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Convective aggregation in idealized stochastic models

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Numerical simulations of radiative-convective equilibrium (RCE) in high-resolution cloud-resolving models (CRMs) have pointed out the tendency of atmospheric convection to self-aggregate on periods of several weeks when the domain is large enough. Nevertheless, even though CRM simulations are able to identify some of the physical mechanisms driving convective clustering, the occurrence of organization seems to be dependent on the model setup and parameterizations. Robust results from simpler, idealized models may thus be used to help analyze and explain the sensitivities detected in CRM simulations.

Based on the work by Craig and Mack (2013), we developed a new simplified stochastic model able to predict the evolution of column relative humidity (CRH) in the tropical free troposphere, mimicking convective clustering in a state of RCE. Novelties with such an approach lie on the fact that the convective moistening term is not modeled as a smooth, deterministic function of the background humidity but accounts for stochastic variability, therefore the model lends itself to be run at high, convective "resolving" resolution. Numerical experiments were performed for different values of the key parameters, namely, subsidence timescale, moisture diffusion coefficient and a parameter determining the shape of the probability density function which governs the choice of convective locations.

Preliminary results are presented. It was hypothesized that subsidence timescale and diffusion coefficient can be combined together to give information about the radius of influence of convective events, i.e., how far convection is moistening. The main finding is that the radius of influence (properly rescaled) can actually be used to predict the transition between non-aggregated and aggregated states in the parameter space, that is, the instability of the RCE state of tropical convection. As already noticed in more complex, full physics CRMs, convective organization is sensitive to domain size and resolution, and the system exhibits hysteresis.

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