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A Case Study of the 8 March 1999 Freezing Rain Event for North Platte, Nebraska

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CRARP 24-03 A CASE STUDY OF THE 8 MARCH 1999 FREEZING RAIN EVENT FOR NORTH PLATTE, NEBRASKA.

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1. INTRODUCTION

During the morning hours of 8 March 1999, freezing precipitation fell over portions of western Nebraska, including the communities of McCook, North Platte and Valentine between midnight and 10:00 A.M. CST. The freezing precipitation resulted in dangerous travel conditions, causing several automobile accidents, along with the delay and temporary closing of area public schools 8 March 1999. The freezing rain changed over to snow later the same morning.

A forecast for snow, rather than freezing precipitation, was issued by the local forecast office. The forecast issued was based predominately on numerical weather prediction guidance, and the observed temperature profile of the atmosphere. The observed temperature profile of the atmosphere was below 0°C throughout its entire vertical extent.

The purpose of this study is to present important components of cloud microphysics that will be useful in an operational forecasting environment. It has been shown in numerous studies that clouds consist predominately of water vapor until the cloud reaches a critical temperature of −15°(Rogers and Yau, 1989.) In general, for the lower 48 conterminous states, ice crystal growth by deposition, aided by the presence of ice nuclei (predominately vermiculite), is maximized at −15°C (Houghton, 1950.)

In this particular situation, an operational forecaster must possess a basic understanding of cloud microphysics in order to accurately assess the atmospheric potential for liquid versus freezing or frozen precipitation. Numerical weather prediction guidance, nomograms, and thickness schemes did not accurately predict precipitation type in this particular atmospheric environment, which included a low level stratus cloud layer at a temperature between 0°C and −10°C. For this case, the synoptic and sub-synoptic-scale environment, as well as vertical atmospheric structure will be examined.

By substituting the latent heat of sublimation for the latent heat of evaporation in the Clapeyron-Clausius equation[1], where H_{vap} = 597.3 cal/gm, and H_{sub}= 677.0 cal/gm, then solving for temperature, it shows that the saturation vapor pressure over ice is less than over water (Smith, 1995.) Therefore, the saturation vapor pressure of super-cooled water droplets is more than that of ice nuclei. Because of this difference in saturation vapor pressures, the ice crystals will grow at the expense of the water vapor droplets in the cloud (the Bergeron Process, Ahrens, 1991.) At temperatures between −10°C and −15°C, ice crystal growth is maximized, as the difference in saturation vapor pressure is greatest (Neuberger, 1967) Once the ice crystal growth process begins, the threat of liquid precipitation falling from the cloud and freezing on surface features becomes minimal. It follows logically then, that at temperatures between 0°C and −10°C, there is a greater threat of super-cooled water droplets falling from the cloud, freezing as they deposit on surfaces.

2. METHODOLOGY

a. Data Sources

The NGM, ETA and AVN graphical model output from 00 UTC 8 March 1999 as well as from 12 UTC 8 March 1999 were analyzed. Surface observations (METARS) were utilized for determining the timing and extent of freezing precipitation. It is important to note that all METAR stations in Nebraska are service type "C" reporting sites, and in accordance with Weather Service Operations Handbook #7 (WSOH #7, 2.7.1) are not required to report drizzle. At the time of this event, two ASOS reporting stations (KLBF and KVTN) in western Nebraska were known to have at least part-time observers on station for manual augmentation. Though freezing drizzle may have been occurring, it was not reported by any stations at any time, in accordance with WSOH #7. Freezing rain was reported if occurring.

Hourly surface observations, climatological data, synoptic analysis, satellite imagery, and raob data required for this study were provided by the National Weather Service through the North Platte Warning Forecast Office, and the National Climatic Data Center.

3. SYNOPSIS:

On 8 March 1999, a short wave trough tracked from New Mexico at 0600 UTC across the Texas panhandle to north central Oklahoma by 0000 UTC. The surface reflection of the short wave trough was evidenced by a low pressure center which developed over southeast Colorado by 0900 UTC 8 March 1999. An inverted trough was evident in the MSL analysis extending from the center of low pressure north through Kansas, Nebraska, and into the Dakotas. This inverted trough was evident throughout the life cycle of the storm (Fig. 1) and tracked east with the surface low center. At 700 mb, the system was an open trough, forecast to cross the central Rocky Mountains shortly before 1200 UTC 8 March 1999.

Freezing rain was first reported by KLBF (North Platte, Nebraska) at 1022 UTC 8 March 1999, an automated weather observation station that is manually augmented 24 hours a day. Freezing drizzle had been falling at KLBF prior to this time, starting shortly after 0600 UTC 8 March 1999 according to eye witness accounts by trained observers staffing the station at that time. Freezing rain was reported at KMCK (McCook, Nebraska) at 1126 UTC, and also at KVTN at 1138 UTC 8 March 1999. The beginning of the freezing rain at KVTN was coincident with the arrival of the contracted part-time observer's arrival for the day. KMCK at this time was a "stand alone" station, and therefore not manually augmented.

Additional lift as a response to differential positive vorticity advection, was coincident with the passage of the

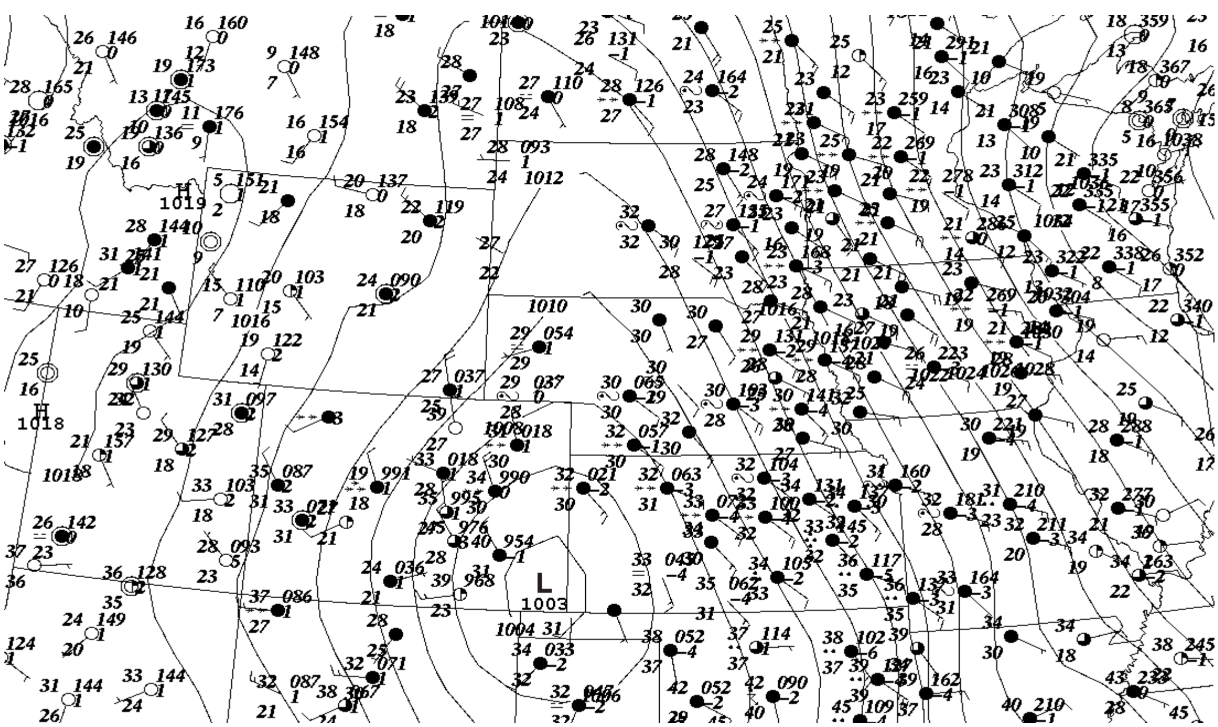

Figure 1: 1200 UTC 8 March 1999 Surface plot and MSL analysis.

700 mb trough. This additional lift, coupled with cold air advection at 700 mb, cooled the atmosphere to the temperature critical for snow production.

KMCK experienced a change from freezing rain to snow shortly before 1200 UTC 8 March 1999. KGRI (Grand Island, Nebraska) reported freezing rain from 0738 UTC until 1200 UTC, with light snow beginning at 1200 UTC.

Freezing rain persisted for the stations north of KMCK and KGRI for several hours longer before changing over to snow. At KLBF, light snow began at 1605 UTC, and at KVTN, light snow began at 1629 UTC 8 March 1999.

Shortly after 1300 UTC 8 March 1999, the National Weather Service office at KLBF began receiving numerous phone calls from sheriff's offices reporting icy roadways, which caused numerous automobile accidents in the immediate area. School administrators in several counties of western Nebraska delayed the start of school, or canceled it altogether for the day.

By 1800 UTC 8 March 1999 the surface low had tracked east southeast along the Kansas-Oklahoma border south of Dodge City, Kansas. Regional radar reflectivity now indicated a classic "comma head" appearance to the storm, with Nebraska and western Kansas beneath the deformation zone. All freezing precipitation had ended, having changed over to snow by this time across Nebraska.

4. UPPER AIR ANALYSIS

The observed 0000 UTC 8 March 1999 KLBF radiosonde data exhibited temperatures below 0°C throughout the atmosphere, with the exception of the surface temperature. The ETA forecast sounding for 1200 UTC 8 March at LBF indicated surface temperatures above freezing. The NGM and AVN forecast soundings indicated temperatures throughout the sounding warmer than the ETA forecast temperatures. The observed 1200 UTC March 8 1999 KLBF sounding (Fig. 2) exhibited temperatures below freezing throughout the atmospheric profile. Therefore, none of the numerical weather prediction models adequately forecasted the vertical thermodynamic profiles.

The arrows (Fig. 2) bring attention to important aspects of the sounding profile. The lower arrow indicates the moist layer in the lower part of the sounding, at a temperature range between 0°C and −10°C. Given that the most likely ice nuclei present was vermiculite (Houghton, 1950), these temperatures were not cold enough to produce solid precipitation (snow). Therefore, what precipitated out of this lower stratus cloud deck was in super-cooled liquid form, freezing upon impingement with solid surfaces.

The arrow pointing to the middle of the sounding (Fig. 2)brings attention to the dry mid levels of the atmosphere at the time of the freezing precipitation. This indicates that there were no clouds within 1.5 km of the top of the lower stratus deck. Had a cloud layer existed above the lower stratus deck within 1.5km, there may have been ice nuclei precipitated into the lower stratus deck, which is known as the "seeder-feeder" process. This would have reduced the threat of liquid precipitation falling to the ground from the low stratus cloud layer. An upper level cloud layer greater than 1.5 km would be less likely to produce the "seeder- feeder" effect, as it is thought that the precipitation would sublimate or evaporate prior to reaching the low stratus cloud layer. As there was no moist layer within 1.5 km

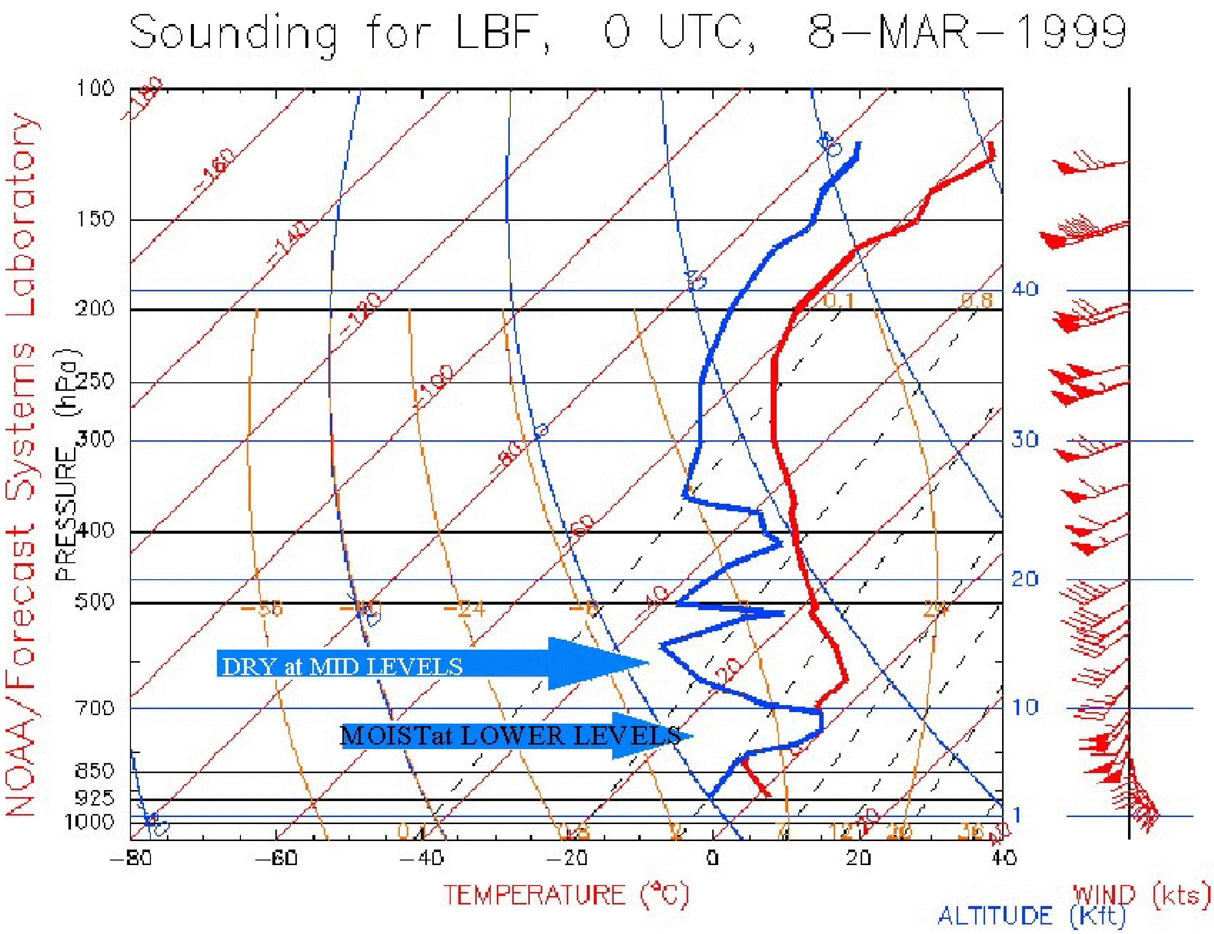

Figure 2: KLBF 0000 UTC 8 March 1999 observed sounding.

above the lower moist layer, there was no “seeder-feeder” process to change the precipitation to snow (Hobbs, 1989.)

5. RADAR ANALYSIS:

The KLNX WSR-88D (Doppler) radar images aided in ascertaining the location of the developing cyclone and its associated precipitation. Reflectivity returns of 4 dBZ to 20 dBZ were common in areas reporting snow (see arrows in Fig. 3). However, during the time that freezing precipitation was known to be occurring at KLBF and KVTN, the radar did not indicate any echo returns over either station at the lowest elevation levels. The radar was most likely overshooting the clouds producing the freezing precipitation. The 0.5 degree elevation angle on the 88D radar is approximately 4,529 ft AGL (7,308ft ASL) at KLBF, and approximately 5,402 ft AGL (7,989 ft ASL) at KVTN. Echo returns between KVTN and KLBF during the time which freezing precipitation was known to be occurring near the radar resembled ground clutter. Radar echoes were consistently weak (−8 to +4 DBZ) in a near circular pattern concentric to the radar site. This pattern is common during benign weather when no precipitation is occurring, or when the radar beam is above the precipitation, and was therefore inconclusive for detection of freezing precipitation.

Cloud tops in the lower tropospheric moist layer were at or below 10,000 feet, as evidenced by the most recent

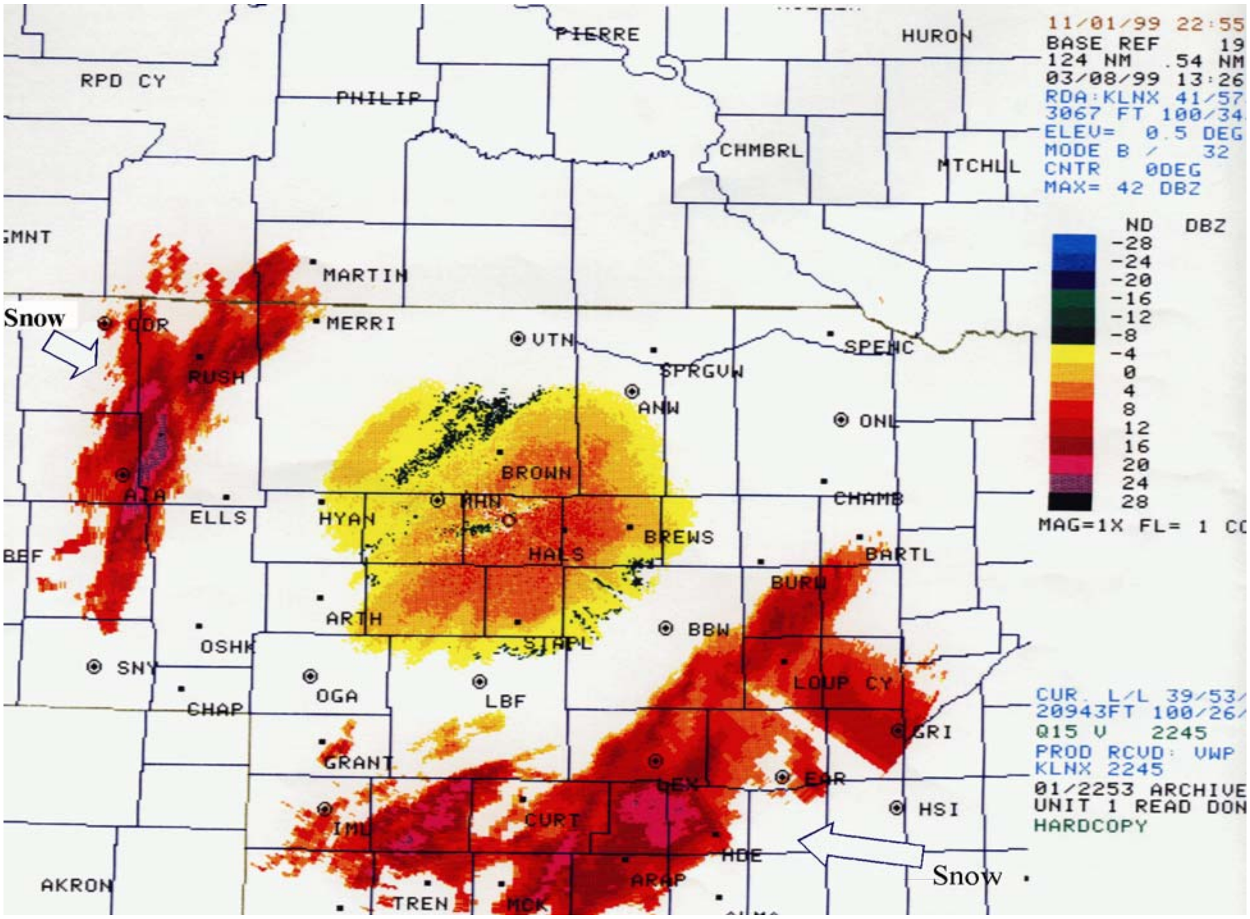

Figure 3: KLNX WSR-88D Base reflectivity image 1326 UTC 8 March 1999.

upper air sounding (Fig.2). Precipitation is detected by radar at a level below the indicated cloud top height, due to the effect of gravity on precipitation. No echo tops were detected within 50 nautical miles of the KLNX radar site through 1400 UTC. It is therefore presumed that the freezing precipitation was below the radar beam, or too small to be in the Rayleigh scattering spectrum, and therefore not detected as precipitation.

6. CONCLUSION

The paucity of mid tropospheric moisture in this case, coupled with moist lower tropospheric layers warmer than −10°C, suggests that the primary atmospheric process that produced the freezing drizzle and freezing rain initially lacked ice crystal seeding, and subsequent diffusion deposition and accretion. Operational forecasters should be attentive to the likelihood of liquid precipitation falling from moist layers colder than 0°C but warmer than −15 °C, coupled with dry atmospheric conditions aloft. Optimal ice crystal formation and subsequent snow production occurs in clouds at temperatures of −15 °C or colder (Byers, 1965.) Any cloud layers between *0*°C and −*10*°C within 5,000 feet of the surface should be considered capable of producing liquid precipitation, provided there are no upper cloud layers which could initiate ice nucleation via the ice crystal seeding process.

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NCDC, National Climatic Data Center, on-line data http://www.ncdc.noaa.gov