Tropical Cyclone Diurnal Cycle as Observed by TRMM

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Using infrared satellite data, previous work has shown a consistent diurnal cycle in the pattern of cold cloud tops around mature tropical cyclones. In particular, an increase in the coverage by cold cloud tops often occurs in the inner core of the storm around the time of sunset and subsequently propagates outward to several hundred kilometers over the course of the following day. This consistent cycle may have important implications for structure and intensity changes of tropical cyclones and the forecasting of such changes. Because infrared satellite measurements are primarily sensitive to cloud top, the goal of this study is to use passive and active microwave measurements from the Tropical Rainfall Measurement Mission (TRMM) Microwave Imager (TMI) and Precipitation Radar (PR), respectively, to examine and better understand the tropical cyclone diurnal cycle throughout a larger depth of the storm's clouds.

The National Hurricane Center's best track dataset was used to extract all PR and TMI pixels within 1000 km of each tropical cyclone that occurred in the Atlantic basin between 1998–2011. Then the data was composited according to radius (100-km bins from 0–1000 km) and local standard time (LST; 3-hr bins). Specifically, PR composites involved finding the percentage of pixels with reflectivity ≥ 20 dBZ at various heights (i.e., 2–14 km in increments of 2 km) as a function of radius and time. The 37- and 85-GHz TMI channels are especially sensitive to scattering by precipitation-sized ice in the mid to upper portions of clouds. Hence, the percentage of 37- and 85-GHz polarization corrected temperatures less than various thresholds were calculated using data from all storms as a function of radius and time. For 37 GHz, thresholds of 260 K, 265 K, 270 K, and 275 K were used, and for 85 GHz, thresholds of 200–270 K in increments of 10 K were utilized. Note that convection forced by the interactions of a tropical cyclone with land (e.g., due to frictional convergence) may disrupt the natural convective cycle of a cyclone. Hence, only data pertaining to storms whose centers were > 300 km from land were included in the composites.

Early results suggest the presence of a diurnal cycle in the PR composites of all Atlantic basin tropical cyclones from a height of 2–12 km from ~0–400 km radius, but the cycle is most apparent above 6 km. At a height of 8 km, there is a peak (minimum) in the percentage of PR pixels ≥ 20 dBZ near 0 (21) LST in the inner core with some indication that this signal propagates outward with time. In contrast, the 37- and 85-GHz composites show little indication of a diurnal cycle at any radii, regardless of the threshold used. Ongoing work with this project will involve sub-setting the composites according to storm intensity to see if the diurnal cycle varies with storm strength. Moderate to strong vertical wind shear often leads to asymmetries in tropical cyclone convection and may disrupt the cyclone's natural diurnal cycle. Therefore, wind shear thresholds will be applied to the composites to determine if the diurnal cycle becomes more apparent in a low shear environment. Finally, other work to be completed will involve developing composites for other tropical cyclone basins, including the East Pacific, Northwest Pacific, South Pacific, and Indian Ocean.