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Local Interactions of Hydrometeors by Diffusion in Mixed-Phase Clouds

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Mixed-phase clouds, containing both ice particles and liquid droplets, are important for the Earth-Atmosphere system. They modulate the radiation budget by a combination of albedo effect and greenhouse effect. In contrast to liquid water clouds, the radiative impact of clouds containing ice particles is still uncertain. Scattering and absorption highly depends in microphysical properties of ice crystals, e.g. size and shape. In addition, most precipitation on Earth forms via the ice phase. Thus, better understanding of ice processes as well as their representation in models is required.

A key process for determining shape and size of ice crystals is diffusional growth. Diffusion processes in mixed-phase clouds are highly uncertain; in addition they are usually highly simplified in cloud models, especially in bulk microphysics parameterizations. The direct interaction between cloud droplets and ice particles, due to spatial inhomogeneities, is ignored; the particles can only interact via their environmental conditions. Local effects as supply of supersaturation due to clusters of droplets around ice particles are usually not represented, although they form the physical basis of the Wegener-Bergeron-Findeisen process.

We present direct numerical simulations of the interaction of single ice particles and droplets, especially their local competition for the available water vapor. In addition, we show an approach to parameterize local interactions by diffusion. The suggested parameterization uses local steady-state solutions of the diffusion equations for water vapor for an ice particle as well as a droplet. The individual solutions are coupled together to obtain the desired interaction. We show some results of the scheme as implemented in a parcel model.