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Self-aggregation of convection in long channel geometry

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Self-aggregation is the spontaneous transition in numerical simulations from randomly distributed convection to organized convection despite homogeneous boundary conditions. We explore the influence of domain geometry on the mechanisms and temperature-dependence of self-aggregation of tropical convection. Specifically, the System for Atmospheric Modeling is used to perform 3-d simulations of radiative-convective equilibrium in a non-rotating framework, with interactive radiation and surface fluxes and fixed sea surface temperature. The results of simulations employing a highly elongated 3-d channel domain, in which self-aggregation takes the form of multiple moist and dry bands, are compared to that of a square domain, in which self-aggregation takes the form of a single moist cluster. For both domain types, and across a range of temperatures, we characterize the fundamental physical mechanisms that lead to self-aggregation as well as its growth rate and spatial scale. The variance budget equation for the vertically integrated frozen moist static energy is used to quantify the mechanisms governing self-aggregation and characterize its time scale. We find that diabatic processes dominate the evolution of self-aggregation in the elongated channel simulations. In contrast, in the square domain simulations, similar diabatic processes dominate the initial stages of aggregation but up-gradient advection by the circulation plays a role in the later stages. Self-aggregation occurs across a much wider range of temperatures with elongated channel geometry than with square geometry. As the sea surface temperature is increased in the channel simulations, the aggregated state is characterized by smaller spatial scales and more regularity. An advantage of the channel geometry is that a separation distance between convectively active regions can be defined, which is a prerequisite for developing a spatial scaling theory.