Impact of activation process on fog life cycle

Marie Mazoyer
Frédéric Burnet, Christine Lac
(CNRM/GAME, Météo-France/CNRS)

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marie.mazoyer@meteo.fr

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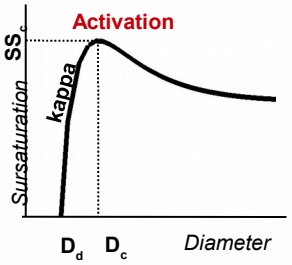
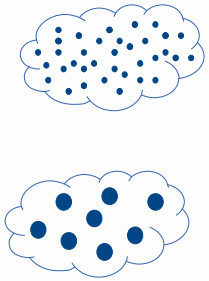
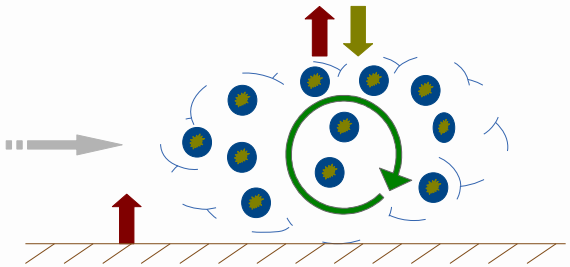
Impact of activation process on fog life cycle

- Impact of activation process on fog life cycle
- Impact of size distribution of water droplets on fog life cycle
- Interest of a two moments microphysic scheme for fog simulation?

Aerosols particles → 1 *Activation* → Droplets → 2 → **Life cycle (dissipation)**







Tools: 1. Experimental – PréViboSS field experiments
- -Concentration and size distribution of aerosols particles
- -Hygroscopic properties of aerosols particles
- -Concentration and size distribution of hydrated aerosols particles and water droplets

2. Numerical simulation – Meso-NH
- -Large Eddy Simulation
- -Two moment microphysic scheme

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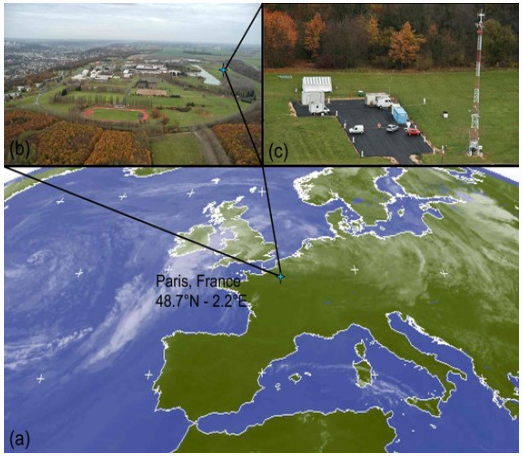
1. Experimental setup : PréViboSS winters 2010-2013

- SIRTA, Palaiseau (semi-urban environment), oceanic, continental, polluted air mass

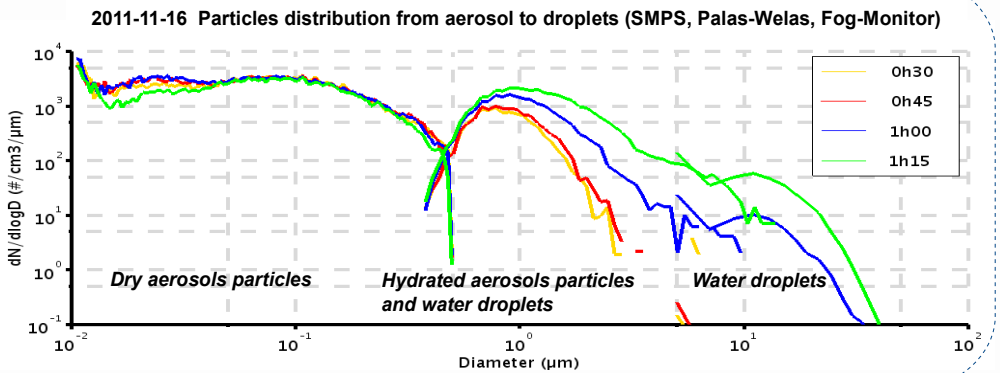


Measurements :
-Surface boundary layer
-Surface and ground
-Radiative
-Remote Sensing
-Microphysics(2,5m)

-Size distribution of aerosols particles :
SMPS (10nm – 496nm)

-Size distribution of hydrated aerosols particles and water droplets :
Palas-Welas + Fog-Monitor (0.4µm -50µm)

-Fraction of CCN among aerosols :
CCNC (0.1 % - 0.5%)



- 114 fogs events including 102 radiative fogs and stratus lowering fogs

+ Instrumentation « in-situ »: 48 events
+ Instrumentation «dry »: 29 events

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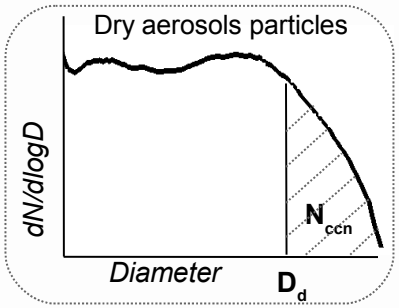
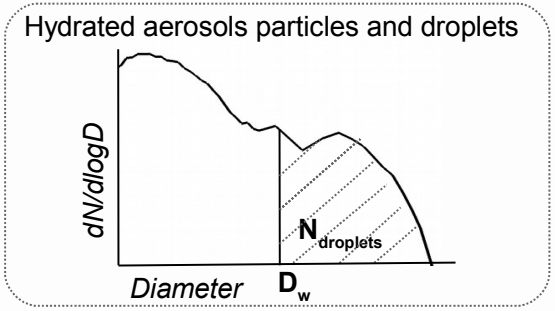
2. Aerosols to droplets: Activation parameters

Retrieval of SS_c, D_w, Kappa, D_d and N_{CCN} at formation

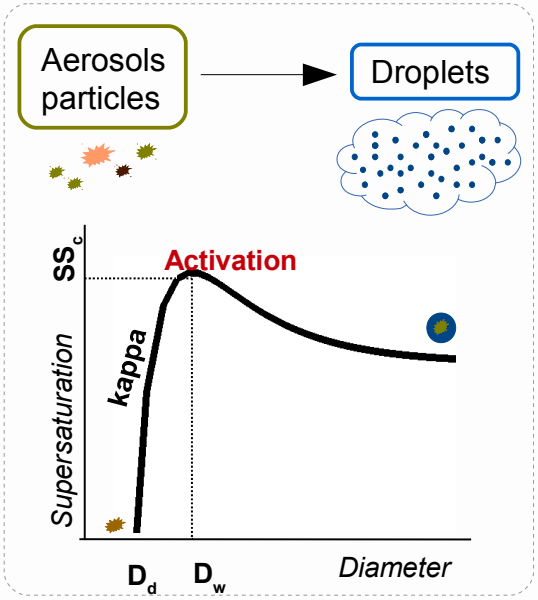
- **Iteration on NCCN to retrieve the activation parameters**



SMPS



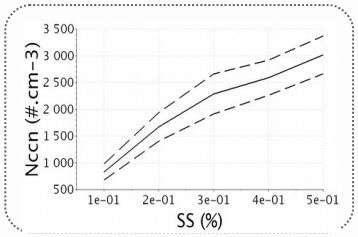
PALAS WELAS + FOG MONITOR



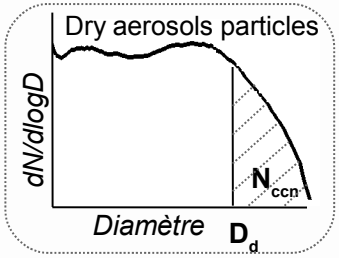
Kappa-Khöler (Petters and Kredenweis, 2007)

- **Kappa retrieval (Aerosols hygroscopicity)**

Nccn=f(SS) → D_d=f(SS) → Kappa=f(SS,D_d)



CCNC

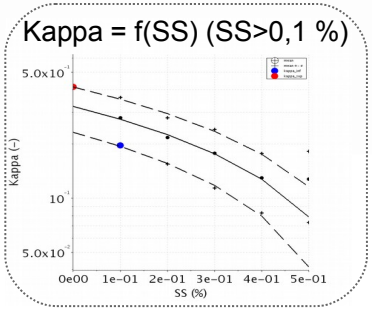


SMPS

$$\kappa = \frac{4A^3}{27D_d^3 ln^2 SS_c}$$

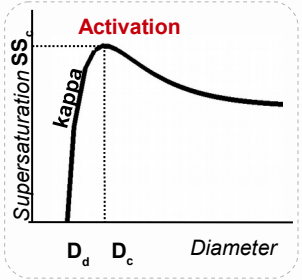
Kappa-khöler

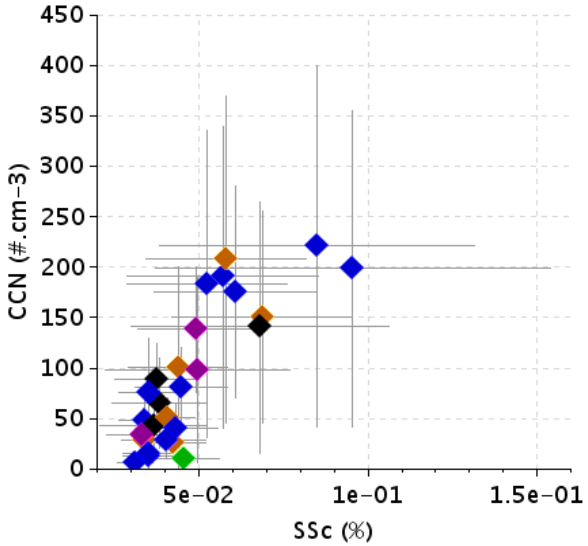
SS<0,1 % in fog (Hudson, 80)
Determination of two Kappa : $Kappa_{1\%}$
$Kappa_{0\%}$

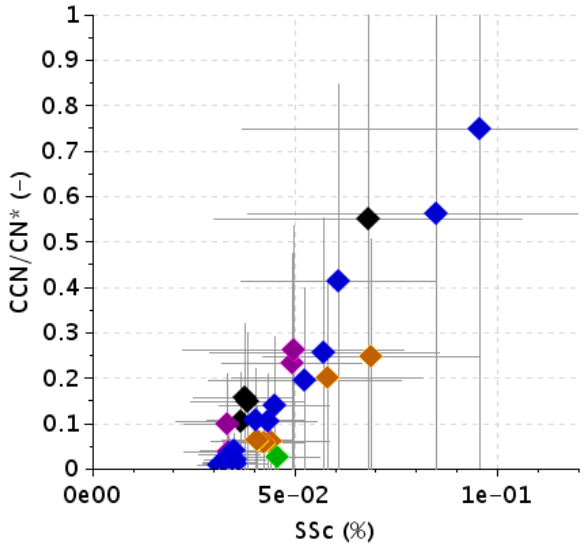


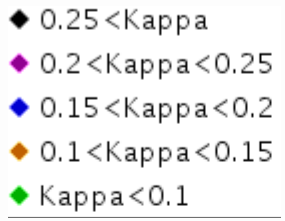
2. Aerosols particles activation : 29 fogs events

- **CCN concentration in fog ~ 100#.cm^{-3}**
- Weak supersaturation ~ 0,05 %
- D_d ~ 0,4 µm, activation of largest aerosols
- Kappa (hygroscopicity) ~ 0,17 : local pollution impact (Andreae and Rosenfeld, 2008)









CN*=CN(200nm-500nm)
Activable particles

- Strong impact of supersaturation on CCN concentration
- Strong impact of aerosols particles concentration (CN) and secondary of particles chemistry (supersaturation modulate by aerosols size distribution)

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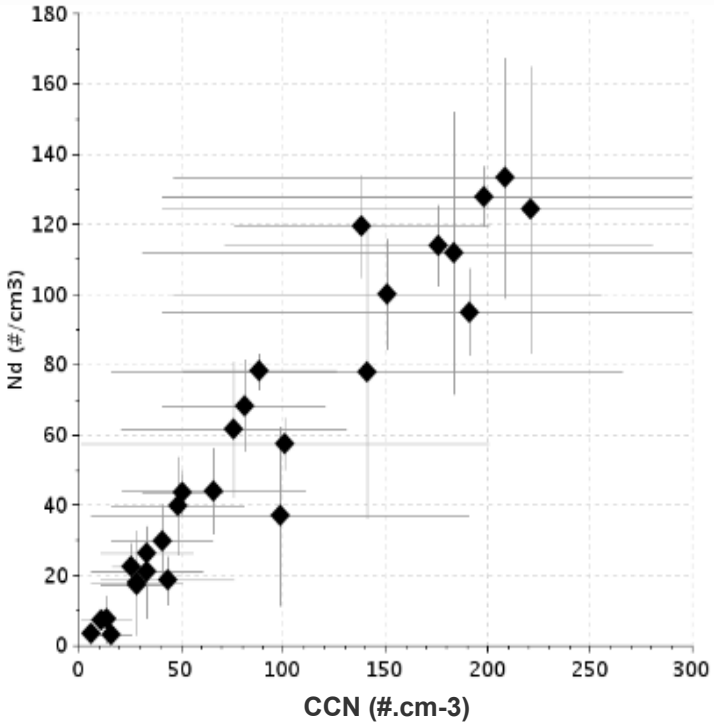
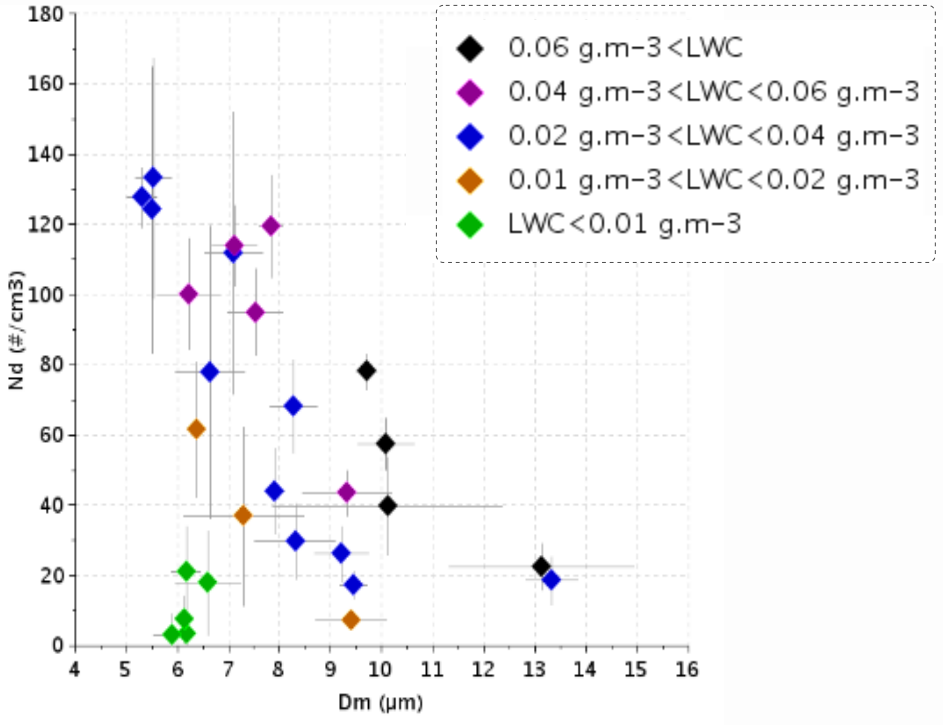
2. Aerosols to droplets : Fog microstructure at formation

- **Impact of the activation process on droplets number size distribution**





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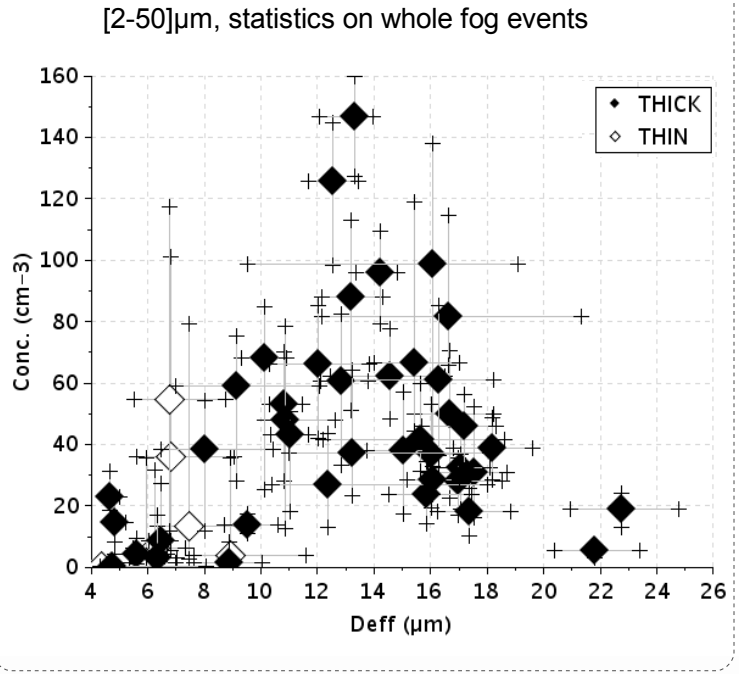
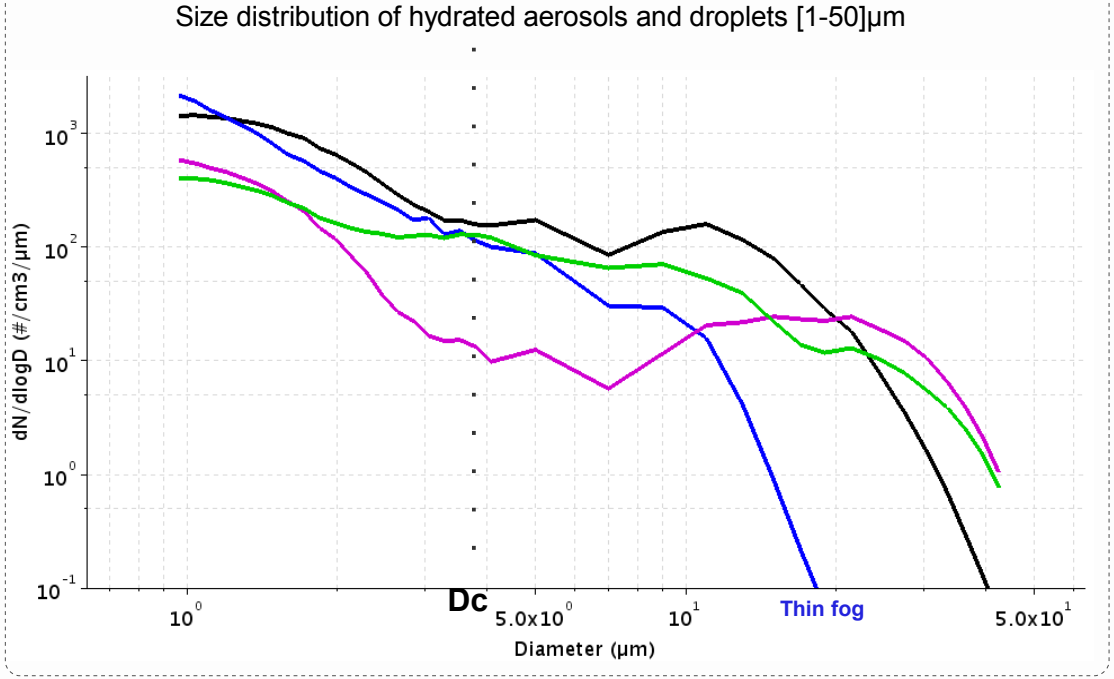
3. Droplets to fog life cycle: Microphysic evolution 48 events





- Great variety of cases
- Case with several droplet modes
- Case with large droplets mode
- Thinner mode for thin fog (undeveloped on vertical)

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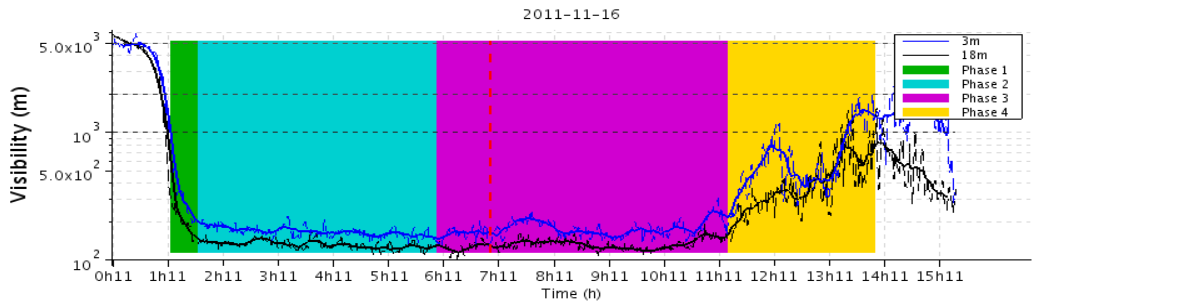
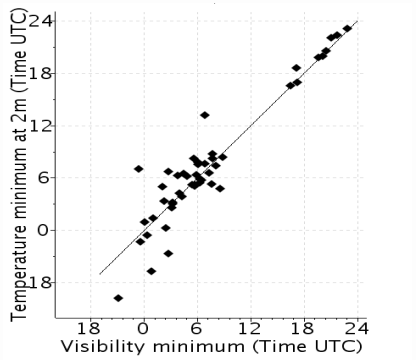
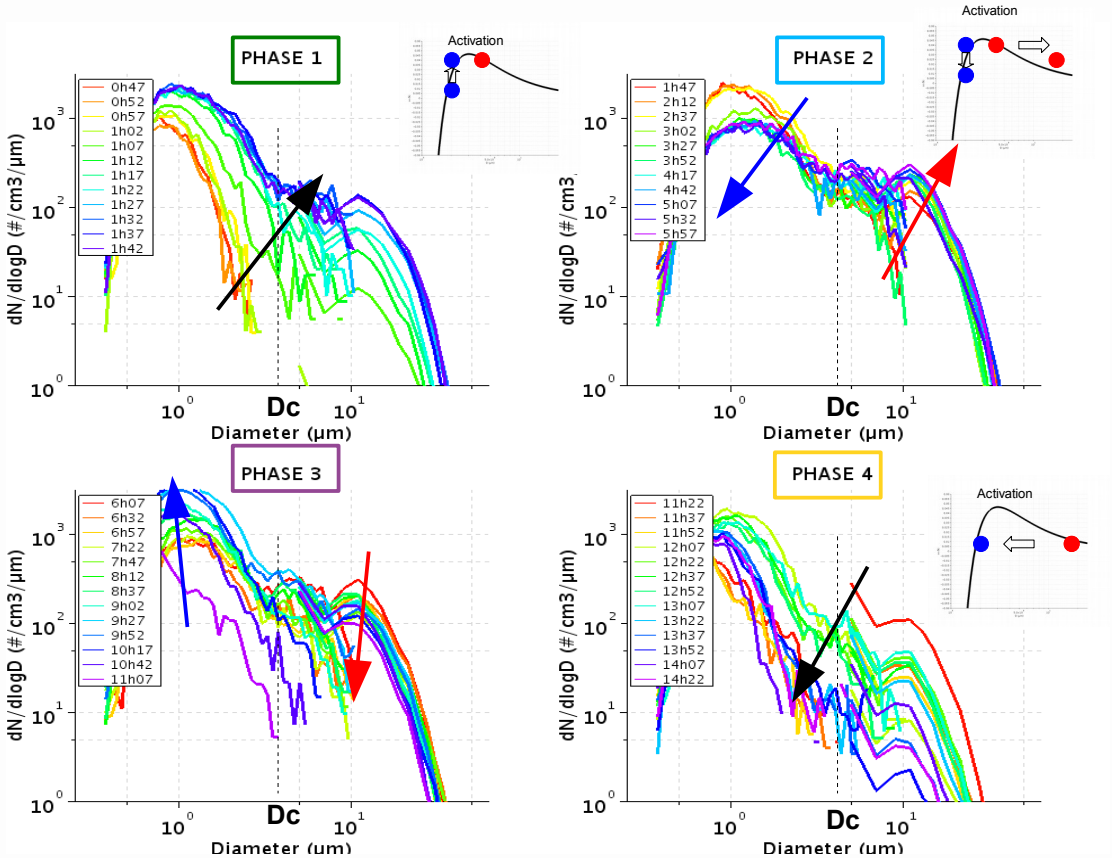
3. Microphysic evolution : Cut in phases based on visibility evolution (Pilié, 74)

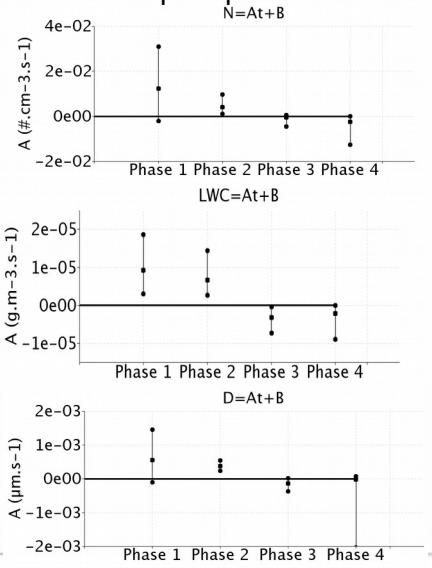


Visibility minimum match with temperature minimum at 2m





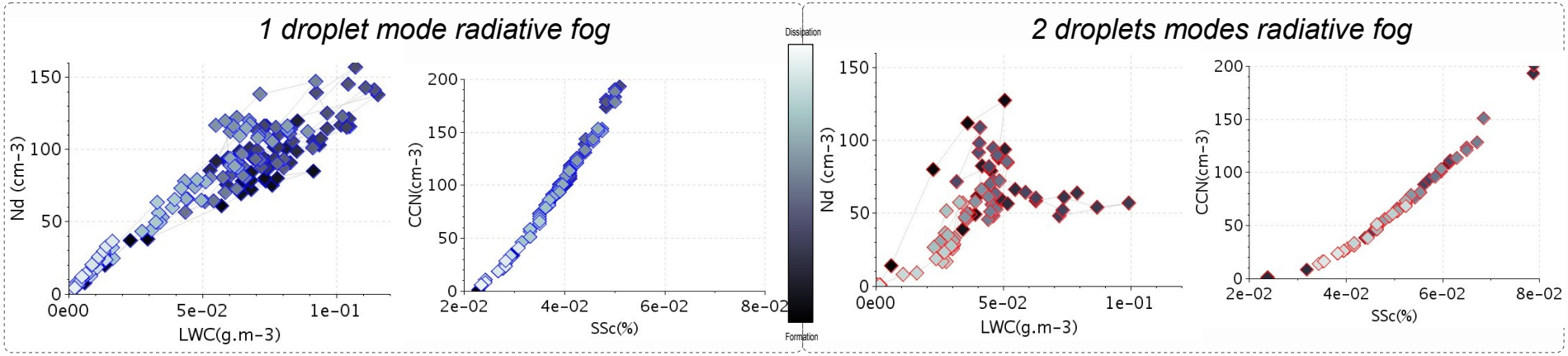
N, LWC, D evolution with time : Slopes quartiles



- Droplets mode stable
- 4 phases 4 distincts evolutions

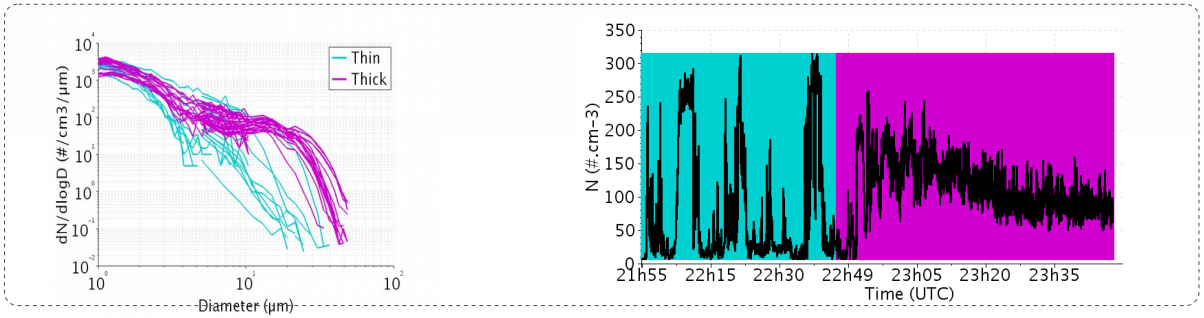
3. Microphysic evolution : processes

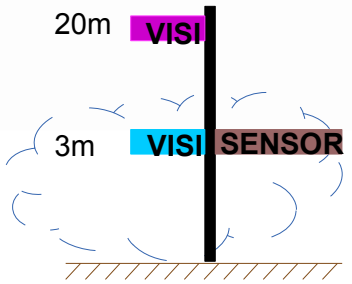
- **Evolution of the distribution of LWC on Nd (Zhao, 2012) and NCCN evolution with SSc**



- Main process : Continuous activation with subsequent condensational growth
- But coalescence process may exist
- Dissipation : droplets evaporation and deactivation

- **Study of fog firstly undevelopped on the vertical, process at fog top**





- Large droplets appears with vertical development
- During thin fog : mixing with clear air, entrainment process

CONCLUSION/OUTLOOK

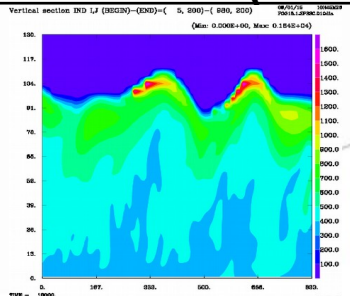
Impact of activation process on fog life cycle

Analysis of microphysical data provided by four instruments during three winter seasons at SIRTA (48 cases)

- Supersaturation values (~ 0.05%) and CCN concentrations (~ 100 #.cm^{-3}) in fog
- Main impact of the aerosol distribution and secondary of the chemistry on the activation
- Impact of the activation on fog microstructure at formation
- Four phases for fog microphysic evolution
- Main physical process: Activation/Condensation Deactivation/Evaporation
- Impact of fog vertical development on droplets growth : mixing with clear air at fog top observed on thin fog

Numerical simulation : LES with Meso-NH, a two moments microphysic scheme and a pseudo-prognostic scheme for supersaturation (Thouron, 2012)

- Agreement with experimental study
- Activation impact on fog life cycle



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Questions ?