14.3 OBSERVATIONS OF TOTAL LIGHTNING ASSOCIATED WITH SEVERE CONVECTION DURING THE WET SEASON IN CENTRAL FLORIDA

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1. Introduction:

This paper will discuss findings of a collaborative lightning research project between the Massachusetts Institute of Technology, the National Weather Service (NWS) office in Melbourne (MLB), Florida and the National Aeronautics and Space Administration. In August 1996, NWS MLB received a workstation which incorporates data from the KMLB WSR-88D, Cloud to Ground (CG) stroke data from the National Lightning Detection Network (NLDN), and 3D volumetric lightning data collected from the Kennedy Space Centers' Lightning Detection And Ranging (LDAR) system. The two primary objectives of this lightning workstation, called Lightning Imaging Sensor Data Applications Display (LISDAD), are to:

a.) Observe how total lightning relates to severe convective storm morphology over central Florida, and,

b.) Compare ground based total lightning data (LDAR) to a satellite based lightning detection system.

This presentation will focus on objective #1.

2. LISDAD Display System

An overview of the LISDAD system related to NWS operations is given here, while a more technical description of the LISDAD system is given by Boldi et. al. (1998, this volume). The LISDAD system continuously monitors and displays lightning and radar data which is collected over most of the Florida peninsula and the adjacent coastal waters. Radar data, including composite reflectivity, echo top information, along with maximum dBz and height of maximum dBz for the thunderstorm cells is ingested into LISDAD from the KMLB WSR-88D radar product generator. Lightning data is gathered from two sources, the Kennedy Space Centers Lightning Detection and Ranging (LDAR) system (Lennon and Maier, 1991), and from the National Lightning Detection Network. LDAR lightning data ("total" lightning information) is ingested via a T1 line between the KSC and NWS/MLB, while the NLDN lightning data (cloud to ground flash information) is integrated into the system via the Integrated Terminal Weather System which is operated at the Orlando International Airport. Lightning data on the LISDAD display is updated in real time every minute, while the radar information is updated every 5 minutes.

The LISDAD system has been modified since 1996 to be a user friendly system for the operational meteorologist at NWS MLB. Forecasters have the option to zoom and re-center on individual thunderstorm cells or to observe convection over most of the Florida peninsula. Forecasters have the option to display all types of data or remove certain products from the display if it becomes to "cluttered". One important feature of the system is that data can be archived for later analysis by NWS MLB forecasters.

In addition to the radar and lightning data, once certain radar criteria are meant, storm cell identification icons are displayed using the NSSL SCIT algorithm. Storm cell identification is used to marry the lightning data to the storm cell. Once a cell is identified, forecasters can click on the cell ID and a history table ("POP-UP" box) of lightning flash amounts and radar trends are displayed. Data displayed include the amounts of CG flashes (per minute) and total lightning flashes (per minute) with the cell. Radar parameters include echo top, maximum dBz value and height of maximum dBz. Once the pop-up box is chosen, data continuously updates automatically as long as the cell is in existence. Three pop-up boxes can be displayed at one time.

3. Data Analysis

This paper will discuss findings of wet season severe convection which occurred over east central Florida during the months of July and August, 1997. Severe storm discernment using LISDAD data during the cool season is discussed in papers by Williams et. al. (1998, this volume), Goodman et. al. (1998, this volume) and Hodanish et. al. (1998, this volume).

July 1997 was a proficient severe weather month over east central Florida. According to Storm Reports (NOAA 1997), 16 of 31 days in the month had severe weather (hail >= 0.75", wind damage or tornado) reported over the region. Of the 16 days, LISDAD was operational 11

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TABLE 1

Storm #	Date	Svr Wx type	Time of SVR WX	Location (county)
1	July 1	Hail	20:45	Martin
2	July 5	Wind	17:21	Okeechobee
3	July 6	Wind/Hail	20:11	Okeechobee
4	July 7	Wind/Hail	23:35	Volusia
5	July 8	Hail	19:48	Osceola
6	July 8	Wind	20:35	Orange
7	July 8	Wind	21:30	Osceola
8	July 9	Wind	19:24	Brevard
9	July 9	Hail	21:43	Brevard
10	July 11	Hail	17:40	Brevard
11	July 11	Tornado	17:58	Osceola
12	July 11	Wind/Hail	19:25	Brevard
13	July 12	Wind/Hail	21:30	Orange
14	July 15	Hail	20:58	Seminole
15	July 25	Wind	23:15	Volusia
16	July 29	Wind/Hail	21:24	Orange
17	July 31	Hail	20:35	Seminole
18	Aug 23	Wind	20:30	Volusia

of the days. A total of 17 severe storms were analyzed, as many of the days had more than one severe weather event. Unlike July, severe weather during August was infrequent, and only 1 severe weather case was documented with LISDAD. Table 1 list the time and location of the 18 severe storm cases documented by the LISDAD system.

In order to observe if any unique total lightning signatures can be identified with the severe thunderstorms listed in Table 1, total lightning data was examined with each severe cell prior to the reports of severe weather.

4. Findings

One of the key findings of this study is that the majority of the severe storms showed a rapid increase in total lightning (or "lightning jump") prior to the onset of severe weather . Of the 18 cases examined in Table 1, only 4 did not indicate significant rise in total lightning. Of these 4 cases, one of the storms was likely out of operational range of the LDAR (total lightning) system (storm 1), while for the other three cases the storms might not have been severe by definition, especially storm 8, in which "minor wind damage" occurred to a mobile home.

In this paper, a lightning jump is defined as: "An increase in *total* lightning over a time period of at least 2 minutes, in which the total flash rate increases at least 50 flashes during the entire lightning jump time period. The end of the jump occurs when 2 consecutive one minute flash rates are less than, or equal to, the prior 1 minute flash rate". Figure 1 shows an example of a "lightning jump".

Analysis of the storms which produced lightning jumps (Table 2) indicate that the average total flash rate prior to the onset of the lightning jump was 56 Flashes Per Minute (FPM), increasing to 189 FPM after the jump was completed. Flash rates typically increased at a rate of 20 flashes per minute over a 6 to 7 minute time period. Interestingly, it was found that cells which lasted over a relative long period of time (~45 minutes), typically had multiple lightning jumps (Fig 2). These long lived cells were usually associated with boundaries, such as the sea breeze front. For this study however, we will only focus on the lightning jump which occurred prior to the first report of severe weather.

Table 2 also indicates the average time between the end of the flash rate increase and the time of reported severe weather was 24.5 minutes. This value however, is believed to be exaggerated. The reason for this is twofold. The first is due to the problems inherent with the verification process, that is; damage report "time" is typically the time of when emergency officials receive the report of severe weather, and not necessarily the time of the actual event (especially for "minor" severe weather events, such as dime size hail or a few trees down). This time inconsistency becomes apparent when reviewing storm cell data on the WSR-88D. Quite a few times the storm had already cleared the region when compared to the "official" report time of severe weather. The second reason is due to population distribution across the peninsula of Florida. Many areas in east central Florida are sparsely populated. A storm might be severe for tens of minutes, but won't be reported as "severe" until the severe weather effects a weather spotter (or a recording weather sensing device such as ASOS).

Total lightning flash rates for the severe cells around the time of severe weather were found to be quite high. Examination of the total lightning flash rates +/- 10 minutes to the report of severe weather indicated values ranged between 120 to 550 flashes *per minute*! The storms which had the higher flash rates were storms which persisted along boundaries or developed when the east coast and west coast sea breeze boundaries collided. One of these cells which interacted with a boundary had total lightning flash rates in excess of 300 FPM for over 1.5 hours (fig. 3)! These boundary interacting storms typically produced numerous severe weather reports.

If total lightning data is ever to be an asset to the warning process, then there must be a signal in the lightning data that will tip off the forecaster that the cell is intensifying, and possibly becoming severe. It is believed that the lightning jump discussed above is the signal that the radar warning meteorologist is looking for. Comparing the end time of the flash rate increase (T2) in Table 2 to the time the warning was issued for the storm (WT), it was found that the lightning jump, on average, had ended 11 minutes prior to the warning being issued. Comparing the time difference between the beginning of the jump (T1) and the time the warning was issued (WT) found a lead time of 17 minutes. It is hypothesized if careful monitoring of total lightning data, once a lightning jump is detected, the warning meteorologist could get a 5 to 8 minute additional lead time on pulse severe storm warnings. Although this paper is NOT recommending lightning data be used solely for warning purposes, it can give a 'heads up" to the warning meteorologist that a storm is intensifying rapidly. One other important consideration is that the lightning data is updated in real time every *one minute*, while the 88D takes 5 minutes to complete a volume scan. If the forecaster monitors total lightning data and notices a rapid increase in lightning activity, then he/she can begin preparing the warning *before* the radar indicates the storm has reached severe criteria.

5. Conclusions and Future Research

Total lightning data, using the LISDAD system, was found to show rapid changes ("lightning jump") prior to storms becoming severe during the wet season across east central Florida. Average one minute flash rates increased from 56 FPM prior to the lightning jump to 189 FPM after the jump was completed. The rapid increase was found to last an average of 6.5 minutes. During the time of severe weather, flash rates ranged between 120 and 550 FPM. It is believed that these unique signals, used in conjunction with the WSR-88D can assist the forecaster in severe storm discernment, and possibly increase the lead time in wet season summer convection over the state of Florida.

This study only examined storms which were known to be severe. During Summer 1998, we plan on analyzing all storms which have flash rates in excess of 100 FPM, and to compare these storms to all NWS MLB warning products and storm reports. By analyzing the storms which have high flash rates, we hope to get a better understanding of the relationship of total lightning activity and severe convective storm morphology.

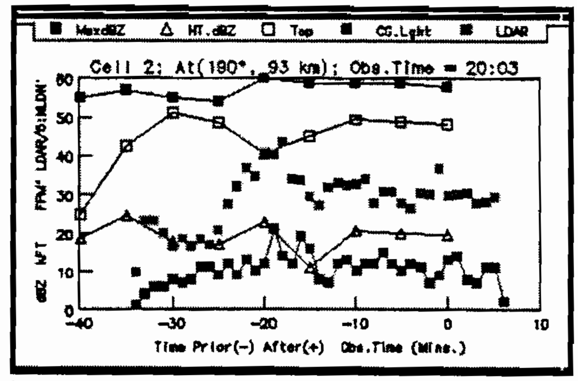

Figure 1. LISDAD "Pop up" box of a severe cell on July 6 1997at 20:03 UTC ("Obs Time"). Total lightning jump (LDAR - light gray solid squares) begins at 19:37 and ends at 19:45 UTC. NOTE: scale on the left must be multiplied by by 5 for total lightning (LDAR) data. The small number next to the letters "LDAR" on the upper left hand side represents the multiplicative scaling factor.

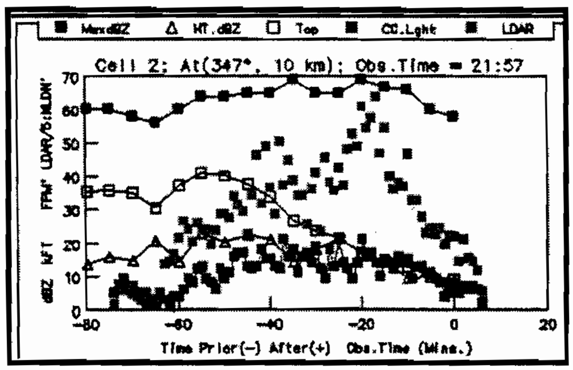

Figure 2. Example of a thunderstorm displaying multiple lightning jumps.

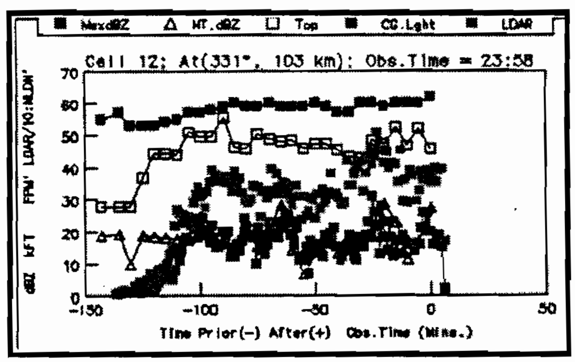

Figure 3. LISDAD pop up box of a long lived thunderstorm displaying nearly continuous total lightning (LDAR) flash rates >= 300 flashes per minute for over 100 minutes.

6. References

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TABLE 2

Date	Time LTG Jump Began: (T1) (UTC)	Total LTG value @ T1 (FPM)	Time LTG Jump Ended: (T2) (UTC)	Total LTG value @ T2 (FPM)	Time Warning Issued (WT) (UTC)	Svr WX Reported (Svr T) (UTC)	Total LTG @ time of Svr WX (+/- 10 minutes) (FPM)	Total LTG Difference (T2- T1) (FPM)	Delta T (T2 - T1) (minutes)	WT minus Total LTG @T2 (minutes)	Svr T minus Total LTG @T2 (minutes)
July 5	17:05	30	17:13	160	17:11	17:30	160	130	8	-2	+17
July 6	19:38	110	19:45	210	20:01	20:11	200	100	7	+16	+26
July 7	22:03	75	22:10	260	22:53	23:35	500	185	7	+43	+85
July 8	&&				19:37	19:48	200				
July 8	20:05	40	20:10	140	20:25	20:35	160	100	5	+15	+25
July 8	21:20	0	21:31	100	No warn	21:30	120	100	11	n/a	-1
July 9	20:53	25	20:59	135	21:09	21:43	325	110	6	+10	+44
July 11	17:29	10	17:31	100	17:44	17:58	160	90	2	+13	+27
July 11	18:07	20	18:15	130	18:20	19:25	450	110	8	+5	+70
July 12	21:07	80	21:13	180	21:20	21:30	200	100	6	+7	+17
July 15	21:01	60	21:04	140	No warn	20:58	140	120	3	n/a	-6
July 25	22:55	80	22:58	290	23:03	23:15	550	210	3	+5	+17
July 29	21:10	125	21:12	275	21:14	21:24	275	150	2	+2	+12
July 31	20:15	75	20:19	225	20:26	20:35	300	150	4	+7	+16
Aug 23	20:16	60	20:35	300	No warn	20:30	300	240	19	n/a	- 5
Ave		56		189			269	135	6.5	11	24.5

&& - This storm had a high flash rate at the time of severe weather, but the LISDAD machine was turned on too late to catch any possible "lightning jumps".

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