EGU24-7679, updated on 19 Apr 2025
https://doi.org/10.5194/egusphere-egu24-7679
EGU General Assembly 2024

Microphysical influence on cloud radiative effect during New Mexico deep convective cloud cases

Declan Finney[1,2], Alan Blyth[1,2], Paul Field[3,1], Martin Daily[1], Benjamin Murray[1], and Steven Boeing[1]
[1]University of Leeds, Institute for Climate and Atmospheric Science, School of Earth and Environment, Leeds, United Kingdom of Great Britain – England, Scotland, Wales (d.l.finney@leeds.ac.uk)
[2]National Centre for Atmospheric Science, Leeds, UK
[3]Met Office, Exeter, UK

Cloud feedbacks associated with anvil cirrus are some of the most uncertain. The Deep Convective Microphysics EXperiment (DCMEX) aims to reduce this uncertainty by improving the representation of microphysical processes in climate models. In support of this aim, we present analysis of the cloud radiative properties from cloud-resolving simulations with the Met Office Unified Model (UM). We apply the Cloud AeroSol Interacting Microphysics (CASIM) module within the UM.

Overall, the results suggest that an increase in cloud droplet number or ice nucleating particles can increase the reflectivity of anvil cloud. However, the magnitude of these effects shows a dependency on environmental conditions such as wind shear.

Our simulations are based upon a number of case studies from the DCMEX 2022 field campaign held over the Magdalena Mountains in central New Mexico. In the campaign, numerous cases of deep convective cloud formation were observed using the FAAM aircraft, radar, ground-based aerosol instruments, and automated cameras. A number of observation-informed, sensitivity simulations have been performed to explore the representation of cloud microphysics within the UM-CASIM model.

With the model sensitivity simulations we explore the effect of a range of measured microphysical features. The features include: 1) Cloud droplet number concentration, 2) Temperature dependence of heterogeneous freezing, and 3) Secondary ice formation rate from the Hallett-Mossop process.

There is consistently higher outgoing radiation from high cloud, and across the whole domain, in experiments using higher cloud droplet concentration. This aggregate radiative effect manifests from changes in anvil cloud area and reflectivity. Experiments using the ice nucleating particle-temperature relationship derived from DCMEX observations are compared to a simulation using the widely-used Cooper curve. We find an increase in high cloud reflectivity in several cases, but the magnitude of the difference varies from 0-10%, depending on environmental conditions. Overall, the sensitivity experiments vary in all-domain mean outgoing radiation by greater than 10

Wm-2.

Our results offer an important contribution to the understanding of anvil cloud effects on climate through describing the potential effect of small-scale processes on radiation. These microphysical processes are not well represented in climate models. Our finding that their effect depends on environmental conditions encourages a focus on evaluation methods that take this into consideration.