# Numerical study of convective precipitation using a high resolved 3D cloud model with detailed microphysics during the COPS field campaign

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## Introduction

Objective : **to improve our understanding of rain formation**

Can detailed cloud modeling in a highly resolved 3D dynamical frame reproduce the observed features of a convective rain event?

The observational case chosen is the 12 August 2007 – a rain event characterized by small cells that were initiated along a crest line of the Vosges Mountains under medium high convective conditions.

In this model study special emphasis is put on :

- Observed and modeled rain drop spectra and radar reflectivities
- The role of atmospheric aerosol particles

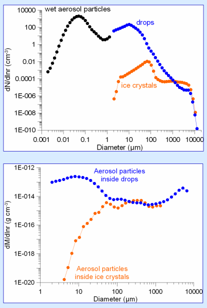
## The X-band Radar

**The X-band radar** is designed to provide the precipitation field over a domain typical of a small catchments basin (about 20km) with a beam inclination of 5° with respect to the ground.

The system major characteristics is the restitution of the radar reflectivity field with high spatial and temporal resolution.

## The Model

**Detailed scheme (DESCAM 3D)** of *Leroy et al.(2007)*

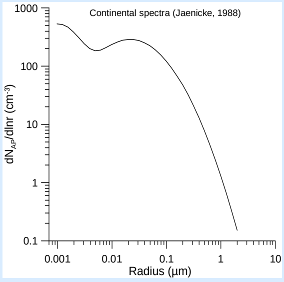



*Warm microphysical processes* :
aerosol particle growth and activation, droplet de-activation, growth of drops by condensation and collision-coalescence, break up.

*Cold microphysical processes* :
homogeneous and heterogeneous nucleation, growth by vapor deposition, riming and melting.

$f_d$ : drop number
$f_i$ : ice crystal number
$f_{AP}$ : wet aerosol particle number
$g_{AP,d}$ : aerosol mass inside drops
$g_{AP,i}$ : aerosol mass inside ice crystals

## Model setup and initialization

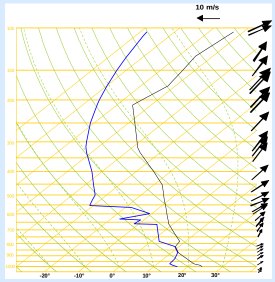



***Nancy sounding:***

12h, 12 August 2007

***Model domain:***

130x130 x 80 points
$\Delta x = \Delta y = 1$km,
$\Delta z = 200$m,
time step:
$\Delta t = 2$s

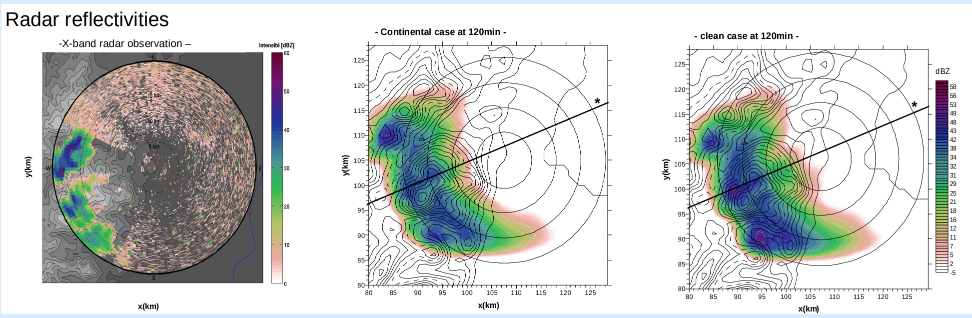



***Aerosol particle spectra:***

*1-continental case:* 700 $cm^{-3}$
*2-clean case:*
The aerosol number is 3 times less in the lower levels

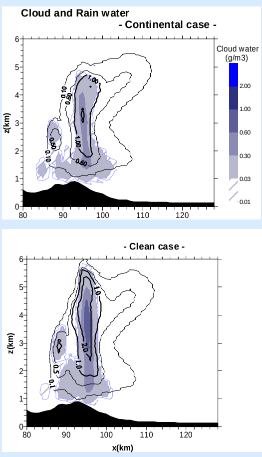
## Model results versus observations

### Model results versus radar observations



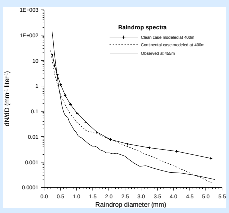

- Comparison between the radar observation and the simulation of the continental case shows that the locations of the three small convective cells are reasonably well reproduced.
- The intensity of the core of the cells is quite well estimated in the continental case but over-estimated in the clean case.
- The horizontal extension of the modeled cells is larger than the observed ones. This is most likely due to the coarse model resolution of 1km which poorly compares with the radar resolution of 60m

### Vertical cross sections * of cloud and rain water contents



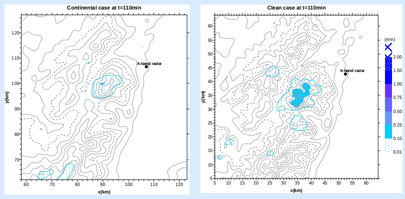

- rain water content is larger in the clean case than the continental case. ($q_c \geq 0.6$ g/$m^3$ ; $q_R \geq 2$ g/$m^3$).
- Raindrops and cloud drops are differently distributed.
- also the dynamics of the cloud develops differently due to the difference in the initial aerosol number concentration

### Modeled versus observed rain drop spectra




- The raindrop spectra observed and the one of the continental case are reasonably similar.
- For the clean case, there are more large raindrop than observed.

## Influence of the aerosol number



- The change of the number of aerosol particles modifies the intensity and the location of rain.
- Total surface rain increases in the clean case.
- Rain on-set is delayed in the continental case.

## Conclusions

**Reproduction of the observed event**

The microphysical model is able to reproduce reasonably well the cloud field (see X-band radar observation) and its precipitation (see raindrop spectra) for a medium convective situation over the Vosges Mountains during the COPS campaign.

**The role of the atm. aerosol particles**

The differences between the raindrop spectra of the continental case and the clean case can be explained by the microphysics that modifies the vertical and horizontal structures of the cloud and rain water fields.

→ Indeed, the continental aerosol particle spectrum inhibits the formation of large drops while a clean aerosol particle spectrum increases it.

**References:**
Leroy D., W. Wobrock and A. I. Flossmann, 2007 : On the influence of the treatment of aerosol particles in different bin microphysical models : a comparison between two different schemes. *Atmos. Res.* doi: 10.106/j.atmosres.2007.01.003.
Leroy D., W. Wobrock and A. I. Flossmann, 2008: The role of boundary layer aerosol particles for the development of deep convective clouds: a high resolved 3D model with detailed (bin) microphysics applied to CRYSTAL-FACE. *Atmos. Res., DOI: 10.1016/j.atmosres.2008.06.001*

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