LIGHTNING ACTIVITY IN HURRICANES

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I. INTRODUCTION

Hurricanes are the most deadly storms on the Earth, with evidence that the strength and number of intense hurricanes (category 4 and 5 of the Saffir-Simpson scale) may have increased in recent decades (Emanuel, 2005; Webster et al., 2005). While the prediction of the trajectory of these storms is now quite accurate (Shen et al., 2006), the forecast of the future storm intensity is more difficult to predict. One way of looking within storms from great distances is to monitor the electrical activity within hurricanes. It has been known for many years that lightning activity is closely related to the microphysics and dynamics of convective storms. In this study we investigate the relationship between lightning activity in hurricanes, and the storm intensity.

II. DATA

To check the connection between hurricane intensification and electrical activity, we have collected pressure and wind data from all 58 category 4 and 5 (Saffir-Simpson scale) hurricanes around the globe over a three year period (2005-2007). The hurricane data giving the location, time, maximum sustained wind speeds, and minimum central pressure were obtained from the 6-hour "best track" estimations provided by the National Hurricane Center (NHC) (http://www.aoml.noaa.gov/hrd/hurdat/), and the Joint Typhoon Warning Center (JWTC) (http://metocph.nmci.navy.mil/jtwc/best_tracks/index.html).

Lightning activity around the globe can be continuously monitored from great distances using low frequency (LF) or very low frequency (VLF) electromagnetic networks on the ground. Recently efforts have been made to develop global networks, such as the World Wide Lightning Location Network (WWLLN) (Lay et al., 2007).

III. RESULTS AND CONCLUSIONS

An example of our analysis for each of the hurricanes is shown in Figure 1 for Hurricane Dennis in 2005. Figure 1a shows the trajectory of the center (eye) of the hurricane from 5-14 July 2005, with the location of the hurricane eye at 12 UTC shown by the open circles. The central pressure and the maximum sustained winds are shown in Figure 1b. As expected, there is a strong negative correlation between minimum pressure within the hurricane and the

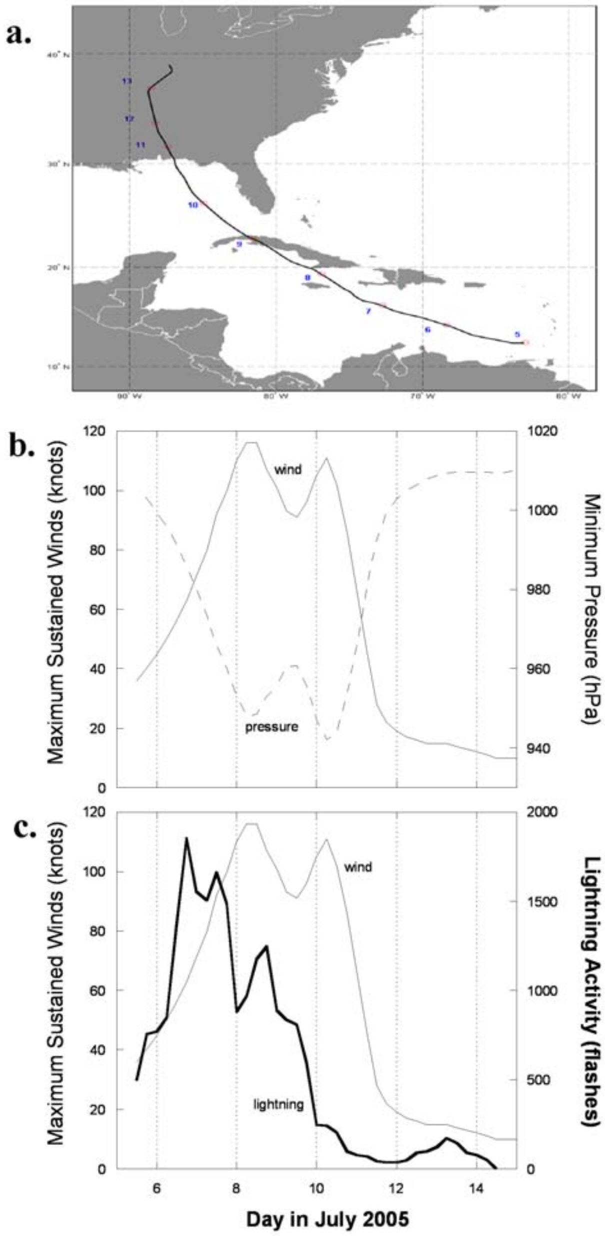

***Figure 1. Hurricane Dennis 5-14 July 2005**. a) The path of Hurricane Dennis, showing the location at 1200UT every day; b) The minimum pressure (dashed curve) together with the maximum sustained winds (solid curve); c) The maximum sustained winds (solid thin curve) and the observed lightning frequencies within a 10x10 degree gridbox centered on the eye of the storm (solid bold curve).*

maximum wind speeds (Figure 1b). The horizontal winds are a result of the intense pressure gradients between the eye of the storm and the surrounding regions. The bold curve in Figure 1c represents the lightning activity detected by the WWLLN within a 10 degree box centered on the eye of the storm, while the thin curve showing the maximum sustained winds is the same as that in Figure 1b. From Figure 1c it can be clearly seen that the lightning activity follows the same pattern as the maximum winds speeds (or minimum pressures), with an approximate one day lag between the peak lightning activity and the peak intensity of the hurricane.

Hurricane Dennis had two periods of peak winds, both of which were preceded by maxima in lightning activity one day before the peak in the maximum sustained winds. The linear correlation between the lightning activity curve and the maximum sustained winds curve, taking into account the one day lag, is 0.95, implying that lightning activity can explain 90% of the day-to-day variability of the maximum sustained winds in this hurricane. The correlation with the pressure curve (Figure 1b) is -0.94.

The same analysis was carried out for all 58 category 4 and 5 hurricanes that occurred during the years 2005-2007. Of these storms, 56 showed statistically significant positive correlations between lightning activity and maximum sustained winds. More than 70% of the hurricanes analyzed have the lightning activity peaking *before* the peak wind intensities, with the most common lag being 30 hours (both the mean and median).

What could be the physical mechanism relating lightning activity to hurricane intensity? This is a topic for future research, although it has been suggested that the development of tropical cyclones is sensitive to the distribution and magnitude of moistening of the lower troposphere by convection (Emanuel, 1995). The horizontal maximum sustained winds are very sensitive to changes in vertical convection that influences the rate of moistening of the lower troposphere. In addition, it has been shown that the time to maximum intensification in hurricanes depends on the intensity of the convection (Emanuel, 1995). It has also been demonstrated that convection can generate potential vorticity anomalies that can lead to vortex intensification (Montgomery and Enagonio, 1998). Since lightning is an indicator of this convection, it follows that the lightning activity should precede the hurricane intensification.

This study shows the promise in using lightning data for understanding the processes related to hurricane intensification. If lightning can predict the intensification of hurricanes in advance, this provides a powerful tool for forecasters, especially in regions susceptible to considerable damage, and which lack proper early warning capabilities. Furthermore, since lightning is directly related to thermodynamic processes that result in the release of latent heat in convective clouds, using lightning locations and intensities for data assimilation in atmospheric models may dramatically improve future hurricane intensity forecasts.

The results of this research are published in the Price et al. (2009) paper in Nature Geoscience.

IV. AKNOWLEDGMENTS

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