# NTU multi-moment bulk microphysical scheme in the WRF model and applications

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Ice microphysics plays an important role on the simulation of deep convection and quantitative prediction of precipitation, but the highly simplified representations of spherical ice crystal shape with a fixed density could lead to large uncertainties. A multi-moment four-ice (pristine ice, aggregate, graupel, and hail) bulk microphysical scheme of NTU (National Taiwan University) has been implemented into the WRF (Weather Research and Forecasting) model version 3.5.1. The NTU scheme has four major improvements over current bulk schemes in WRF: (1) applied triple-moment (the zeroth, second, and third moments) closure method on all ice categories, (2) allowed the ice crystal shape to evolve with gradual adjustment to the primary growth habit according to Chen and Tsai (2016) together with the prognostic shape of aggregate, (3) permitted the predictable apparent densities of pristine ice, aggregate, and graupel, (4) fully coupling among crystal shape, apparent density, and fall speed for all solid hydrometeors referred to a theoretical parameterization of Mitchell and Heymsfield (2005). A squall line system in the U.S on 20 May 2011 during the field campaign of Mid-latitude Continental Convective Clouds Experiment (MC3E) was the first study case. Preliminary validations against to ground-based radar observations depicted that the NTU scheme improved several major features, such as the vertical structure of radar reflectivity and updraft strength, of the simulated convective system. Further evaluations and mechanism analyses will be presented, as well as the second study case in Taiwan.

## References

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