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Sensitivity of simulated cloud droplet number concentration and cloud radiative effects to vertical velocity and aerosol population

Petri Räisänen (1), Harri Kokkola (2), Sami Niemelä (1), Sami Romakkaniemi (3), Juha Tonttila (1), and Heikki Järvinen (1)

(1) Finnish Meteorological Institute, Helsinki, Finland (petri.raisanen@fmi.fi), (2) Finnish Meteorological Institute, Kuopio, Finland, (3) University of Kuopio, Kuopio, Finland

The cloud droplet number concentration (CDNC) formed in an ascending air parcel depends both on the properties of the aerosol population and the vertical velocity. In this work, we study the influence of these two factors on the CDNC and the cloud radiative effects using input data generated by the fine-scale numerical weather prediction model AROME. The procedure involves three steps. (1) First, instantaneous data is extracted from the AROME model run at 2.5 km horizontal resolution. These data include vertical profiles of vertical velocity, cloud properties, temperature and water vapour, as well as other parameters needed for radiation calculations. (2) Second, these data, together with assumptions about aerosol properties, are fed into a 0-dimensional box model to simulate the CDNC. The Nenes and Seinfeld (2003) parameterization is used for aerosol activation. (3) Third, the data from the AROME model and the CDNC simulated by the box model are used as input for off-line radiation calculations. The radiative transfer scheme used in the ECHAM5.4 GCM is employed for the calculations.

This framework provides us with a convenient means to study the sensitivity of CDNC and cloud radiative effects to changes in both vertical velocity and aerosol properties. Preliminary experiments for a summertime case in the Baltic Sea region show, for example, that doubling the aerosol concentration and the magnitude of vertical velocity have, on average, similar impacts on radiative fluxes. Both increase the CDNC typically by 40%. However, the response to both vertical velocity and aerosol concentrations varies substantially from one grid point to another.