Geophysical Research Abstracts
Vol. 20, EGU2018-3672-1, 2018
EGU General Assembly 2018

Diurnal circulation modes of tropical cyclones

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Observations of the diurnal cycle in tropical cyclones (TCs) pose a conundrum, whereby the diurnal peaks in the intensity of precipitation and upper-tropospheric clouds – both typically taken to indicate the vigor of deep convection – are systematically out of phase by ∼half a diurnal cycle. This study addresses this conundrum through storm-resolving numerical simulations. The conundrum arises due to two diurnal modes, which are distinct in the vertical and in quadrature in time. The daytime mode is an upper-level thermally direct circulation driven by the top-heavy warming from solar radiative absorption in the storm core. Sundown triggers the spin-up of the nocturnal mode, wherein increased radiative cooling in the upper troposphere stimulates deep convection rooted in the boundary layer, which in turn drives a circulation in the lower troposphere. While this nocturnal mode taps into the moisture-rich lower troposphere, hence causing precipitation to increase overnight, the daytime mode only increases clouds, nonetheless effectively imprinting itself onto satellite measurements of brightness temperature. Prior modeling studies and observations are tapped to assess the generality of these findings. From the transverse circulation of tropical cyclones to the Hadley cell driven by convection in the ITCZ, these two diurnal modes appear without discrimination based on the large-scale regime.