A Lagrangian View of Deep Convection

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Abstract:

As part of a major project to update parameterizations of atmospheric physics in the Canadian Global Environmental Multiscale model, a Lagrangian perspective was adopted in the representation of deep convection. This viewpoint replaces the traditional framework for convective parameterization schemes (CPS), which was developed for models running at low resolution with time steps that were on the same order as the time scales of convection itself. In such a system, the assumptions that equilibrium clouds are stationary at the grid scale are reasonable. However, as model resolutions approach the convective greyzone (both spatially and temporally), theses assumptions break down: observed clouds can move many grid lengths as they evolve throughout their life cycle.

These effects can be built into a CPS through a parcel treatment of convective initiation and the introduction of convective cloud objects. The former involves a modification to the existing trigger function of the CPS and the advective transport of an estimate of temperature perturbations in rising thermals. The latter requires the development of a new object-based entity in the model, which exists for its full lifecycle at the subgrid-scale, yet behaves in a physically realistic manner as it moves and evolves over time.

The adoption of a Lagrangian view for the CPS is shown to eliminate precipitation structure problems that exist when the traditional framework is used. Because parcel treatment and cloud objects are both largely external to the implementation details of the CPS, the Lagrangian perspective is easily adopted in a range of schemes. Furthermore, information about cloud properties (position, updraft, age, microphysical quantities, etc) can be exploited to further improve the characterization of the cloud lifecycle in the future.