Title: "Self-Aggregation of Convection in Radiative-Convective Equilibrium"

Abstract:

In models of radiative-convective equilibrium it is known that convection can spontaneously aggregate into one single localized moist region if the domain is large enough. The large changes in the mean climate state and radiative fluxes accompanying this self-aggregation raise questions as to what simulations at lower resolutions with parametrized convection, in similar homogeneous geometries, should be expected to produce to be considered successful in mimicking a cloud-resolving model.

We investigate this self-aggregation in a non-rotating, three-dimensional cloud-resolving model on a square domain without large-scale forcing. Self-aggregation is known to occur only on large domains; we also find that it is sensitive to the resolution. The sensitivity of self-aggregation to resolution and domain size in this model is due to the sensitivity of the distribution of low clouds to these two parameters. Indeed, the mechanism responsible for the aggregation of convection is the dynamical response to the longwave radiative cooling from low clouds. The role of cold pools has also been raised recently and will be discussed.

The mechanism responsible for the onset of self-aggregation (longwave cooling from low clouds) may be different from the mechanism responsible for hysteresis and the maintenance of self-aggregation. Low clouds are needed for the onset of self-aggregation, but once the aggregated climate is reached, the strong clear-sky radiative cooling in the dry region is sufficient to maintain the convective aggregation. The hysteresis increases the importance of the aggregated state, since it expands the parameter span over which the aggregated state exists as a stable climate equilibrium. The existence of the aggregated state appears to be less sensitive to resolution than the self-aggregation process.