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Contrasting sensitivities of two cases of convective showers in the summertime UK to warm rain production

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The interaction of aerosols with clouds is known to significantly affect cloud dynamics and the patterns and intensity of precipitation. However, aerosol-cloud interactions are very poorly handled in low resolution climate and operational NWP models. For example, in the global operational NWP Met Office Unified Model (UM), simple land-sea contrasts in cloud droplet concentrations are specified. In reality, changes in cloud condensation nuclei affect warm rain production, which goes on to affect the ice production in mixed-phase convective clouds. It is important to establish the value of including such interactions in these models. In the framework of the ASCI (AeroSol Cloud Interactions) project, in which we are developing a coupled version of the UM with multi-moment bulk cloud and aerosol schemes, we consider the sensitivities of two UK case studies of mixed-phase convection to warm-rain production.

A suite of (one way) nested models was used with grid lengths of 12, 4, 1, 0.333 and 0.1 km. This configuration allows us to evaluate the impacts of changing warm-rain production by autoconversion at very high resolution and evaluate the uncertainties in this impact according to the grid resolution.

The two case studies were observed during the Convective Storm Initiation Project (CSIP) field campaign in southern England in 2005 and have contrasting characteristics. The first case is characterised by moderately intense convective showers forming throughout the day in a north-westerly airstream below an upper-level PV anomaly, with a shallow boundary layer and low freezing level. The second case is warmer with a deeper boundary layer with weaker winds and less shear, and is characterised by isolate convective cells, with one persistent stronger storm. The less organised convection in the second case requires a smaller grid-spacing than the more organised showers in the first case. The first case is almost insensitive to even very large changes in autoconversion, while in the second case a change of a factor of 10 in auto-conversion rate or a factor of 3 in assumed cloud-droplet number affects total precipitation by approx. 17%. In both cases the sensitivity to autoconversion is similar at all grid-spacings < 1km. We discuss the role of ice production and the evolution of clouds through many life cycles in producing these contrasting sensitivities.