An Evaluation of the 01- 02 February 2003 South Central Montana and Northern Wyoming Snow Storm

Don Moore
WFO Billings, MT

Storm Overview

A significant storm system impacted south central Montana and northern Wyoming from 01 February 2003 to 02 February 2003. The precipitation started in a southwest fetch of moisture extending from Hawaii to Montana. This brought widespread rain and snow above 8000 feet through the afternoon of 01 February. The heaviest precipitation on the first was on the southwest side of the Bearthooths and Absorakas Mountains such as Cooke City where over an inch of liquid fell (see figure 1 for location of terrain features). Since snow levels were above 8000 feet during this time, snow accumulations were less than four inches for most mountain locations. While the rain and snow fell in the mountains, strong 800-600mb frontogenesis coupled with a middle level speed max aided in widespread rain over the lower elevations.

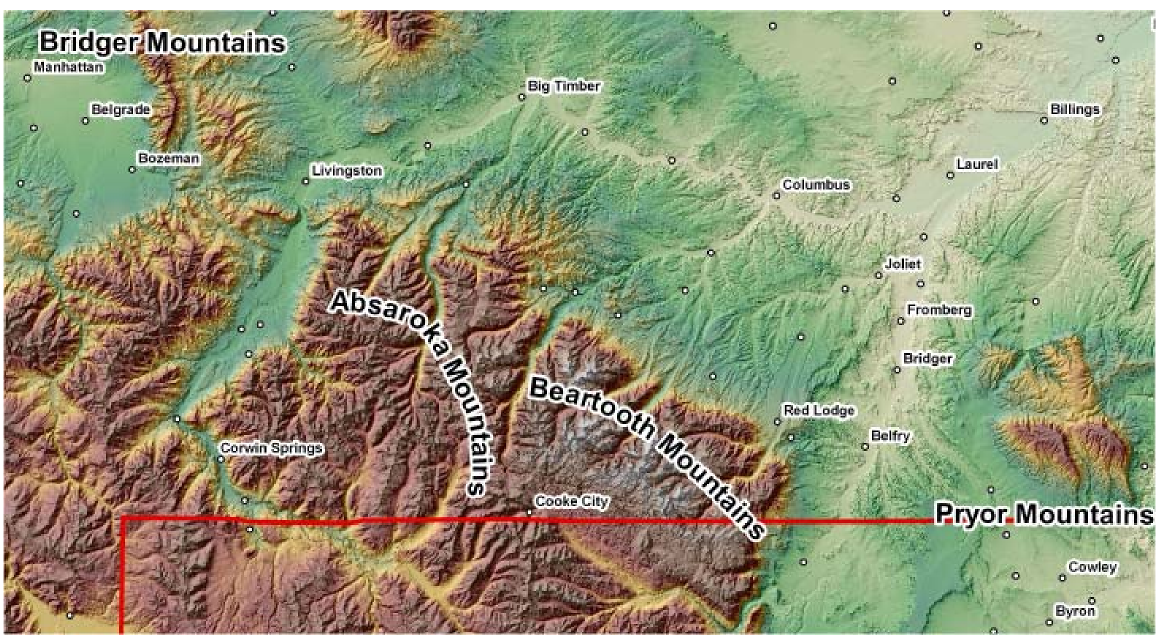

Figure 1. Topographic Map of south central Montana and northern Wyoming showing the Beartooth and Absaroka Mountains in relation to population centers.

As a short waved dropped south through northern California, the middle and low level flow became northerly over Montana. This brought cold air advection and unstable conditions. As this happened, the heavy precipitation shifted to the north side of the Beartooth Mountains late on 01 February and continued through 02 February. More than a foot of snow was common in the northern foothills and slopes of the Beartooth Mountains during this time. Most of the heavy snow came in two bursts; 1) The evening of 01 February associated with the southward movement of a frontogenic band through the area; and 2) between 5am and noon 02 February as a 600-500mb short wave trough moved through.

While this is not an uncommon evolution for snow storms in the region, the amount of snow that fell on the north slopes in this event is much less common and was not forecast well. As a result, this event was revisited on the WES to help forecasters identify the factors leading to such a significant snow.

Important forecasting considerations for the 01 February 2003 to 02 February 2003 storm

Model errors were a problem for forecasters in this event because the models were driving the moisture south too quickly. While the precipitation onset was correctly forecast, the ending of the precipitation was forecast about 8 hours too soon. In addition, the models completely missed a minor, yet very important, short wave that dropped south through the area early on the 2nd. While identifying this short wave proved to be extremely difficult 24 hours in advance of its influence, there were several clues in water vapor and model trends that indicated the system would be more amplified and slower to exit the area on the 2nd. Clearly overlaying upper level model RH with satellite imagery and viewing model trends were important techniques to identify the model errors ahead of time (figure 2 and 3).

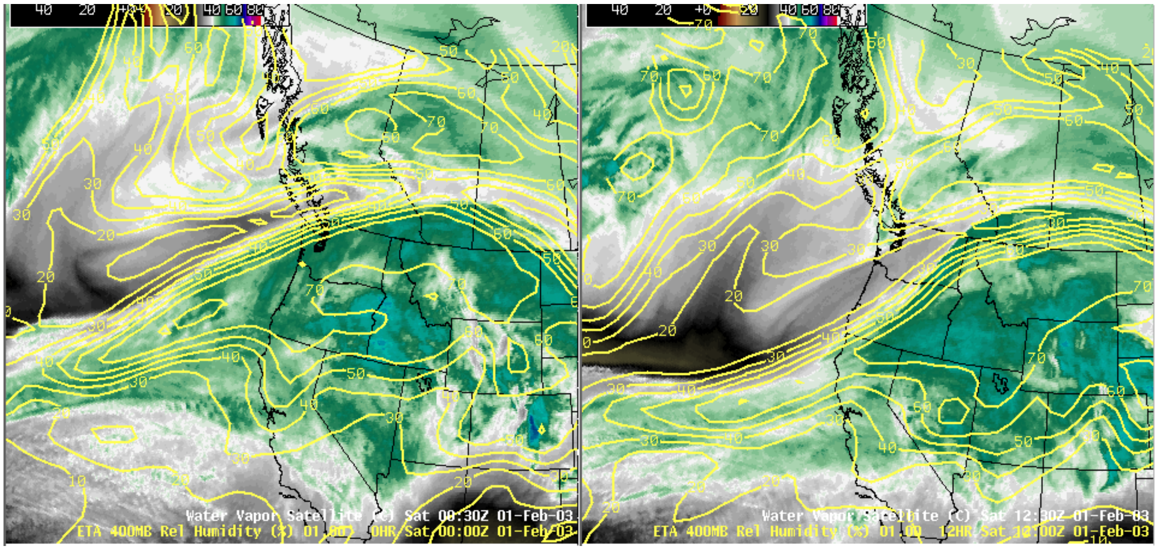

Figure 2. 01Feb 2003, 00Z Eta 400mb Relative Humidity valid 01Feb 2003, 00Z (left) and 12Z (right). Notice the moisture in the Eta is too far south with the system digging off the California coast and too far south with the moisture riding over top of the ridge in southern Canada. This suggests the model is not amplified enough with the trough off the coast and ridge over the northern Rockies. This often results in a slower progressing system.

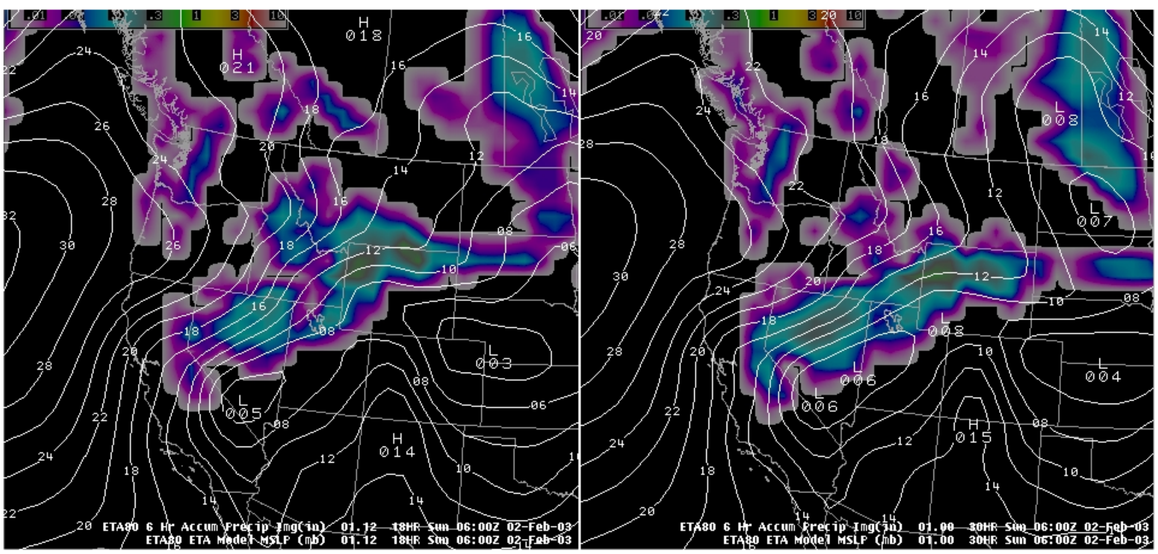

Figure 3. 01 Feb 2003, 00Z (right) and 12Z (left) Eta MSLP and 6 hour QPF valid 02 Feb 2003 06Z. Notice the QPF is farther north in the 12Z run.

One aspect that was forecast very well by the models was the amount of instability from the surface to 650mb when the northerly flow developed. That instability, along with air flowing at 15 to 25 knots into the foothills and mountains, were able to generate snowfall rates between quarter and half inch an hour under weak synoptic scale forcing. When the synoptic forcing was enhanced, snowfall rates were able to increase dramatically and reach rates of 3 inches an hour for several hours. Properly diagnosing the amount of moisture and instability present in these types of events, along with model reliability, can be crucial to providing a more accurate forecast. This is not to say that every northerly flow event with instability and moisture will bring heavy snow though, because the region of best ice crystal growth will play a role.

One important factor that needs more investigation is the height and depth of the dendritic growth region. In this event, and two other heavy snow events highlighted in a previous TA lite (Moore 2003), the -12C to -18C layer resided around and below 600mb where instability was high. Orographic forcing in the Beartooth Mountains is maximized between 800 and 700mb under northerly flow. It is possible that strong orographic ascent in that layer can lead to significant snow when temperatures are -12C to -18C and instability is high It was previously thought that temperatures would be too cold for dendrites or broad leafed plates, which have very high snow ratios. However it seems that based on three previous events with similar thermal profiles, this scenario is ideal for significant snow with snow ratios of 25 inches of snow or greater to 1 inch of liquid.

References

Moore, Don, "Two Similar Mountain Snow Events with Significant Model Dry Biases", Western Region TA-Lite #04-44, November 2004.