16.4 A MESOSCALE HEAVY SNOW EVENT OVER THE GRAND MESA OF WESTERN COLORADO

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1. INTRODUCTION

Snowfall distributions in the western Colorado mountains are largely dependent on the aspect of the topography and the wind direction. For many winter storms, snow amounts are also a function of elevation, where heavy snow is usually confined to the higher elevations. For one particular storm, these constraints were unimportant when heavy snow fell over the Grand Mesa during a 24 hour period beginning on 1200 UTC 15 January 2006. During this event, highest snowfall amounts ranged from 61 to 91 cm (Table 1). The heaviest snowfall occurred during the evening hours, or between 00 and 06 UTC of 16 January. What made this storm unique was that the focus of the heaviest snow was over the Grand Mesa while higher mountain ranges in western Colorado (e.g., Elk and San Juan mountains) received significantly lesser amounts (less than 30 cm). This presentation will look at the synoptic conditions and the mesoscale environment and explain why the heavy snow was concentrated over the Grand Mesa, but “missed” the higher mountains. Were there any similarities to the “One hundred inches in one hundred hours” Wasatch mountain storm that was discussed in detail by Steenburgh (2003)?

2. SYNOPTIC CONDITIONS

Near midday on 15 January, a broad low pressure trough covered the Great Basin. Western Colorado was under southwest flow with an embedded short wave moving across this area. A deep surface low had formed to the lee of the Rocky Mountains and centered over the northern Plains. The 250-hPa 160 knot jet core extended south from California around the base of the trough and northeast across Arizona and New Mexico. Southwest Colorado was on the northernmost edge of the jet. The highest moisture content was entering the southwest corner of Colorado during this time with the 700-hPa mixing ratio ranging from 2.75 g kg^{-1} to 3.25 g kg^{-1}.

Location	Elevation	Snowfall	
	Meters	cm	Inches
6S Mesa	2377	27	10.5
Powderhorn Ski Area	2499-3002	64	25
Overland Reservoir	3011	30	12
Park Reservoir	3035	43	17
Skyway	3048	76	30
Mesa Lakes Lodge	3048	91	36
Douglas Pass	2590	23	9
Columbine Pass	2865	18	7
Telluride Ski Area	2659-3736	23	9
3NW Ridgeway	2407	37	14.5
McClure Pass	2895	38	15
Sunlight Ski Area	2404-3017	33	13
Schofield Pass	3261	38	15
Burro Mtn	2865	15	6
WFO-GJT	1480	6	2.4
4NE Crawford	1981	14	5.7
2SW Collbran	1889	14	5.6
Rifle	1615	5	2
1E Mesa	1706	13	5

Table 1: Storm total snowfall.

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By 0000 UTC 16 January, with the low pressure system moving through Utah (Figure 1), the moisture had decreased with 700-hPa mixing ratio varying between 2.25 g kg^{-1} to 2.75 g kg^{-1}. The

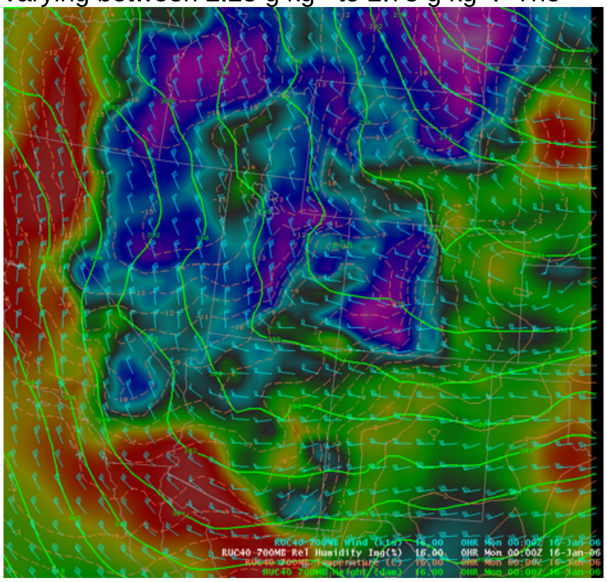

Figure 1 – 700-hPa depiction of heights, temperature, wind speed, and relative humidity at 0000 UTC 16 January.

trough had become less compact with the 250-hPa 140 knot jet diving southward behind the trough axis (Figure 2), but the jet associated with the front was a bit stronger at 160 knots and moving over northwestern Mexico into New Mexico. Over Colorado, the gradient flow weakened with westerly winds in the process of veering.

By 0600 UTC the trough had become split. The stronger southern portion of the trough was located over western Arizona. In the northern branch, the trough axis was centered over the northern Plains but trailed back into Colorado. The winds aloft had veered to a northerly component. Surface high pressure followed behind the trough and had shifted into Utah. The moisture content had become drier with the 700 hPa mixing ratio between 2.0 g kg^{-1} and 2.5 g kg^{-1}.

Summarizing the synoptic conditions impacting western Colorado:

- Incoming trough axis split as it approached Colorado
- Jet energy brushed southwest Colorado during the day, but was not a factor during the period of heavy snow
- Moisture content showed a drying trend as the trough approached Colorado.

With these conditions, it's quite reasonable to expect some snowfall in the mountains, but widespread heavy snow was not anticipated.

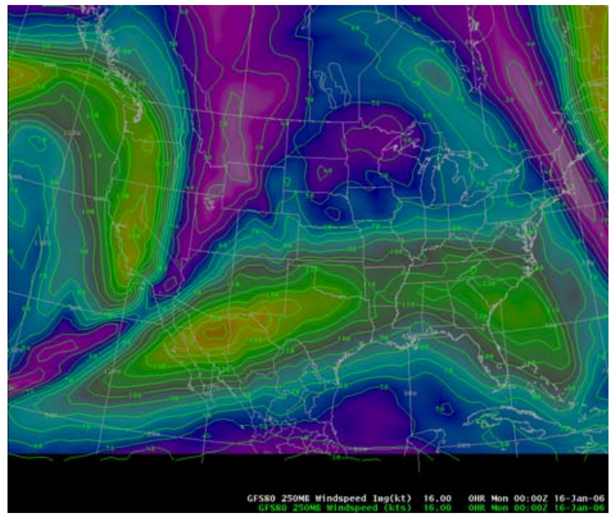

Figure 2 – 250-hPa wind isotachs at 00 UTC 16 January

3. MESOSCALE

Despite unimpressive synoptic scale forcing, the 0000 UTC January 16 upper air sounding showed a conditionally unstable air mass with a lifted index of -0.3 (Figure 3). Although the moisture was not abundant, microphysical processes may have become a more dominant factor, due to the dendritic ice crystal growth process. The efficacy of this process would be dependent on the release of potential instability, as well as the temperature and moisture profiles of the atmosphere. The 1981/1982 Colorado Orographic Seeding Experiment showed the importance of environmental conditions where the cloud top temperature was near the dendritic growth regime (-13º C to -17º C) to enhanced precipitation efficiency (Rauber, 1987). Visual observations by NWS personnel and trained spotters in Grand Junction and near the Grand Mesa indicated that the predominant habit during the heaviest snowfall was lightly-moderately rimed dendritic aggregates.

Surface high pressure shifted east across northern Utah after 0000 UTC which increased the pressure gradient across the Wasatch mountain range, which separates western and eastern Utah.

A low pressure surface trough existed near the Utah and Colorado border with a weak gradient evident. This created an area of convergence as surface high pressure began to move into northeast Utah. As the leading edge of high pressure reached the conditionally unstable environment, this triggered the convection that le d to the heavy snow. Satellite images (not shown) indicated two areas of convective enhancement. The first convective area developed over the Tavaputs Plateau of east central Utah, and this area moved over Grand Junction and the Grand Mesa. The second enhanced convective area formed over the Abajo mountains of southeast Utah. This second area was not as intense per infrared satellite images, and snowfall reports in this area are sparse. There is only one remote sensor in the Abajo Mountains and there are no ski areas or towns to report snowfall.

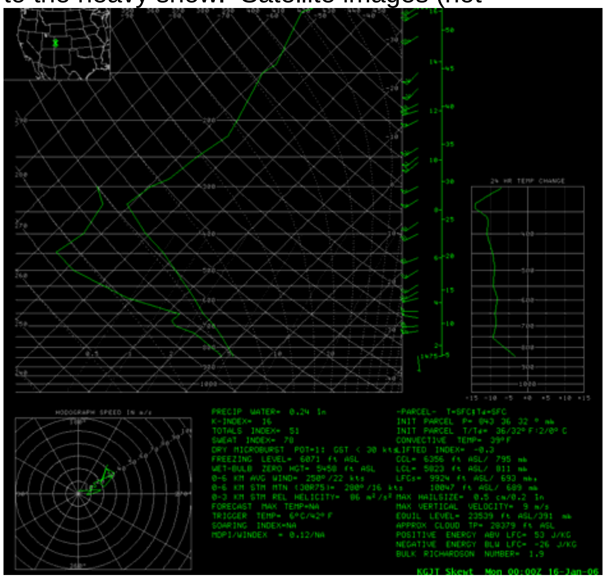

Figure 3 – 0000 UTC January 16 upper air sounding data at Grand Junction, Colorado.

4. Lessons Learned and Summary

The synoptic scale weather pattern was not favorable for widespread heavy snowfall over western Colorado. Given the conditional instability that was present, additional attention was given to mesoscale patterns. A convergence zone beneath the passing trough axis enabled strong convection to develop. Because of the lack of significant steering winds aloft as gradient flow was relatively light, the convective cells were nearly stationary, and were positioned over the Grand Mesa for several hours. The majority of the snowfall that fell over the Grand Mesa was attributed to these convective cells.

Given the synoptic conditions, it was reasonable to expect that widespread heavy snow was unlikely. Certain mesoscale processes must be evaluated when the atmosphere is conditionally unstable. Evaluation of some of those processes can be very similar to that of the warm season. While the synoptic pattern may seem unfavorable for heavy snow, strong convection may still develop from interaction of a surface boundary in a potentially unstable environment to generate localized areas of heavy snow. The release of potential instability cannot be overlooked, regardless of the synoptic weather pattern. If there is a mechanism to generate upwards vertical motion, potential instability will likely be released.

Although the Grand Mesa 16 January storm was considerably different than the “100 Inches in 100 hours” Wasatch mountain storm, one similar characteristic was low equivalent potential temperature aloft ahead of a surface boundary. In addition, microphysical cloud processes played a significant role as aggregate snowfall was observed.

6. Acknowledgements

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7. References

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