P1.8 24 FEBRUARY 2007 SNOW EVENT OVER THE PARK RANGE OF NORTHERN COLORADO: A MICROPHYSICAL PERSPECTIVE

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1. Introduction

Cloud microphysical processes play an active role in the development of precipitation, but to what extent? In the operational forecast environment, dynamical meteorology is given considerable attention before cloud microphysics is usually considered. In the wintertime, the Bergeron-Findeisen process, ice crystals growing at the expense of liquid droplets where the relative humidity is 100%, cannot be ignored. The 24 February 2007 snow event over the Park Range is one such event where the cloud microphysics may have played a bigger role than the dynamical meteorology. This poster will look at the synoptic pattern for 24 February 2007 over northwest Colorado. The microphysical data were part of the Inhibition of Snowfall by Pollution Aerosols (IPSA) project at Steamboat Springs, Colorado in January-February 2007. The Integrated Sounding System (ISS) was deployed for the IPSA project and provided the microphysical data in this poster.

2. Synoptic Summary

A low pressure system at 700 mb was moving into eastern Colorado, placing the Park Range in favored orographic northwest flow (Figure 1). The 1200 UTC 24 February Rapid Update Cycle (RUC) analysis showed wind speeds of 10 m/s (20 knots) from the northwest with relative humidity near 100%; these conditions were ideal for snow production over the Park Range. At 500 mb (Figure 2), northwest Colorado was in a region of weak flow with a sheared vorticity axis over Utah. With the closed low moving into the Texas Panhandle, the brunt of the weather system had passed Colorado. A strong jet overhead can enhance snowfall over the Park Range, but a strong jet did not exist over northwest Colorado on this particular day. The North American Model 12 km resolution (NAM12) time-height at Steamboat Springs (Figure 3) from 0000 UTC 24 February through 0000 UTC 25 February

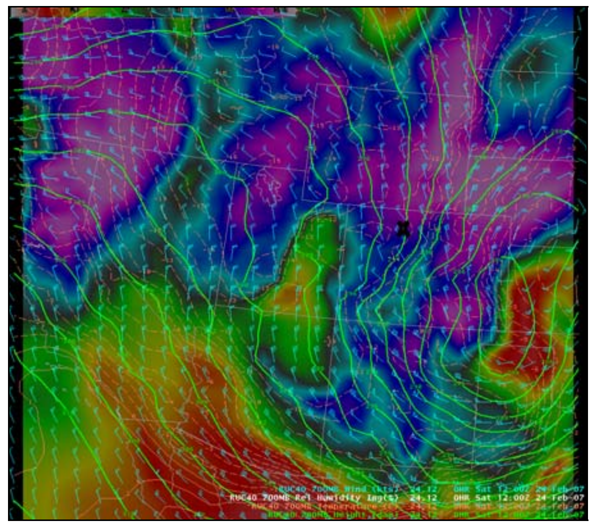

Fig. 1 – 1200 UTC 24 February 700 mb RUC analysis
Black **X** marks Steamboat Mountain

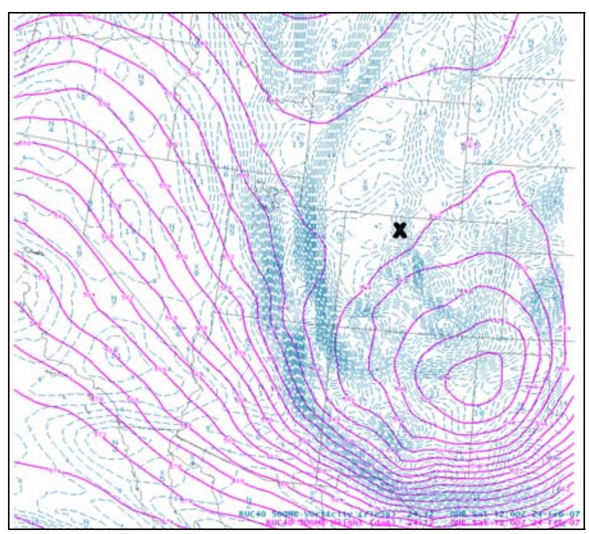

Fig. 2 – 1200 UTC 24 February 500 mb RUC analysis
Black **X** marks Steamboat Mountain

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showed adequate low level moisture and continuous northwest flow through 1800 UTC. Equivalent potential temperature decreased with height, an indicator of instability, was shallow and reached 700 mb (approximately mountain top where Mt. Werner sits at 3224 m

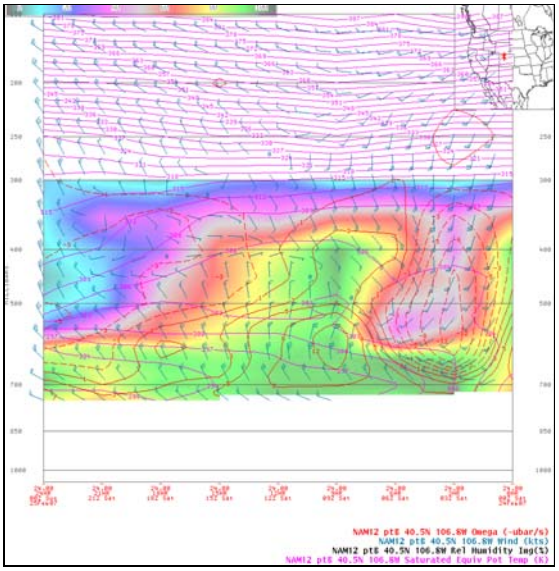

Figure 3 – NAM12 time height at Steamboat Mountains for 24 February

(10,568 feet). Above the 700 mb level, equivalent potential temperature increased with height indicating a stable layer above mountain top. Typically, conditional instability is important for mountain snow when moisture is lacking. Also, wind speed decreased with height and orographic forcing would be weak. The 24 hour accumulation precipitation total from the NAM12 model (Figure 4) showed a precipitation maximum near Steamboat Mountain of 6 mm (0.24" inches). Model data and forecaster judgment suggested that significant snowfall would not be likely for Steamboat Mountain.

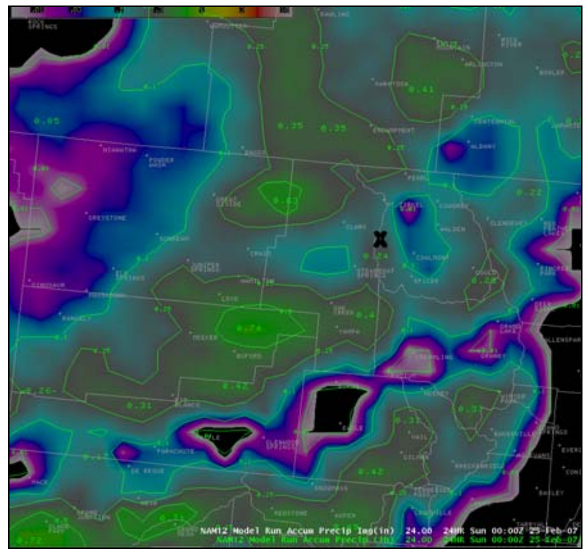

Figure 4 – NAM12 24 February Precipitation where **X** marks Steamboat Mountain

SNOWFALL (IN INCHES) ASSUMING THE GIVEN RATIO (DENSITY)							
Inches:		**10:1**	**12:1**	**14:1**	**16:1**	**20:1**	**30:1**
Water equivalent:		**10.0%**	**8.3%**	**7.1%**	**6.2%**	**5.0%**	**3.3%**
Steamboat Mountain	**0.33-0.39**	**3-4**	**4-5**	**5-5**	**5-6**	**7-8**	**10-12**
Steamboat Springs	**0.20-0.26**	**2-3**	**2-3**	**3-4**	**3-4**	**4-5**	**6-8**

Table 1 – Output of the Rhea-Thaler Orographic Snow Model

3. Rhea-Thaler Orographic Snow Model

The National Weather Service forecast offices in Colorado (Boulder, Pueblo, and Grand Junction) use the Rhea-Thaler orographic snow model (Szoke, 2000). The Rhea-Thaler orographic snow model forecasts snow amounts for various Colorado locations given meteorological parameters at the forecaster's discretion (Rhea, 1978). Forecasters input 700 mb temperature, wind speed and direction, base of saturated layer, the top of the saturated layer, duration, and whether the air mass is moist adiabatic. For the 24 February 2007 event, the following parameters for 24 hours were used as input (similar conditions that the time height showed at Steamboat Springs in Figure 7):

700 mb wind: 280 deg @ 7.5 m/s (15 knots)
700 mb temp: -15° C
Moisture base/top: 800/500 mb
Average lapse rate: moist

Using the Table 1 on the previous page for 30:1 ratio and a water equivalent range from 5 to 10 mm (0.20 to 0.39 inches) of precipitation, then a forecast of 15 to 30 cm (6 to 12 inches) of snow would be reasonable.

4. Verification

Quotes from Straight Talk Snow Reports provided by the Steamboat Mountain website summarized the 24 February 2007 event, "…today was our epic day of the year thus far... two feet by 9am, dumping about 1-2" an hour…" The next morning, the Straight Talk snow report stated "14 inches on top of yesterday's epic dump made for one sweet Sunday morning!" With a storm total of 94 cm (37 inches), how could the models and forecasts be off by so much?

5. Microphysical Summary

To what extent did the cloud microphysical processes account for the significant snowfall? Examining the soundings taken in Steamboat Springs, the air mass was saturated at and below 600 mb at 0400 UTC (Figure 5) and 1600 UTC (Figure 6). More important, the air mass was saturated, possibly supersaturated, in the critical -12°C to -18°C layer, the temperature regime for maximum dendritic ice crystal growth. More specifically, the 0400 UTC and 1600 UTC soundings showed cloud top temperatures in the 15°C to -20°C range. Hanna et al., 2008, stated that cloud top temperature at -16°C produces the most amount of snow.

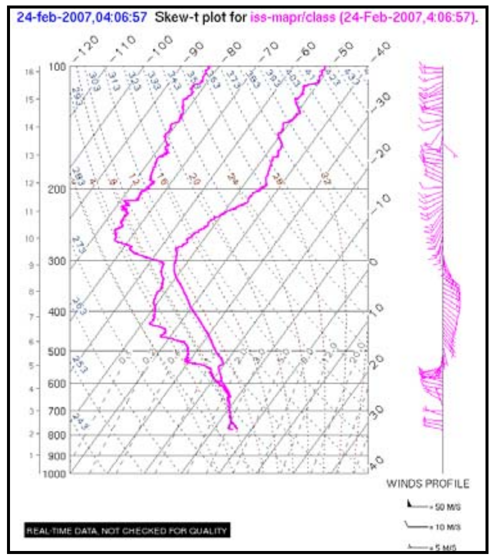

Figure 5 – 0400 UTC 24 February observed sounding for Steamboat Springs

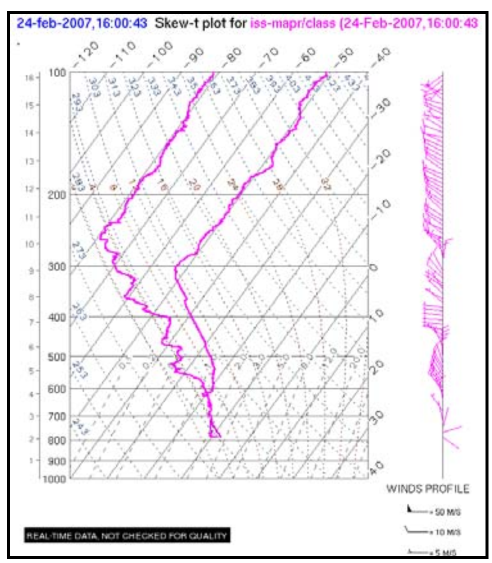

Figure 6 – 1600 UTC 24 February observed sounding for Steamboat Springs

Wind profiler data verify the model data that orographic flow was indeed relatively weak (Figure 7) with the wind from the northwest at 10 m/s. This changed around 1300 UTC when the northwest winds dropped to near 5 m/s. Orographic flow into the Park Range existed, but most likely was not a significant contributor to the heavy snow. Borys (2007, personal communication), who observed this storm first hand, called this particular event “The Perfect Storm.” The storm was efficient and it had to be because the storm was shallow and the Bergeron process was very active and converted most of the available atmospheric moisture into precipitation. The snow over the Park Range on 24 February 2007 would not have occurred without the dynamical conditions and orographical forcing; it was the microphysical processes that accounted for the heavy snowfall!

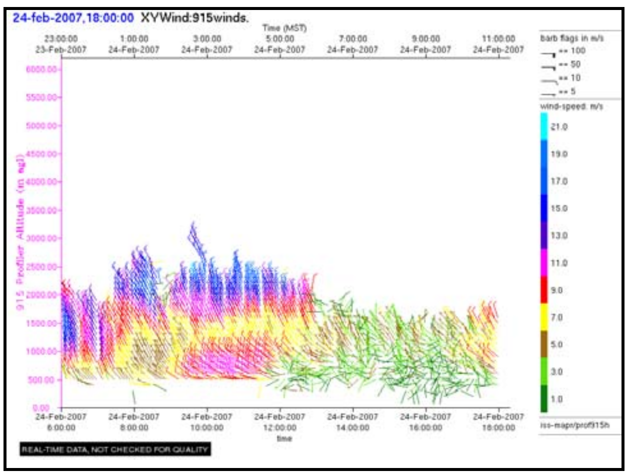

Figure 7 – Wind Profiler for 24 February in Steamboat Springs

6. References

Hanna, J.W., Schultz, D.W. and A.R. Irving, 2008: Cloud-Top Temperatures for Precipitating Winter Clouds. Journal of Applied Meteorology and Climatology, 351-359.

Rhea, J.O. 1978. Orographic precipitation model for hydrometeorological use. PhD Dissertation, Colorado State University. Department of Atmospheric Science, Fort Collins, Colorado. 198.

Szoke, E, 2000: An assessment of the utility of a local model for operational mountain snowfall prediction. Web Link: http://laps.noaa.gov/presentations/szoke_mtnconf2000/mtnconf_2000_talk.htmls.