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POST ANALYSIS OF THE DECEMBER 27TH WINTER STORM IN SOUTHEAST WYOMING, NORTHEAST COLORADO, AND THE PANHANDLE OF NEBRASKA

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1. Overview

A major snowstorm pounded southeast Wyoming, northeast Colorado, and the panhandle of Nebraska from late Saturday, December 26th, through Sunday, December 27th. The snow, wrapping around a northeasterly-moving closed upper low, began in northeast Colorado late Saturday morning and spread north-northwest into southeast Wyoming and the Nebraska panhandle early Saturday evening. This was the same storm that had dropped four to eight inches of snow on these areas December 23rd.

By the time the second round of snow ended early Monday morning (December 28th), five to 15 inches of new snow had fallen throughout these same areas. In addition to the snow, strong north winds of 25 to 40 mph produced blizzard conditions and drifts up to six feet deep. Most roads and highways were closed by the storm.

Though this was obviously a big storm, neither the computer models nor the forecasters in the affected states were that worried about it. As late as the Friday (Christmas) afternoon zone package, only the Cheyenne forecast office had mentioned a good likelihood of light snow for Saturday night into Sunday. Even this forecast was downgraded with the issuance of the Christmas evening zones. Omaha and Denver only mentioned a chance of flurries.

On Saturday, the morning forecasts were still virtually unchanged for Saturday night and Sunday. Although the event began coming into focus by Saturday afternoon, the forecasts issued did not mention near the snow amounts that would later fall. It was not until late Saturday evening that forecasters finally grasp the reality of the situation. They, like the models, were playing catch-up with the storm.

2. Analysis

The upper air charts, valid 00Z Saturday December 26th, showed an upper (H5) low along the southern Arizona border southeast of Yuma, Arizona. The 00Z model computer run took the low east and then northeast to near Dodge City, Kansas by 12Z Sunday, December 27th (Figure 1). The next run (12Z Saturday)

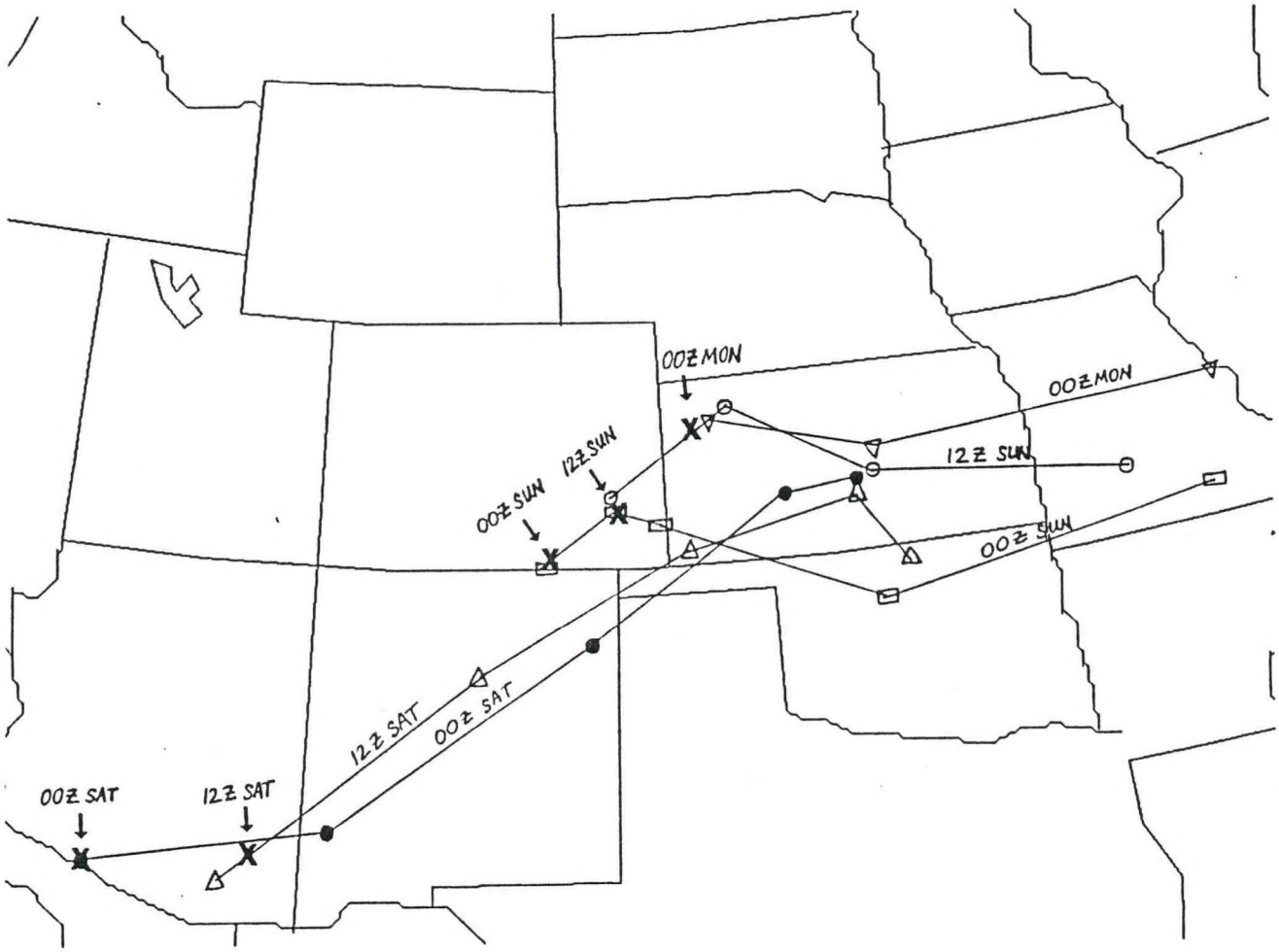

Figure 1. Track of 500 mb low as progged by consecutive RGL Model runs. Actual positions of 500 mb low are shown by "X." Line and solid circle denote 00Z Saturday, December 26, 1987 run. Line and point-up triangle denote 12Z Saturday, December 26, 1987 run. Line and square denote 00Z Sunday, December 27, 1987 run. Line and open circle denote 12Z Sunday, December 17, 1987 run. Line and point-down triangle denote 00Z Monday, December 28, 1987.

was slower but once again moved the low northeast to just west of Wichita, Kansas by 00Z Monday, December 28th. Both of these storm tracks were too far southeast to produce very much winter weather in the tri-state area.

A much different solution than the models were hinting at, however, began to unfold Saturday afternoon. A large band of snow was over northeast Colorado moving northwest. An updated Satellite Interpretation Message (SIM) was sent from the Satellite Field Service Station (SFSS) at Kansas City at 2143Z, discussing the reformation of the upper low northeast along a shear axis. The low was over northern New Mexico, and eventually ended up near Trinidad, Colorado by 00Z Sunday, December 27th. This was more than 100 miles northeast of the 12 hour progged position!

The upper air analyses for 00Z Sunday, December 27 showed the H5 low to be just south of Trinidad, Colorado. At H85, (Figure 2) a long fetch of moist air (dew point depressions of one degree) extended all the way from the Gulf of Mexico north into southern Nebraska. Southeast, upslope winds were wrapping this moisture around the low into the tri-state area. A large area of relatively moist air had also pooled on the north side of the low as indicated on the H7 analysis (Figure 3).

The 00Z (December 27) Regional (RGL) model run looked reasonable for the first 12 hours, taking the H5 low to just west of Lamar in southeast Colorado by 12Z Sunday, December 27th (Figure 1). However, beyond 12 hours, the model incorrectly took the H5 low southeast and then east. This caused forecasters to keep snow amounts on the lighter side, rather than going for a "full blown" winter storm. (It was here that some clues began to appear suggesting a winter storm event. This will be discussed in a later paragraph.)

Late Saturday evening, it became painfully obvious that the H5 low was continuing due northeast and that heavy snows were going to fall in the tri-state area. Winter storm warnings for heavy snow and blowing and drifting snow were issued with the early morning zone forecasts Sunday, December 27th. Some of these were upgraded later that morning to blizzard warnings as winds increased and visibilities lowered to near zero.

The 12Z analysis Sunday showed that the H5 low was indeed near Lamar, Colorado, but was still moving northeast (rather than southeast as the computer models from just 12 hours ago had forecast). Finally, the 12Z December 27 RGL model run correctly took the H5 low northeast to just east of Goodland, Kansas by 00Z Monday, December 28th, before moving it on to the east during the day Monday.

Something had definitely gone wrong in the prediction of this storm. Was it the forecasters themselves who performed poorly or the computer models, or both?

Certainly the models performed quite poorly during this event, with each successive run further north and west and a little slower on the progged track of the upper low (Figure 1). This difference in movement, even through the 12Z Saturday run, led forecasters to incorrectly believe that the storm would stay

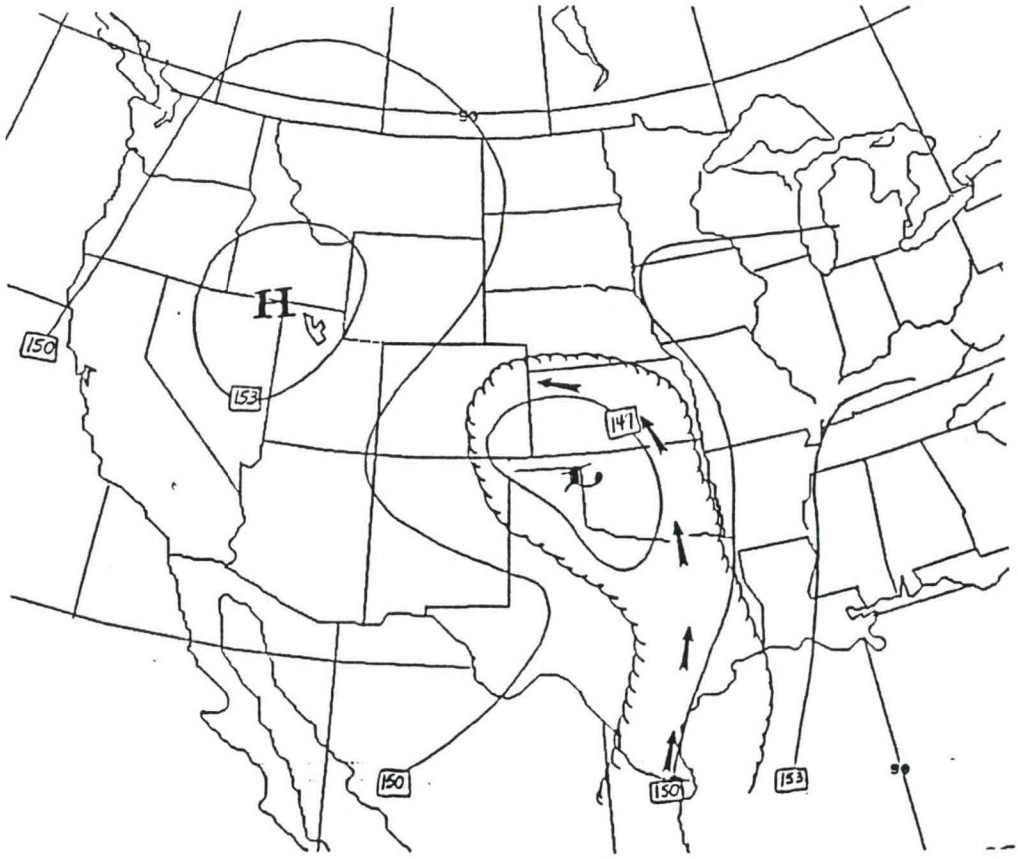

Figure 2. 850 mb 00Z Sunday, December 27. Area within scallops depicts dew point depression $\leq 1^{\circ}C$.

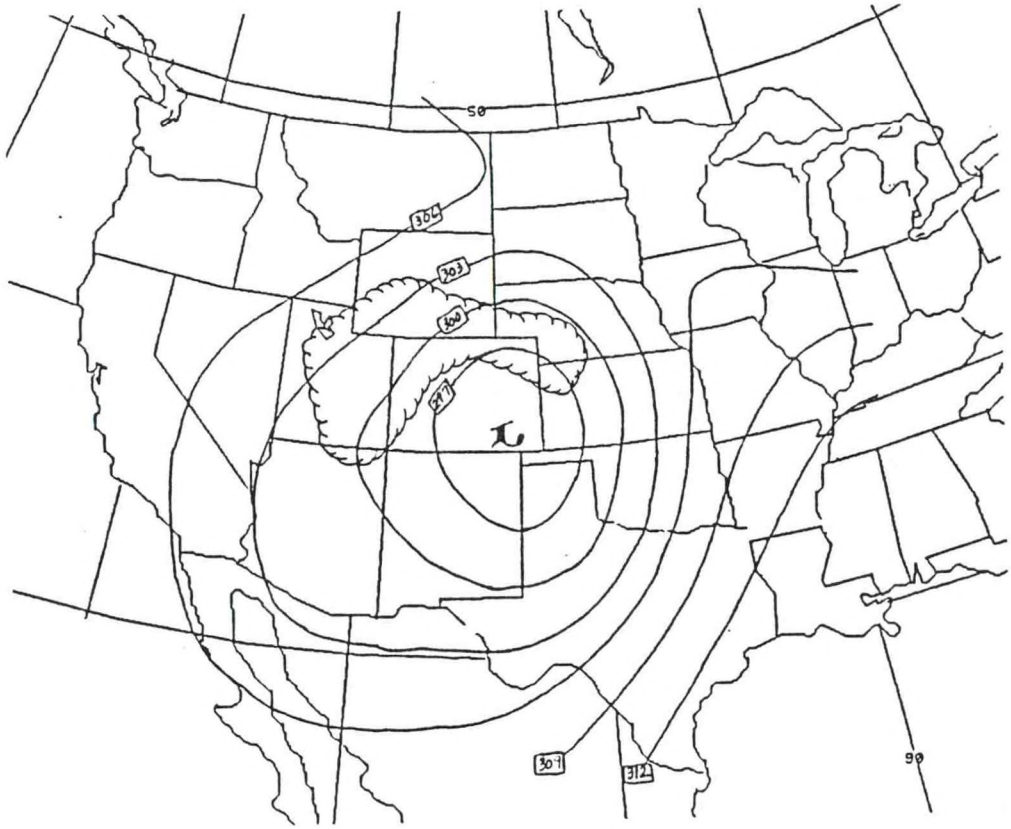

Figure 3. 700 mb 00Z Sunday, December 27. Area within scallops depicts dew point depression $\leq 1^{o}C$.

too far southeast for a major impact on the tri-state area. All forecasters realize the extremely critical importance of storm track in a developing winter storm situation.

The ERL model (LFM) did so poorly that the highest MOS POP it generated for CYS during the entire snowstorm was only 40%. This was for the first period from the 00Z Sunday, December 27th model run. The RGL model fared only slightly better, although it usually has a typical "wet" bias. The highest MOS POP the RGL generated was still just 50%, though it consistently did this for late Saturday and Saturday night as early as the Friday evening run (00Z December 25th). The amount of precipitation for CYS from the FRH data for both models was similarly far too low.

Why did the models fare so poorly? Reasonable speculation gives the following scenario. First of all, the models forecasted too much deepening of an upper trough offshore around 135W, which led to too much amplitude of the building upper ridge near 118W. (Progged H5 heights in the Great Basin were 30 to 60 meters too high.) This, in turn, resulted in the H5 low being pushed out too quickly, too far to the southeast, and not as deep as later observations would verify. Secondly, the models were unable to correctly forecast the two maximums in cyclonic relative vorticity rotating around the upper low. This may be linked to the poor parameterization the models have with respect to orographics. One of these two rotated around the north side of the upper low Saturday night, aiding to the low's northeast movement rather than to the east or even southeast as the models suggested. Finally, the models had limited data resolution due to a relatively sparse rawinsonde network. The mid and upper tropospheric lows were probably further north than the constant pressure analyses implied.

The relatively poor performance of the models in turn affected the forecasters, who look for discrepancies and/or similarities among the models. Certainly, a case may be made that forecasters tend to be too model dependent, using guidance for more than the word implies. However, in this event all three (ERL, RGL, and AVN) models were essentially handling the upper low in the same manner, moving it on a track too far to the southeast. With the guidance from all the models suggesting nearly the same prognosis, forecasters "leaned" that way until it was too late for much advance notice to the public.

3. Conclusions

What can be learned from this event? Most importantly, this snowstorm pointed out the need for forecasters to not just look at the models, but the trends of the models. As noted earlier, each successive RGL run, beginning with 00Z Saturday, December 26th, pulled the track of the upper low further to the north and west (several times this distance was over 100 miles, see Figure 1). This difference meant that instead of being missed by the storm, the tri-state area was coming more under the gun. Secondly, forecasters can ill afford to simply accept what the models predict without "getting their hands into the data." Since this storm was basically limited to the mid and upper levels of the troposphere (the deepest the surface low ever got was 1014 mb), forecasters needed to really delve into the constant pressure analyses. Indeed, some clues of an upper low movement contrary to what the models had predicted could have been gathered Saturday evening (00Z Sunday, December 27th).

At H3, the winds ahead of the low at both DDC and LBF had backed 30 to 50 degrees from 12Z to more of a southerly direction (this was discussed on the 2330Z SIMMKC). Also, despite the fact that the largest height fall at H5 that evening was 100 meters at DDC, a 70 meter fall was noted at DEN. Given the due northeast movement of the H5 low from 12Z that (Saturday) morning, a height fall over 100 meters almost certainly occurred in southeast Colorado where there were no rawinsonde stations. The low was still continuing on a due northeast track, rather than east or southeast as the models suggested. Armed with this information, plus the fact that plentiful moisture was available to tap at both H85 and H7, forecasters could have gotten the jump on the storm right here.

This event showed that forecasters must keep from becoming too dependent on the NWP guidance. In this case, all three models had nearly the same solution, yet they were all incorrect. A slight shift in the storm track from what the models had shown brought a significant winter storm to the tri-state area rather than just a few snow flurries. Ultimately, the best tools in forecasting this storm turned out to be SWIS and the constant pressure analyses.

The computer models typically have a problem in handling systems crossing the Rockies, performing much better once the storm gets east of the mountains. As forecasters, we must remember that the models will only be as good as the data and data resolution put into them. At a critical point in this storm event, the upper low was analyzed a little too far southwest by the models due to a large distance between rawinsonde sites from DEN to DDC (about 300 miles). The models then took the low on a track too far to the southeast.

Forecasters often hesitate to go "against" the models when all of them show almost the same prognosis. This is especially true when the forecasters of adjoining states are "going" with the models, making the one who doesn't appear as the lone dissenter, with non-consistency across state lines. As forecasters, we must take it upon ourselves to review our dynamics and understand how the models work. Forecasters must pay close attention to the trends in the models and to details in the upper air analyses, in addition to using SWIS and the SIM products. This will keep us from being led astray by the NWP guidance and allow us to make more accurate forecasts.