P2.2 BEHAVIOR OF LIGHTNING AND UPDRAFTS FOR SEVERE AND NON-SEVERE STORMS IN NORTHERN ALABAMA

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1. INTRODUCTION

Numerous studies (e.g. Deierling 2006; Kuhlman et al. 2006; Lang and Rutledge 2002; Wiens et al. 2005) have demonstrated that various metrics of updraft intensity are well correlated to lightning production in thunderstorms, particularly severe thunderstorms. Indeed, the relationship between updraft and lightning flash rate is hypothesized to be the physical connection between a lightning "jump" signature (a large increase in total lightning flash rate over a time period of 1-3 minutes) and impending manifestations of severe weather such as tornadic activity.

This study will examine the physical coupling between lightning and thunderstorm updraft characteristics for a collection of storms sampled in north Alabama using a combination of dual-Doppler wind retrievals and lightning mapping array data. The dual-Doppler data are used to construct three-dimensional wind fields for a number of severe and non-severe convective storms and the retrieved vertical velocity fields subsequently compared to collocated total lightning flash rates observed by the NALMA (in three-dimensions). Particular attention is paid to the timing of updraft pulses relative to changes in the flash rate, with the goal of quantitatively assessing the physical relationship between lightning increases, thunderstorm morphology and lifecycle, and the impact on warning decision lead times.

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2. DATA AND METHODOLOGY

Data were collected using the UAH ARMOR dual polarimetric radar (Petersen et al. 2007), the Hytop, AL NEXRAD Doppler radar (KHTX), the North Alabama Lightning Mapping Array (NALMA) for events that occurred in the dual-Doppler lobes of ARMOR and KHTX (Fig. 1).

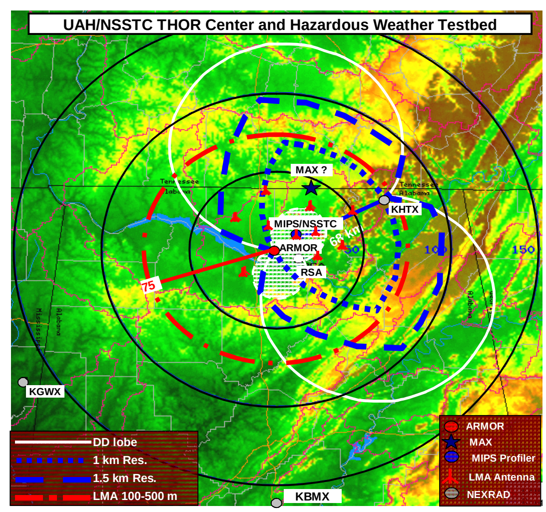

Figure 1. Schematic of dual-Doppler coverage. Storms that occur within the white "lobes" can be used for the dual-Doppler synthesis. (Adapted from Petersen et al. 2005)

2.1 Radar analysis methods

Both the ARMOR and KHTX data sets were converted to sweep format and edited using NCAR SOLOII software. Once the velocity data were unfolded and other edits completed, the data were gridded in

Cartesian coordinates (1km x 1km x 1km, centered on ARMOR) using NCAR's REORDER (Oye et al. 1995) software package. Using NCAR's Custom Editing and Display of Reduced Information in Cartesian Space (CEDRIC, Mohr et al., 1986), the dual-Doppler synthesis is performed with a manual input of storm movement (speed and direction). The dual-Doppler synthesis uses the mass continuity equation to diagnose the vertical velocities.

2.2. Lightning analysis methods

NALMA source data were accessed and run through a flash clustering algorithm developed by McCaul (personal communication, 2007). The algorithm groups sources into a flash by using time and space limiters on the extent of a flash. The user can set a threshold to eliminate single source point flashes or those under a set source value to constitute a flash. For this study, threshold of 10 source points were required for a set of VHF sources to be a flash. According to Wiens et al. (2005) and Deiering (2006) the chosen value of minimum source points per flash should not affect the flash rate trend.

3. PRELIMINARY RESULTS

Preliminary case study results from the analysis (example, Figure 2) of at least one strong Alabama thunderstorm suggest that the temporal correlation between updraft strength and lightning flash rate can be "blurred" via evolution of the precipitation ice core aloft which forms within and along the periphery of the updraft, but drives the strongest charge separation via its relative descent back through ascending smaller ice crystals in the updraft. For this particular case (e.g., Fig. 2), a several minute lag was observed between the most intense and deepest extent of the updraft pulse and the peak in lightning flash production (a manifestation of the "jump signature" and an important physical consideration in considering lightning-trend related nowcast lead times). Several other case types, both severe and non-severe, will be examined to discern degrees of systematic behavior in lightning and updrafts across a spectrum of storm types.

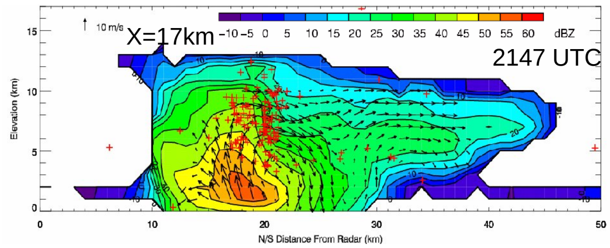

Figure 2. Example north-south cross-section of reflectivity (dBZ; shaded and contoured) with lightning flash locations (+), and 3-D vector winds for a storm observed by the ARMOR-KHTX radars on 3 May 2006. Vectors represent air motion retrieved using dual-Doppler synthesis with reference vector in upper left of image. The x-axis is distance N/S of ARMOR (0,0) and the y-axis is altitude in km. Lightning flashes plotted represent those detected 3 minutes either side of the cross-section time. A time series of images for this storm showed a pulse in the updraft followed by a decrease in updraft coincident with an increase in flash rate. This image contains the first substantial increase of lightning activity following the previous updraft pulse.

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