Paradigms for Tropical-Cyclone Intensification

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We review four paradigms of tropical-cyclone intensification that have emerged over the past five decades, discussing the relationship between them and highlighting their positive aspects and limitations. A major focus is on a new paradigm articulated in a series of recent papers by ourselves and colleagues. Unlike the three previous paradigms, all of which assumed axial symmetry, the new one recognizes the importance of rotating deep convection, which possesses local buoyancy relative to the azimuthally-averaged virtual temperature of the warm-cored vortex. This convection comes under increasing rotational control as the vortex intensifies. It exhibits also a degree of randomness that has implications for the predictability of local asymmetric features of the developing vortex. While surface moisture fluxes are required for intensification, the postulated 'evaporation-wind' feedback process that forms the basis of an earlier paradigm is not. The details of the intensification process as well as the structure of the mature vortex are sensitive to the boundary-layer parameterization used in the model. The spin up of the inner-core winds in the new paradigm occurs within the boundary layer and is associated with the convergence of absolute angular momentum in this layer, where absolute angular momentum is not materially conserved. This spin up is coupled with that of the winds above the boundary layer through boundary-layer dynamics. Balanced and unbalanced contributions to the intensification process are discussed. An application of the new paradigm is given to help describe and understand a simulated intensification process in a realistic numerical weather prediction model.