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Balanced Dynamics and Convection in the Tropical Atmosphere

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This talk presents a conceptual picture of balanced tropical tropospheric dynamics inspired by recent observations. The most important factor differentiating the tropics from middle and higher latitudes is the absence of baroclinic instability; upward motion occurs primarily via deep convective processes. Thus, convection forms an integral part of large-scale tropical motions. Since convection itself is small-scale and chaotic in detail, predictability lies in uncovering the hidden hands that guide the average behavior of convection. Two appear, balanced dynamics and thermodynamic constraints. Contrary to conventional expectations, balanced dynamics plays a crucial role in the tropical atmosphere. However, due to the smallness of the Coriolis parameter there, non-linear balance is more important in the tropics than at higher latitudes. Two thermodynamic constraints appear to play an important role in governing the average behavior of convection outside of the cores of tropical storms. First, the production of precipitation is extraordinarily sensitive to the saturation fraction of the troposphere. Second, "moisture quasi-equilibrium" governs the saturation fraction, with moister atmospheres being associated with smaller moist convective instability. The moist convective instability is governed by the balanced thermodynamic response to the pattern of potential vorticity, which in turn is slowly modified by convective and radiative heating. The intricate dance between these dynamic and thermodynamic processes leads to complex behavior of the tropical atmosphere in ways that we are just beginning to understand.

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