3A.2 INTERANNUAL VARIATIONS IN TROPICAL CYCLONE TRACKS

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1. INTRODUCTION

Regardless of the criteria used in defining North Atlantic hurricane activity, the last 6 years of the 20th century are among the most prolific in the modern record (Wilson 1999, Elsner et al. 2000a). Goldenberg et al. (2001) note a 2.5-fold increase in strong hurricanes (maximum sustained near-surface winds exceeding 50 m s^{-1}) and a 5-fold increase in Caribbean hurricanes. This upswing in hurricane activity is related to warmer ocean waters and less vertical wind shear in areas that typically spawn hurricanes. When these conditions coincide hurricane activity increases. Here we suggest that results from hurricane track research (Harr and Elsberry 1991; Lander 1996; Elsner et al. 2000b; Elsner and Liu 2001) can also inform us about hurricane climate variability.[1]

2. DATA AND ANALYSIS

We use hurricane locations based on the "best-track" (HURDAT) data set maintained by the National Hurricane Center. The data set is considered reliable for these types of studies beginning with 1944 (Neumann 1999). This is the year in which aircraft reconnaissance information about the storms is available. Since our interest is tropical cyclones of hurricane intensity, this bias will not seriously influence the results. The analysis begins with a broad grouping of hurricane tracks. Grouping is based on a k-means cluster analysis using latitude and longitude coordinates at maximum and final hurricane intensities. Here we use 3 clusters, but results are not significantly altered if 2 or 4 clusters are used.

As the main development region is the central tropical Atlantic, hurricanes which threaten North America north of about 35°N latitude, or that remain offshore are termed 'recurving' (R) hurricanes, whereas hurricanes that threaten the Caribbean and North America south of this latitude are termed 'straight-moving' (SM). As anticipated, SM hurricanes have a greater mean maximum intensity (50.6 m s^{-1}) compared to R hurricanes (47.7 m s^{-1}). The one-side p-value is 0.092. The p-value is based on a Wilcoxon rank-sum test under the null hypothesis of no difference in mean rates. Thus, despite their shorter average lifespan (owing to landfall), SM hurricanes tend to reach a greater maximum intensity.

The influence of the El Niño/Southern Oscillation (ENSO) and the North Atlantic oscillation (NAO) on the annual occurrence of SM hurricanes is modelled with a Poisson regression. ENSO, indicated by a standardized August-October averaged SST over the central equatorial Pacific (Smith et al. 1996), is a significant predictor of the number of SM hurricanes. The p-value on the NAO model coefficient is 0.04 providing evidence that NAO is important in explaining annual variations in SM hurricane activity after accounting for ENSO. Residual analysis reveals nothing to suggest a poor model.

To extend this analysis over additional earlier years, hurricane landfalls are used as a proxy for SM hurricanes. SM hurricanes hit the U.S. coast between Texas and South Carolina. The correlation between annual counts of SM hurricanes and hurricane landfalls along this stretch of coastline is 0.55 over the period reliable 1944–2000. A Poisson regression model is again employed, but annual landfall counts are used instead of annual SM hurricane counts. The model is based on data over the period 1900–2000. As before May-June averaged NAO values explain a significant portion (p-value = 0.02) of U.S. landfalls (TX-SC) after accounting for trends and ENSO. Fig. 1 illustrates this NAO-U.S. hurricane relationship. Values of the May-June av-

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eraged NAO index during the 20 weakest years range between −0.12 and −0.27 standard deviations, while values during the 20 strongest years range between +0.06 to +0.29 standard deviations. Correlation between the NAO and ENSO over the 101-yr period is a mere 0.056. Thus the NAO is an additional independent factor in explaining annual variations in hurricane landfalls.

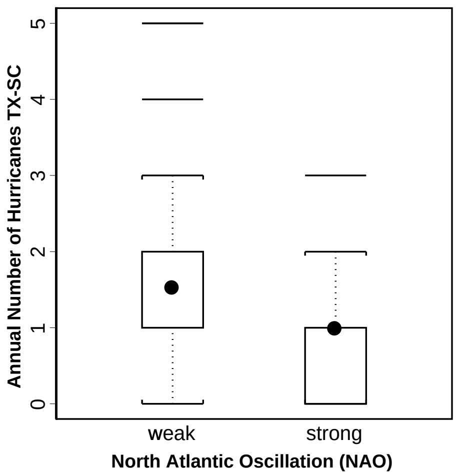

Figure 1. Distribution of annual U.S. hurricane counts from Texas to South Carolina stratified by extremes of the NAO (20 years of strongest, and 20 years of weakest May-June averaged values). A hurricane making landfall more than once is counted only once. The circle is located at the median value.

4. CONCLUSIONS

Results lead us to suggest that unravelling the causes of changes in hurricane activity requires not only understanding the factors that influence their origin and development, but also understanding the factors that influence where they will track. In this regard, the NAO is a potential candidate as a weaker NAO during boreal spring is likely associated with a subtropical high pressure cell displaced farther south and west of its mean position (near the Azores) during the following hurricane season (Elsner et al. 2000b; Elsner et al. 2001). Tropical cyclones forming and remaining equator-ward of the subtropical high tend to intensify at low latitudes, crossing through the Caribbean en route to North America.

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