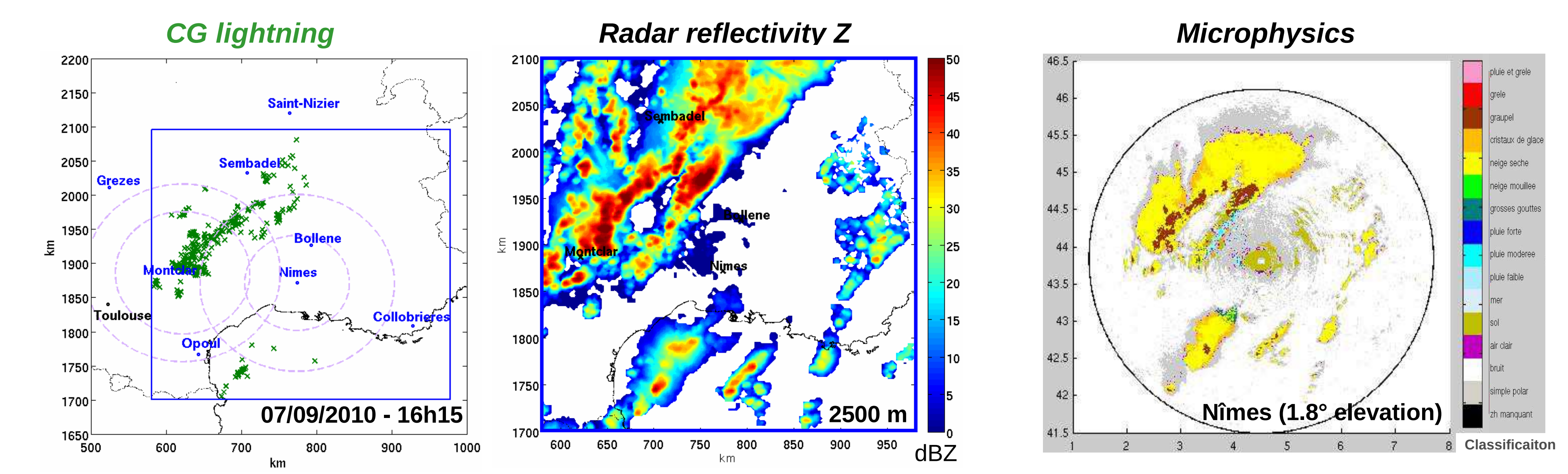
Contribution of lightning observation for improving numerical prediction of heavy precipitating events?

⟶ *data assimilation?*

Cloud physics deduced from lightning observation?

→ *links between lightning and clouds characteristics (reflectivity, precipitating and non precipitating ice mass and mass fluxes)*





- **CG** : EUCLID / METEORAGE

  CG lightning criterion : 0.5 s - 5 km

- **Radar reflectivity and wind speed (u,v,w)** : 3D radar composite (Météo France)

  Cartesian grid : 2.0 km × 2.0 km × 0.5 km

  Domain : 400 km × 400 km × 12 km

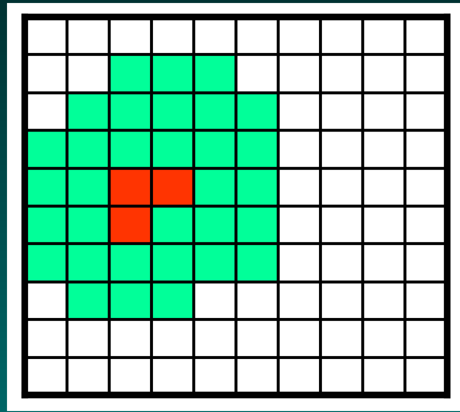
  Temporal resolution : 15 minutes

- **Microphysics and radar reflectivity** : S-band (Nîmes) and C-band (Montclar) radars (Météo France)

  Dual-polarization Doppler radars with 15-minutes temporal resolution

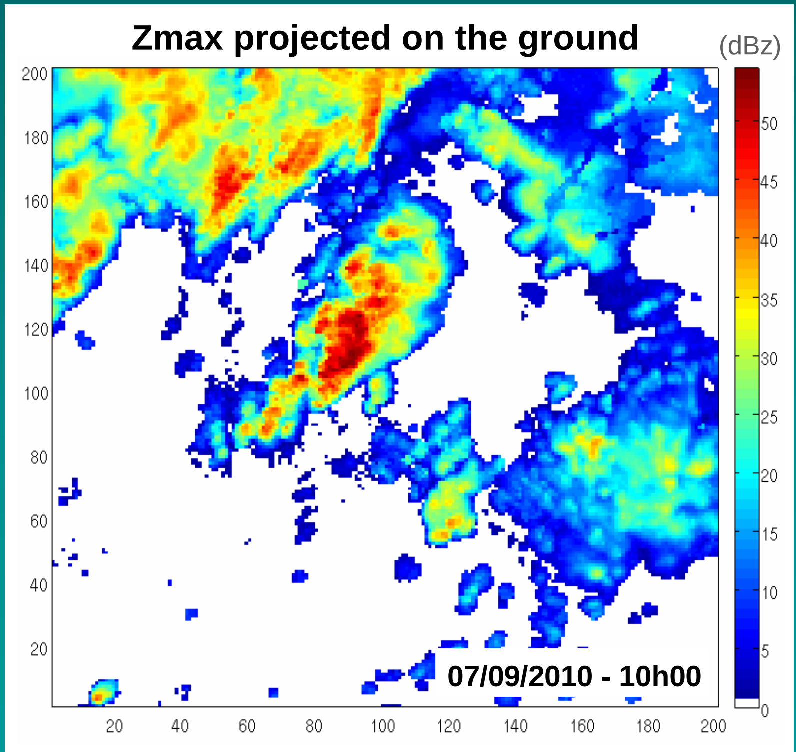
Definition of thunderstorm areas (TA)

used for studying the links between lightning and radar data (every 15 minutes)

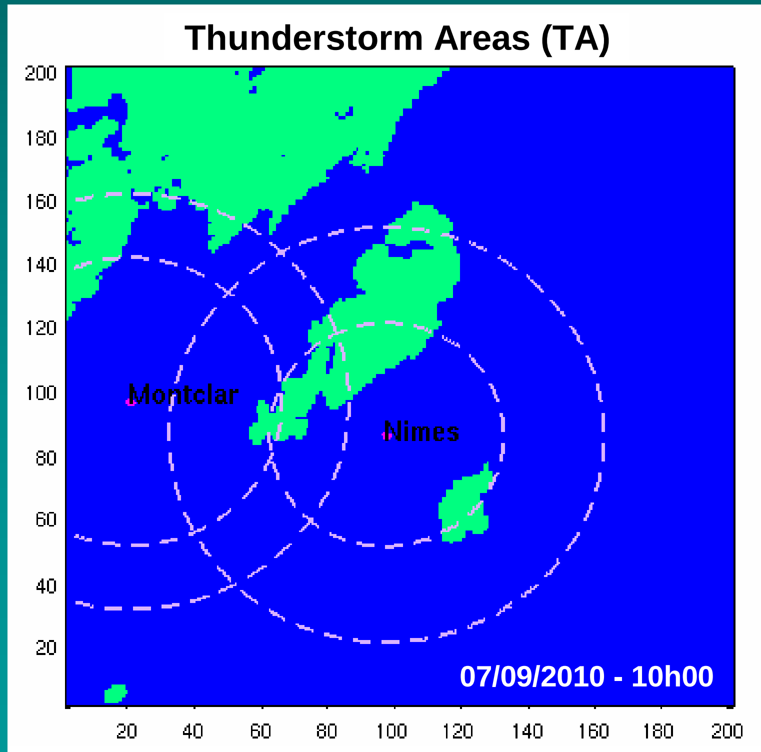


Searching for Z > 40 dBZ

Conservation of surrounding pixels with Z ≥ 20 dBz



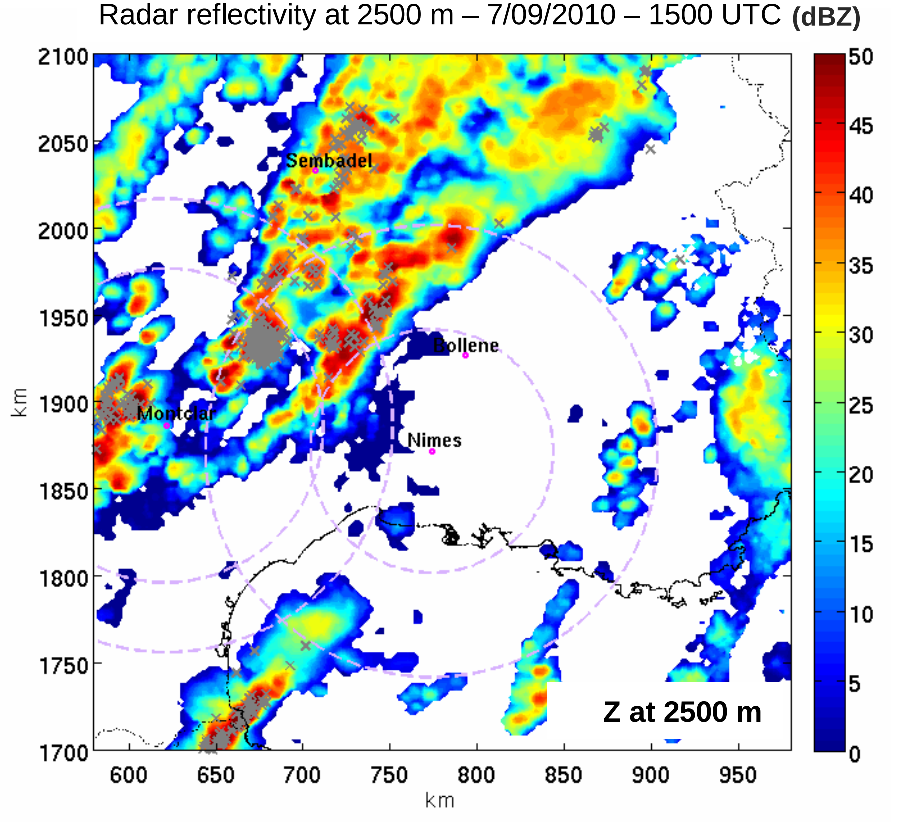
200 × 200 pixels

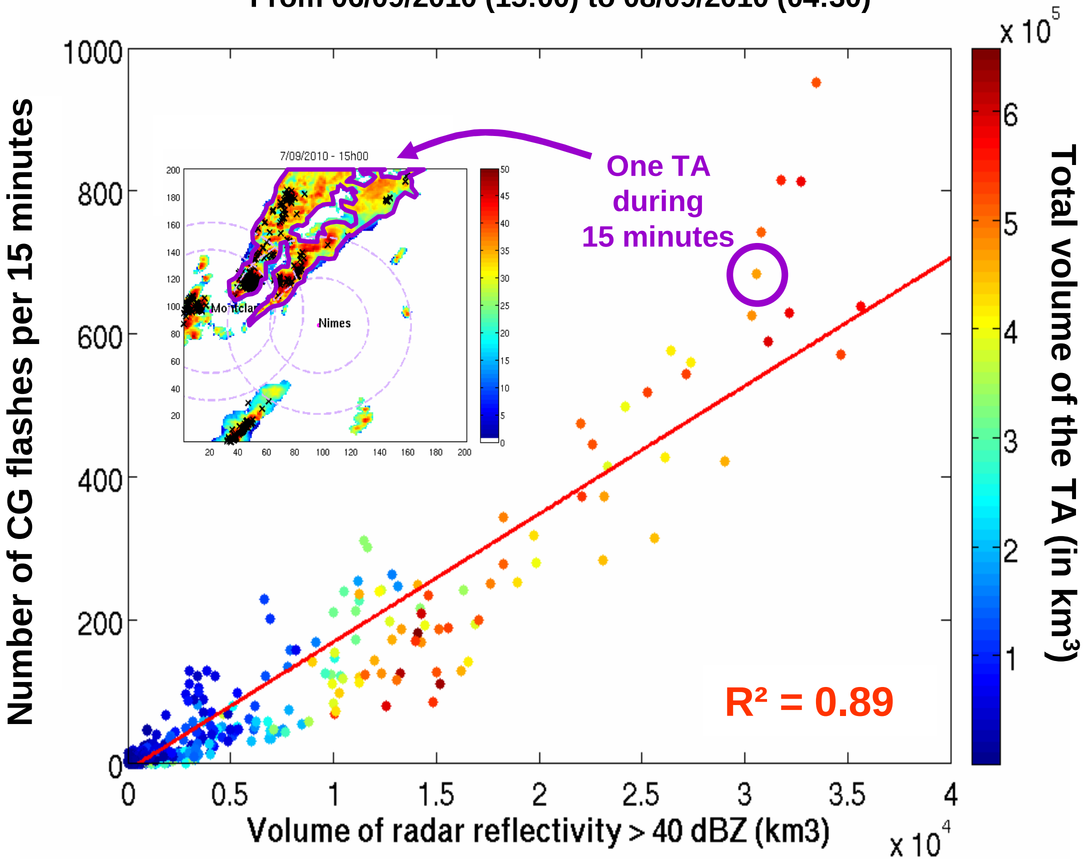


Relationship between CG flash rate and high radar reflectivity volume (precipitation/graupel)

In each TA and every 15 minutes :
- Determination of the volume of radar reflectivity > 40 dBZ
- Determination of the number of CG lightning flashes

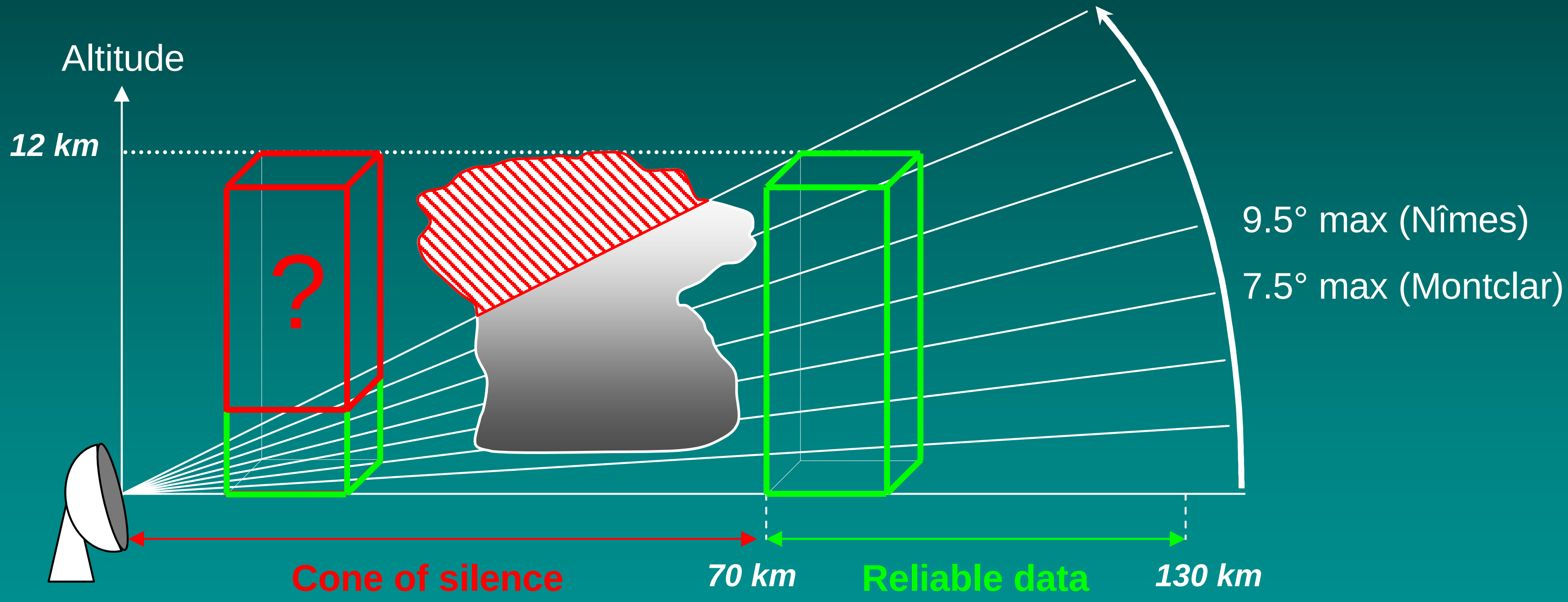
Close relationship between both quantities

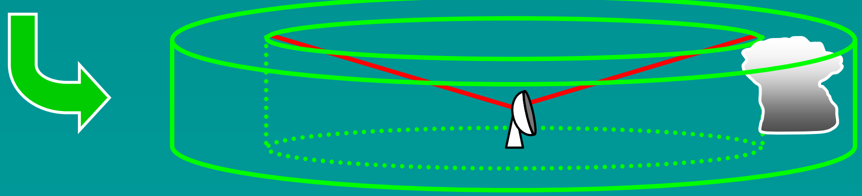




Microphysics observation

- Requirement : full depth of the cloud up to 12 km of altitude
- Problem : cone of silence above the radar





Reliable data : in hollow cylinder

Montclar : inner radius = 90 km (7.5° max)
outer radius = 130 km

Nîmes : inner radius = 70 km (9.5° max)
outer radius = 130 km

Methodology for cloud ice mass determination

Precipitating Ice (PI) = graupel, hail, mixture of rain and hail above -5°C isotherm
Non-Precipitating Ice (NPI) = ice crystals and dry snow above -5°C isotherm

- **Calculation of IWC for each microphysical point (Z-M relationships)**

  IWC (n) = f(Z)

- **Interpolation of IWC for PI and NPI**

  $1/d^2$ weighted interpolation on the cartesian grid

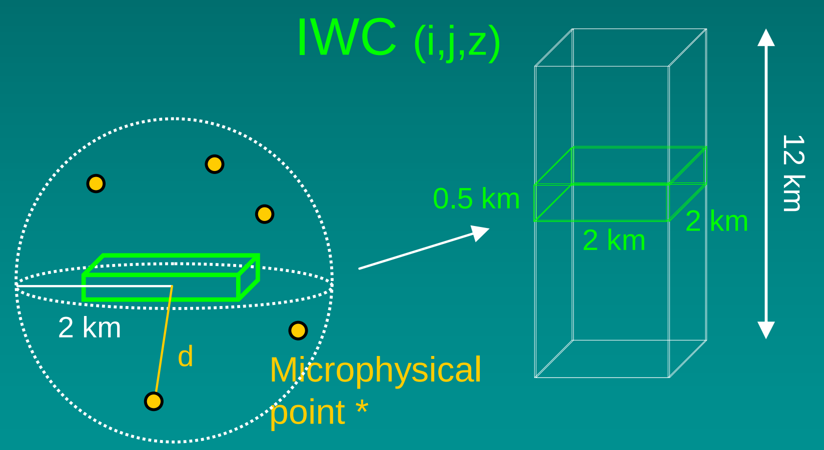
  Sphere 2 km in radius centered on the grid box

- **PI or NPI mass in a grid box**

  IWC (i,j,z) × grid box volume

- **Total PI or NPI mass in TA**

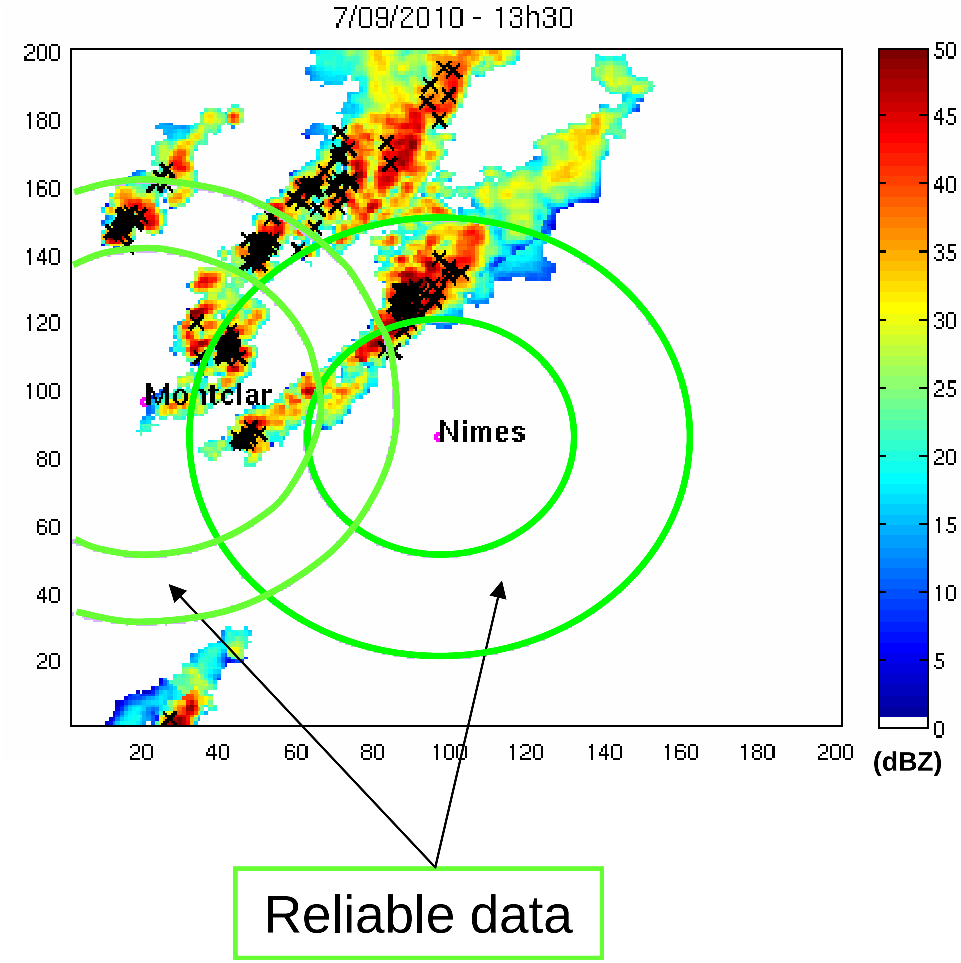
  Sum of the ice mass values of all grid boxes in the considered TA



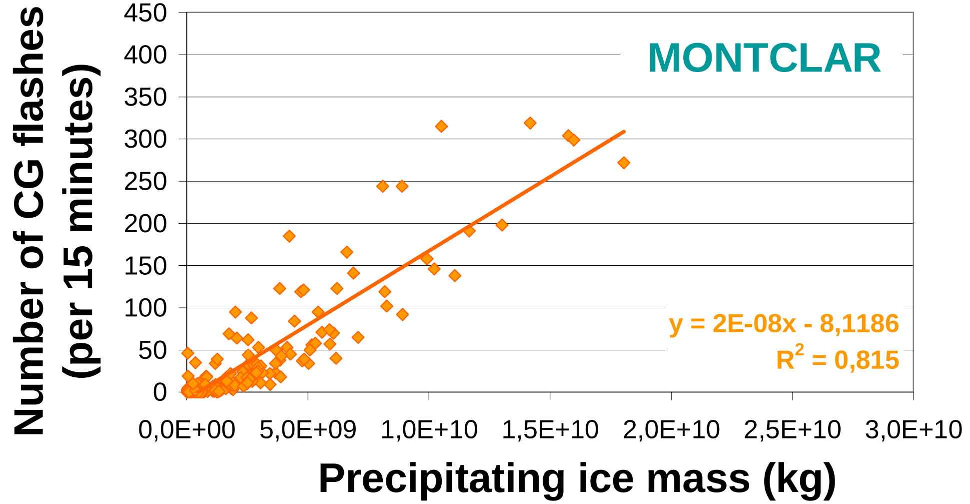
* Microphysical point : dominant microphysical type and corresponding reflectivity in an elementary radar volume (Météo France product)

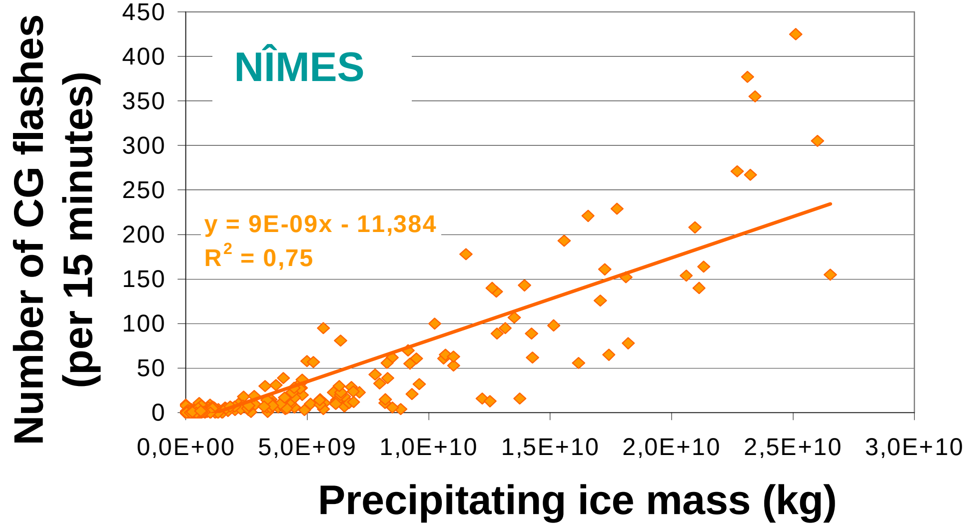
Relationship between CG rate and precipitating ice mass in the TAs

Radar reflectivity at 2500 m + CG in thunderstorm areas

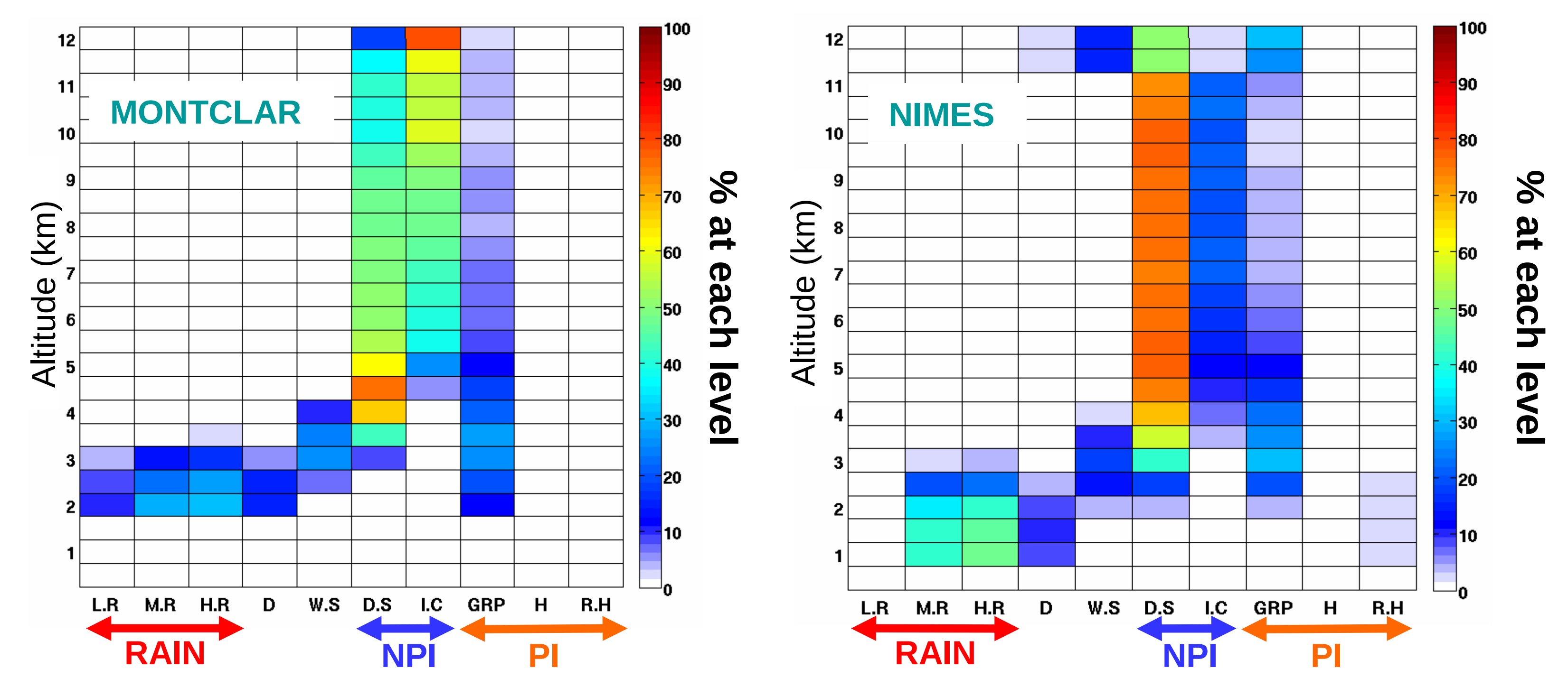


Precipitating ice mass versus number of CG in each TA
From 6 (15:00 UTC) to 7/09/2010 (23:45 UTC)





Global vertical distribution of the microphysical species



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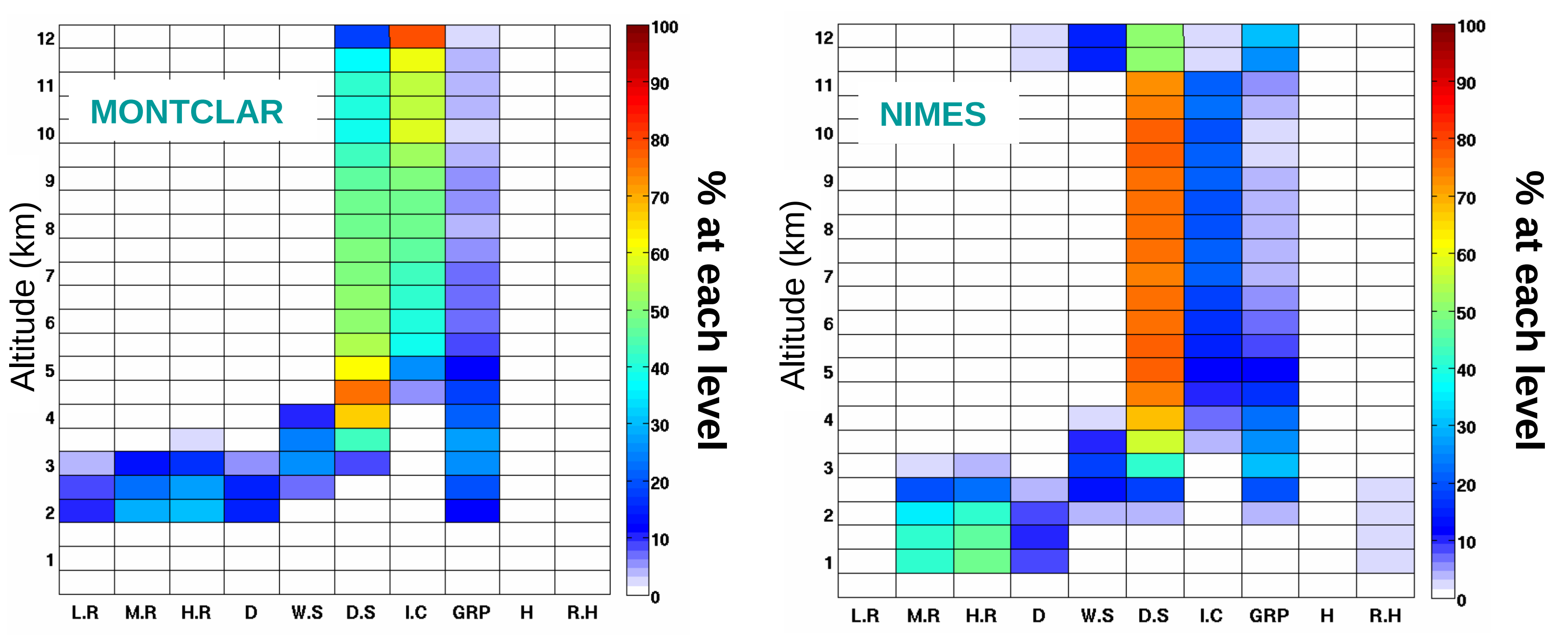
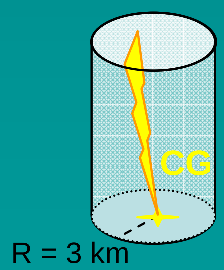
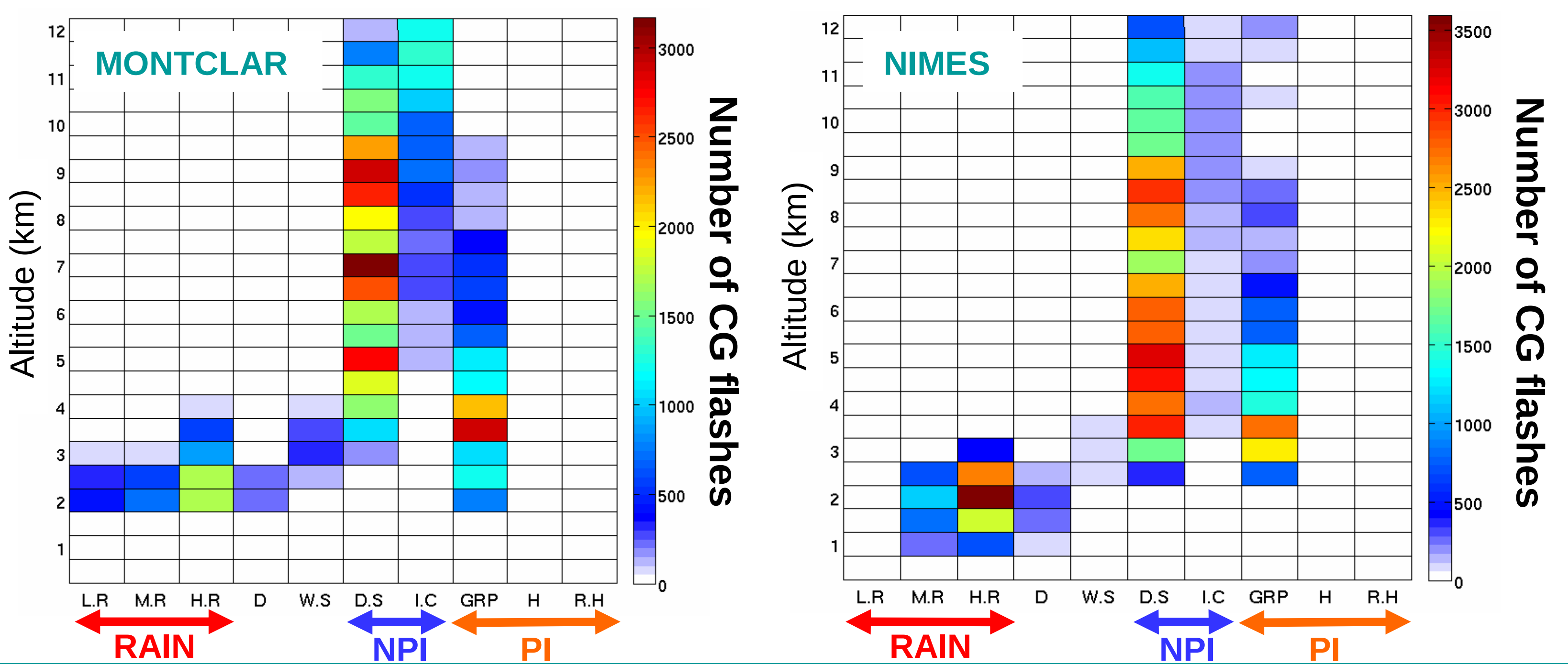


Vertical distribution of the microphysical species close to the CGs (3 km)





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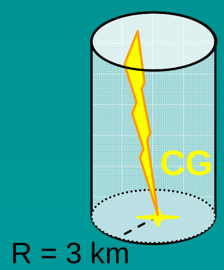
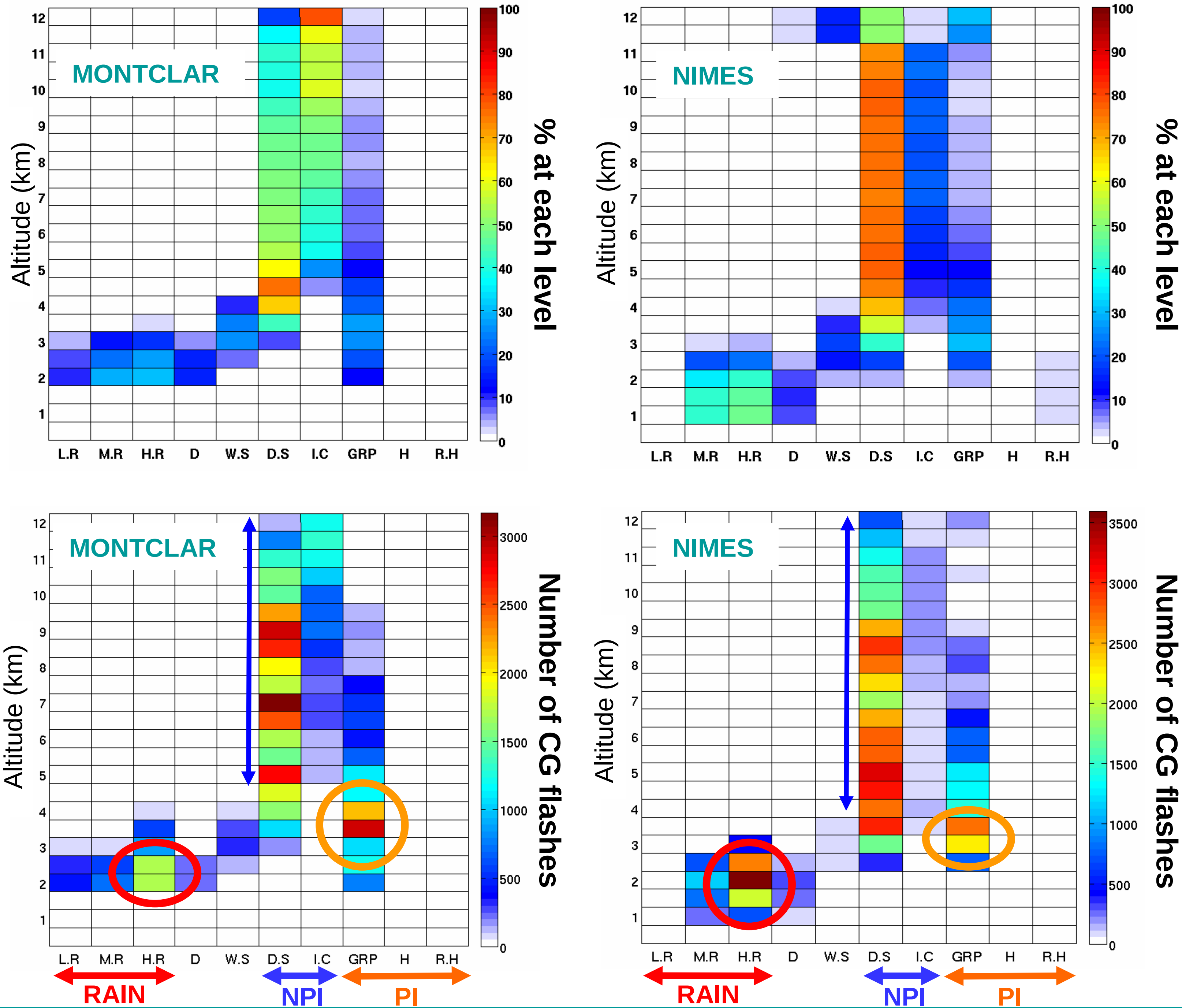
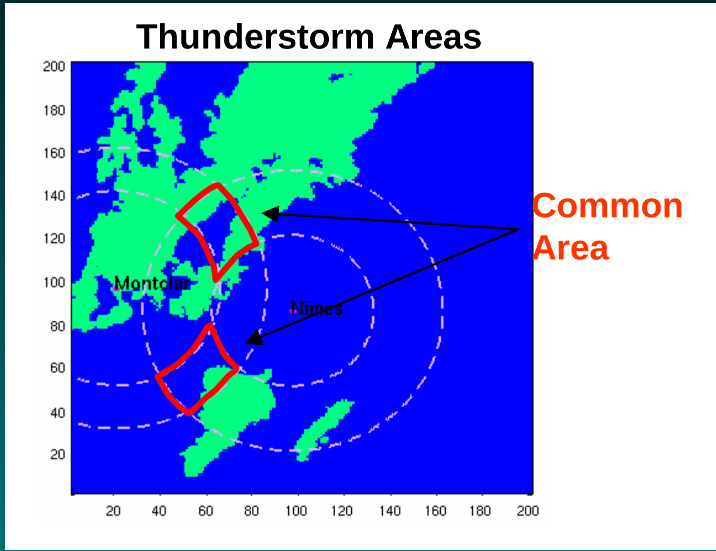


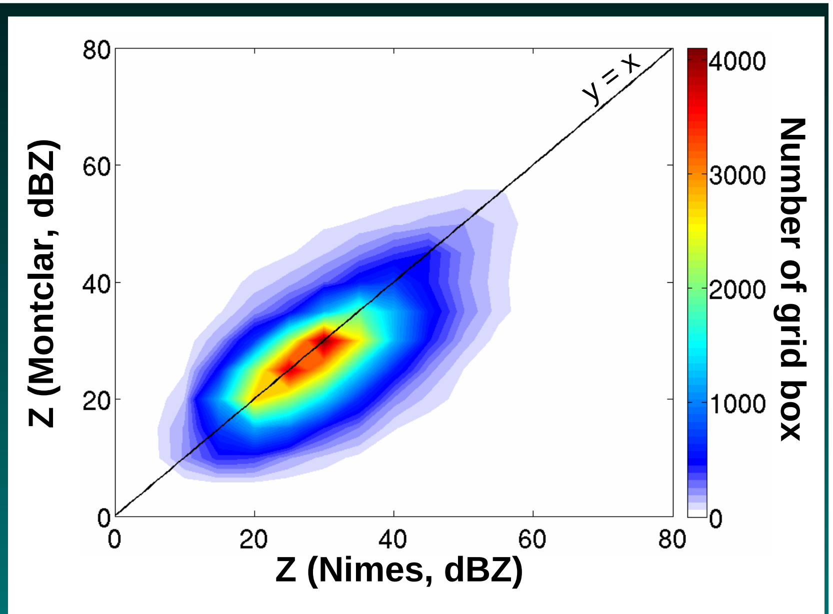


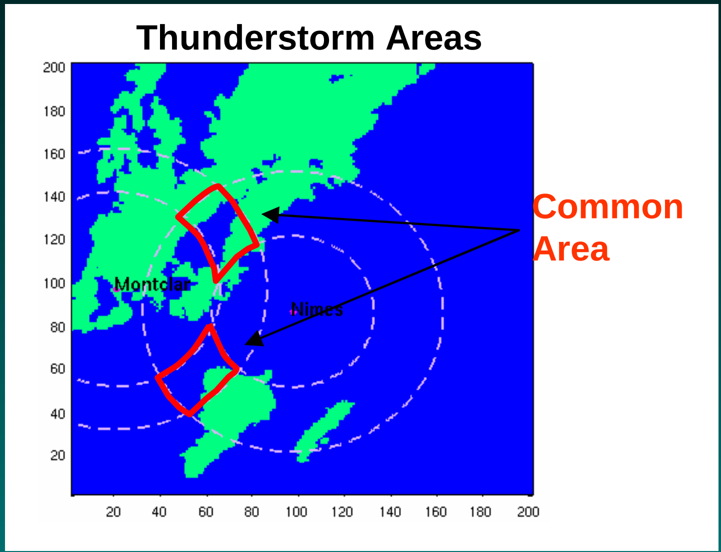


Comparison of radar reflectivity deduced from Nîmes and Montclar :

Reflectivity interpolated in each grid box:

2 km x 2 km x 0.5 km, in each TA in the common area





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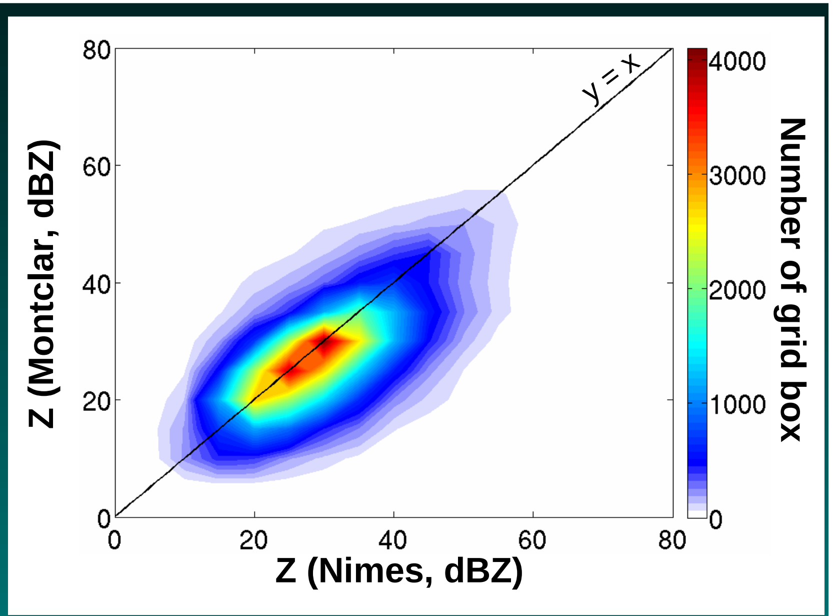
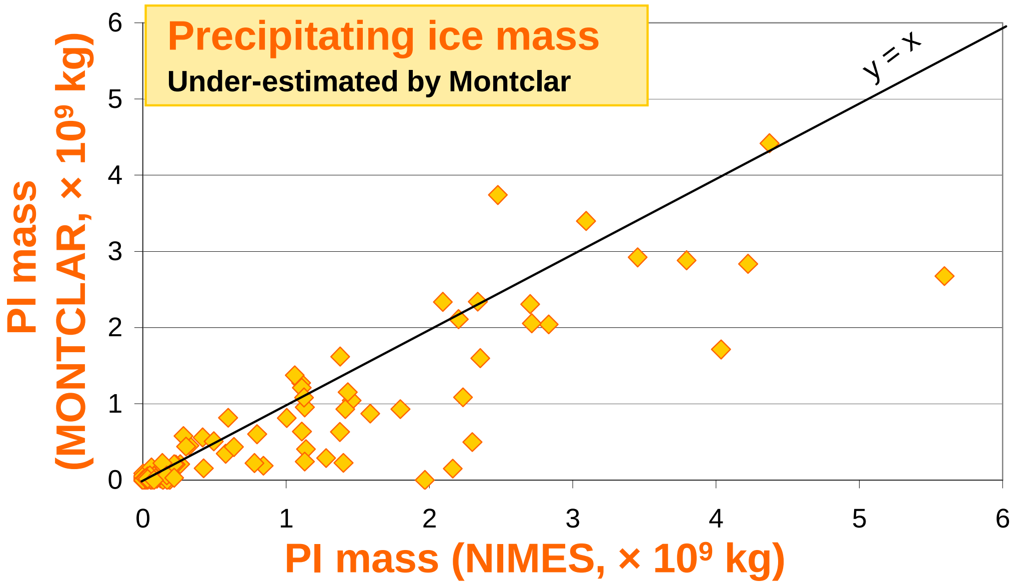
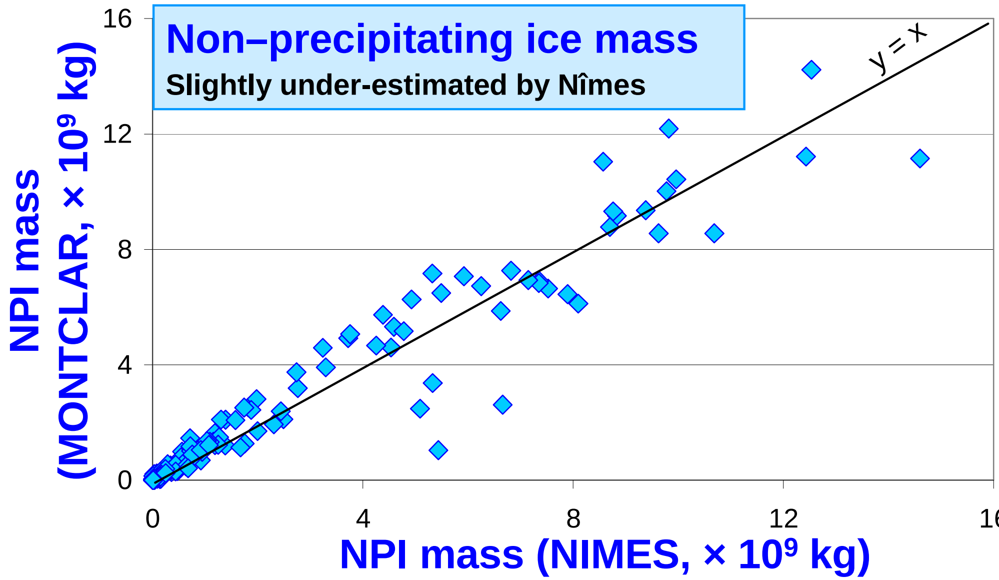


Comparison of ice masses deduced from Nîmes and Montclar :

Ice masses calculated in each TA in the common area





CONCLUSION

Good correlation between CG flash rates and :

- **Volume of radar reflectivity > 40 dBZ** (R^2 = 0.89)
- **Precipitating ice mass** (Montclar: R^2 = 0.82 and Nîmes: R^2= 0.75)

↳ Perspective : focusing on convective areas for CGs, take into account the IC discharges

Comparison of ice masses deduced from the S-band radar of Nîmes and the C-band radar of Montclar :

- PI : Under-estimated by Montclar (attenuation)
- NPI : **Good correspondence** between both radars

↳ Need to make a comparison at shorter time scale between both radars (Talk 2.5, Hassan Al-Sakka, Monday PM) and in details to test the other factors (hydrometeor classification, beam blockage ….).

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Thank you !

Z-M relationships for different categories of hydrometeor

Hydrometeor Categories	Z(mm^6 m^{-3}) – M(g m^{-3}) Relationships	Authors and considered cases
Rain and large drop	$LWC = 9.8\ 10^{-4} \times Z^{0.696}$	Sekhon and Srivastava, 1971, Thunderstorm case
Wet snow	$SWC = 0.0134 \times Z^{0.389}$	Sekhon and Srivastava, 1970 Data from several studies
Graupel	$IWC = 0.0052 \times Z^{0.5}$	Heymsfield and Miller, 1988 6 thunderstorm cases (CCOPE)
Hail and mix hail & rain	$IWC = 0.017 \times Z^{0.529}$	Heymsfield and Miller, 1988 6 thunderstorm cases (CCOPE)
Ice crystal and dry snow	$IWC = 4.4\ 10^{-5} \times Z^{0.71}$	Heymsfield and Palmer, 1986 Thunderstorm case (CCOPE)