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Miniature tropics and bi-diurnal oscillations

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Convective self-aggregation is a well-studied atmospheric state, obtained in typically multi-week idealized numerical experiments, where boundary conditions are constant and spatially homogeneous. As radiative convective equilibrium is approached, the atmosphere develops a heavily precipitating moist patch, which is surrounded by subsiding, cloud-free regions. It was recently shown that a homogeneous, but temporally oscillating surface temperature can quickly lead to the emergence of so-called mesoscale convective systems (MCS, diameters of >100 km) - on temporal scales of only a few days. Furthermore, the patterns formed by these MCS remind of checkerboards, and alternate from day to day [1].

We here extend this finding further, to add realism to the otherwise preserved idealization: Mimicking a form of “miniature tropics” we retain a laterally periodic domain (Lx, Ly), but impose spatial variation in mean surface temperature along one dimension - reminiscent of a meridional reduction in mean surface temperature, when moving poleward from the equator. By making the wavelength of spatial variation commensurate with domain size, we retail double-periodic lateral boundary conditions. When the diurnal cycle is set to zero, the system quickly organizes to a forcefully aggregated caricature of the actual tropics - with heavy convection near the equator and pronounced subsidence and enhanced long-wave cooling in the subtropics. When the diurnal cycle is increased, bi-diurnal temporal oscillations appear, which lead to a single precipitation peak centered on the equator on one day, but a bimodal meridional pattern with precipitation away from the equator on the next.

Our findings, obtained for a still idealized numerical experiment, may have implications for “edge intensifications” suggested from observations and numerical modeling of tropical precipitation patterns near the ITCZ [2,3].

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