JpGU-AGU Joint Meeting 2020

Characterizing Convective Cells Using Cloud-Resolving Simulations

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Convection is a fundamental process in the atmosphere, driving global and regional circulations and producing the bulk of surface rainfall. Convective updraft cores, the engine of convective clouds, have a finite spatial scale of several kilometers, and temporal scale of less than one hour. Although convective cores are responsible for most of the heat and vertical mass transport in convective clouds, their structural and evolution characteristics are not well quantified due to the many difficulties in directly measuring updraft velocity in deep convection. Better convection parameterization remains one of the key factors in improving climate predictions. This study contributes to characterizing convection cells using ensembles of high-resolution, cloud-resolving model simulations.

The Goddard Cumulus Ensemble (GCE) model and the Weather Research and Forecast (WRF) model are used to conduct idealized ensemble simulations ranging from small-domain, single convective cells, to large-domain, case studies of convective systems. The emphasis is to build a large sample of individual convective cells through automatic feature identification and tracking algorithms. A k-mean clustering method is used to identify updraft cells with occasional human intervention. TrackPy toolkit is used to track the evolution of these cells through their lifecycle. We first present convective cell statistics derived from this database. The second part of the study explores how convective cell characteristics vary with environment variables (e.g., CAPE, wind shear, moisture) and model numerics (e.g., resolution, microphysics, radiation and turbulent mixing schemes). Lastly, applications of these statistics to understanding the global circulation, and to improving cumulus parameterization in GCMs will be discussed.

Keywords: Convection, Cells, Cloud-Resolving Model

