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Competition between shear-organized and unorganized convection in large-domain CRM simulations

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Multicellular organization of deep convection is commonly observed, but ignored in contemporary global circulation model parameterizations. Is it important, and if so how? In an atmosphere destabilized by homogenous forcing, would a region of more organized convection out-compete regions with spotty convection for the resulting moist convective instability?

A set of idealized simulations is built to address those questions using large-domain simulations with Cloud Model 1 (CM1), a 3D cloud-resolving model with explicit representations of both convective-scale and domain-scale circulations. A double-periodic domain as large as we can afford (currently 570 km x 570 km) is uniformly destabilized with a homogeneous cooling of -4K/day and a constant SST at 301K with fixed wind speed of 5 m/s in the bulk aerodynamic flux formula. After a spin-up time of 10 days, experimental runs are continued for another 10 days, after introducing and maintaining vertically sheared zonal wind profiles in an east-west strip covering only part of the y-domain. In the sheared area, and perhaps in the vertical vorticity-rich areas on its flanks, convection organizes. Robe and Emanuel (2000) showed that different shear profiles produce along-vertical-shear rolls or across-vertical-shear squalls. Background vertical vorticity can also be important, but the zonal mean zonal wind is fixed every time step so that convection-vorticity interactions are restricted to a zonal eddy component. If organized convection on average heats the atmosphere more (or less) than the unorganized convection in the unsheared area, zonal-mean meridional circulations develop, with rising branches in whichever regime is most efficient at converting the uniform destabilization into latent heat release. Moisture transport reinforces this development of east-west banding, cleanly isolating and then amplifying the most positive of the convection-organizing effects of a prescribed nondivergent shearflow.

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