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The influence of aerosol particle number and hygroscopicity on the evolution of convective cloud systems and their precipitation

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A 3D cloud model with detailed microphysics for ice, water and aerosol particles (AP) is used to study the role of AP on the evolution of summertime convective mixed phase clouds and the subsequent precipitation. The model couples the dynamics of the NCAR Clark-Hall cloud scale model (Clark et al., 1996) with the detailed scavenging model (DESCAM) of Flossmann and Pruppacher (1988) and the ice phase module of Leroy et al. (2007). The microphysics follows the evolution of AP, drop, and ice crystal spectra each with 39 bins. Aerosol mass in drops and ice crystals is also predicted by two distribution functions to close the aerosol budget.

The simulated cases are compared with radar observations over the northern Vosges mountains and the Rhine valley which were performed on 12 and 13 August 2007 during the COPS field campaign.

Using a 3D grid resolution of 250m, our model, called DESCAM-3D, is able to simulate very well the dynamical, cloud and precipitation features observed for the two different cloud systems. The high horizontal grid resolution provides new elements for the understanding of the formation of orographic convection. In addition the fine numerical scale compares well with the high resolved radar observation given by the LaMP X-band radar and Poldirad.

The prediction of the liquid and ice hydrometeor spectra allows a detailed calculation of the cloud radar reflectivity. Sensitivity studies realized by the use of different mass-diameter relationships for ice crystals demonstrate the role of the crystal habits on the simulated reflectivities.

In order to better understand the role of AP on cloud evolution and precipitation formation several sensitivity studies were performed by modifying not only aerosol number concentration but also their physico-chemical properties. The numerical results show a strong influence of the aerosol number concentration on the precipitation intensity but no effect of the aerosol particle solubility on the rain formation can be found.