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Sub-grid Parameterization of Cumulus Vertical Velocities for Climate and Numerical Weather Prediction Models

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Microphysical and aerosol processes determine the magnitude of climate forcing by aerosol-cloud interactions, are central aspects of cloud-climate feedback, and are important elements in weather systems for which accurate forecasting is a major goal of numerical weather prediction. Realistic simulation of these processes demands not only accurate microphysical and aerosol process representations but also realistic simulation of the vertical motions in which the aerosols and microphysics act. Aerosol activation, for example, is a strong function of vertical velocity. Cumulus parameterizations for climate and numerical weather prediction models have recently begun to include vertical velocities among the statistics they predict. These vertical velocities have been subject to only limited evaluation using observed vertical velocities. Deployments of multi-Doppler radars and dual-frequency profilers in recent field campaigns have substantially increased the observational base of cumulus vertical velocities, which for decades had been restricted mostly to GATE observations. Observations from TWP-ICE (Darwin, Australia) and MC3E (central United States) provide previously unavailable information on the vertical structure of cumulus vertical velocities and observations in differing synoptic contexts from those available in the past. They also provide an opportunity to independently evaluate cumulus parameterizations with vertical velocities tuned to earlier GATE observations.

This presentation will compare vertical velocities observed in TWP-ICE and MC3E with cumulus vertical velocities using the parameterization in the GFDL CM3 climate model. Single-column results indicate parameterized vertical velocities are frequently greater than observed. Errors in parameterized vertical velocities exhibit similarities to vertical velocities explicitly simulated by cloud-system resolving models, and underlying issues in the treatment of microphysics may be important for both. The dependence of convective microphysical properties on vertical velocities and consequences for microphysics of simulation errors will be illustrated. Underlying limitations in the parameterization and model resolution will be discussed as explanations for differences between observed and simulated vertical velocities.