Geophysical Research Abstracts
Vol. 20, EGU2018-4610, 2018
EGU General Assembly 2018

Investigating the Genesis of Convective Updraughts using Large-Eddy Simulation

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This work investigates the genesis of convective cumulus clouds, and in particular examines how the method of convective triggering determines cloud properties and dynamics in order to better represent such clouds in weather and climate models. This is achieved by performing idealised large-eddy simulations with the Met Office and NERC Cloud model (MONC). Three types of simulation are run, with convection initialised using three different mechanisms: 1) convection generated through warm bubbles, 2) convection driven by surface heating (using both constant and time-decaying surface heat fluxes), and 3) convection above a zone of convergence (through the collision of cold pools). A sensitivity study of updraught dynamics to MONC's spatial resolution reveals that the value of cloud-top height begins to converge for a vertical resolution of 100m, suggesting that this is the minimum vertical resolution required to resolve the turbulent dynamics of these clouds.

Temperature and humidity profiles conducive to moderate-to-deep convection were used for the model initial conditions. These are based on observations from the Convective Precipitation Experiment (COPE), a field campaign during the summer of 2013 which explored the influence of atmospheric dynamics and microphysics on the formation of heavy convective precipitation over southwestern England. Radiosonde data from the 3rd August 2013 over Davidstow, collected just prior to an observed convective event, provide the initial atmospheric conditions for the MONC simulations.

Results from each of the three simulation types are compared in order to evaluate differences in the updraught dynamics. Quantitative updraught diagnostics include maximum updraught speed, cloud-top height, cloud width and cloud longevity. Mixing processes between cloudy and environmental air are also measured using a passive tracer, which makes it possible to measure the dilution of a given cloud over time.