Supporting figures: Tropical cyclone outer size impacts the number and location of tornadoes

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1 Introduction

The document provides information about the supplementary figures including: 1) the number and location of radiosondes (Fig. S1), 2) sensitivity of the results to TC intensity and VWS (Figs. S2–S4), and 3) sensitivity of the convective-scale environments to TC intensity (Figs. S5–S8).

2 Text S1: Radiosonde data location

Figure S1 shows the VWS-relative and outer size-relative location of radiosondes for large, medium, and small TCs. There are more radiosondes to the left of the VWS vector coinciding with the location of the continental United States given the typical westerly VWS (Corbosiero & Molinari, 2003; Schenkel et al., 2020). There are also more radiosondes with larger TC sizes as an artifact of the outer size-relative radial coordinate used here.

3 Text S2–S4: Identifying and accounting for TC intensity and VWS differences among outer size regimes

Figure S2 shows differences in TC intensity and VWS magnitude among small, medium, and large TCs. Specifically, statistically stronger TC intensity (at the 5% level) is often associated with large TC outer size, whereas there is no relationship between TC outer size and VWS magnitude. Specifically, median TC intensity is 35 kt, 50 kt, and 65 kt for small, medium, and large TCs, respectively. These small increases in TC intensity with outer size are consistent given the weak correlation of 0.36 between TC intensity and r_6, similar to prior work (Merrill, 1984; Chavas & Emanuel, 2010).

To isolate the effects of TC size on helicity, we reconstruct Fig. 4 from the manuscript to include only TCs within the lowest tercile of intensity (Fig. S3). This removes the TC intensity differences among the outer size subsets (Fig. S4). Figure S3 shows similar results to Fig. 4 from the manuscript. Specifically, helicity is generally similar among outer size subsets at all radii, especially in the outer region, suggesting that the region of favorable helicity may scale with outer size. Helicity also generally exceeds guidelines associated with TC tornadoes (i.e., 100 $m^2\ s^{-2}$; McCaul & Weisman, 1996; McCaul et al., 2004) for radii $\leq 0.4r_6$ in the downshear left quadrant and $\leq 0.6r_8$ in the downshear right quadrant among all outer size subsets. These results suggest TC outer size more strongly impacts convective-scale environments than intensity.

4 Text S5–S8: Sensitivity of convective cell-relative helicity and CAPE to TC intensity

Figures S5 and S6 show radial profiles of convective cell-relative helicity and CAPE, respectively. These figures are similar to Figs. 4 and 5 from the manuscript but stratified by TC intensity terciles from the NHC Best-Track data (Landsea & Franklin, 2013) instead of outer size. Specifically, weak, moderate, and strong TCs in Figs. S5 and S6 are defined as the first (<40 kt), second (40–60 kt), and third (>60 kt) terciles of TC intensity (i.e., 1-min maximum 10-m wind speed), respectively, for all North Atlantic TCs from 1995–2019 as given in Best-Track data (Knapp et al., 2010). Figure S5 shows smaller differences between helicity in weak and strong TCs in the downshear half of the TC compared to the outer size bins in Figs. S3. Finally, there are generally no statistical CAPE differences among TC intensity categories in Fig. S6. However, these plots of TC intensity terciles contain systematic differences in TC outer size .

To isolate the role of TC intensity, 0–3 km convective cell-relative helicity data was pared further to only include large TCs (i.e., upper tercile of r_6 distribution) as shown in Fig. S7. This ensures that there are no longer differences in TC outer size in the subset (Fig. S8). The radial profiles of helicity in large TCs with weak, moderate, and strong TCs show no systematic differences with stronger TC intensities (Fig. S7). Most importantly, the strong TC intensity category frequently does not have the highest helicity in the downshear half of the TC. Together, Figs. S3–S8 suggest that TC outer size more strongly influences the convective-scale environment where most tornadoes occur than TC intensity. This result is also consistent with prior work showing that TC outer size and structure is agnostic to TC intensity (Merrill, 1984; Schenkel et al., 2020).

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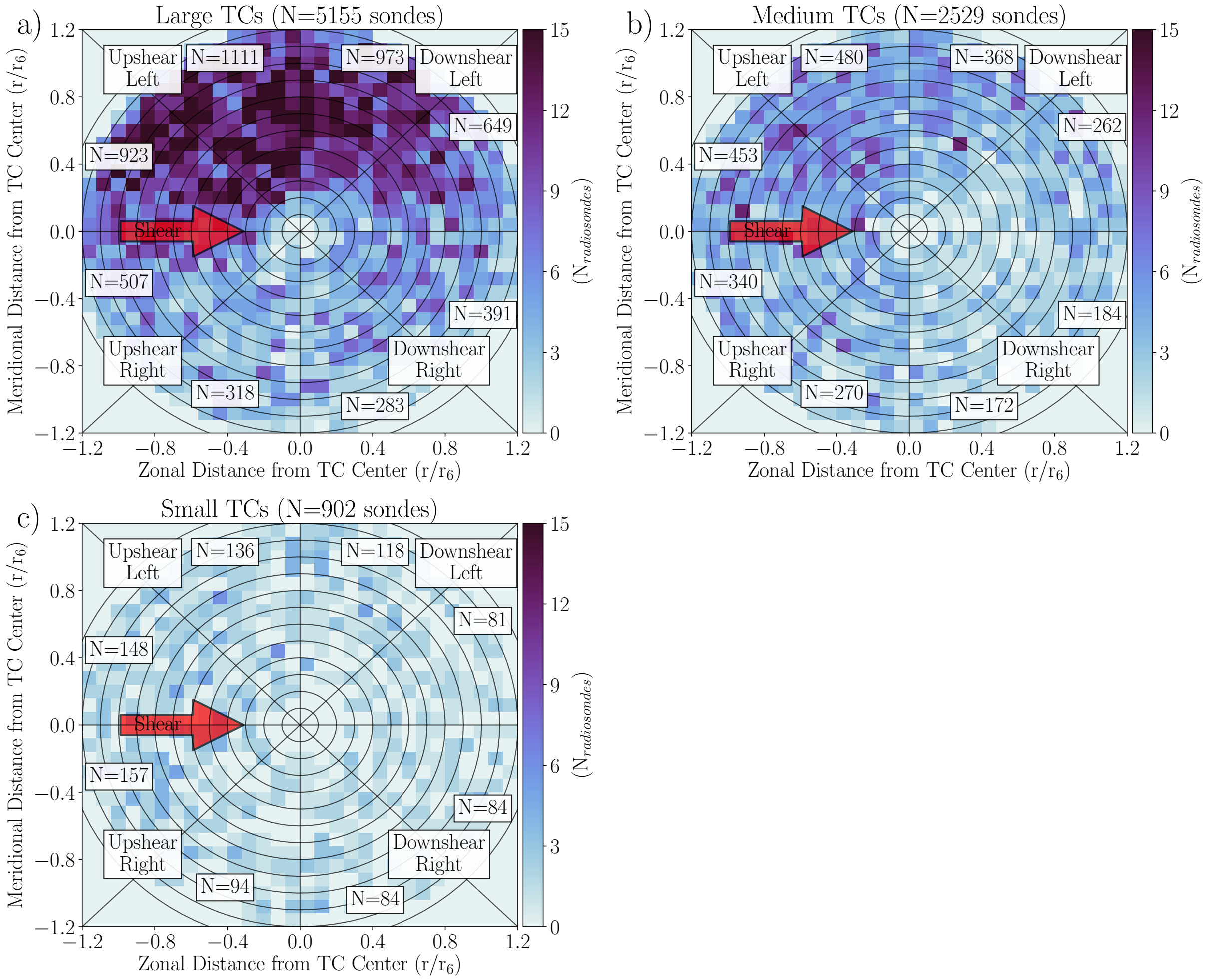

Figure S1. Plan view of radiosonde location ($N_{radiosondes}$; shaded gridboxes) in a TC-relative radial coordinate normalized by r_6 and VWS-relative azimuthal coordinate for (a) large, (b) medium, and (c) small TCs. Radiosonde locations have been rotated around the plot such that the VWS vector is pointing to the right in each figure. Range rings are shown every $0.1r/r_6$.

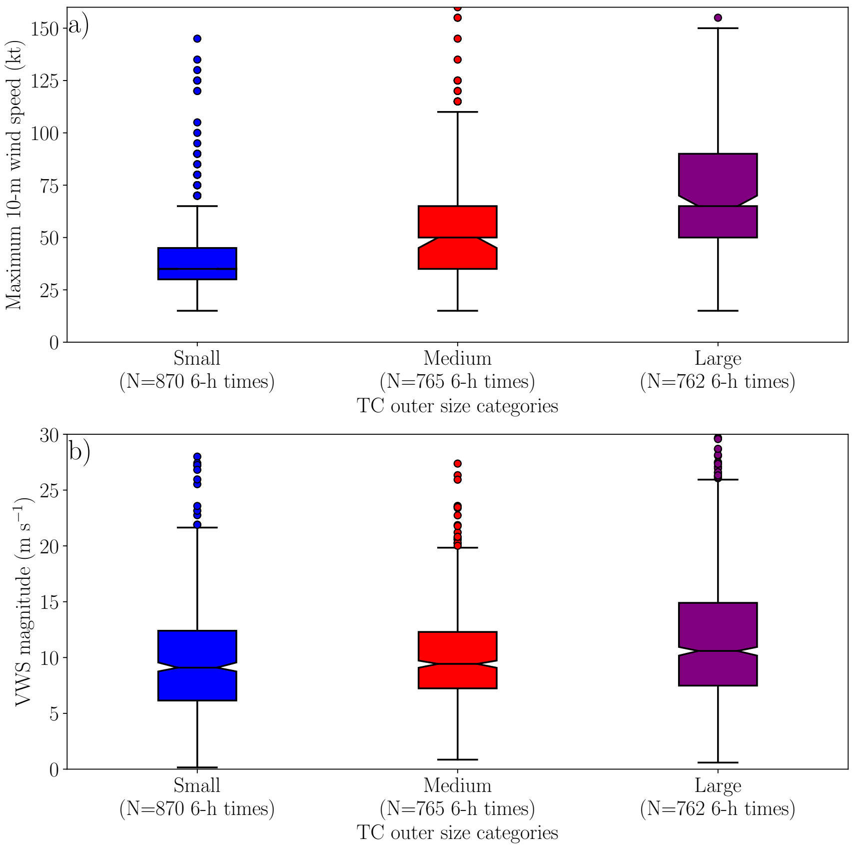

Figure S2. Box-and-whiskers plots showing (a) TC intensity (kt) and (b) VWS magnitude (m s^{-1}) for the three TC outer size bins. The box plot displays the median (black horizontal line near box center), the 95% confidence interval of the median calculated from a 1,000-sample bootstrap approach with replacement (notches on boxes), the interquartile range (box perimeter; [q_1, q_3]), whiskers (black capped lines; [first datum above [q_1-1.5(q_3-q_1)], first datum below [q_3+1.5(q_3-q_1)], and outliers (filled circles)

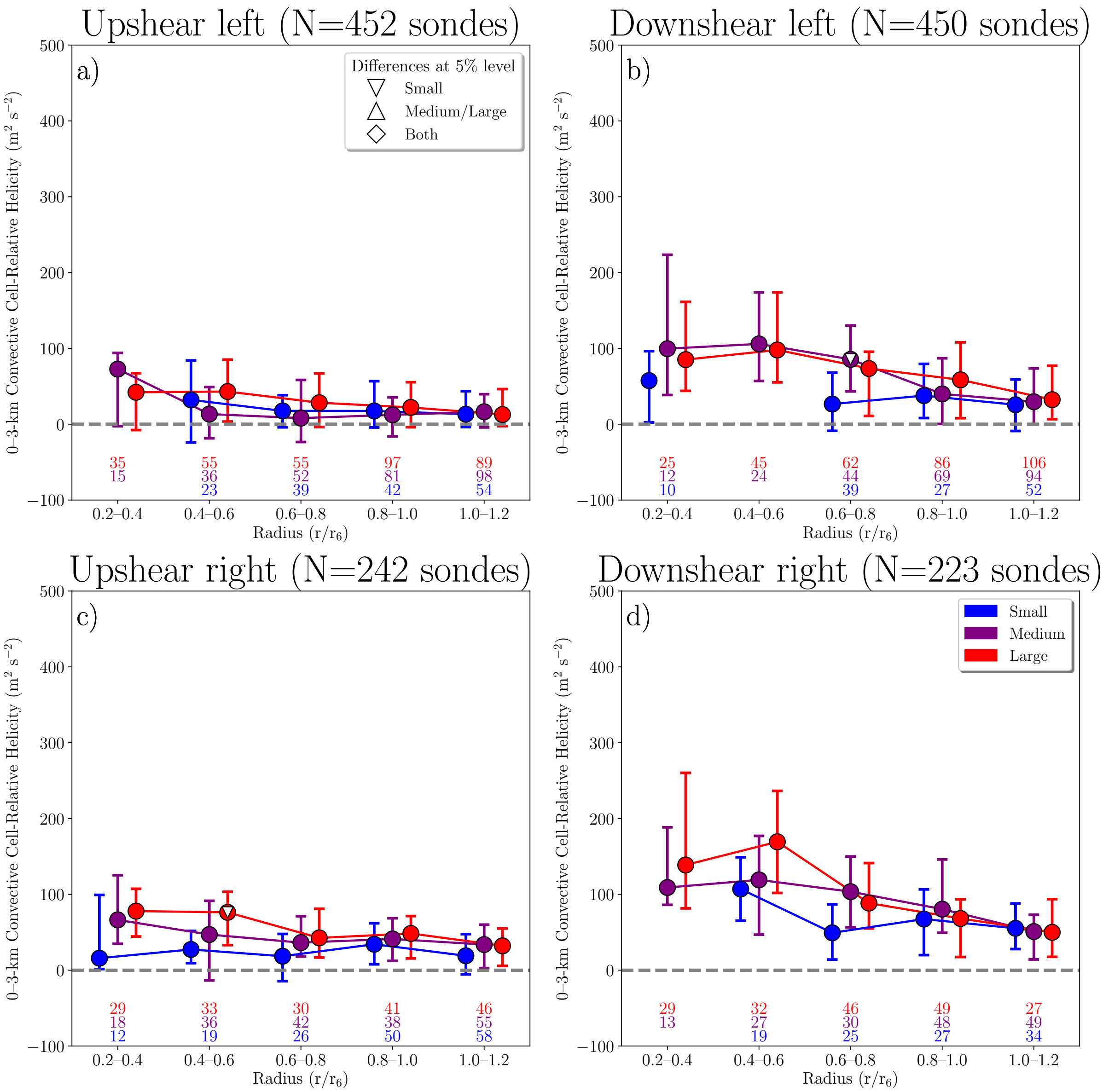

Figure S3. As in Fig. 4 from the manuscript, but for a subset of small, medium, and large TCs with weak intensity (i.e., lowest 33rd percentile of TC intensity). Bins with less than 10 radiosondes are not shown.

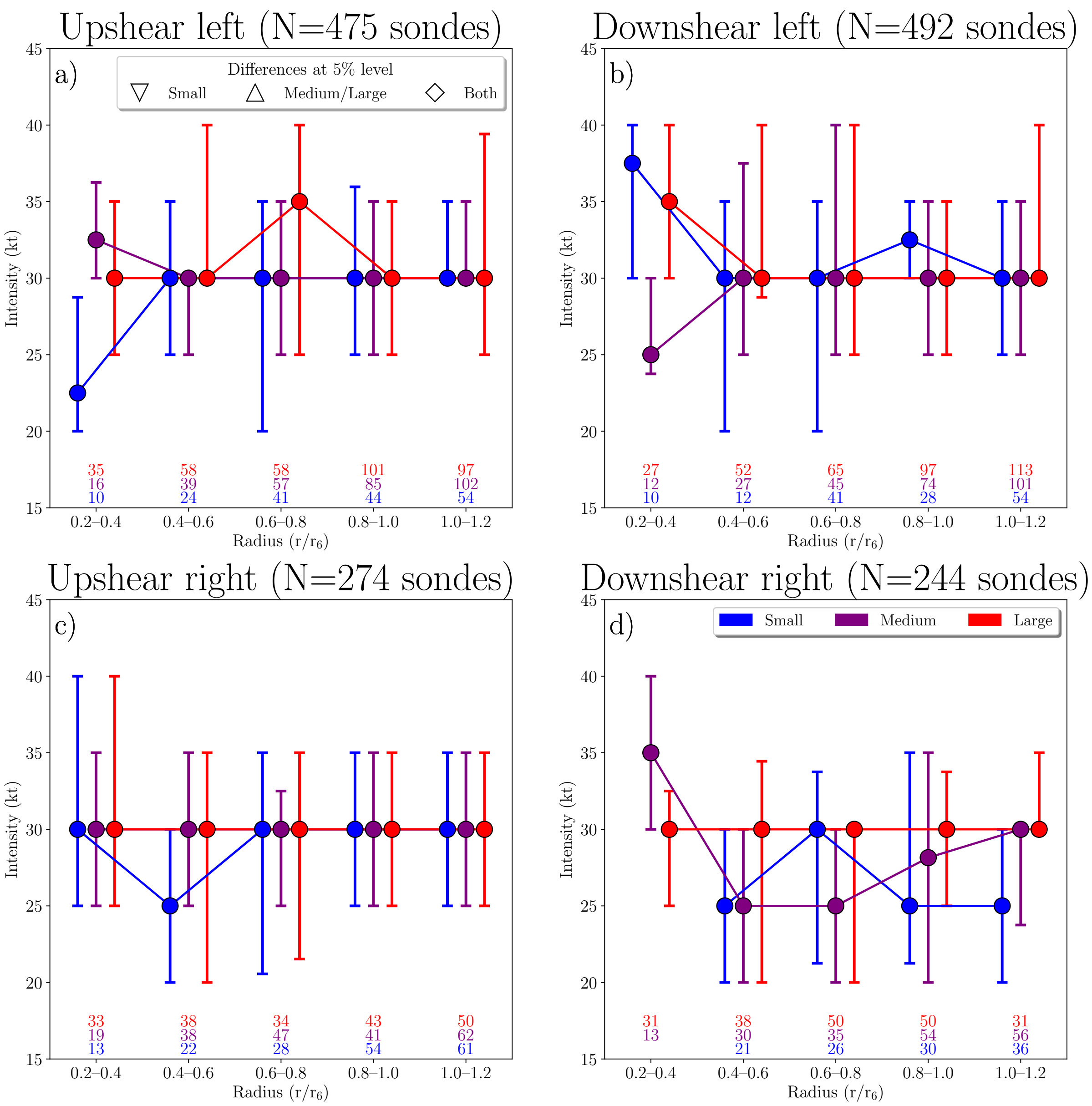

Figure S4. As in Fig. 4 from the manuscript, but for TC intensity (kt) for a subset of small, medium, and large TCs with weak intensity (i.e., lowest 33rd percentile of TC intensity).

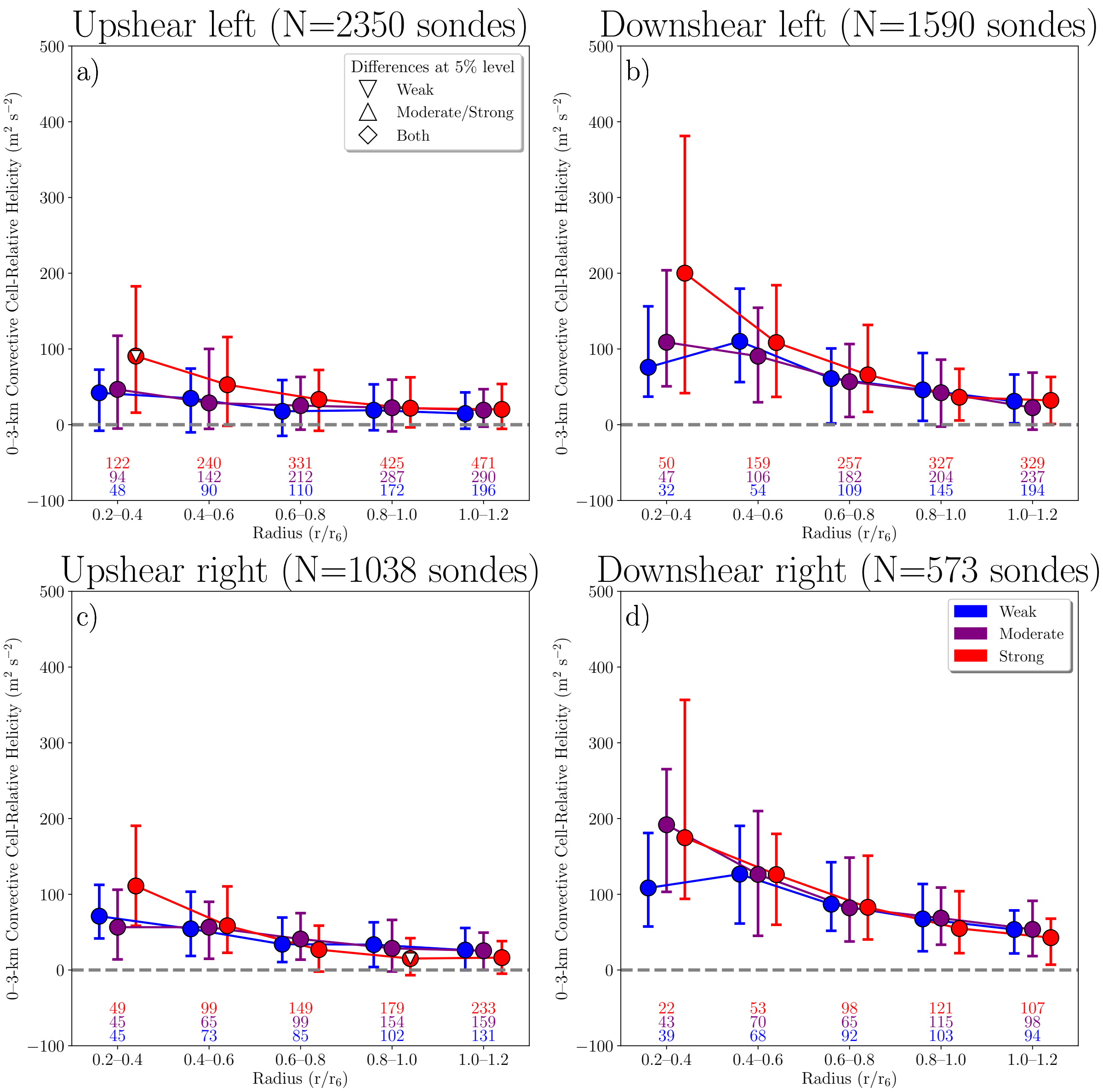

Figure S5. As in Fig. 4 from the manuscript, but for TCs with weak, moderate, and strong TC intensity defined as the terciles of the TC intensity distribution (kt) .

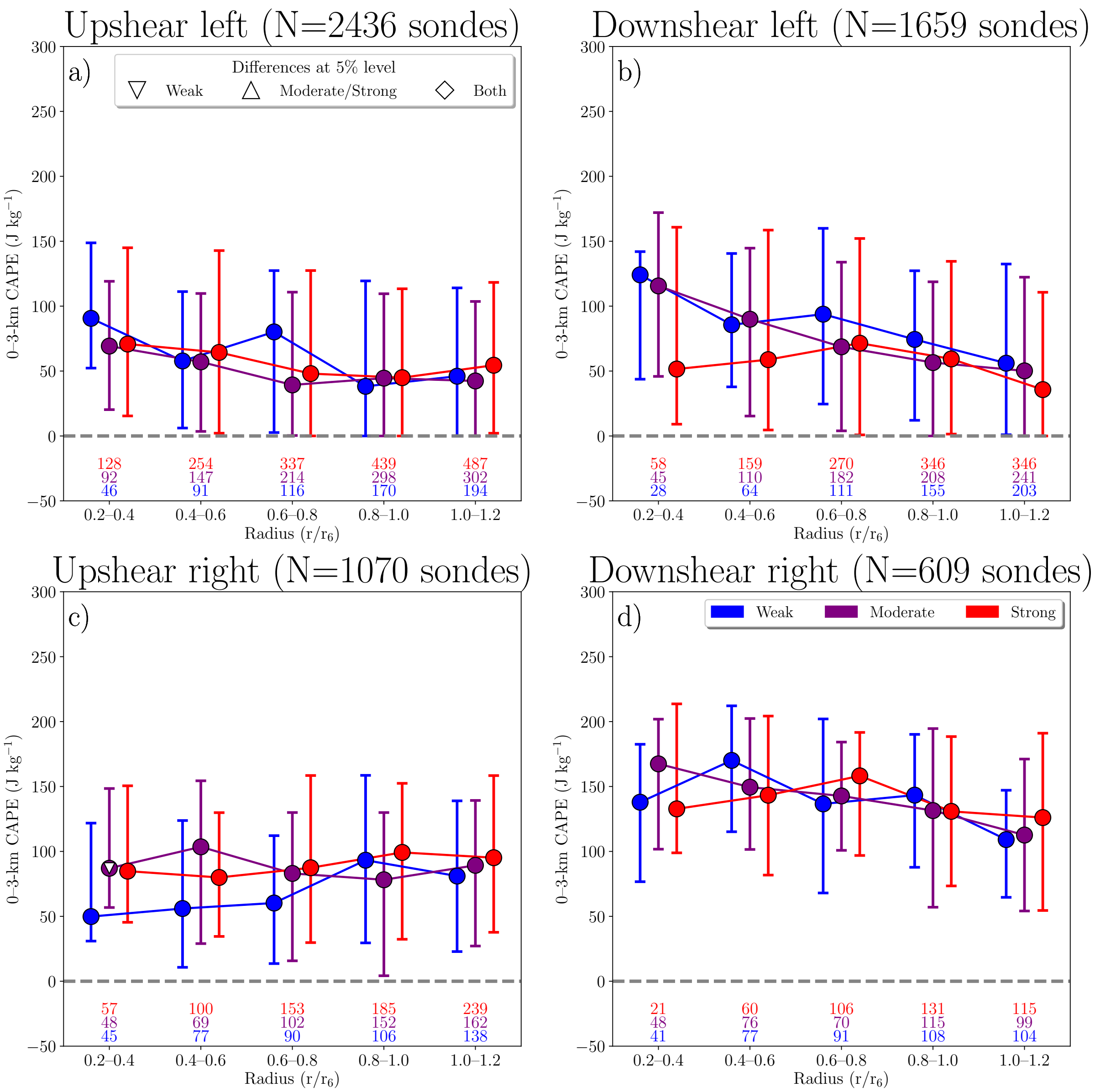

Figure S6. As in Fig. 5 from the manuscript, but for TCs with weak, moderate, and strong TC intensity defined as the terciles of the TC intensity distribution (kt).

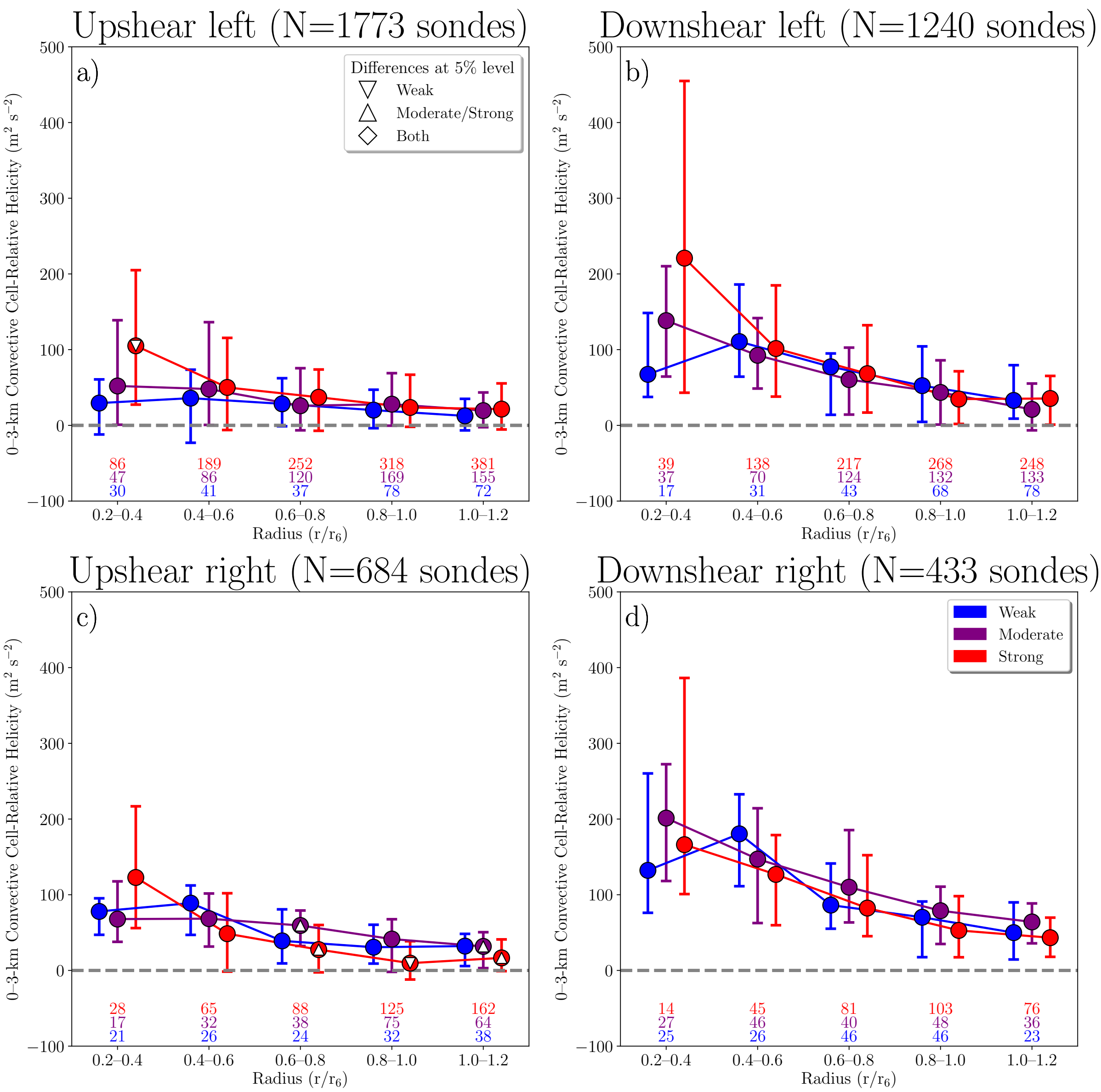

Figure S7. As in Fig. 4 from the manuscript, but for large TCs (i.e., upper 33rd percentile of r_6) with weak, moderate, and strong TC intensity defined as the terciles of the TC intensity distribution (kt).

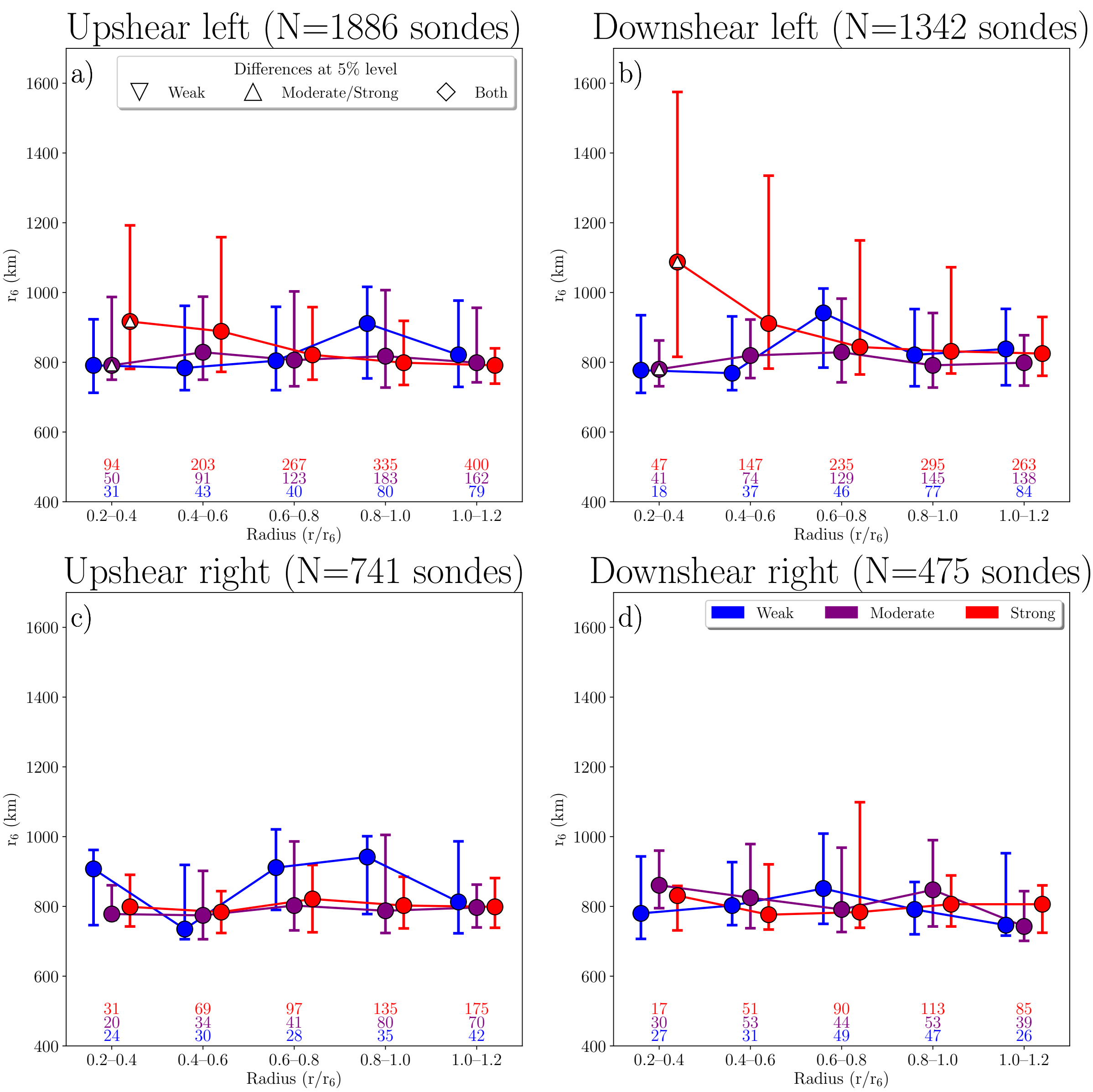

Figure S8. As in Fig. 4 from the manuscript, but for r_6 (km) for large TCs (i.e., upper 33rd percentile of r_6) with weak, moderate, and strong TC intensity defined as the terciles of the TC intensity distribution (kt).