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THE RELATIONSHIP BETWEEN STORM MOTION, VERTICAL WIND SHEAR AND CONVECTIVE ASYMMETRIES IN TROPICAL CYCLONES

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1. INTRODUCTION

Corbosiero and Molinari (2002a) found a strong correlation between the azimuthal distribution of electrified convection and the direction of vertical wind shear. For magnitudes of shear greater than 5 m s^{-1}, over 80% of the flashes occurred downshear of the center. A preference for downshear left was found for flashes in the eyewall and inner bands (within 100 km of the center), while a strong preference for the downshear right quadrant was found for flashes in the outer rainbands (100-300 km from the center).

In the current study, the effects of storm motion on convective asymmetries, as measured by lightning frequency and distribution, will be evaluated. All named storms between 1985 and 1999 in the Atlantic basin that moved within range of the National Lightning Detection Network (NLDN) will be studied as long as they remained classified as tropical systems by the National Hurricane Center (NHC).

Since both vertical wind shear and storm motion are continuously and simultaneously interacting with the tropical cyclone to create asymmetries, it follows to ask which of the effects plays a greater role in determining the overall distribution of lightning. It is possible that either signal may simply be an artifact of the other if the shear and motion have a systematic relationship.

2. DATA AND METHODOLOGY

Lightning data were obtained from archived observations of the NLDN, currently operated and maintained by Global Atmospherics, Inc. A full description of the operation and equipment of the NLDN can be found in Cummins et al. (1998).

Because the ECMWF analyses used to calculate the vertical wind shear are available only twice daily, all lighting was grouped into two 12 hour periods per day centered on the analyses times. To insure robust results, a lower limit flash criterion was formulated to restrict the number of 12 hour periods that were examined. A count of 50 flashes per time period was chosen for the flashes in the inner 100 km area and 400 flashes per time period for the 100-300 km ring.

The flashes in the surviving time periods were then rotated around the storm centers through an angle equal to that necessary to align the shear or motion vector for that period with due north. The quadrant or octant with the highest number of flashes was then determined.

For a more detailed explanation of the data and methodology used in this study, please see Corbosiero and Molinari (2002a).

3. RESULTS

Figure 1 shows the number of times the flash count was highest in both the inner core and outer band regions for the a) shear-rotated time periods with vertical wind shear > 5 m s^{-1} and b) the motion-rotated time periods with storm motion > 3 m s^{-1}. The greatest lightning activity in the core is downshear and downshear left of the center, while the outer band activity is concentrated downshear right of the center. The preferred regions for lightning with respect to shear are marked above the octant plots with a solid line.

With respect to storm motion, Figure 1 b) shows a preference for inner core flashes in front and to the right of storm motion. The outer band flashes are most often observed clockwise of the inner maximum, extending from the right front to right rear quadrant. These results closely resemble those from observational studies that have examined the distribution of precipitation derived quantities with respect to storm motion as detailed in Corbosiero and Molinari (2002b). The expected regions of lightning with respect to motion are marked with a dotted line above the octants in Figure 1 b).

Figure 2 shows all flashes that occurred in the outerband region of the time periods where the shear and motion vectors are between 135 and 225^{o} apart. With this angle separation, the expected shear and motion-related lightning maxima are on opposite sides of the storms as indicated by the solid and dotted lines, respectively. Over 77% of the flashes are found downshear of the center, with 53% downshear right. Contrary to the expected motion signature, only 11% of flashes are found in the right front quadrant, and the left side of the storms had significantly more flashes than the right side (65% vs. 35%).

More examples of how the shear signature is seen to dominate the observed asymmetries and how the shear

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and motion vectors relate to each other will be presented in the talk.

4. ACKNOWLEDGEMENTS

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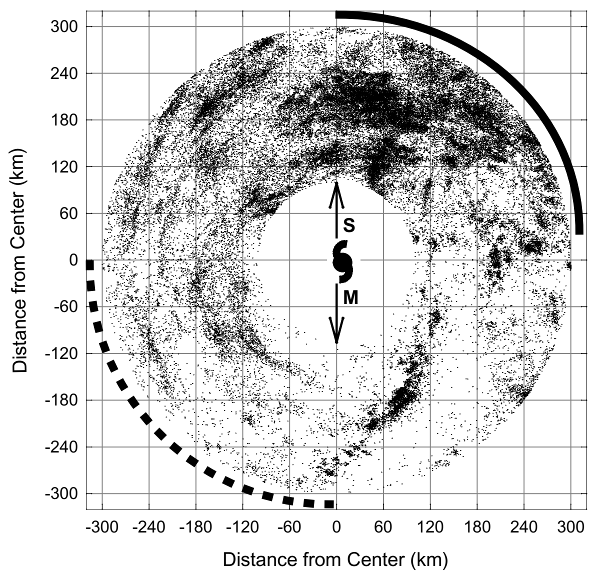

Figure 2. All flashes in the outer band region of the 33 time periods with an angle of separation between the shear and motion vectors of 135-225°. The flashes have been rotated such that the shear vector in each period points due north; thus the average motion vector is approximately 180° from the shear vector.

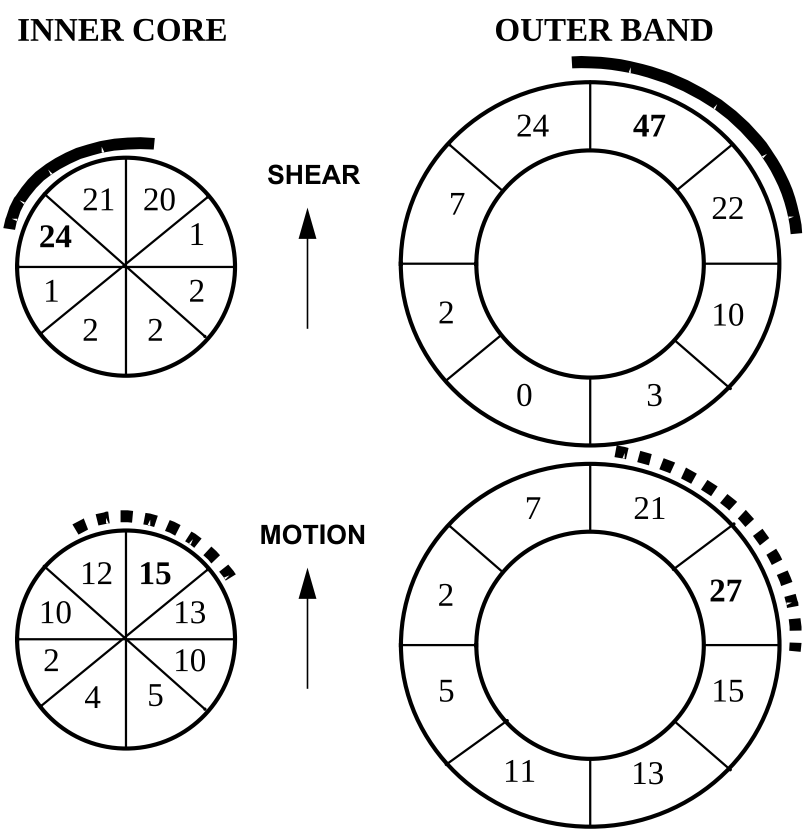

Figure 1. The number of times the flash count was highest in the core and outer band regions of a) the time periods with vertical wind shear > 5 m s^{-1} and b) the time periods with storm motion > 3 m s^{-1}. The heavy solid lines in a) represent the favored quadrants for lightning with respect to vertical shear and the heavy dashed lines in b) the preferred quadrants with respect to storm motion.