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CORRELATING NLDN FLASH DATA TO HEAVY SNOW

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1. INTRODUCTION

Although assumptions have existed for some time that lightning and thunder within a snowstorm must be accompanied by locally heavier snowfall, MacGorman and Rust (1998) rightly point out that no study has examined the veracity of such an assumption. This study will examine data from snowstorms associated with extratropical cyclones (ETC) over the central Unites States in order to arrive at several conclusions. The present study approaches the problem from two different directions.

First, and perhaps most appropriately, this study seeks to determine the relationship between reports of lightning (and/or thunder) and locally heavy snowfall. In essence, we are asking if thunder and lightning within snowstorms tend to be associated with locations experiencing heavier snowfall at the time of the lightning flash (e.g., *short-lived* areas or bands of snow that are embedded, spatially and temporally, in the larger snowstorm). Second, and perhaps more importantly, this study seeks to determine the relationship between reports of lightning (and/or thunder) and storm total snowfall. Specifically, we are asking if regions within snowstorms having thunder and lightning also have greater snow accumulations, not just for a short period, but over the lifecycle of the parent storm.

2. DATA AND METHOD

2.1 Data

Data for this study comes from multiple sources. For the study of short-term snowfall rates associated with lightning flashes, data from Doppler radar sites of the National Weather Service (WSR-88D) were used in conjunction with data from the National Lightning Detection Network (NLDN) generally for cases since 2003. For cases prior to 2003 (the beginning of the larger project and archival of thundersnow cases in real-time), surface weather observations (METARs) from manned airport weather stations are used to compare to data from the WSR-88D.

For the study of thundersnow reports and their relationship to the fields of storm-total snow accumulations, historical surface weather observations are used from the period 1961-1990 (the same dataset used by Market et al. 2002) and compared to daily snowfall totals from Cooperative Climate Observer (CCO) stations. Preference was given to events that occurred more than six hours prior to the reports of daily snowfall. For instance, during the period when most CCO stations reported snowfall at 1800 Central Standard Time (CST), events were preferred where the thundersnow event was observed prior to 1200 CST on that day. Of the 22 events examined, 21 met this condition.

2.2 Method

To satisfy our first inquiry, surface observations and NLDN flash data were plotted against WSR-88D reflectivity data in order to determine the nature of the reflectivity field (e.g., banded, uniform, etc) at the time of the thundersnow report. Indeed, a great deal of recent effort has been invested in the study of banded heavy snowfall (e.g., Martin 1999; Novak et al. 2004; Moore et al. 2005) a category into which many thundersnow events over the central U.S. events seem to fall. For this line of inquiry, several pieces of data were compiled. First, is there any structure in the reflectivity field? Second, if a band is present, does the lightning report exist within one-half the bandwidth of the reflectivity maximum? Third, what is the typical reflectivity over the site of the surface observation (or NLDN flash)?

For our second line of inquiry, the daily snowfall data from the CCO stations were plotted, and analyzed to determine if any structure or pattern existed in the fields of snowfall totals. Unfortunately, a clear pattern did not always present itself. Moreover, structures sometimes appeared in which a maximum of only 7.5 to 10 cm (3 to 4 inches) of accumulated snow appeared. As such, we chose to look instead for occasions of > 15 cm (6 inches) and > 25 cm (10 inches) in proximity (≤ 1° of latitude) to thundersnow reports.

Although patterns (linear, circular, etc) did not always appear in the daily snowfall total maps, we make a distinction here that will arise from time to time in this paper. In both the instantaneous and daily snow total fields, linear features do occur. We define, short-lived, radar-detected, linear features in the precipitation field as ***snow bands*** (Fig.1a), while those longer-term, surface-measured, linear features in the precipitation field are referred to as ***snow swaths*** (Fig. 1b).

3. RESULTS

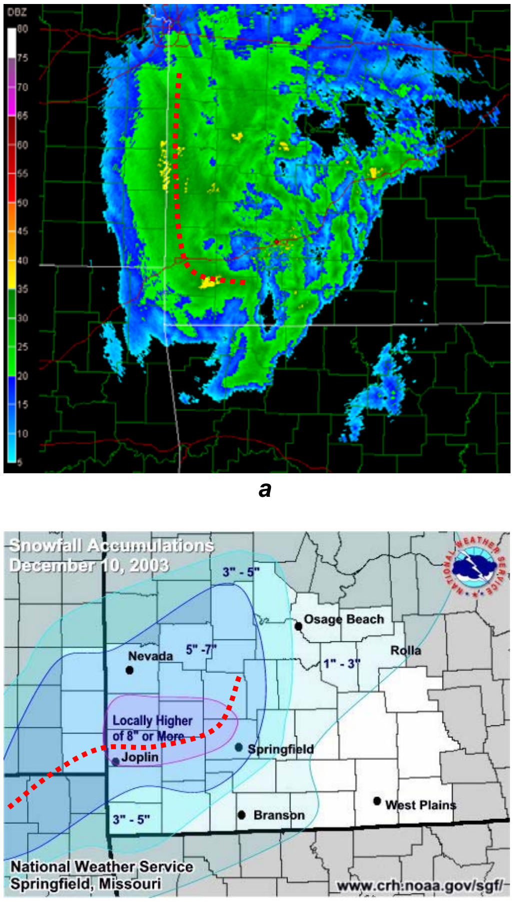
3.1 Snow bands

For those thundersnow events occurring prior to 2003, weather observations from staffed surface stations were used as a proxy for NLDN data. All of the events that were compared to WSR-88D data are shown in Table 1. To be sure, many of these events were noteworthy or even newsworthy, as they all featured heavy snowfall (except for 2003 February 11). In each instance, an elongated region of snowfall (whose major axis was more than twice the length of the minor axis), which we loosely term a snow band, was present at or very near the location of observed lightning.

Recognizing, too, that snow may drift a great distance horizontally from its origins in the parent cloud, we observe, however, that most lightning occurs within the region between the core values in the band and where those values drop to one half of the maximum value. A typical reflectivity occurring in the vicinity of a flash (or surface report of lightning) is 30 dBz, but range in these seven cases from a low of 18 to a high of 40 dBz. One event did experience thundersnow with sleet also (1999 December 09 at KLBB).

3.2 Snow Swaths

For the snowfall total maps, we focused on two categories of interest (Table 2). The first category included any case in which 15 cm (6 in.) or more of snow fell within an area. That area encompassed a circle centered at the reporting station with radius of 1° of latitude. The second category included any case in which 25 cm (10 in.) or more of snow fell within the area. These snowfall markers were chosen as representatives of significant snowfall events of different severity. Of the 22 cases studies, 19 (86%) were determined to fit into category 1 while 10 overall (45%) fit into category 2.



a

b

Figure 1. Examples of ***a***) an instantaneous snow ***band*** in the WSR-88D reflectivity field (dBz; legend at left) from Springfield, MO, at 0805 UTC 10 December 2003, and ***b***) a snow ***swath*** in the surface-observed storm-total snowfall observations (values in inches) for the same event. Axes of band and swath in ***a*** and ***b***, respectively, are defined by dashed red line. (Bottom image courtesy the NWS-SGF website.)

If one considers the maximum snowfall over the entire map (hereafter known as

”max”), 20 of the snowstorms showed a max somewhere of 15 cm (6 in.) or greater. This consideration provides an even stronger correlation between thundersnow reports & heavy snowfall totals. Specifically, if a given snowstorm had a max somewhere on the map of 15 cm (6 in.) or greater, 95% of the time the thundersnow event was a category 1. Similarly, of the 12 snowstorms with a max of 25 cm (10 in.) or greater, 83% corresponded to a category 2 thundersnow event. In 36% of the cases (8 of 22) the exact max value was located in the area of interest.

In other words, this sample suggests that the presence of thundersnow in the larger snowstorm is indicative of an ETC capable of snow in excess of 15 cm (6 in.) somewhere in the storm. However, the greatest snowfall totals tend to occur near the thundersnow event in only 1 of every 3 storms.

4. CONCLUSIONS

This brief paper helps to confirm some long-held assumptions about thundersnow events. First, comparison was drawn between surface observations of lightning, as well as data from the NLDN, and reflectivity from WSR-88D radars. This analysis reveals that lightning in these events tends to occur in relatively close proximity to instantaneous regions of stronger reflectivity. Second, a comparison of historical surface observations and regional 24-hour snow totals shows that thundersnow events tend to be associated with regions of higher (>15 cm) snowfall accumulations, but not the very deepest totals.

It is hoped that this analysis has clarified the importance of these events. The existence of lightning and thunder tends to point to a more vigorous, precipitation-producing portion of Midwestern extratropical cyclones. This is true on the short term (in a snow band sense) as well as over the length of the snowstorm’s life cycle (in a snow swath sense).

5. ACKNOWLEDGEMENTS

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TABLE 1. Thundersnow events examined for short-term banding and associated lightning activity during the years 1999-2003.

Date	Location	WSR-88D examined	Associated with a banded structure?	Lightning Data Source	Surface Ob Stations (if applicable)
1999 Dec 05	KS	KVNX	yes	METAR	KICT, KIAB
1999 Dec 09	TX	KAMA, KLBB	yes	METAR	KAMA, KLBB
2000 Mar 11	MO	KLSX	yes	METAR	KSTL, KSUS
2002 Jan 31	IL	KLOT	yes	METAR	KPDA, KAAA
2002 Dec 23	OK/MO	KTLX, KINX	yes	METAR	KOKC, KTUL, KCQB
2003 Feb 11	IL	KILX	yes	NLDN	-------
2003 Dec 10	MO	KSGF	yes	NLDN	-------

TABLE 2. Thundersnow events examined for storm-total snowfall accumulations and associated surface-observed lightning activity during the years 1961-1990.

Date (YYMMDD)	TSSN Station	TSSN Time (Z)	Max Snowfall in Storm (inches)	Max Snowfall within 1° Radius (inches)	6 inches within 1° ?	10 inches within 1° ?
880422	MCW	1200	3	3	No	No
830409	MSN	1200	5	1	No	No
830327	RFD	0500	12	6	Yes	No
820131	STL	0400	18	18	Yes	Yes
811120	MKG	0600	14	13	Yes	Yes
800409	MSP	0000	9	9	Yes	No
790303	DLH	0000	9	9	Yes	No
771209	CAK	0300	18	12	Yes	Yes
770322	SBN	0600	9	9	Yes	No
770318	FWA	0300	9	6	Yes	No
770303	EAU	1200	14	12	Yes	Yes
760316	STL	0600	7	7	Yes	No
760305	MSP	0600	18	12	Yes	Yes
760221	ALO	0600	14	9	Yes	No
	DSM	1500	14	9	Yes	No
751127	MLI	0300	12	10	Yes	Yes
750224	MSN	0900	14	10	Yes	Yes
	GRB	1200	14	7	Yes	No
750212	IND	0300	6	6	Yes	No
740222	RFD	0900	15	12	Yes	Yes
	MKE	0900	15	12	Yes	Yes
721114	FNT	0600	9	6	Yes	No
720327	ORD	0300	8	4	No	No
710319	MKE	0300	18	18	Yes	Yes
710227	DLH	0000	15	14	Yes	Yes