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Observational analyses and numerical simulations of the transition of a tropical wave critical layer to a tropical depression

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In recent research my collaborators and I have hypothesized that tropical cyclones in the deep Atlantic and eastern Pacific basins develop from the cyclonic Kelvin Cat's eye of a tropical easterly wave critical layer located equatorward of the easterly jet axis that typifies the trade wind belt. The genesis sequence is likened to the development of a marsupial infant in its mother's pouch, and for this reason has been dubbed the "Marsupial Paradigm". In this talk I will summarize our previous observational findings using the ERA-40, TRMM and best-track data sets and then report on our first multi-scale numerical test of the Marsupial Paradigm that revisits the enigmatic problem of the transformation of an idealized African easterly wave-like disturbance into a tropical storm vortex. The results are found to support key elements of the Marsupial Paradigm by demonstrating the existence of a vorticity dominant region with minimal strain within the critical layer pouch that contains strong cyclonic vorticity and high saturation fraction. This localized region within the pouch serves as the "attractor" for an upscale "bottom up" development process while the wave and pouch move together. As part of the research, I will also report on our findings concerning the evolution of stratiform vs. convective precipitation within the Cat's eye. It is shown that moist deep convection is sustained near the center of the Cat's eye. The convergence profile within the Cat's eye is found to become dominantly convective with persistent convection. Low-level convergence plays a key role in establishing and intensifying the near-surface circulation, while the non-advective vorticity flux and the mid-level convergence associated with stratiform precipitation help to increase the mid-level circulation and build a tropospheric-deep vortex. Implications of these findings are discussed in relation to a newly proposed field experiment for the most active period of the Atlantic hurricane season in 2010/2011 that is to be conducted collaboratively between the NOAA and the NSF.