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Regulation of the climate in coupled convection-permitting simulations

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The question of the regulation of the climate, in particular the existence of a stable climatic state and its basic characteristics, is investigated in this study. In contrast to previous studies, we use a convection-permitting simulation with an explicit representation of convection and of cloud cover. The grid spacing amounts to 3 km. The simulation is coupled to a slab ocean and is integrated in an idealized set-up of radiative convective equilibrium without rotation, without continent and with spatially uniform insolation.
It is found that the system equilibrates at a sea surface temperature near the one of the present-day tropics. The equilibration results from the self-aggregation of convection that generates the dry and clear subtropics needed to radiate the excess heat from the system. When artificially preventing the self-aggregation, the existence of a runaway greenhouse cannot be ruled out. This is very different from what happens when performing a similar simulation at low resolution (T63) with a General Circulation Model (GCM) and parameterized cloud and convective processes. In that case, the atmosphere cools through an increase in planetary albedo arising from clouds. The total cloud radiative effect is 2.5 times larger than in the convection-permitting simulation. Perturbing the system by increasing the solar insolation also reveals a different behavior of the two simulations, with a larger warming in the convection-permitting simulation than in the GCM due to their distinct cloud feedbacks.