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Bridging the gap between GCMs and CRMs

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Radiative Convective Equilibrium (RCE) has proven to be a useful framework for process studies. In the past there has been little direct overlap of the studies made using General Circulation Models (GCMs), and Cloud Resolving Models (CRMs). GCMs use global or near global domain sizes with resolutions ranging from 300 km to 20 km, while CRMs normally use domains roughly equivalent to a single GCM grid cell and resolutions ranging from 5km to 0.1km. Here we study the atmosphere of a General Circulation Model (GCM) with boundary conditions that approximate Radiative Convective Equilibrium (RCE) across a range of domain sizes (from 45 % of the surface of the Earth to 500x500 km̂2) and resolutions of 20 km and 10 km. To that aim we use the newly developed nonhydrostatic, primitive equation model named ICON with horizontally uniform insolation and ozone, no rotation, and a prescribed surface temperature. Comparison of the simulations leads to a better understanding of the mechanisms and assumptions that underlay the parameterizations of GCMs.

Climate sensitivity and convective organization are the two physical processes we focus on with this study. Both of these processes are important components of a physical understanding of the Earth system. Convective organization strongly influences the mean state of the atmosphere and the various feedback responses to radiative perturbations. We compare changes in the TOA radiative imbalance which result from prescribed changes in the surface temperature across our simulations. This provides a direct calculation of the various feedback mechanisms. The magnitude of the influence these feedbacks have on a system is commonly diagnosed through the climate sensitivity. We examine the dependence on domain size and parameterization schemes of the convective organization and climate sensitivity. Initial results with two physics parameterization packages indicate that ICON provides a convenient modelling framework that will allow a unified approach for the study of the inevitable future overlap between CRMs and experiments with parameterized physics at relatively high resolution.