



The particle-based mixed-phase cloud microphysics model McSnow

Workshop on Eulerian vs. Lagrangian methods for cloud microphysics, Cracow, 15.-17. April 2019

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Simulation-based parametrization development



Christoph Siewert, Jeremie Bec and Giorgio Krstulovic, Steady-state condensation of droplets in turbulent flow, JFM 810, pp. 254-280, 2017





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Current status of microphysical modeling

- Current simplifications: •
 - fixed form of size distribution ٠

$$f(x) = A x^{\nu} e^{-\lambda x^{\mu}}$$

categorization ٠



Locatelli & Hobbs 74

Idea: continuous particle-based model ٠

















Coupling to NWP model ICON



new online trajectory model for ICON



Zängl et al. 2015

non-hydrostatic equations on triangular grid \rightarrow in/out and interpolation complex saturation adjustment \rightarrow keep cloud water in the bulk total momentum: moist air + hydrometeors

 \rightarrow coupling issue?







Idealized 2D warm bubble





Instability in Monte-Carlo collision method





Piggy-backing: How not to do

Idea: Start with passive McSnow

 q_c stays in bulk (saturation adjustment) \rightarrow not duplicate T, q_v , q_c , q_{nc} (just other hydrometeors)

But if schemes behave very differently, not conserving mass becomes an issue

Next step: duplicate also T, q_v, q_c, q_{nc} (not u,v,w, ρ)? ICON uses barycentric (total) ρ ,u,v,w in conservation equation q_x << q_a, but q_xw_x ~ q_aw_a \rightarrow hydrometeor vertical momentum not negligible







Comparison to 2-Moment bulk scheme

























A super-particle evolution



→ Particle based approach allows to look at individual particles for detailed understanding





Single Particle melting in sub-saturated air







3D technically works but, reach computational limits

Performance issues:

- load-imbalance
- collision time-step

Open questions:

- size of collision box
- how-to initialize/sample at creation
- etc..

Partial solution:

- merging in all single-dimensions if N_{sp} > 100

16.04.2019

 \rightarrow Next slide, rime fraction in 3D











Conclusions

- Goal:
 - Understand and parametrize better mixed-phase microphysics
- \rightarrow Need for "microphysics-resolving" model
- Approach:
 - Developed the particle-based mixed-phase particle model McSnow
 - Developed trajectory model for ICON
- Results:
 - Approach is feasible on storm-scale
 - Initial analysis shows potential
- ToDo:
 - Performance issues
 - Represent geometric variability







DWD



