Geophysical Research Abstracts
Vol. 13, EGU2011-2315, 2011
EGU General Assembly 2011

Large-eddy simulation of a shallow cumulus field with a double-moment warm-rain microphysics

Joanna Slawinska (1), Wojciech Grabowski (2), Hanna Pawlowska (1), and Hugh Morrison (2)

(1) Institute of Geophysics, Faculty of Physics, University of Warsaw, Warsaw, Poland (joanna.slawinska@igf.fuw.edu.pl, hanna.pawlowska@igf.fuw.edu.pl), (2) MMM Division, NCAR, Boulder, USA (grabow@ucar.edu, morrison@ucar.edu)

This paper presents application of the double-moment bulk warm-rain microphysics scheme to the simulation of a field of shallow convective clouds based on the Barbados Oceanographic and Meteorological Experiment(BOMEX) observations. Three key components of the scheme are: i) prediction of the cloud and rain drop concentrations in addition to the prediction of the mixing ratios as in single-moment schemes; ii) prediction of the in-cloud supersaturation field; and iii) representation of various subgrid-scale mixing scenarios associated with the evaporation of cloud water due to entrainment. Prediction of the supersaturation field allows secondary in-cloud activation of cloud droplets above the cloud base. Pristine and polluted aerosol environments conditions are contrasted.

Numerical simulations show that about 40\% of cloud droplets originates from CCN activated above the cloud base. As a result, the mean cloud droplet concentration is approximately constant with height in agreement with aircraft observations and in contrast to simulations where the activation above the cloud base is disabled. The in-cloud activation occurs in specific places, typically near cloud edges and seems to mimic entrainment-related activation seen in previous high-resolution simulations of shallow convective clouds. The in-cloud activation significantly affects the vertical distribution of the effective radius and thus the mean albedo of the cloud field. The difference between pristine and polluted conditions are consistent with the previous modeling studies, but the impact of the subgrid-scale mixing scenario is significantly reduced. Possible explanations of the latter involve a combination of numerical and physical aspects. The numerical aspect concerns relatively small role of the parameterized subgrid-scale mixing when compared to mixing and evaporation due to numerical diffusion, with only the former considered in the subgrid-scale mixing scenario and the latter treated as homogeneous mixing in the model numerics. The physical aspects involve two effects: i) the counteracting effects of the subgrid-scale mixing and in-cloud activation, and ii) mean characteristics of the environmental cloud-free air entrained into a cloud. A simple analysis is presented suggesting that the entrained cloud-free air is on average close to saturation. The nearly saturated air entrained from a narrow descending-air shell surrounding the cloud leads to a small difference between various mixing scenarios.

These results will be discussed in the context of recent observational and modeling studies concerning indirect aerosol effects in shallow convective clouds.