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MULTIPLE SCALES IN CUMULUS CONVECTION AND THEIR IMPLICATIONS FOR CUMULUS PARAMETERIZATION IN LARGE-SCALE MODELS

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Cumulus convection is a major element of the atmospheric general circulation. Shallow cumulus convection is ubiquitous and transfers heat, moisture, momentum, and tracers between the planetary boundary layer and the free atmosphere. Deep cumulus convection is less frequent in space and time and owes its importance to its span of the depth of the troposphere. Understanding of interactions between cumulus convection and large-scale flows remains quite limited after nearly four decades of research on the problem of parameterizing cumulus convection for large-scale models.

This presentation will focus on the importance of treating the multiple scales of cumulus convection in parameterizations for large-scale models. Most of the major atmospheric general circulation models employed by leading climate and numerical weather prediction centers are based on simple sub-grid models of cumulus elements, at best ensembles of cumulus updrafts, but often only a single bulk updraft. Observational studies have identified mesoscale circulations as crucial components whose characteristic scales should be included in parameterizations. The probability density functions of convective vertical velocities arising from studies of field data, high-resolution cloud models, and theory all suggest a wide range of scales. Due to nonlinearity in processes driven by convective vertical velocities, like cloud microphysics (of great importance to radiation and climate), account must be taken of these variations. Strategies for doing so will be outlined, and examples of the roles of these nonlinear, multiple-scale sub-grid processes in the atmospheric general circulation will be shown.