Radiative-Convective Instability

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We show that above a critical specified sea surface temperature, ordinary radiative-moist-convective equilibrium (RCE) state becomes linearly unstable to large-scale overturning circulations. The instability migrates the RCE state toward one of the two stable equilibria first found by *Raymond and Zeng* [2000]. It occurs when the clear sky infrared opacity of the lower troposphere becomes so large, owing to high water vapor concentration, that variations of the radiative cooling of the lower troposphere are governed principally by variations in upper tropospheric water vapor. We show that the instability represents a subcritical bifurcation of the ordinary RCE state, leading to either a dry state with large-scale descent, or to a moist state with mean ascent; these states may be accessed by finite amplitude perturbations to ordinary RCE in the subcritical state, or spontaneously in the supercritical state. As first suggested by *Raymond* [2000] and by *Sobel et al.* [2007], the latter corresponds to the phenomenon of self-aggregation of moist convection, taking the form of cloud clusters or tropical cyclones. We argue that the non-robustness of self-aggregation in cloud system resolving models may be an artifact of running such models close to the critical temperature for instability.