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Using a New Hybrid Bulk-Bin Method to Improve Cloud Microphysics Parameterizations

Adele Igel
University of California, Davis

Which properties of hydrometeor size distributions should we predict in bulk microphysics schemes to best simulate clouds and precipitation? We traditionally predict the total mass, number, and possibly reflectivity (3rd, 0th, and 6th moments), but no study to our knowledge has shown that these choices are optimal. We seek to address this question through the development and testing of a new hybrid bin-bulk microphysics scheme.

The new hybrid bin-bulk microphysics (HBB) scheme is quickly summarized here. During a time step in this scheme, current values of bulk moments are used to initialize an ideal binned gamma distribution. Bin scheme parameterization routines are then used to simulate physical processes. At the end of a time step, bulk moments are calculated and saved. All of the detailed bin information is then discarded. The hybrid bin-bulk scheme always predicts the third moment in order to ensure mass conservation. Otherwise the scheme is flexible – any additional one or two moments may be predicted.

We will present results from box model simulations using the new HBB and compare them to simulations using the standard bin scheme upon which the HBB is built. Condensation, evaporation, and autoconversion in the box model will be discussed. The results show that the evolution of mass during condensation is predicted accurately with the HBB regardless of the combination of moments. Evaporation is more difficult to predict well, and generally the HBB performs better when high moments of the distribution are predicted. Autoconversion is the most difficult. Even though the collision-coalescence routines are identical in the bin and HBB schemes, the HBB underpredicts autoconversion rates relative to the bin scheme regardless of the combination of moments predicted. We also find that combinations of moments that predict one process well sometimes predict another poorly. Despite that, we will make broad recommendations based on our results for which moments double and triple moment bulk schemes should explicitly predict.