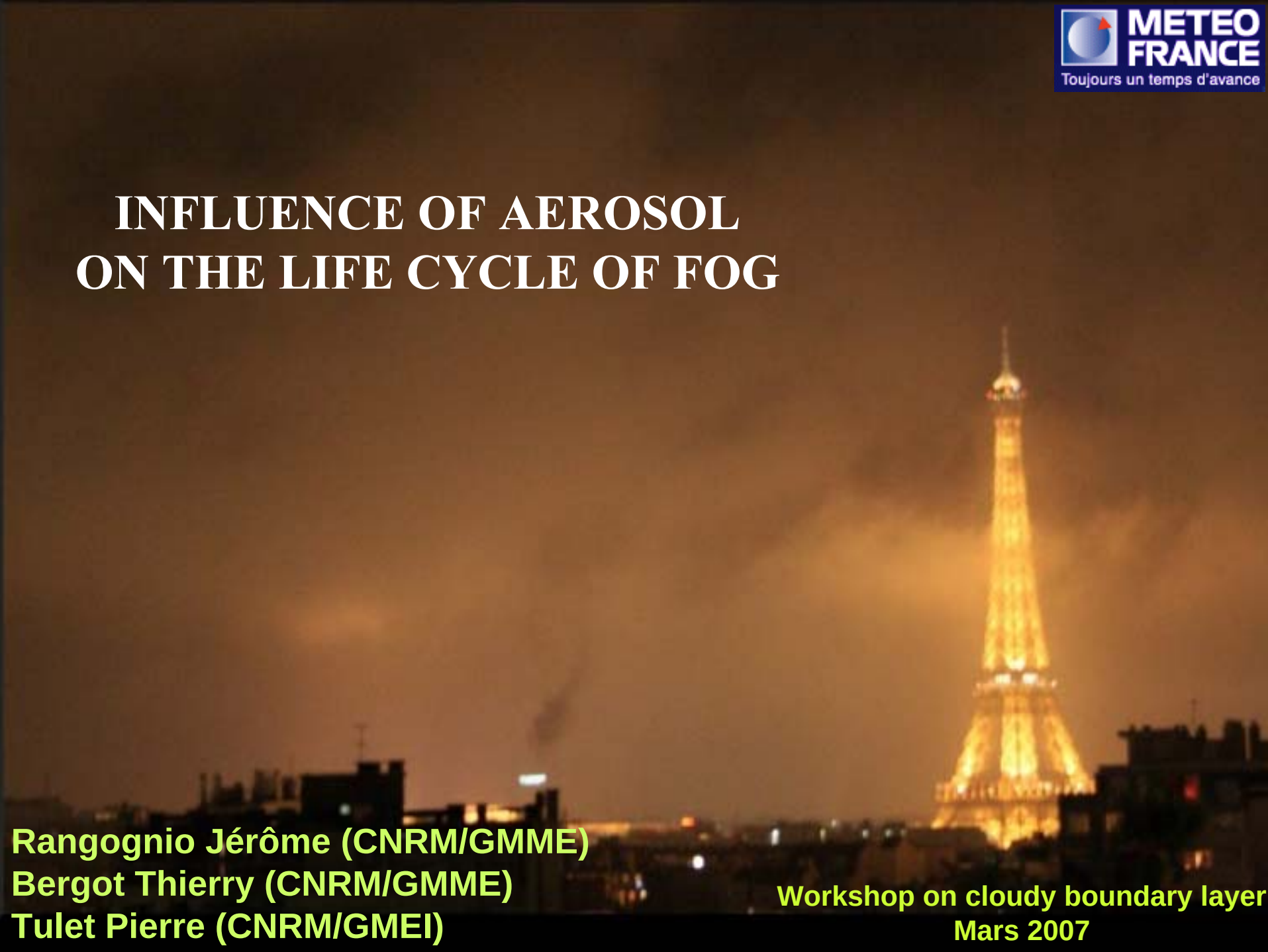

INFLUENCE OF AEROSOL ON THE LIFE CYCLE OF FOG

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Workshop on cloudy boundary layer
Mars 2007

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II. ORILAM model and ReLACS2 and MPMPO schemes

III. Examples of 1-D simulations of fog

IV. Perspectives for the Parisfog ‘s Field Experiment

I. Introduction : Radiative fog

<u>Definition</u>: Clouds droplets with hygroscopic particles saturated of size of micrometers. The main condition for the apparition of fog is that the atmosphere is saturated in the first meters over the land surface (see picture)

•<u>3 main types of fog (Cotton & *al.*, 1989):</u>

-radiation

-advection

-mix of air in an area contrasted on temperature and humidity

•<u>Characteristics of radiative fog:</u>

-local cooling of atmospheric layers near the land surface: fundamental role

-night on the continental surface

-anticyclonic conditions without clouds

-weak wind but not zero

•The life cycle of radiative fog: the onset, the development and the dissipation

The onset: influenced by three main parameters

1. High cooling radiative of the land surface → condensation point

2. Turbulence in the lowest atmospheric layers

3. Exchanges between atmosphere and surface

I. Life cycle of radiative fog

The development : three main effects

1. **Radiative cooling on the top of fog layer** (stable layer)

   Divergence of radiative fluxes

2. **Turbulent scattering**

   Loss of thermal inversion in the fog layer → mixing layer

3. **Sedimentation of droplets**

(Importance of horizontal advection for the development)

The dissipation : the main reason : the sun

From the sunrise

Absorption of radiance in the fog layer

Heating of the fog layer

From the sunrise

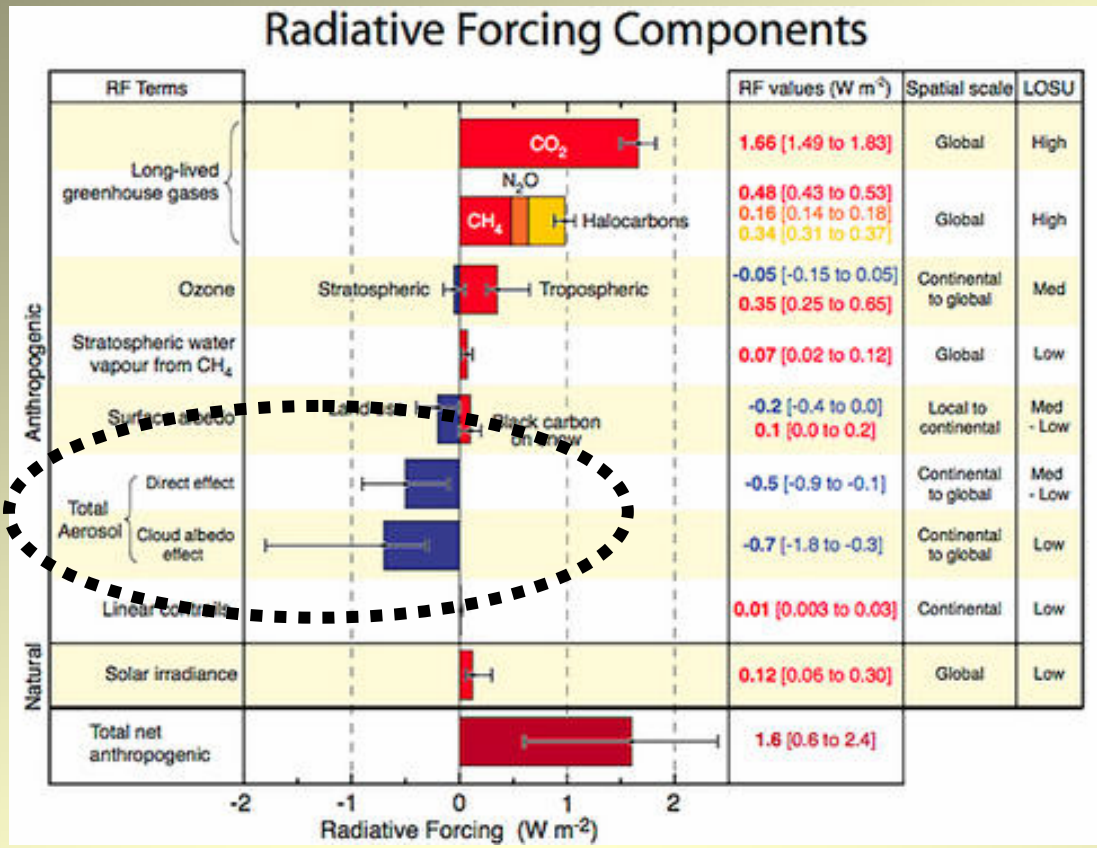
Heating of the land surface by the radiance decreased by the fog layer

Acceleration of the evaporation of liquid water at the root of fog

=> EVOLUTION INTO STRATOCUMULUS

Importance of study of aerosols

IPCC 2007: WG1-AR4



- Affect the planetary radiation balance

→ directly by scaterring sunlight to space

→ indirectly through their influence on cloud droplet concentration and thus cloud albedo

→ highly uncertainly on the estimates of the indirect radiative effect of aerosols

- Aerosol's composition
  - Inorganic materials (NO_3^-, SO_4^{2-}, Na^+, Cl^- …)
  - Organic materials
    - Black carbon (BC)
    - Organic carbon (OC) → SOA

ORILAM model *(Tulet & al., 2005)*

ORILAM (Organic Inorganic Log-normal Aerosol Model

Log-normal model | **3 Moments (D_g, σ_g and N)**

→ Prognostic evolution of the aerosol size distribution determined by a general dynamical equation *(Friedlander, 1977, Seinfeld and Pandis, 1997)*:

$$\frac{\partial n(r_p)}{\partial t} = f(n(r_p))$$, n is the function of aerosol size distribution and r_p the aerosol radius

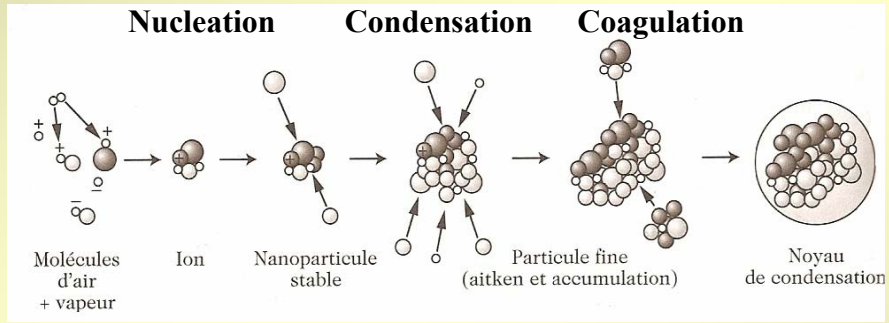
→ Three modes implemented: nuclei mode, accumulation mode and dust represented by a lognormal distribution *(Whitby et al., 1991)*

$$n(\ln D) = \frac{N}{\sqrt{2\pi}\ln\sigma_g}\exp\left(-\frac{\ln^2\left(\frac{D}{D_g}\right)}{2\ln^2(\sigma_g)}\right)$$

N the particle number concentration (part./m^3)
D is the particle diameter (µm)
$\mathbf{D_g}$ the number median diameter
$\boldsymbol{\sigma_g}$ is the geometric standard deviation of the modal distribution

► assumes that the aerosol size distribution consists of lognormal modes that can be described by 3 moments of the size distribution

Microphysics



- ►Coagulation
- ►Nucleation (H_2SO_4) (*Kulmala et al. (1998)*)
- ►Condensation:
  - → Condensation of H_2SO_4 is explicit
  - → Thermodynamic balance of Inorganics: NH_3, HNO_3, H_2O solve by neuronal network or some classical parameterization; ARES or ISORROPIA
  - → Thermodynamic balance of Organics : MPMPO need to take a specific chemical scheme
- ►Sedimentation
- ►Dry deposition

Atmospheric Model (MesoNH)

Whitby et al. (1991), *Binkowski and Shankar* (1995), *Ackermann et al.* (1998)

II. ORILAM Model : Schemes

Chemical scheme: ReLACS2
(Reduced Lumped Atmospheric Chemical Scheme 2)

→ Reference chemical scheme : CACM (Caltech Atmospheric Chemistry Mechanism) ***(Griffin & al., 2005, Tulet & al., 2005)***

(For computationnal reasons CACM has been reduced on ReLACS2)

→ Used with ORILAM (named ORILAM-SOA)

→ Low numerical cost

→ 82 prognostic species

►To predict of all SOA precursors

Thermodynamical scheme: MPMPO *(Griffin & al, 2003)*
(Model to Predict the Multiphase Partitioning Of Organics)

→ Chemical equilibrium between organic phase and gas phase: Raoult's law

→ Chemical equilibrium between acqueous phase and gas phase: Henry's law

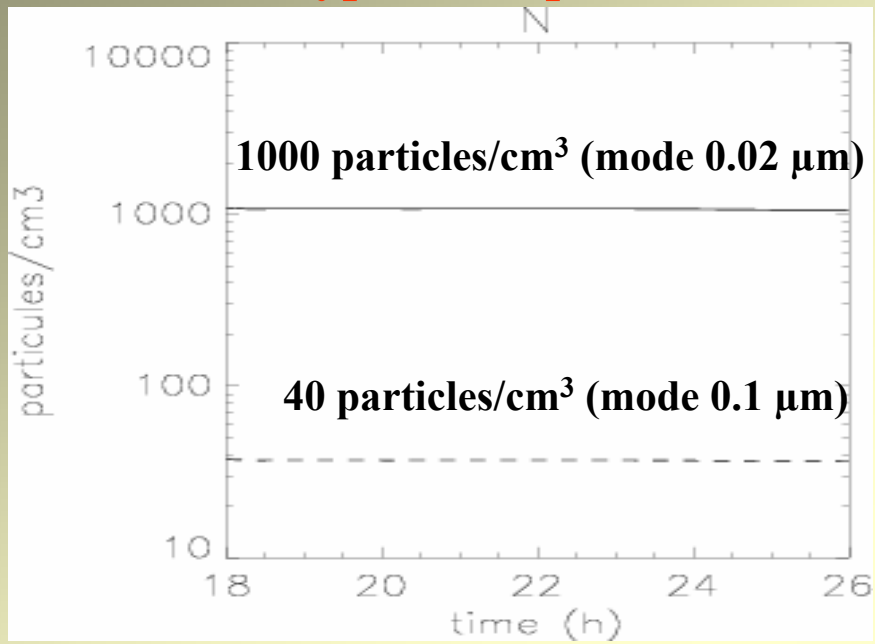
→ Equilibrium (acid/base) within the acqueous phase

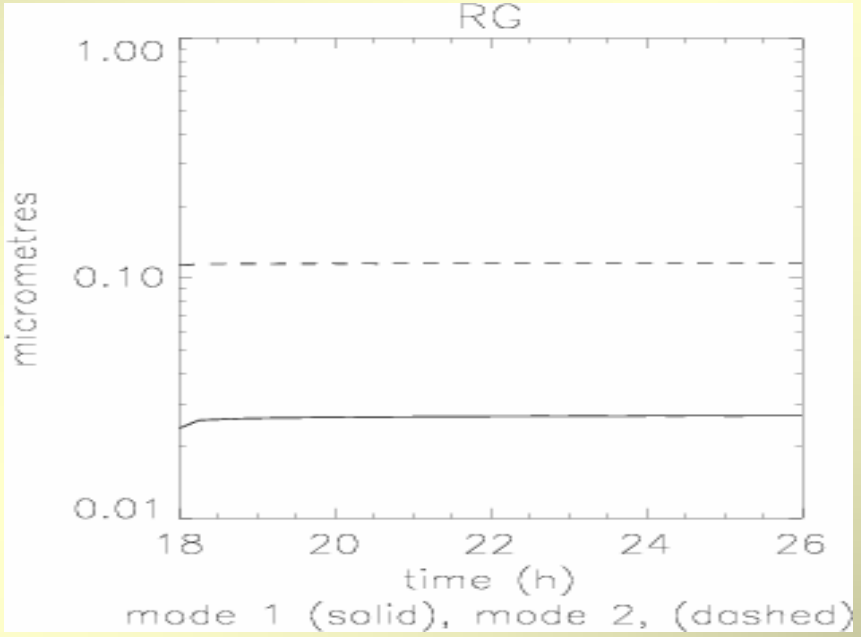
►To calculate SOA added to the surface area of preexisting aerosol

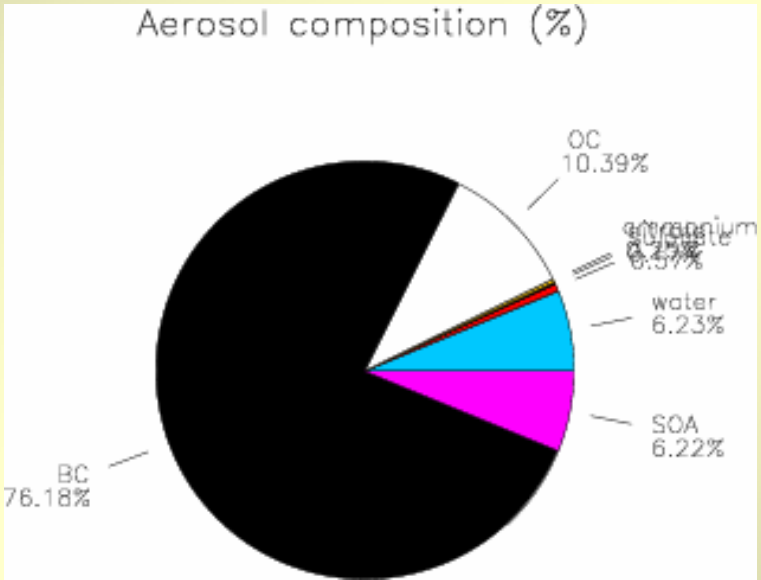
III. Examples: 1D simulations

Simulation with ORILAM / C2R2

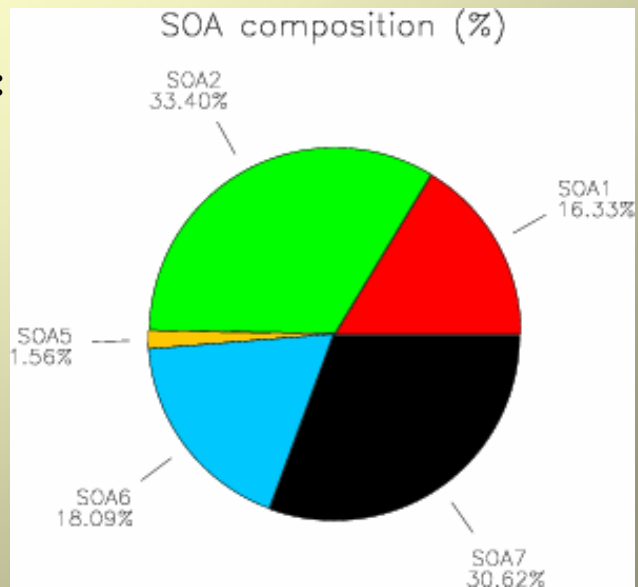
Type 1: No polluted conditions and hydrophobic aerosols







Main composition: Black Carbon



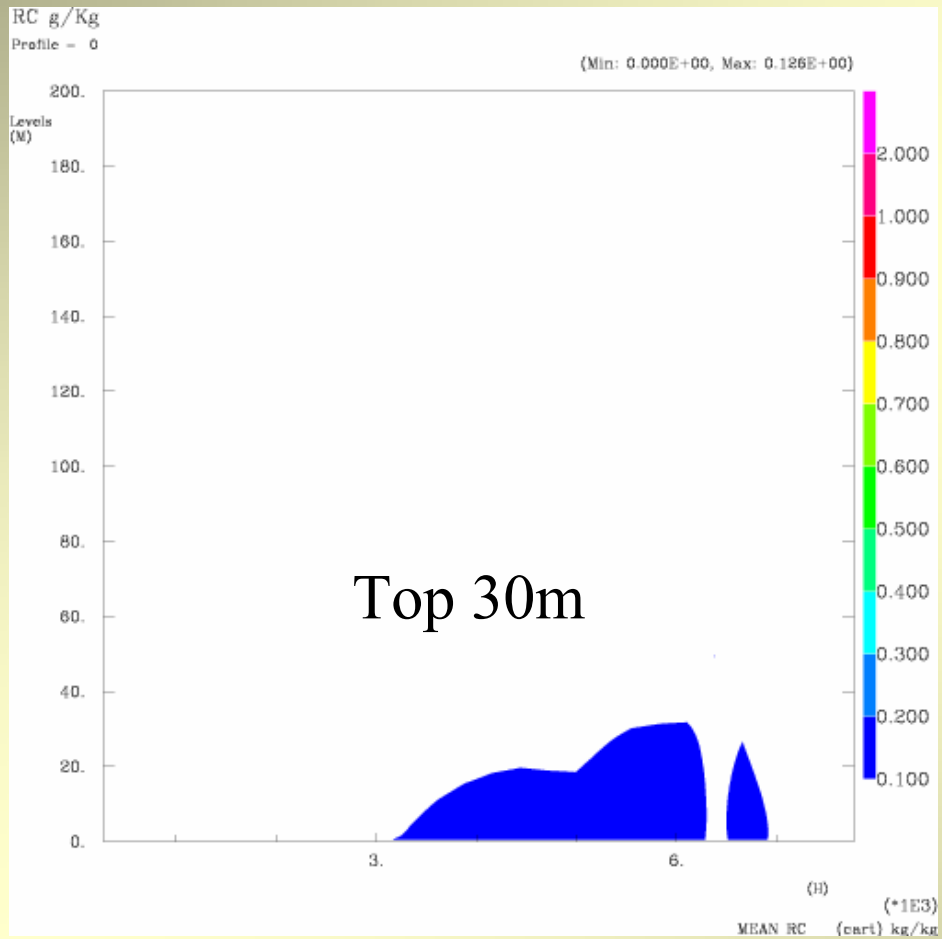
III. Examples: 1D simulations

Simulation with ORILAM / C2R2

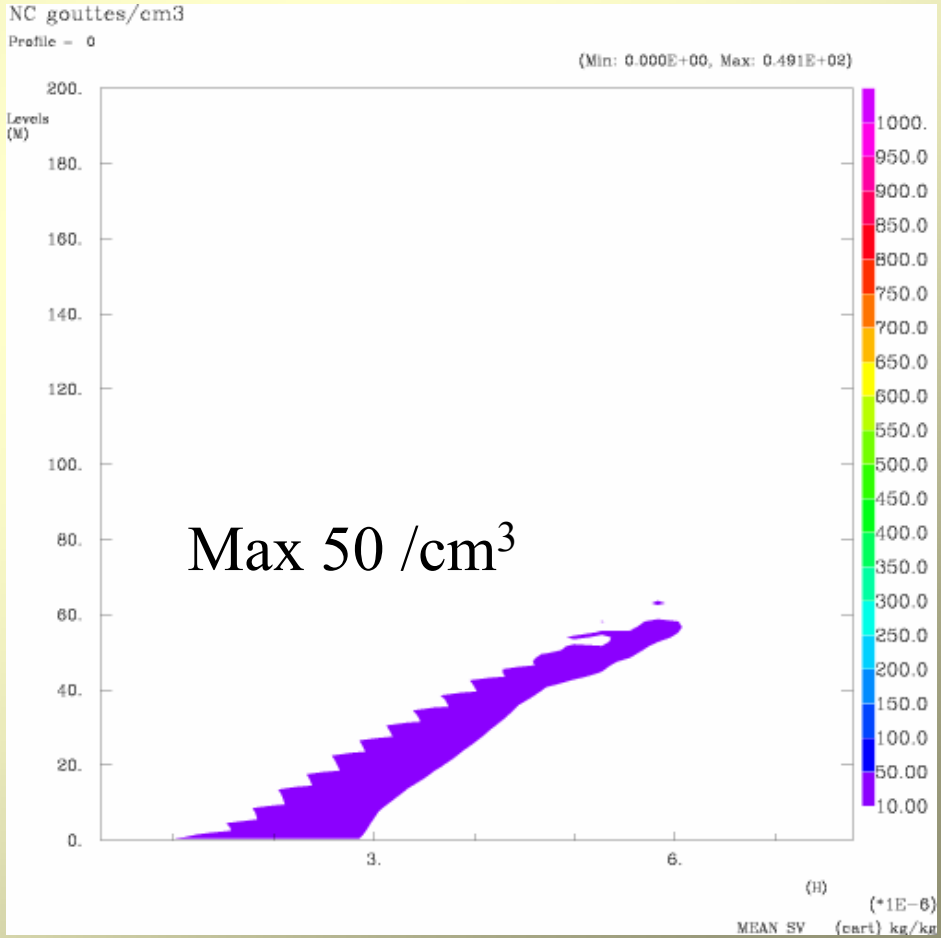
Type 1:No polluted conditions and hydrophobic aerosols

=> Low fog

Cloud water (g/kg)



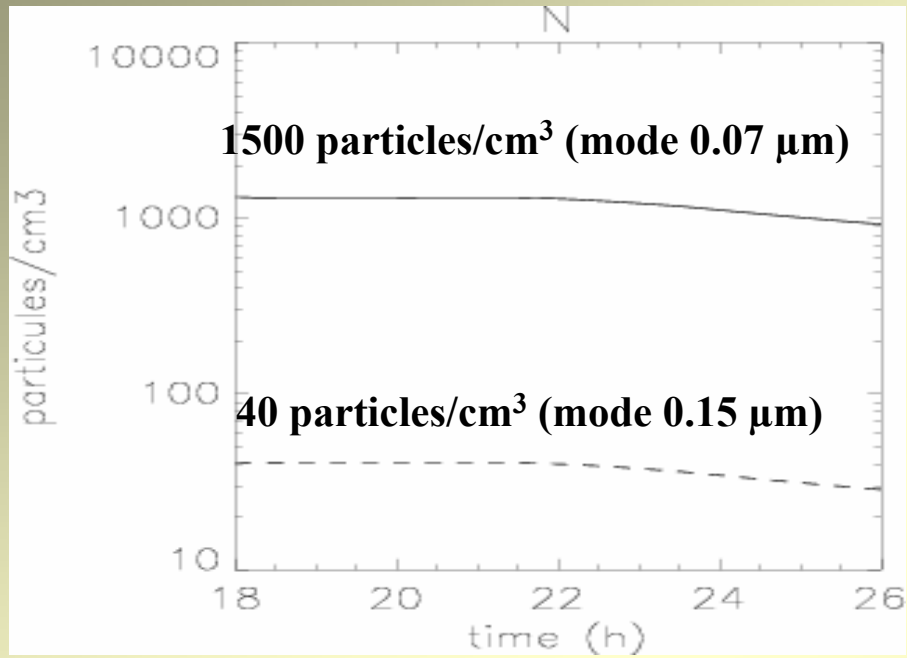
Droplets numbers (/cm^3)

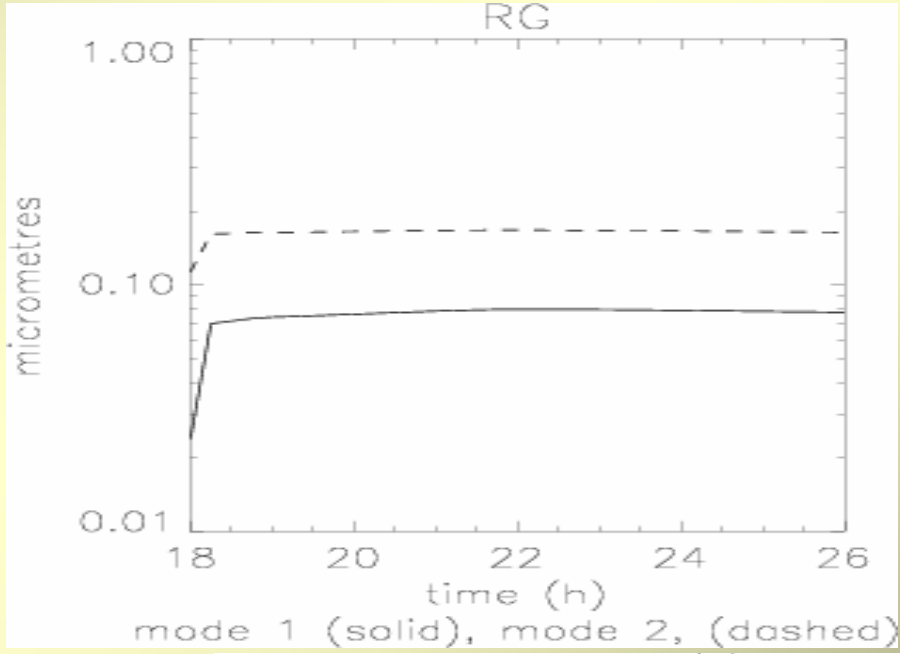


III. Examples: 1D simulations

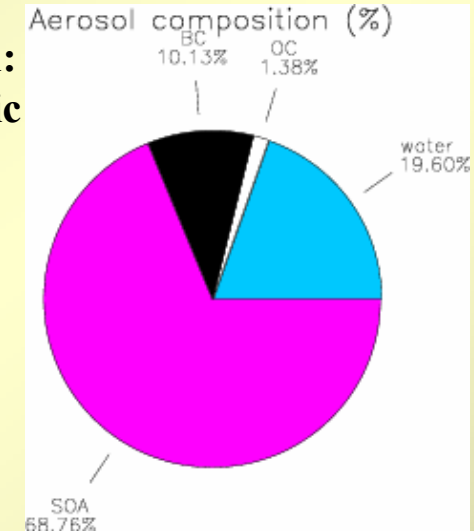
Simulation with ORILAM / C2R2

Type 2: Mean polluted conditions and highly hydrophilic aerosols

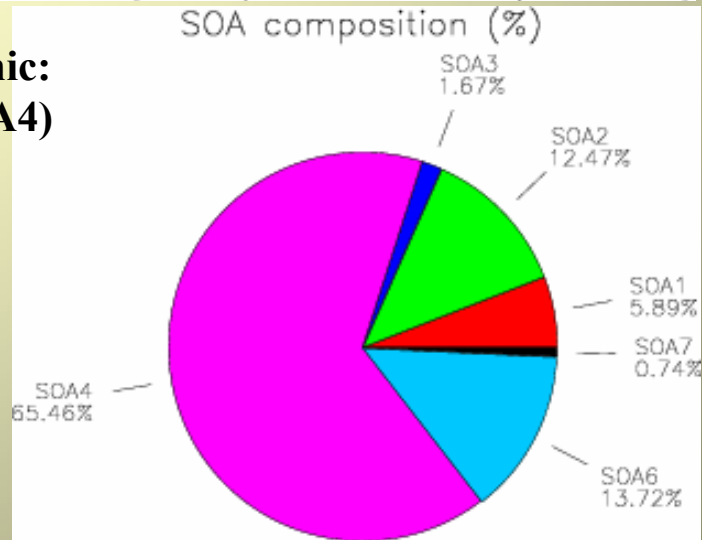




Main composition: Secondary Organic



Secondary Organic: Hydrophilic (SOA4)

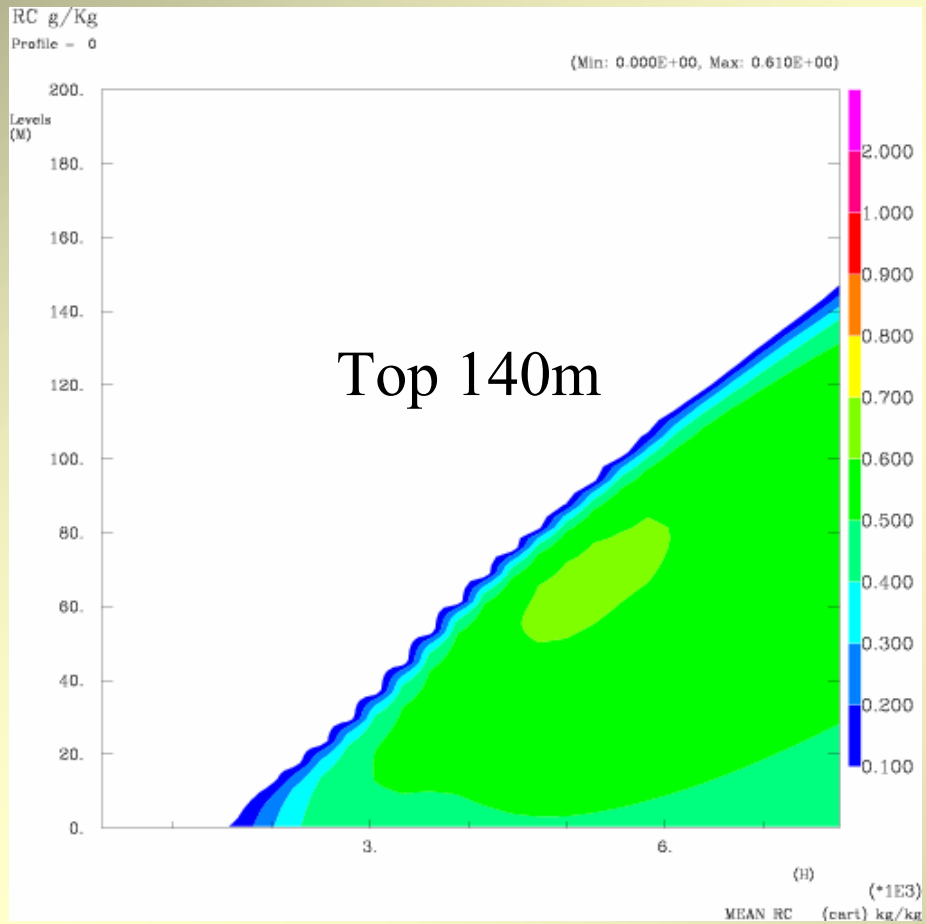


Simulation with ORILAM / C2R2

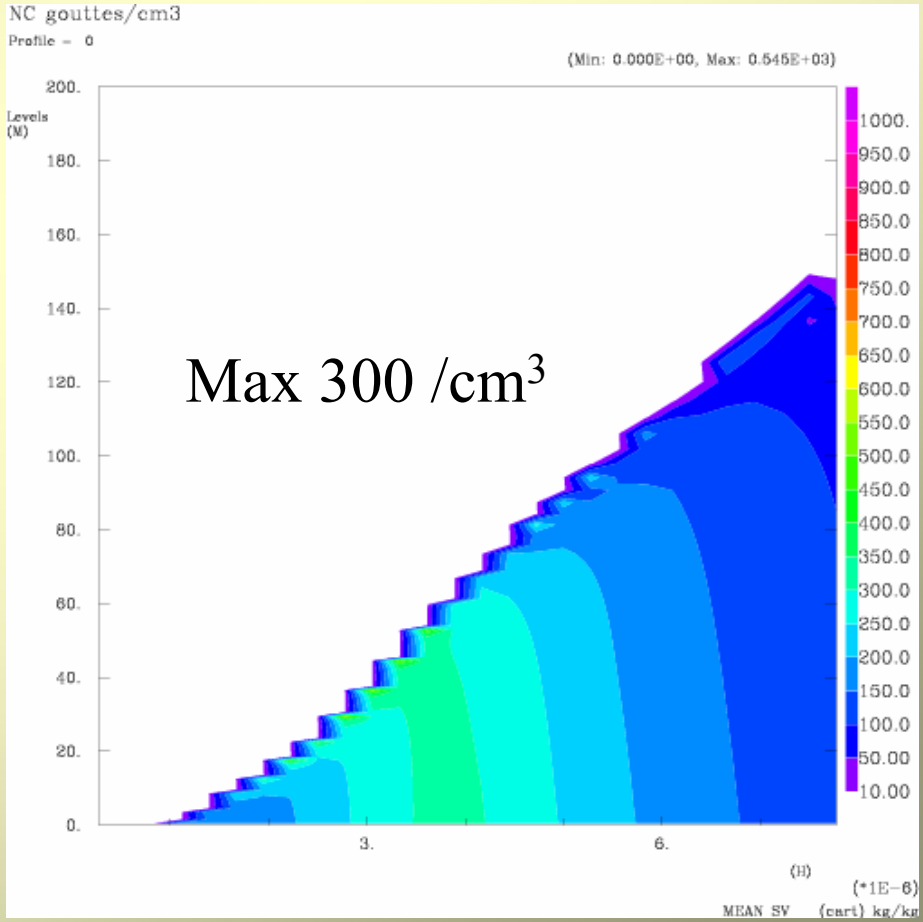
Type 2: Mean polluted conditions and highly hydrophilic aerosols

=> Important fog : layer of 140m

Cloud water (g/kg)

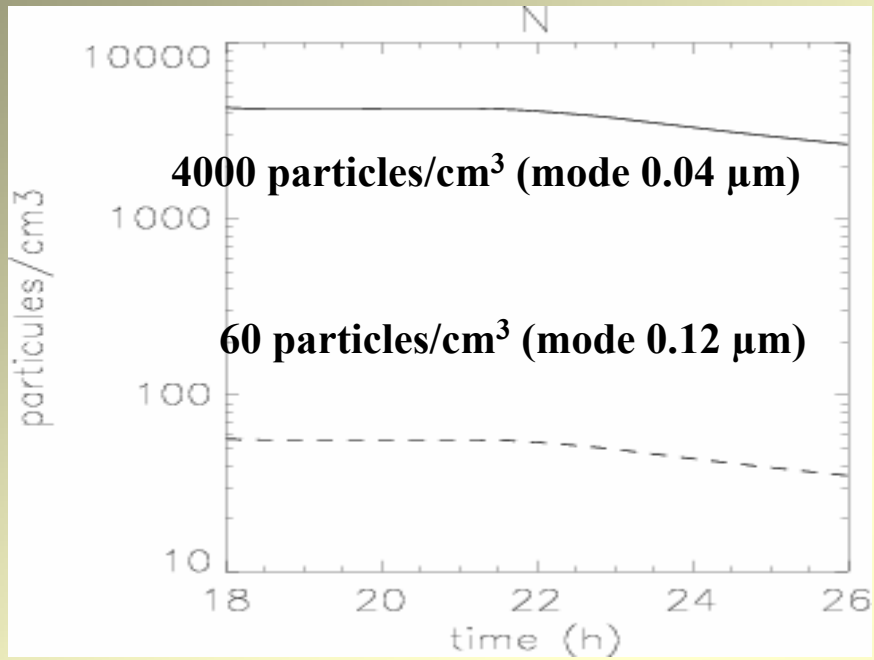


Droplets numbers (/cm^3)



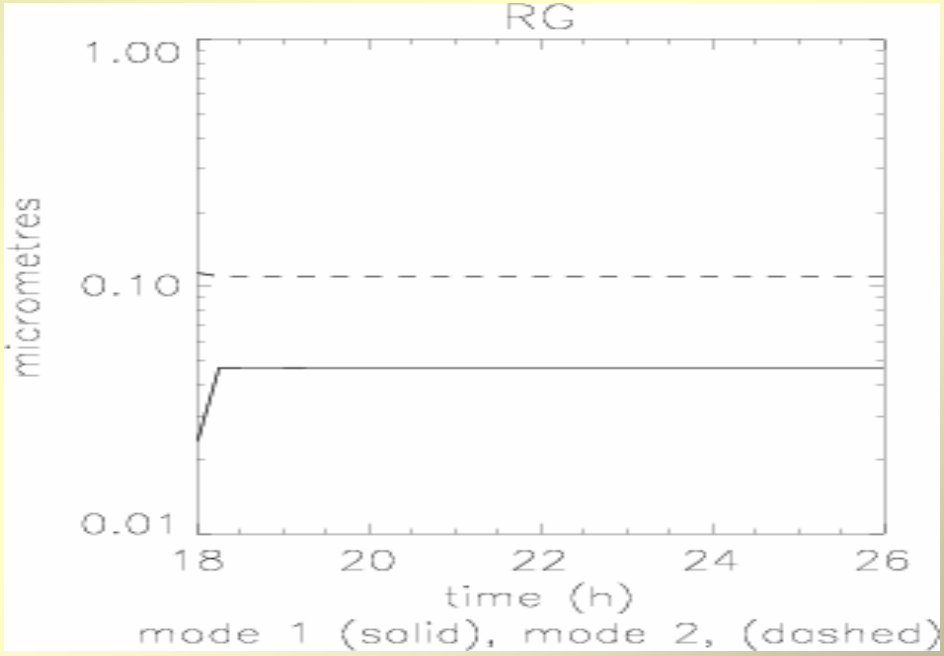
III. Examples: 1D simulations

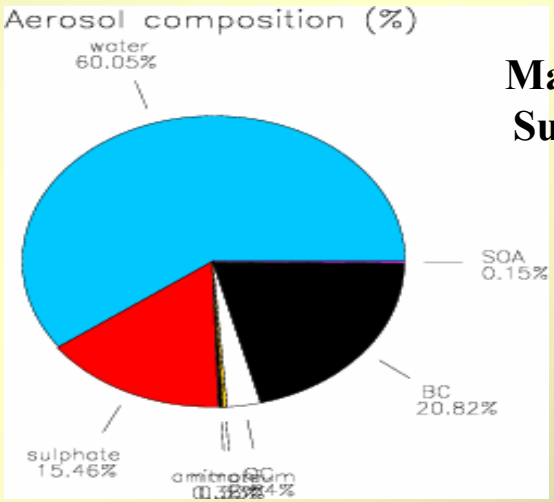
Simulation with ORILAM / C2R2
Type 3: Polluted conditions and highly hydrophilic aerosols



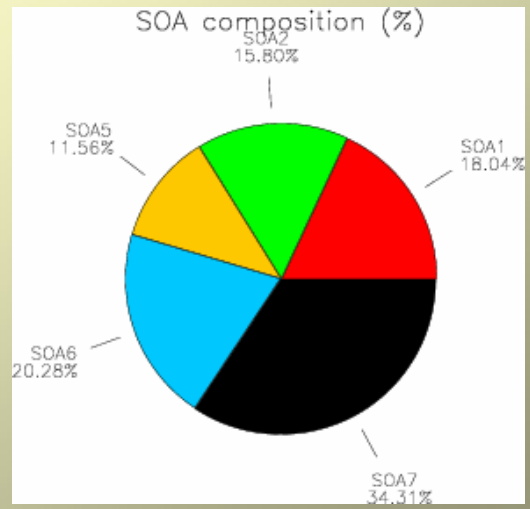
4000 particles/cm^3 (mode 0.04 µm)

60 particles/cm^3 (mode 0.12 µm)





Main composition:
Sulphates and BC



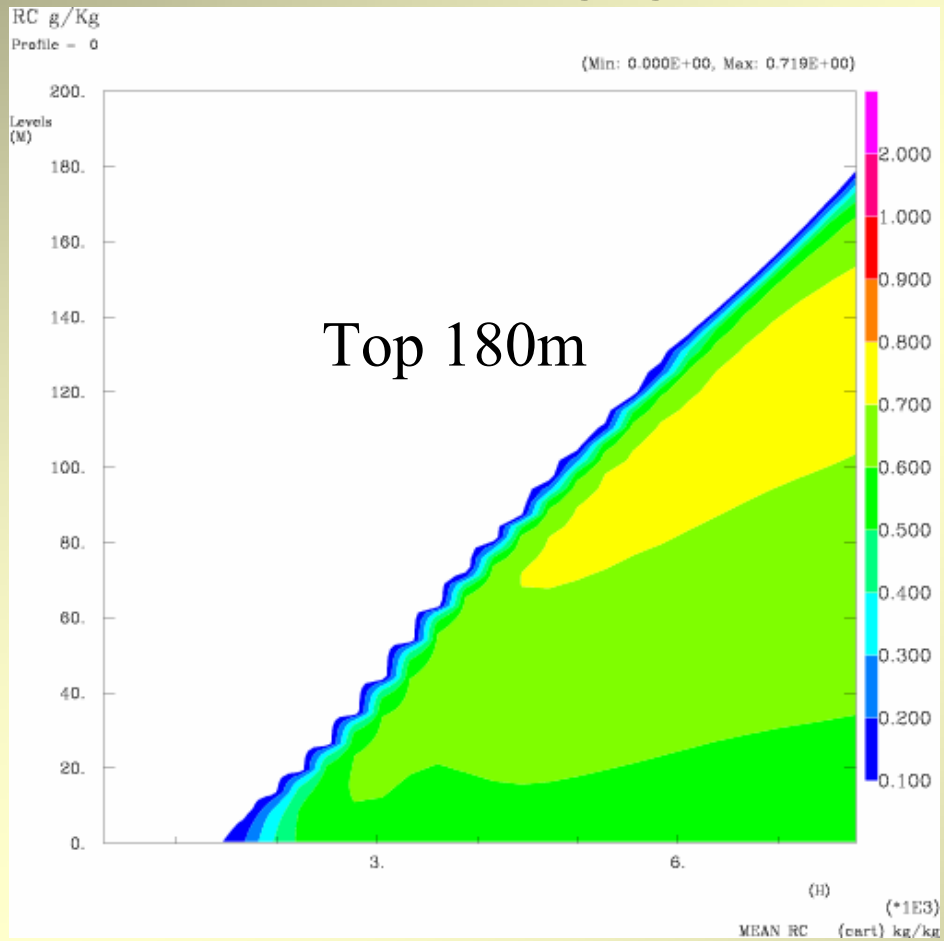
III. Examples: 1D simulations

Simulation with ORILAM / C2R2

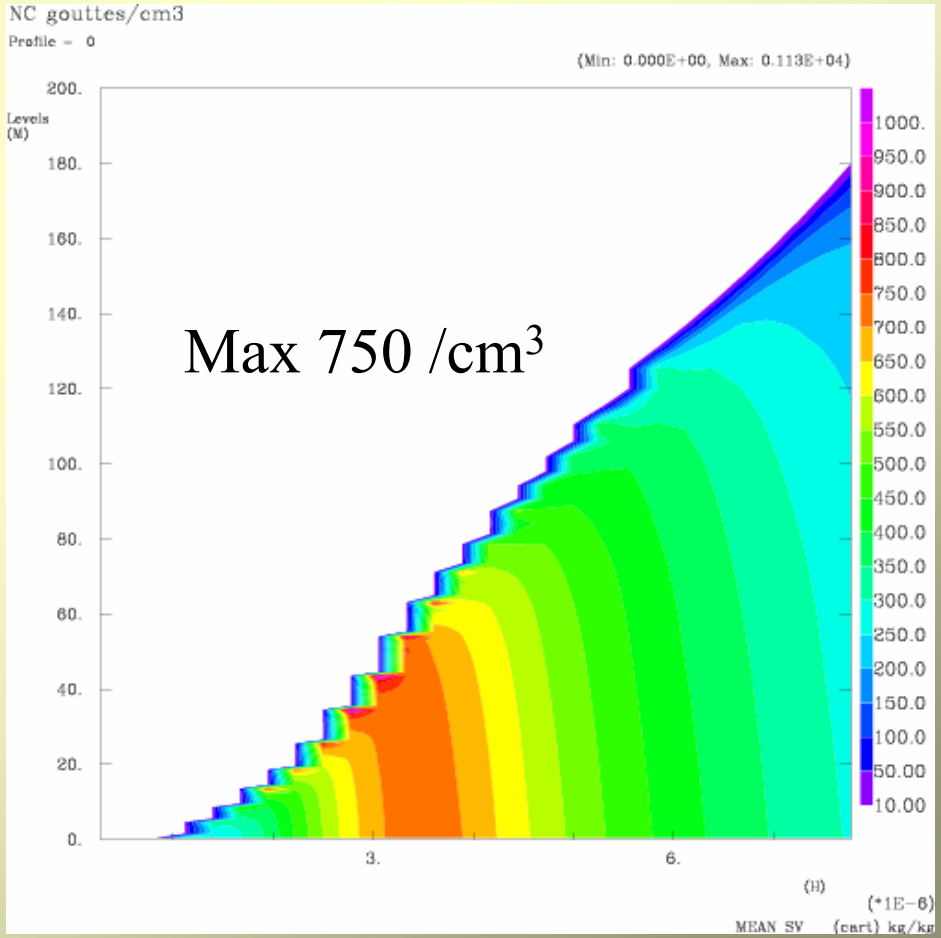
Type 3: Polluted and high hydrophilic aerosol (type Sulphates)

=> Heavy fog : layer of 180 m

Cloud water (g/kg)



Droplets numbers (/cm^3)



Perspectives : Parisfog's field experiment

→ **From October 2006 to April 2007**

→ **Cooperation between CNRM , IPSL and CEREA**

→ **2 objectifs:**

1. To provide information on the whole processes which take place during the life cycle of fog (turbulence, microphysic and radiation)

2. To improve our understanding and our ability to simulate numerically the life cycle of fog and the whole processes

►Main aim : Improving of the fog's prediction

See presentation of Bergot Thierry tomorrow: Parisfog experiment

Parisfog's field experiment: Data Base Aerosols: Objectifs

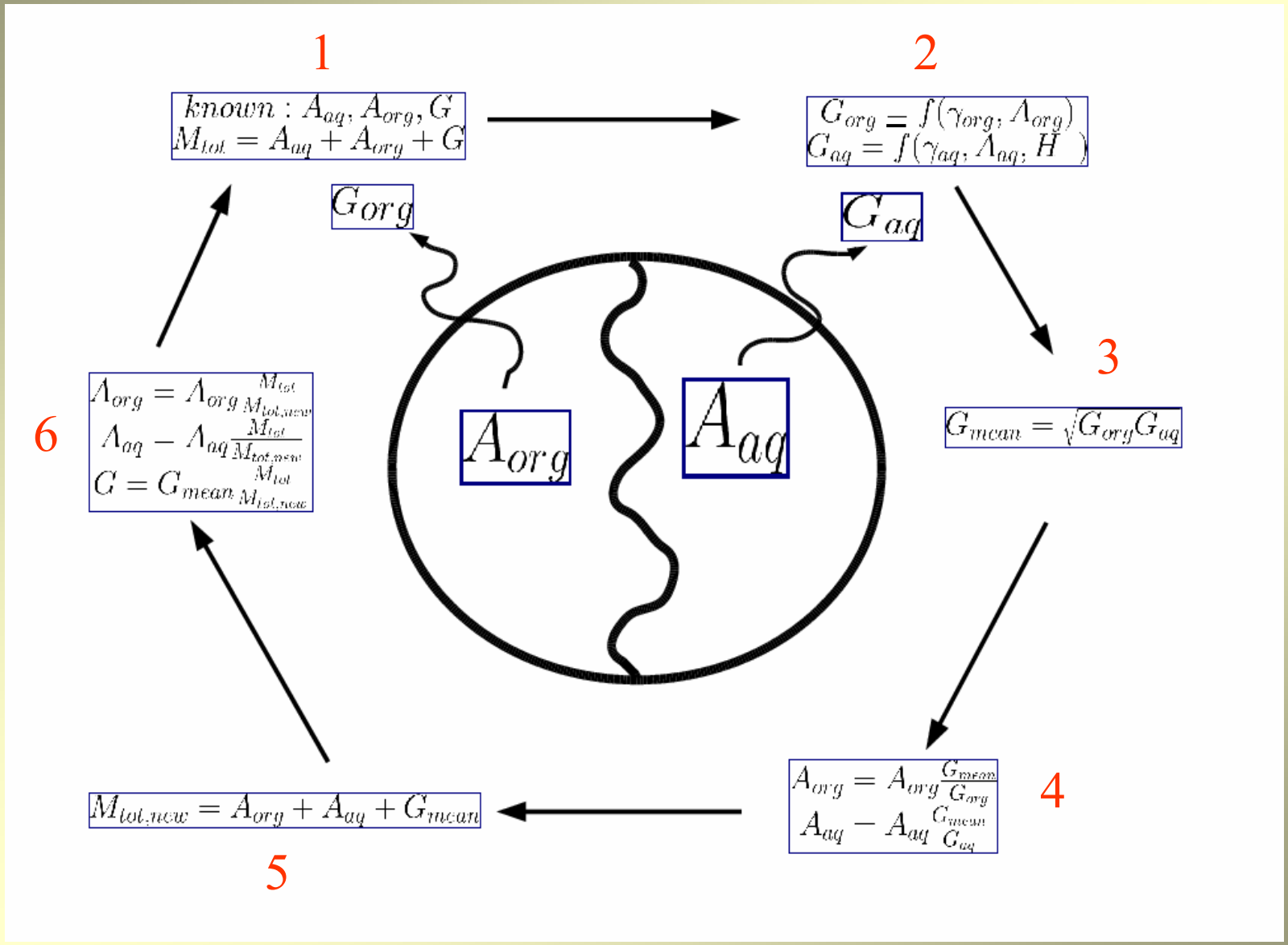
- Validation of parametrizations between the microphysic of aerosols and the microphysic of clouds (Meso-NH/ORILAM)
- Comparison between simulations of coupling chemistry-aerosol-atmosphere and observations
- 1-D simulations → interactions between microphysic and radiation
- Validation of activation schemes by a best caracterization of the cloud condensation nuclei
- Validation of microphysic scheme by comparing the fog's droplet – composition - optical properties to observations
- 3-D simulations of the life cycle of fog

Acknowledgments

THANKS

QUESTIONS ?

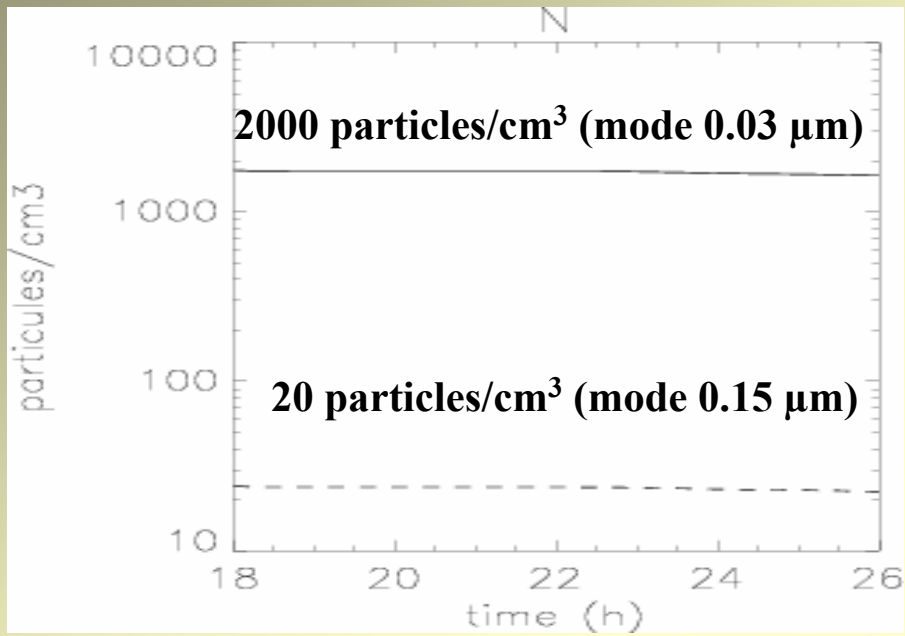
The MPMPO scheme

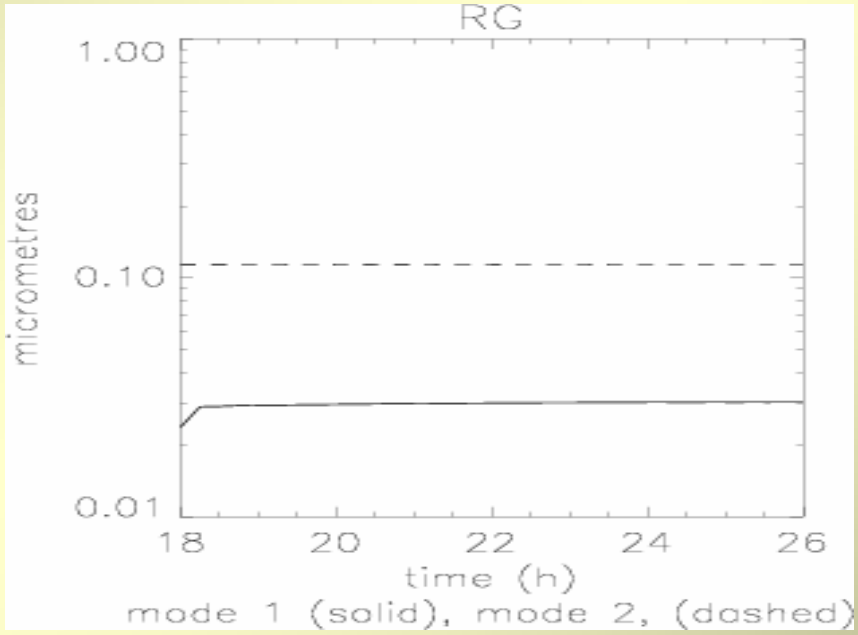


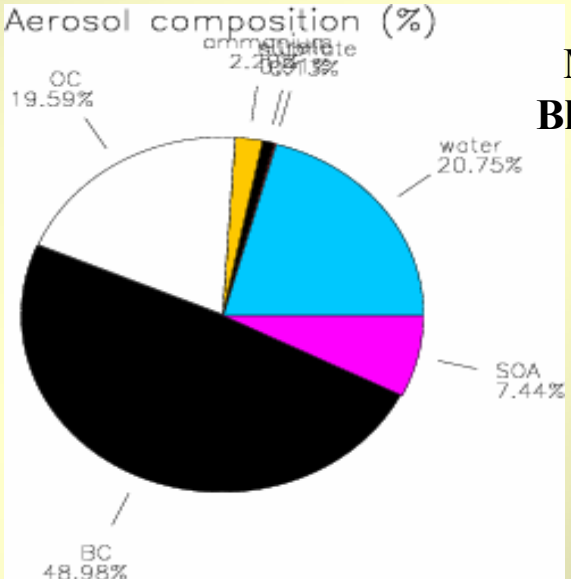
III. Examples: 1D simulations

Simulation with ORILAM / C2R2

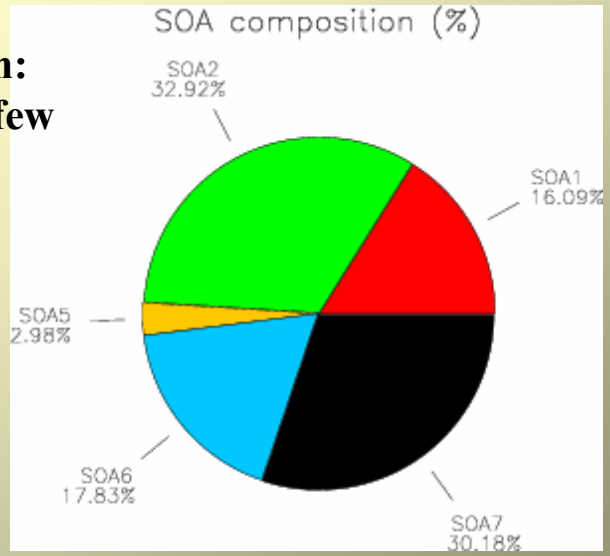
Type 2: Mean polluted conditions and mostly hydrophilic aerosols







Main Composition: Black Carbon and few SOA



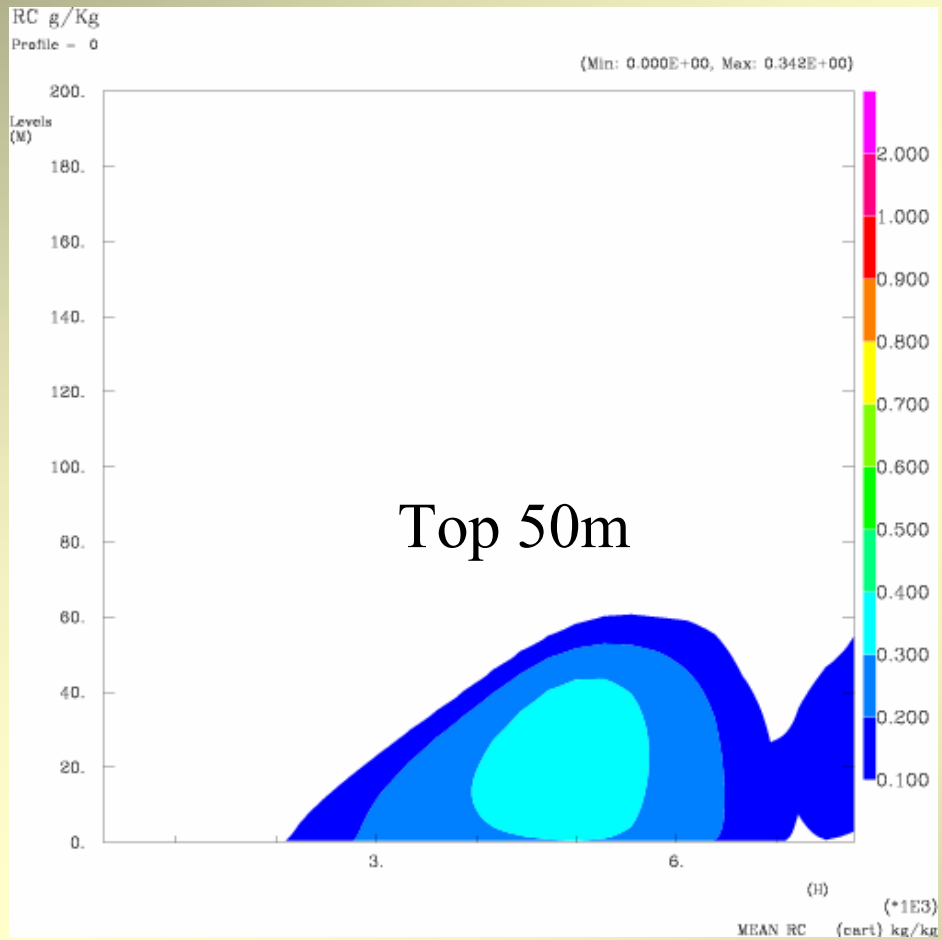
III. Examples: 1D simulations

Simulation with ORILAM /C2R2

Type 2: Mean polluted conditions and mostly hydrophilic aerosols

=> Low formation of fog ; clear away

Cloud water (g/kg)



Droplets numbers(/cm^3)