COMPARISONS BETWEEN TOTAL LIGHTNING DATA, MESOCYCLONE STRENGTH, AND STORM DAMAGE ASSOCIATED WITH THE FLORIDA TORNADO OUTBREAK OF FEBRUARY 23 1998

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1. Introduction

During the late evening and early morning hours of February 22/23 1998, the worst tornado outbreak in recorded history occurred over the peninsula of central Florida (Sharp et. al., 1998, this volume). Analysis of KMLB Doppler radar data indicated at least 9 supercells developed over the region, with 4 of the supercells producing tornadoes. These 4 tornadic supercells produced a total of 7 tornadoes, some of them on the ground for tens of miles (Fig. 1.). A total of 42 fatalities were reported with over 260 injured. Monetary losses totaled over 100 million dollars.

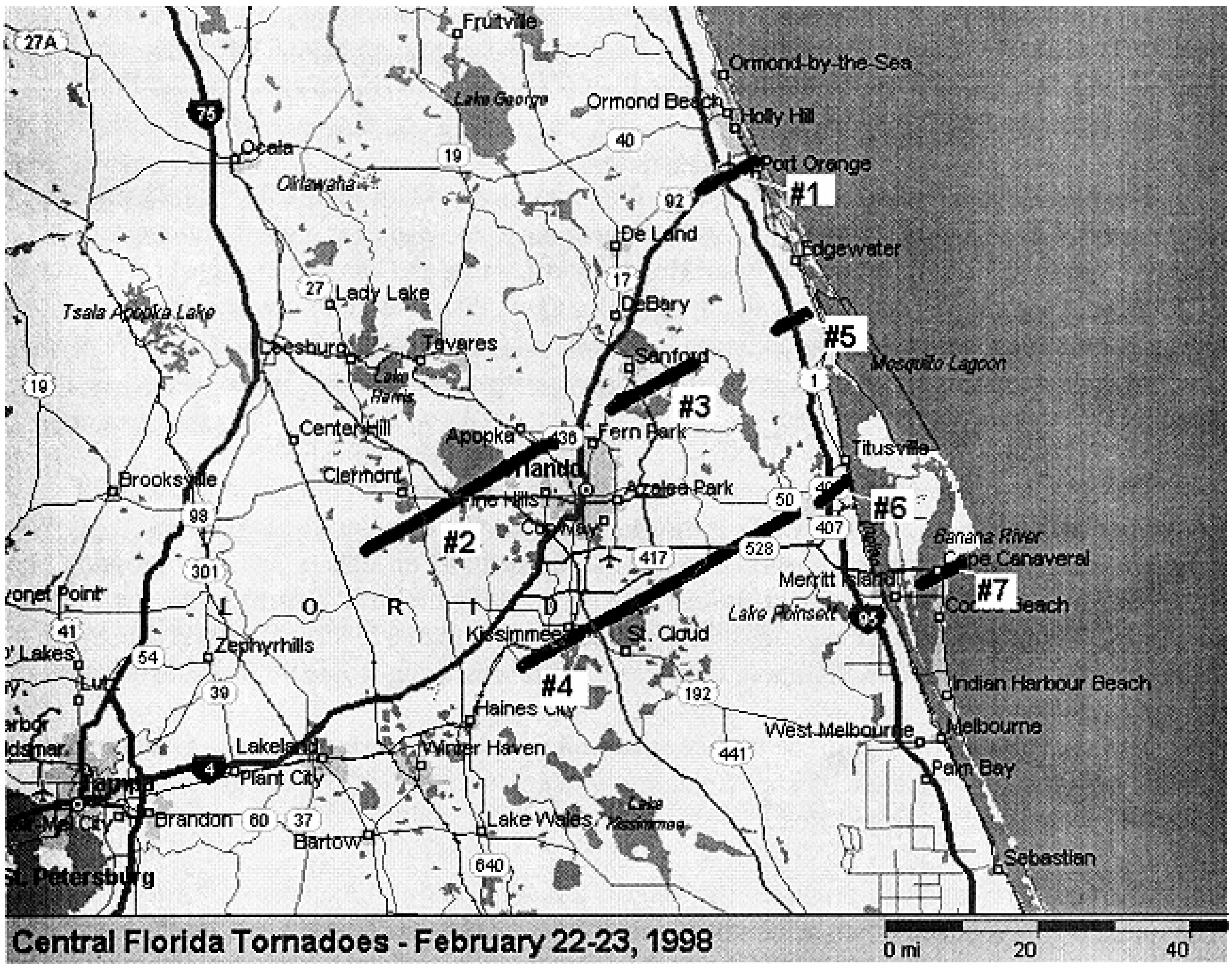

Figure 1. Tracks of the 7 tornadoes which affected east central Florida. Tornadoes #4 and #6 are associated with the third supercell which is analyzed in this study. The KMLB WSR-88D radar is located in Melbourne (lower right). The LDAR unit is located at the Kennedy Space Center.

During this severe weather outbreak, National Weather Service Melbourne, in collaboration with the National Aeronautics and Space Administration and the Massachusetts Institute of Technology, was collecting data from a unique lightning observing system called Lightning Imaging Sensor Data Applications Display (LISDAD). This system has the capability to combine radar reflectivity data collected from the KMLB WSR-88D, cloud to ground data collected from the National Lightning Detection Network, and total lightning data collected from NASA's Lightning Detection And Ranging (LDAR) system. The object of this study is to compare total lightning data collected from the LISDAD system to mesocyclone strength as observed from the KMLB WSR-88D. These data will then be compared to the times of tornadic winds.

2. Data

This study compares the relationship between mesocyclone strength, total lightning data and tornadic winds. We will concentrate on analyzing the velocity data associated with the third tornadic supercell (tornadoes #4 and #6 in figure 1) as: 1.) This storm was in a favorable location relative to both the KMLB WSR-88D radar and the LDAR system, and: 2.) This storm had a long history and produced a long tracking F3 tornado (#4) and a brief F1Tornado (#6). Data for the remaining 3 supercells will be shown at the poster session at this conference (A similar case study of the first tornadic supercell was completed by Williams (1998, this conference).

Storm relative rotational velocity (Vr) data for this tornadic supercell was gathered from two sources. The first source was from the WSR-88D Algorithm Testing and And Display System (WATADS), while the second source was from manual analysis from the WSR 88D Principal User Processor (PUP). Both analysis techniques were found to have advantages and disadvantages over each other. Data gathered from the WATADS system has the advantage over manual analysis as: 1.) The data can be quickly analyzed, and is available throughout the depth of the storm in question. 2.) Specific Vr values for each volume slice are available, while the Vr values which are calculated from the PUP are averaged into predefined range bins due to software limitations of the PUP. 3.) The Vr values are objective as they are calculated from an algorithm. Advantages of manual analysis techniques are: 1.) The storm in question is not dependent on the Storm Cell Identification and Tracking (SCIT) algorithm for identification (If the storm is not identified by the SCIT algorithm, then storm scale analysis of the cell is not possible. 2.) The analysis is subjective: The manual analysis technique can quickly identify any spurious or bad data that the algorithm might consider valid data.

Total lightning data was detected from the Lightning Detection and Ranging (LDAR) system (Lennon and Maier, 1991). Using an algorithm defined by Boldi et. al. (1998, this volume), lightning flashes are constructed from the point source LDAR data and displayed on the LISDAD system.

Similar to the WATADS system, total lightning analysis on the LISDAD system is dependent on the SCIT algorithm. It has been found that if the SCIT algorithm threshold is too low, then multiple "algorithm identified cells" are detected. In this case, multiple cells are identified and a true representation of the lightning data associated with the entire storm in question is not observable. This problem was found to be even more of a nuisance when LISDAD was tracking an isolated cell for an extended period of time, but, during this isolated cells lifetime, a new "cell", which would only exist for a volume scan or two, would be identified very close to the long lived cell. When this occurred, the lightning trends with the long lived cell would suddenly drop off, and then rise again after the nearby short lived cell no longer existed. This type of cell identification problem did occur multiple times during the lifetime of the Kissimmee tornadic supercell. It was found the best way to remedy this "SCIT cell proximity problem" was to simply add the lightning data of the two cells together.

It has also been found that if the SCIT algorithm threshold on LISDAD is too high, then the storm is not identified until after lightning activity was well underway. However, this was not found to be a concern during this event.

3. Analysis Of Total Lightning and Storm Relative Rotational Velocity (Vr)

Figure 2 is a comparison between total lightning flash data (top) and storm relative rotational velocity (Vr, knots, [bottom]), derived from WATADS. Total lightning data in figure 2 is plotted at 1 minute intervals while the Vr data is plotted in 5 minute intervals.

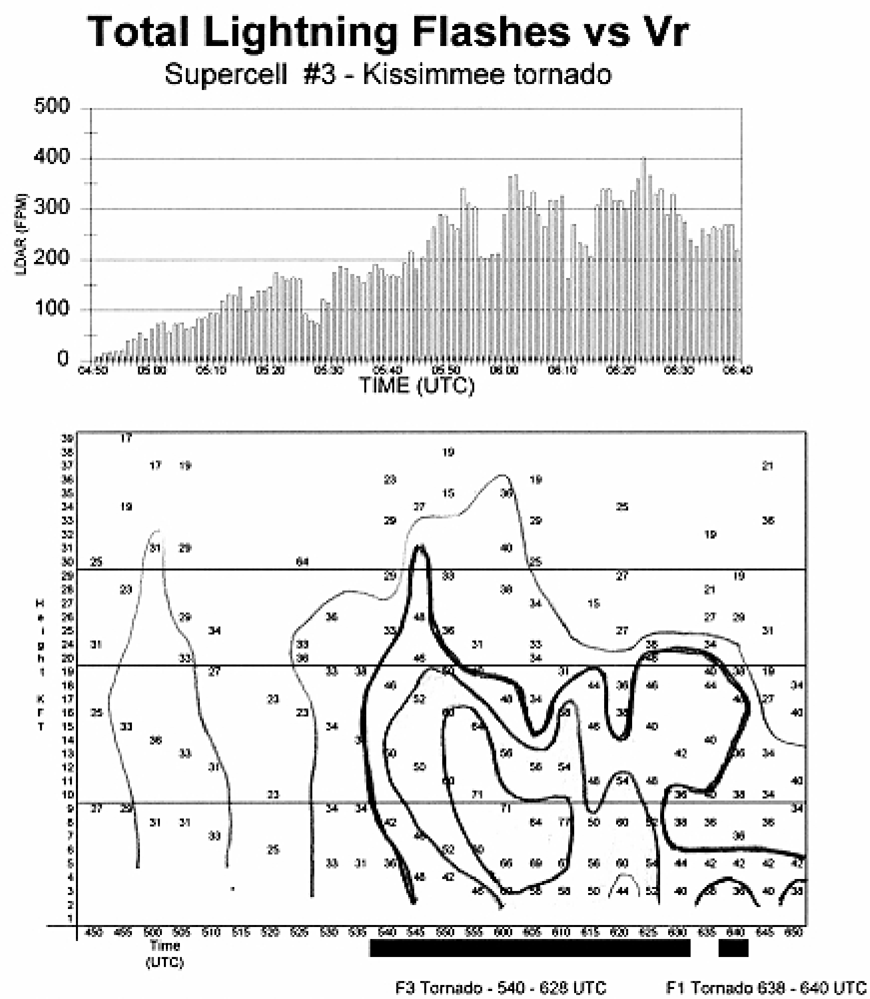

Figure 2. Total lightning flashes per minute (top) and storm relative rotational velocity, Vr, (bottom). Rotational velocities from NSSL WATADS display. Thirty, 40, 50 and 60 knot contours shown. Dark black line represents time of tornadoes. Data at 515 UTC was not available. Units for rotational velocities are knots.

Figure 3 is similar to figure 2, except figure 3 is manual analysis of the Vr data.

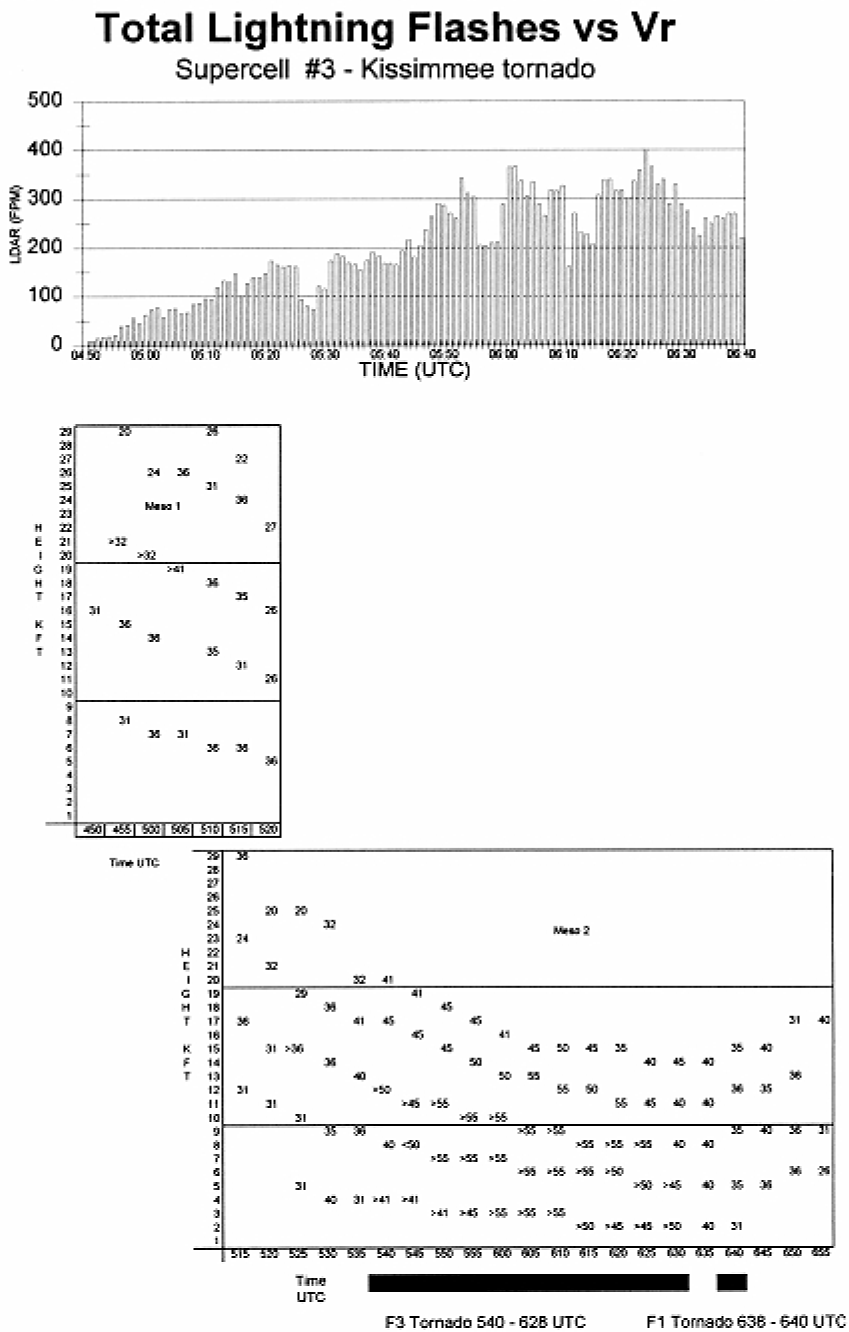

Figure 3. Total lightning flashes per minute (top) and storm relative rotational velocity (Vr) for mesocyclone 1(center) and mesocyclone 2 (bottom). Rotational velocities from WSR-88D PUP (manual analysis). Note: If inbound and/or outbound storm relative velocities were greater than 50 knots, then a ">" symbol is assigned to the value. Units for rotational velocities are knots.

The supercell which would produce the devastating F3 tornado which moved through the Kissimmee area first began to show signs of rotation (manual and algorithm analysis) around 0450 UTC. At this same time, LISDAD began to identify total lightning flash activity associated with this cell. The mesocyclone slowly strengthened and deepened through 0500 UTC while at the same time the total flash activity increased. This mesocyclone remained fairly steady state through 0510 UTC. Between 0510 and 0520 UTC, manual analysis (fig. 3) indicated mesocyclogenesis a few kilometers south of the original mesocyclone. The WATADS SCIT algorithm during this time period (fig. 2) had difficulty identifying the cell, and "lost" the cell between the 0510 and 0520 UTC volume scans.

Interestingly, lightning data decreased shortly after the first mesocyclone dissipated, but began to increase again after the second mesocyclone developed. This increase in lightning activity was rather rapid, as flash rate jumped from ~75 FPM at 0528 UTC to ~190 FPM at 0532 UTC.

Between 0520 UTC and 0540 UTC, both the manual and algorithm analysis of the Vr increased, reaching values in excess of 20 ms-1 (40 knts) throughout the depth of the mesocyclone. It was at the end of this time period that the F3 tornado first touched down southwest of Kissimmee.

During the time of tornadic activity (0540 - 0628 UTC), the mesocyclone became quite strong. Strongest rotational velocities were first observed in the mid levels of the storm at 0540 UTC, with the high rotational velocity values working downwards with time, reaching maximum values of 30 to 35 ms-1 in the lowest elevation scans by 0600 UTC. Lightning data during this time of tornado ranged between 200 and 400 FPM. Pulsing of the lightning data was also noted during this time with fluctuations in the flash rates of 100 FPM per minute occurring at times.

After the first tornado dissipated at 0628 UTC, the rotational velocities weakened to 18-20 ms-1 in the lowest elevation scans. Lightning data also decreased slightly, however values remained relatively high, with flash rates remaining between 240-270 FPM. The second tornado then touched down at 0638 and lasted briefly until 0640 UTC.

4. Discussion and Conclusion

The behavior of the long lived supercell which produced the Kissimmee tornado and a second short lived tornado differed from other studies related to this topic. Goodman et. al., (1998 this conference) and Williams et. al., (1998, this conference), in their analysis of a short lived supercell tornado and waterspout found that the peak flash rate preceded the tornado. The Kissimmee case also differed in the sense that the upper level rotation increased rather than decreased during and after the appearance of the tornado. One common feature in all the cases, however, is the strong building of rotational velocity aloft, presumably by the vertical vortex stretching during the ramp-up of the total flash rate.

5. Acknowledgments

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