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The particle-based ice microphysics McSnow in ICON

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To overcome some deficiencies of current bulk and bin microphysics schemes, like the artificial choice of pre-defined ice categories, we have developed the particle-based Monte-Carlo mixed-phase cloud microphysics model McSnow.

In McSnow each individual particle is represented by its ice mass, rime mass, rime volume, liquid mass and the number of monomers. The evolution of these properties is predicted using a particle-based process formulation of nucleation, vapor diffusion, sedimentation, riming, ice multiplication, melting, shedding and breakup. In the super-particles approach similar particles are combined into super-particles to reduce computational costs. Thus the interactions between particles such as aggregation and riming need to be handled by a Monte-Carlo method. Compared to current bin microphysics models, McSnow provides a more consistent description of complex hydrometeors as it, e.g., tracks the rime density for each super-particle. In addition, individual particle histories can accessed to gain an in-depth understanding of the growth of hydrometeors.

Building on a new and efficient Lagrangian trajectory model, McSnow is coupled to the non-hydrostatic numerical weather prediction model ICON. In storm-resolving large-eddy simulations, ICON is typically run with the two-moment mixed-phase bulk microphysics Seifert-Beheng scheme. Here we compare this bulk scheme with the particle-based scheme McSnow for idealized deep convective events in two- and three-dimensional large eddy simulations. We will show how these sophisticated simulations with several million super-particles help to improve our understanding of cloud microphysics and thus also enabling improvements of bulk microphysics schemes for numerical weather prediction and climate models.