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LIGHTNING DATA USES IN NOWCASTING CONVECTIVE SNOW EVENTS

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1. INTRODUCTION

On 28 November 2005, blizzard conditions existed over parts of Nebraska. As a part of this event, lightning occurred during several periods in the storm. While in-cloud (IC) lightning, as reported by Automated Surface Observation System (ASOS) stations, appears to have been plentiful during brief periods in this event, cloud-to-ground (CG) lightning detected by the National Lightning Detection Network (NLDN) was sparse. This paper serves as a case study of the event, including a deeper analysis of the atmosphere during the periods when lightning was detected. In addition, we hope to shed some light on the difficulties of detecting in real-time, and verifying in a post mortem sense, the existence of lightning activity in wintertime snow-bearing thunderstorms.

2. SYNOPSIS

Significant snow totals (Fig. 1) as well as strong wind gusts (Fig. 2) occurred over north central Nebraska with this thundersnow event. Occurring in association with the trough of warm air aloft (known as the *trowal*), much of the snow fell west of the circulation center of the larger extratropical cyclone (Fig. 3). Indeed, the surface cyclone was clearly occluded, placing the blizzard conditions and attendant thundersnow firmly in the cold air north and west of the surface low (Fig. 4).

3. EVENT VERIFICATION

Research has shown that lightning and thunder within a Midwestern U.S. snowstorm exists in close proximity (~100 km) to regions of heavy snowfall a majority of the time (Crowe et al. 2006). Consequently, we continue in our quest to understand better those snowstorms that feature lightning. Post mortem case studies of archived events are our primary route to that goal. As such, it becomes paramount to verify the existence of lightning and snow together.

3.1 Lightning Data

Two sources of lightning data were available from this event, each of which represents a different time. The first source was the NLDN, which detected a single CG flash in the vicinity of Aurora, NE (AUH), near 1310 UTC 28 November 2005. This is the only CG flash data for this time. The second data source is the local lightning detection system on the ASOS at Valentine, NE (VTN), which reported lightning on and off from 1622 UTC to 2109 UTC 28 November 2005. The VTN ASOS is equipped with a system that detects lightning by detecting changes in the electrical field as well as through the use of an optical sensor. Clearly two separate periods of lightning were detected. Although the former is of interest, as it represents clearly a time when thundersnow was occurring, both are important because heavy snow and strong winds occurred in conjunction with both instances of lightning.

3.2 Soundings

Work by Market et al. (2004; 2006) has determined a typical composite sounding for Midwestern thundersnow events. Specifically, thundersnow events often occur above a frontal inversion in an elevated layer that is typically moist neutral to weakly conditionally unstable. Additionally, the most unstable parcel originates from a mean level of 671 hPa, with a mean temperature there of -8.7°C; the 700-500 hPa layer features a mean lapse rate of 6.5°C km^{-1}. Finally, while several constituents in the composite pool did possess convective available potential energy (CAPE), most did not. Generally, the composite thundersnow sounding of Market et al. (2006) matches well with the findings of Van Den Broeke et al. (2005) for cool-season lightning production, with the exception of adequate CAPE.

We turn now to soundings from the Rapid Update Cycle (RUC) model in order to assess the vertical thermodynamic profile at the time of each of the events. We begin at AUH (Fig. 5) at 1300 UTC 28 November 2005, and note a sounding similar to that described by Market et al. (2006). The most unstable parcel originates from a level just above the top of the inversion. It also begins its journey at a slightly lower level (700 hPa) than its composite cousins and possesses a temperature of -8°C. The 700-500 hPa lapse rate is also 6.5°C km^{-1}, and no CAPE is present. Additionally, the atmosphere remains saturated up to ~500 hPa, above which drying occurs fairly rapidly.

By contrast, the RUC sounding for VTN (Fig. 6) at 1900 UTC 28 November 2005 (neither 2000 nor 2100 UTC were available) does not compare as well to the findings of Market et al. (2006) or Van Den Broeke et al. (2005). In fact, the broad qualitative resemblance to the composite by Market et al. aside, none of the quantitative variables from this later VTN sounding compare favorably to their numbers. Therefore, we arrive at one of two conclusions: either *1)* the lightning observations at VTN were in error, or *2)* the atmosphere that harbors IC lightning is of a more stable configuration than that which generates CG flashes.

4. CONCLUSIONS

In the absence of CG data from the NLDN, verifying an event becomes a matter of meticulously picking through surface METAR reports in hopes of finding reliable observations from a station that is actually staffed by human observers. Failing that, the analyst is often left unsure of the true nature of some events. In this case, we are able to classify the storm as a thundersnow event because of the NLDN data at earlier in the day at AUH. Given this history and no reason (as yet) to doubt the veracity of the VTN ASOS, we also consider the later period at VTN to be an active thundersnow period (in spite of the RUC sounding profile which is less than ideal).

Although an interesting case on its own merits, the Nebraska blizzard and thundersnow event of 28 November 2005 is doubly interesting in that it provides an outstanding case study of lightning/snow verification. Moreover, it raises questions about the relationship between lightning character, static stability, and snow rate.

5. ACKNOWLEDGEMENTS

The authors would like to thank the students enrolled in Synoptic Meteorology II at the University of Missouri-Columbia during the winter 2006 semester. Much of the large scale analysis was accomplished by them, and we regret only that more of their exemplary efforts could not appear on these pages.

6. REFERENCES

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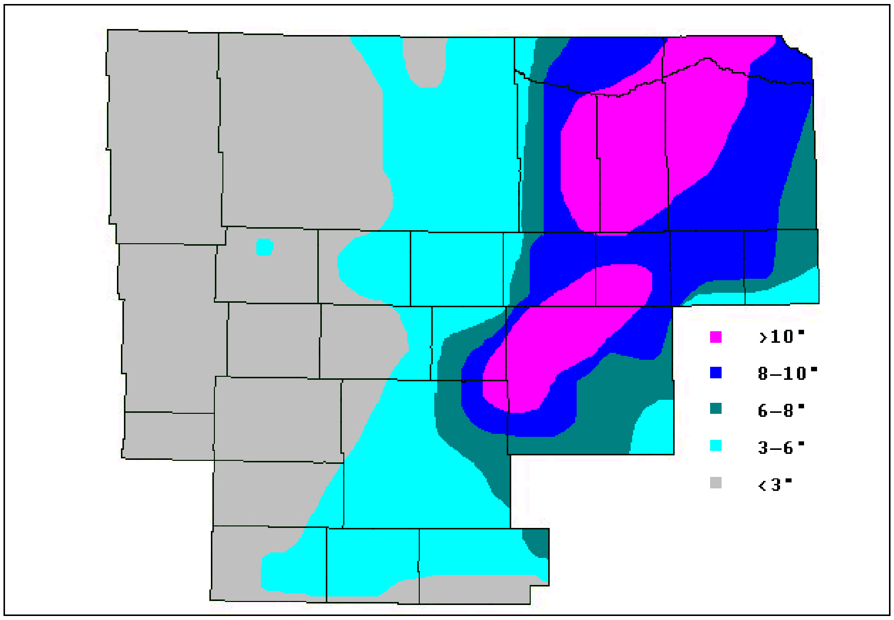

Figure 1. Snowfall totals (in inches) for north central and northeastern Nebraska from the blizzard of 28 November 2005. (Taken from the NWS North Platte, NE, website.)

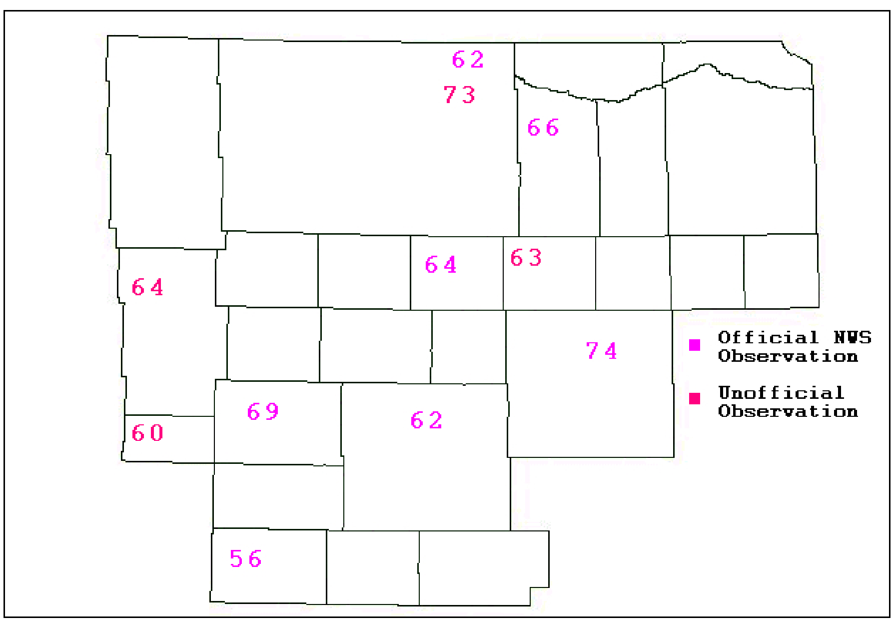

Figure 2. Wind gusts (in miles per hour) for north central and northeastern Nebraska from the blizzard of 28 November 2005. (Taken from the NWS North Platte, NE, website.)

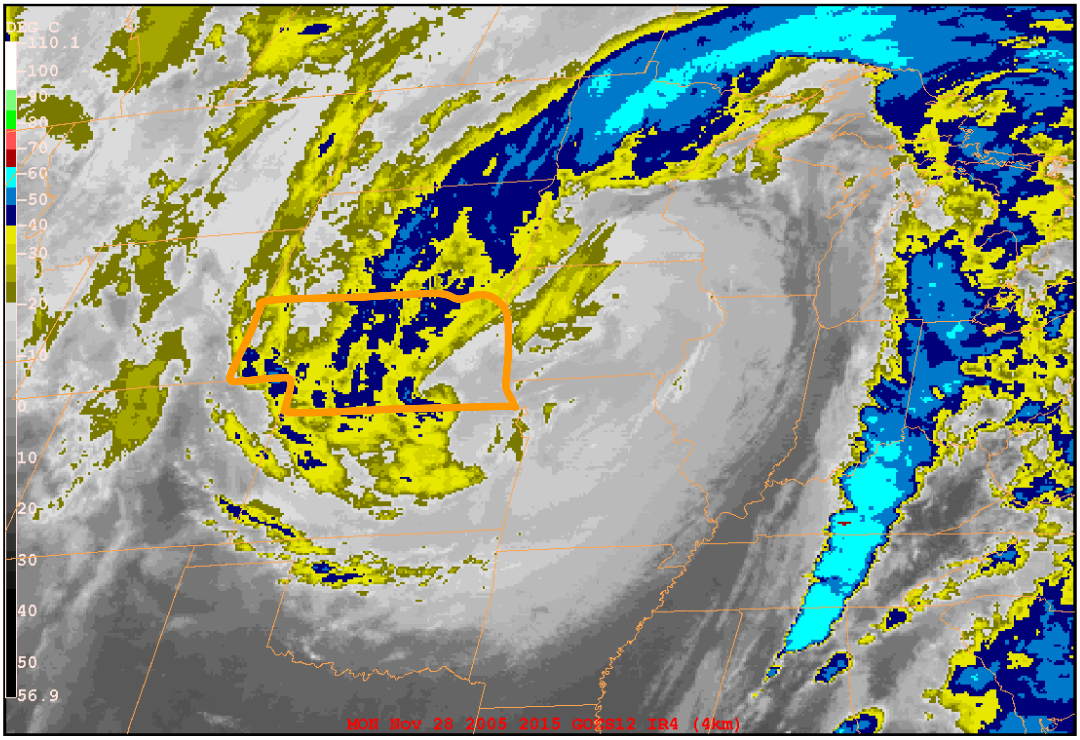

Figure 3. False-color GOES-12 infrared satellite image valid at 2015 UTC 28 November 2005 during an active thundersnow period in Nebraska. Color bar to left denotes temperature. The Nebraska border is highlighted in orange.

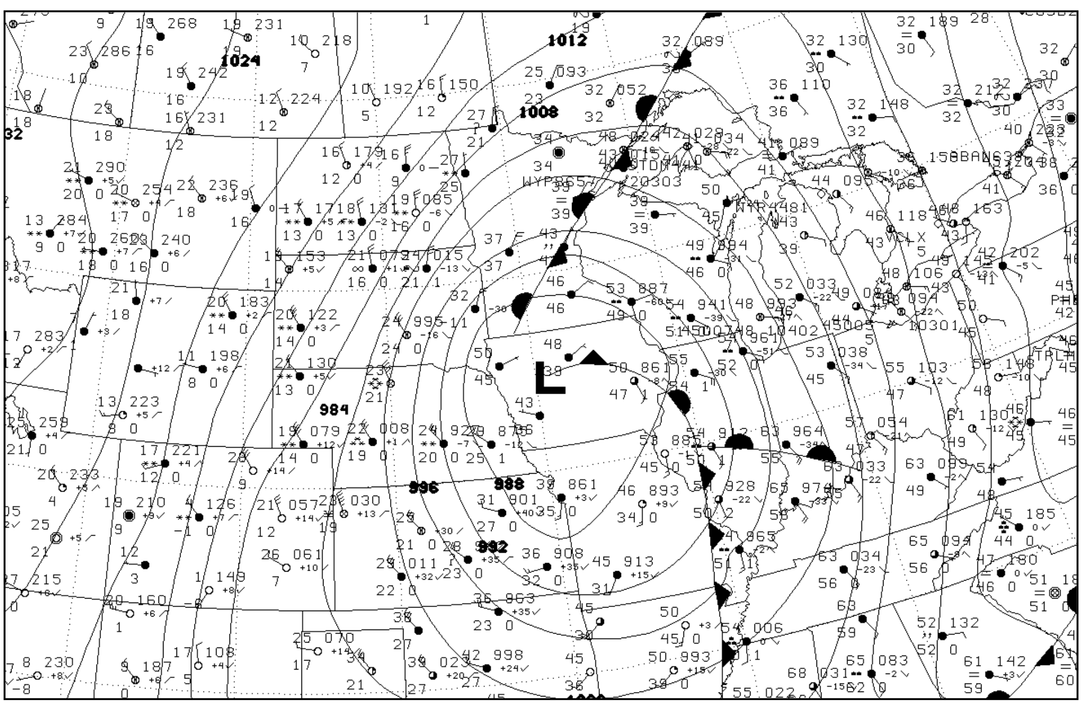

Figure 4. Section of a NCEP/HPC surface weather analysis, valid 1200 UTC 28 November 2005.

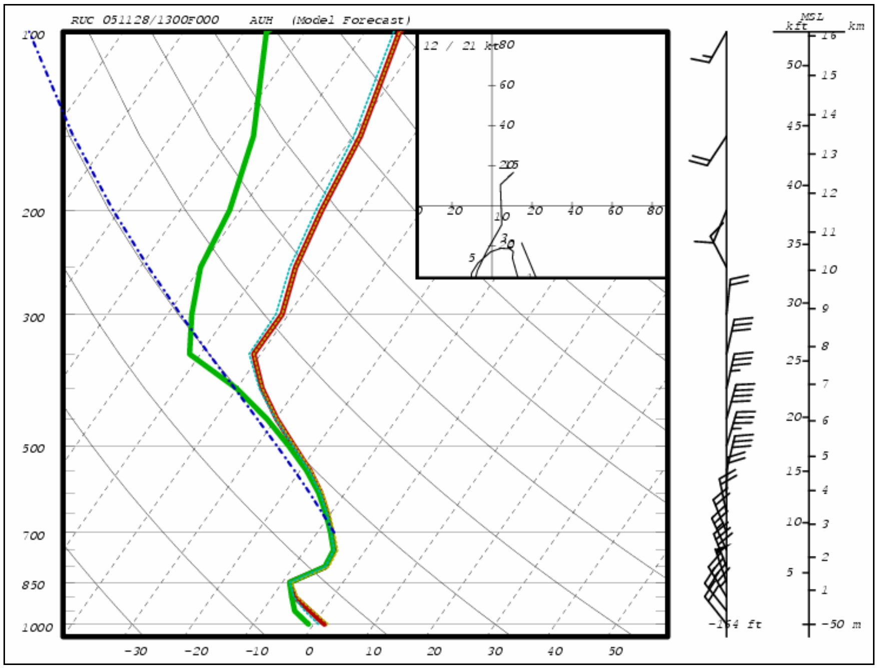

Figure 5. Sounding from RUC initial fields for 1300 UTC 28 November 2005 at Aurora, Nebraska (AUH).

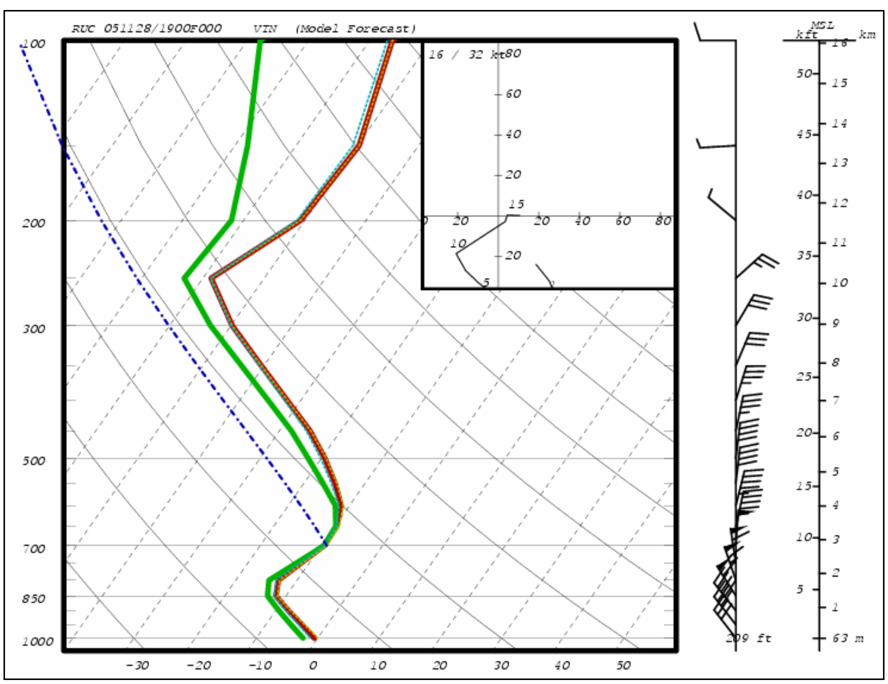

Figure 6. Sounding from RUC initial fields for 1900 UTC 28 November 2005 at Valentine, Nebraska (VTN).