Towards a Better Representation of High Density Ice Particles in a State-of-the-Art Two-Moment Bulk Microphysical Scheme

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Forecasting high density ice particles (large graupel, hail) in convective storms poses a challenge to every cloud microphysical model due to highly nonlinear initiation- and growth processes (riming, wet growth, re-freezing, re-circulation), especially in the Eulerian framework used by todays NWP models. Most of these processes as well as sedimentation velocities of such particles are quite sensitive to the particle size distribution (PSD), and details of melting/shedding and wet growth may be important. Further, re-circulation into subsequent updrafts may contribute to the formation of large particles.

Due to explicitly resolved PSDs, bin microphysical schemes are expected to be superior in this context, but are very expensive for detailed cloud resolving 3D simulations. As a compromise, two- or three-moment bulk schemes seem to be attractive as they are able to predict at least parametric approximations to the PSDs.

The two-moment bulk microphysical scheme of Seifert and Beheng (2006) has recently been modified (Noppel, 2006) by taking into account prognostic variables and budget equations for a class of high density particles, in addition to cloud droplets, rain, cloud ice, snow and graupel. In a simplified approach, this ”hail” is initiated solely by frozen raindrops, which subsequently may grow by riming and may melt into rain drops (no consideration of partial melting).

With this, radar reflectivity in the ice region of high-resolution-simulated convective clouds is very low compared to typical radar observations, caused by the presence of very many and very small graupel and ”hail” particles in the simulations. These compete for the available supercooled water w.r.t. riming, hindering the formation of larger particles.

To improve this and to render the ”hail” particles more hail-like, crucial microphysical parameters and process descriptions have been changed. For example, ice and graupel bulk density and fallspeed have been increased, leading to slower ice-to-graupel conversion and at the same time enhanced riming growth of graupel. Additionally, only relatively large frozen raindrops do serve as "hail" embryos (instead of all frozen raindrops independent of size), thus decreasing the number of "hail" particles. It is shown that, as a result, growth rate and mean size of graupel and "hail" are increased, alleviating the abovementioned problems. Additionally, graupel-to-hail conversion by wet growth of large graupel is considered. The presentation discusses these changes and their impact on convective cloud simulations as well as drawbacks and limitations.