13A.2 CONVECTIVE ASYMMETRIES IN TROPICAL CYCLONES

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1. INTRODUCTION

The advent and subsequent upgrades of the National Lightning Detection Network (NLDN) have allowed for study of the organization of convection in tropical cyclones as revealed by flash location. Samsury and Orville (1994) noted in their study of Hurricanes Hugo and Jerry (1989) that the majority of flashes occurred to the right of the track. A similar pattern was found by Molinari et al. (1999) who plotted all flashes occurring within 300 km of the centers of nine Atlantic tropical cyclones during hurricane stage only. The majority of flashes occurred to the south and southeast of the centers with a minimum in flash count to the northwest. Considering the typical north or northwest motion of tropical cyclones as they approach the United States coastline, the flash counts were therefore highest in the rear and right rear quadrant of the storms.

It was suggested by Molinari et al. (1999) that the azimuthal distribution of lightning was likely to vary with the direction of vertical wind shear, the direction of storm motion, the presence of upper tropospheric phenomena and the distribution of land and water over which the storm is passing. In the current study, 23 Atlantic basin tropical cyclones between 1985 and 1997 were examined to explore the relationship between the directions and magnitudes of vertical shear and storm motion and the azimuthal pattern of lightning in both the core (inner 100 km) and rainbands (100-300 km ring) of tropical cyclones.

2. DATA AND METHODOLOGY

Lightning data were obtained from archived observations of the NLDN, originally developed at the University at Albany, and currently operated and maintained by Global Atmospherics, Inc. The raw flash data of the NLDN contains the date, time, latitude, longitude, polarity, multiplicity and signal strength of the first stroke and is processed using programs provided by GAI. Full descriptions of the operation and equipment of the NLDN can be found in Orville et al. (1987) and Cummins et al. (1992, 1998).

Vertical wind shear calculations were made using gridded analyses from the European Centre for Medium Range Weather Forecasts (ECMWF).The grids are uninitialized, contain 12 vertical pressure levels and1.125 ° latitude-longitude horizontal resolution. The grids are interpolated bilinearly in the horizontal to yield cylindrical grids as in Molinari and Vollaro (1989) with dr=100 km and dλ=5°. Following Molinari (1993), the mean Cartesian wind components are calculated as an area weighted average on the cylindrical grid. This calculation removes the axisymmetric vortex component of the wind so that the resulting winds measure the basic current across the storm at each level. The average vertical wind shear is then calculated in the 850-200 mb layer over a 500 km radius.

The National Hurricane Center "best track" dataset was used to determine time intervals when the storm centers were within 400 km of at least one NLDN sensor, the nominal limit of the network (Molinari et al., 1994), and to calculate a storm motion vector every six hours.

For each hour of study in all storms, flashes were totaled and plotted with respect to the interpolated hourly center position. Because the ECMWF analyses are available only twice daily, the hourly periods were grouped together into two 12 hour periods a 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. Rotations were done separately for each time period that met the flash criteria for the inner and/or outer regions with respect to both shear and motion vectors.

To be able to easily compare the azimuthal distribution of flashes between time periods, an average flash position for each case was calculated. Using a great circle transform, the position of each flash around the center was converted into Cartesian coordinates. The flashes in each period were then plotted in x-y coordinates with respect to the storm center (0,0 point) and an average flash position was calculated by adding up the x and y coordinates separately and dividing by the number of flashes. These positions were then stratified by the magnitude of shear and motion and plotted in the correct rotated quadrant.

3. RESULTS

Figures 1 and 2 show the number of average flash positions in each shear rotated quadrant for the inner 100 km and 100-300 km ring regions respectively. Over 80% of the average flash positions occur in the downshear quadrants of the storms, with core flashes having a downshear left preference and rainband flashes exhibiting a downshear right preference. In both regions, as the speed of the deep layer shear increases, a larger proportion of flashes appear downshear, illustrating the large degree to which vertical wind shear plays in organizing the convection in tropical cyclones.

With respect to storm motion, a consistent signal of more flashes to the right than to the left of motion is seen (not shown). Core flashes tend to occur in the right front quadrant of the storms, while in the outer bands, lightning is most frequent in the right rear. As the speed of the storms increases, the preference for flashes to occur to the right of motion increases

These results will be compared to observational and numerical studies in the literature in the presentation.

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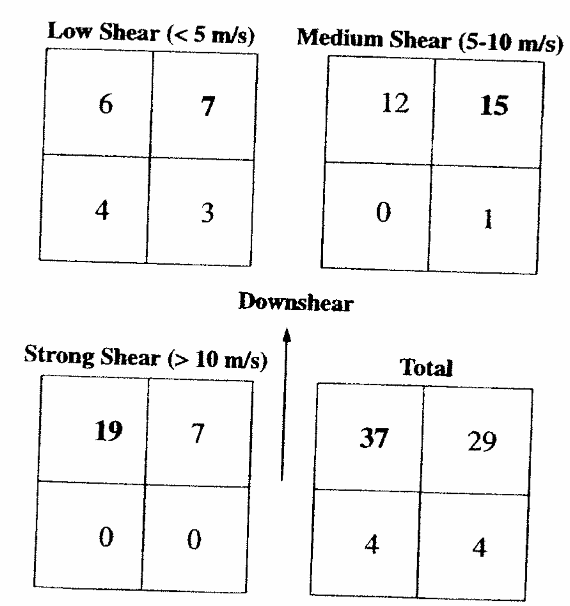

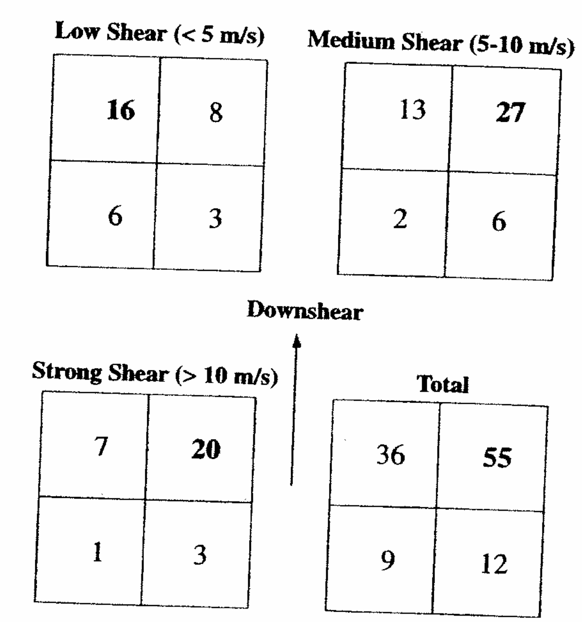

Figures 1 and 2. Box plots showing the number of average flash positions in each shear rotated quadrant for weak, medium and strong shear cases meeting the inner 100 km and 100-300 km ring flash criterion respectively.