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CENTRAL REGION TECHNICAL ATTACHMENT 89-7

SUBJECTIVELY ADDING LOW LEVEL MOISTURE TO THE RGL GUIDANCE

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1. Introduction

Forecasting in the age of numerical weather prediction many times comes down to answering a perplexing problem: how to subjectively update a model with newer information. On November 18, 1988, the forecaster was presented with just such a challenge. Although the accuracy of the human forecast fell far short of perfection, it was tangibly better than that of the model. What the forecaster did right and did wrong is discussed. In particular, how the use of an isentropic cross section could have materially benefited the forecast is discussed.

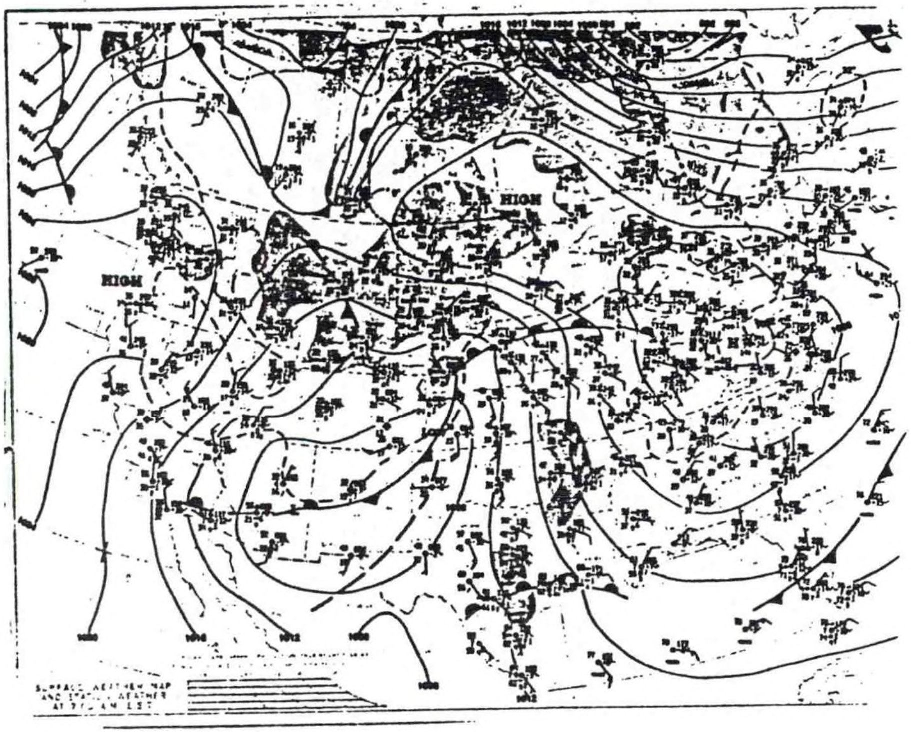
2. Initial Conditions

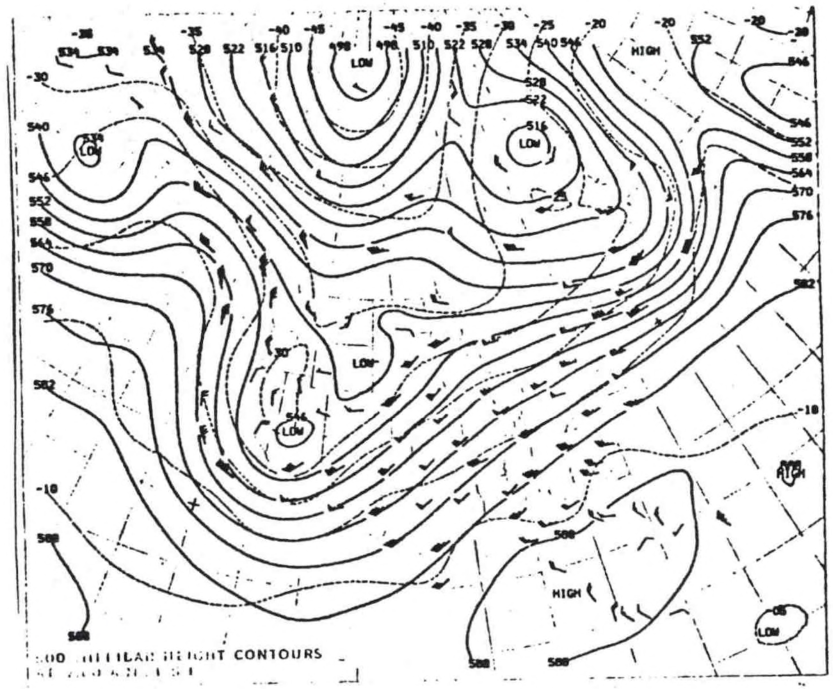
At 12Z, November 18, the 500 mb analysis (Fig. 2) showed a moderately strong trough over western North America. The upper flow was fractured with an identifiable low over Wyoming and a closed low over extreme southern Utah. The surface analysis for the same time (Fig. 1) depicted a wavy front from the upper Midwest into the desert Southwest. Note, in particular, that high dew points from the Gulf of Mexico were already surging into extreme southern Texas.

Also, at 12Z, November 18 (see Fig. 3), strong warm advection at 200 mb was occurring from Utah into the south half of Minnesota. Much of the southern two-thirds of Minnesota was located within the 1520 m and 1540 m mid-level (850-700 mb) thickness band.

3. The 12-hr RGL Forecast

The 12-hr RGL forecast verifying at 00Z, November 19, suggested that the main development and precipitation would occur in association with the upper low coming out of the southwestern United States; and its effect would be far south of Minnesota. The RGL did show increasing mean relative humidity (see Fig. 4) across central Minnesota. It also depicted (see Fig. 5) strong 200 mb warm advection from northern Arizona into the south half of Minnesota. The 1520-1540 m mid-level thickness band was forecast to be located over the south half of Minnesota. The only RGL precipitation forecast for Minnesota (for the 12 hours





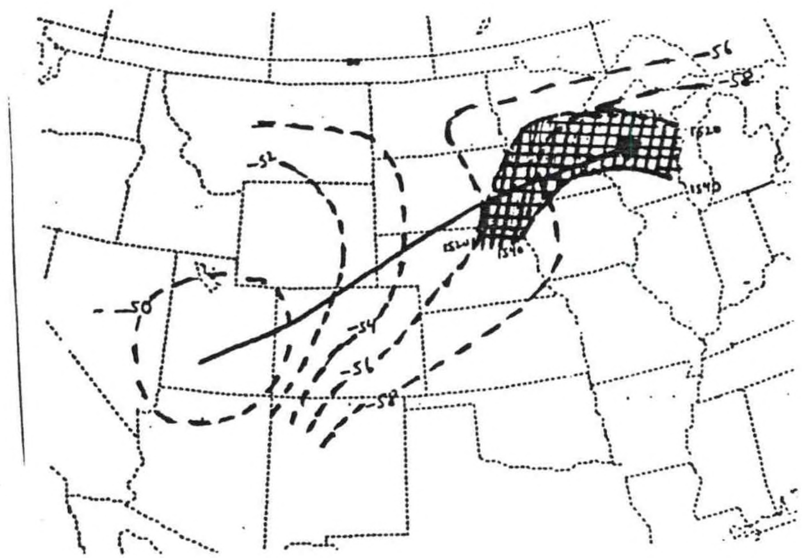


Fig. 1. (upper left). 12Z, 11/18/88. Surface Analysis.

Fig. 2. (upper right). 12Z, 11/18/88. 500 mb Analysis.

Fig. 3. (lower right). 12Z, 11/18/88. Observed 200 mb isotherms (dashed), a representative 200 mb streamline (arrow), and the 1520m-1540m mid level thickness band (cross-hatched).

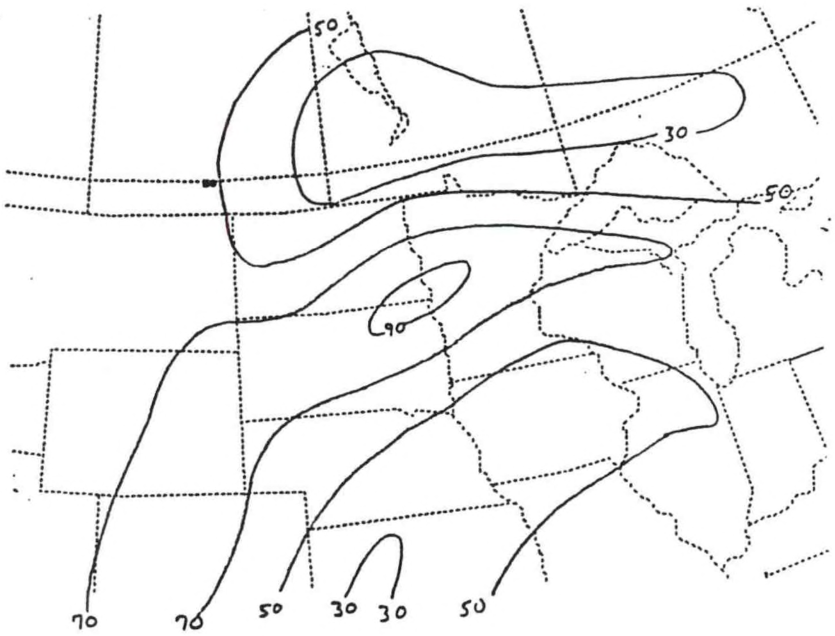


Fig. 4. 12-hr RGL mean relative humidity valid at 00Z, 11/19/88.

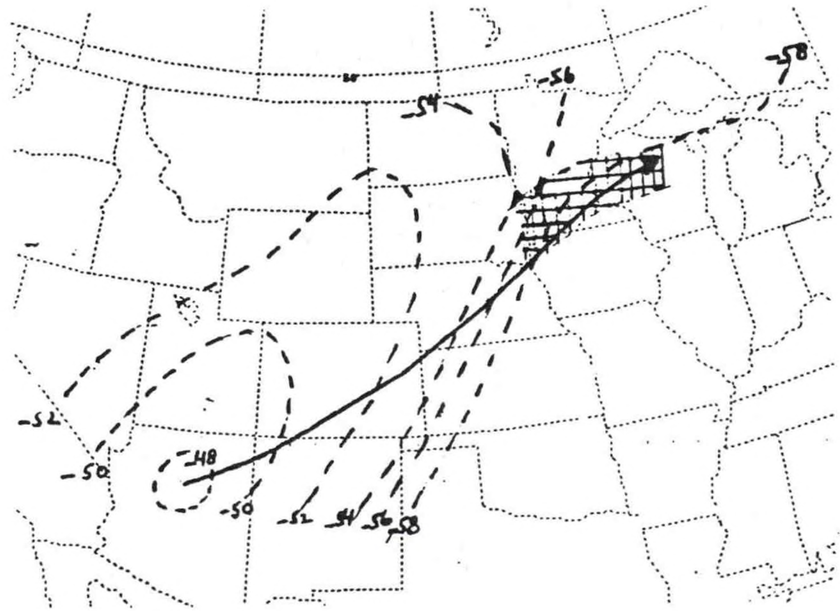


Fig. 5. 12-hr RGL forecast valid at 00Z, 11/19/88. 200 mb isotherms (dashed), a representative 200 mb streamline (arrow), and the 1520m-1540m mid level thickness band (cross-hatched).

ending at 00Z, November 19) was a few hundredths in northwest Minnesota. The boundary layer relative humidity showed Gulf of Mexico moisture extending as far north as extreme southeastern Missouri.

4. The 24-hr RGL Forecast

The 24-hr RGL forecast verifying at 12Z, November 19, indicated that the upper flow would split, with almost all the energy remaining well south of Minnesota. The RGL did show mean relative humidity above 70 percent (see Fig. 6) across northern Minnesota. It also depicted (see Fig. 7) weak 200 mb warm advection still occurring in southern Minnesota. The 1520-1540 m mid-level thickness band was forecast to be located over southeastern Minnesota. The only RGL precipitation forecast for Minnesota (for the 12 hours ending at 12Z, November 19) was a few hundredths in northwest Minnesota. The boundary layer relative humidity showed Gulf of Mexico moisture extending no farther north than extreme southern Missouri.

Integrating the RGL QPF forecasts from 12Z, November 18, through 00Z, November 20, and assuming a 10:1 snow to water ratio yielded the RGL's snow forecast in Minnesota. That forecast is depicted in Fig. 8. Note that maybe an inch or so was forecast for northwest Minnesota.

5. The MSP Prog

The WSFO Minneapolis snow forecast (the MSP Prog) issued about 22Z, November 18, used the B. J. Cook Snow Index (Cook, 1980), but adjusted it southward to better fit the favored mid-level thickness band for heavy snow. Details on using this technique can be found in Central Region Technical Attachment 88-36 (Naistat, 1988). The MSP prog is shown in Fig. 9. Note that the MSP Prog forecast considerably more snow over a much larger area than did the RGL.

6. What Really Happened

Two to five inches of snow did fall across much of central and northern Minnesota (see Fig. 10). Thus, the snowfall forecast by the MSP prog was correct in terms of amount; but was largely inaccurate in terms of location. The RGL failed on both counts. Of course, it's easy to bash the model, but the model is only there to give forecasters clues.

7. The MSP Prog--What Went Wrong

Recall that the MSP forecaster used the technique espoused in Central Region Technical Attachment 88-36. Unfortunately, this technique was designed for predicting heavy snow (amounts greater than six inches), and has far less accuracy in forecasting lesser snow events. Even if the B. J. Cook Snow Index (Cook, 1980) had been used, the forecast still would have been inaccurate. The reason for both techniques' failures was that the juxtaposition of the favored mid-level thickness and the 200 mb warm air advection did not occur in an area that was to become saturated or nearly so (say having a mean RH of greater than 90 percent). Thus, a key point learned from this is: WHEN USING CENTRAL REGION

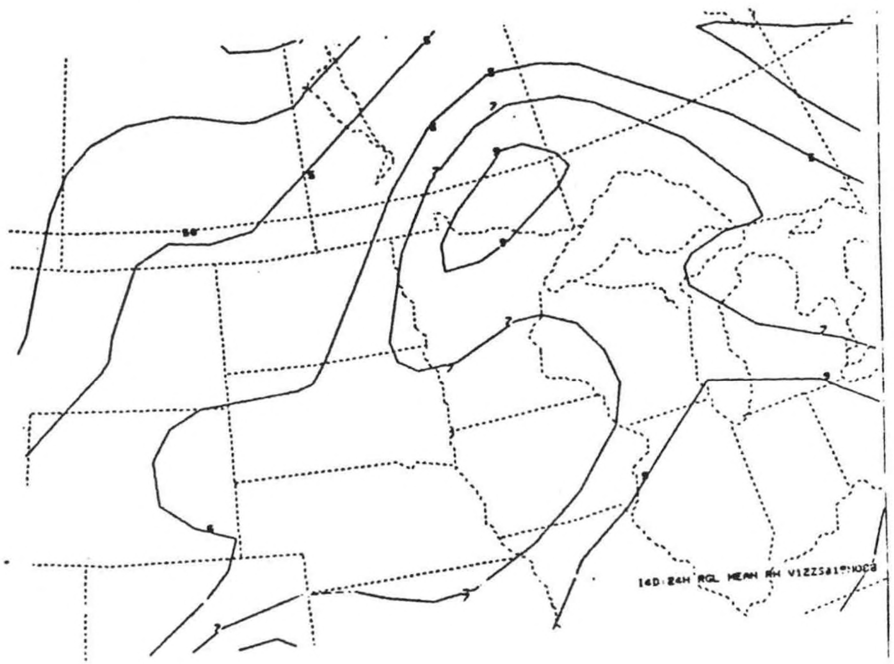


Fig. 6. 24-hr RGL mean relative humidity valid at 12Z, 11/19/88.

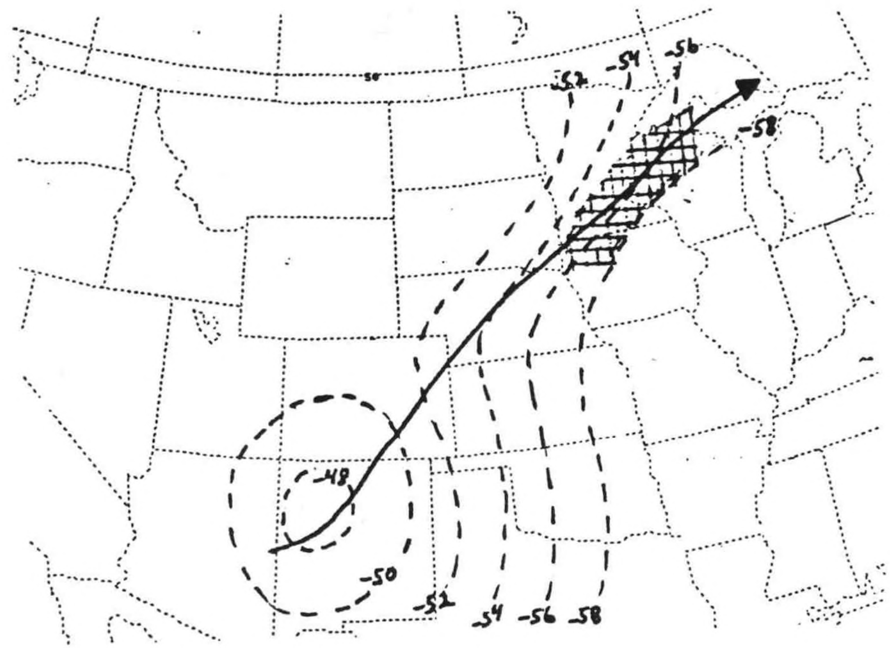


Fig. 7. 24-hr RGL forecast valid at 12Z, 11/19/88. 200 mb isotherms (dashed), a representative 200 mb streamline (arrow), and the 1520m-1540m mid level thickness band (cross-hatched).

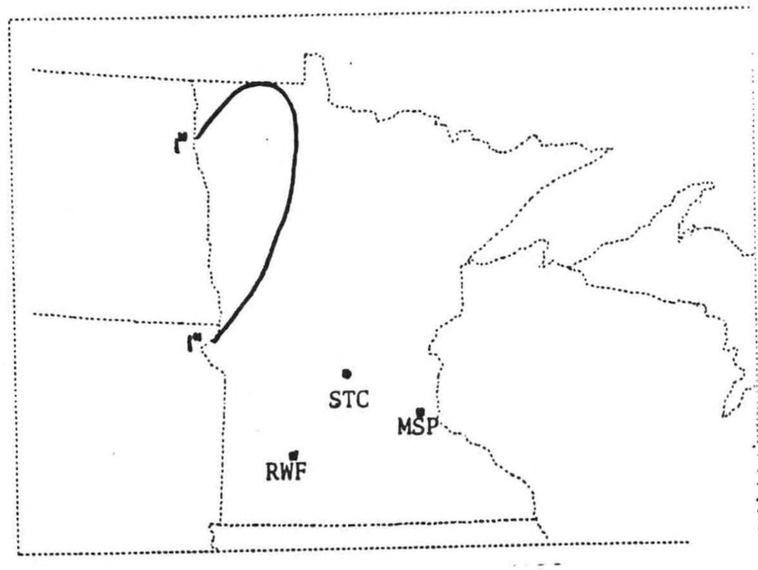


Fig. 8.
RGL snow forecast for 18 hours ending 18Z, 11/19/88.

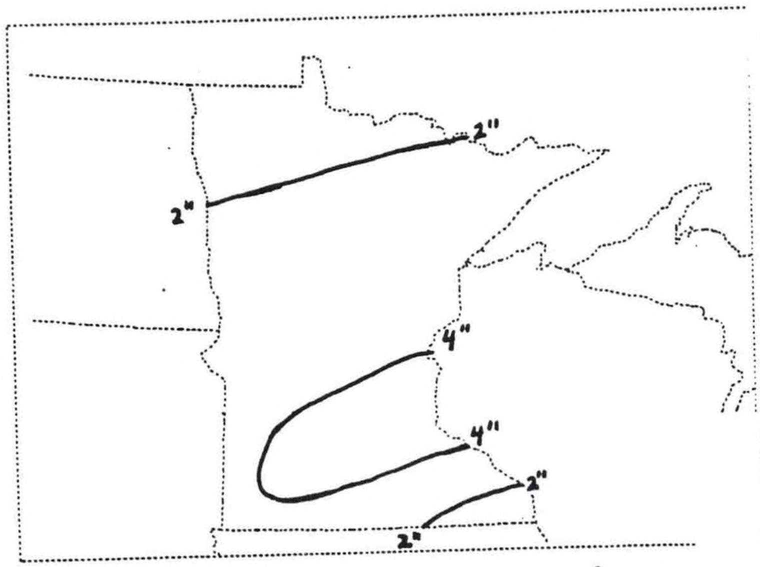


Fig. 9.
WSFO MSP snow forecast for 18 hours ending 18Z, 11/19/88.

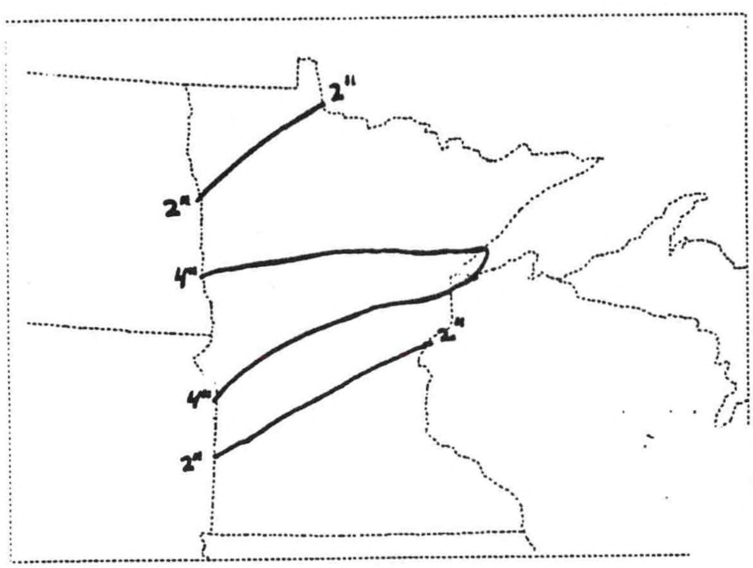


Fig. 10.
Observed snowfall for 18 hours ending 18Z, 11/19/88.

TECHNICAL ATTACHMENT 88-36 OR THE B. J. COOK SNOW INDEX, BE RELATIVELY SURE THAT THE TARGETED AREA WILL BECOME SATURATED (HAVING A MEAN MEAN RH GREATER THAN 90 PERCENT).

In this case, the forecaster was well aware that the RGL forecast the higher mean RH to occur only in central and northern Minnesota (see Figs. 4 and 6). However, the forecaster had been watching, on SWIS, the northward advance of Gulf of Mexico low level moisture induced stratus. Based on the stratus' movement (see Fig. 11) and the low level flow, the arrival of this abundant low level moisture supply in Minnesota after 00Z, November 19, seemed a certainty. This was in contrast to what the RGL "thought" would happen as discussed in sections 3 and 4.

The forecaster reasoned that given the RGL forecast of upward vertical motion over Minnesota and the addition of the low level moisture, not forecast by the RGL, that saturation would occur farther south than the RGL had forecast. Thus, saturation would happen in southern Minnesota, as well as central and northern Minnesota. Why this did not happen can be seen by examining isentropic cross sections. In the cross sections discussed below, keep in mind that the low level flow was basically from south to north (or left to right as you are viewing Figs. 12 and 13).

At 12Z, November 18, moisture was just arriving near OKC near the ground or close to or on the 288°K isentrope (see Fig. 12). If the air parcel were not saturated at this point, it would have moved upward along the isentropic surface. It would have reached the condensation pressure of 815 mb between OMA and STC, probably on the Iowa border south of RWF--IF the isentropic surface itself was stationary. However, this was NOT the case since the 288°K isentropic surface moved northward during the day. By 00Z, November 19 (see Fig. 13), the parcel originally near OKC would have reached the condensation level somewhat north of STC, rather than well south of it. Indeed, saturation did occur somewhat north of STC; the MSP prog had incorrectly guessed this would happen south of STC.

Admittedly, the forecaster had not used the 12Z, November 18, cross section. However, even if he had, the forecast would still have been wrong BECAUSE the isentropic surface moved northward during the ensuing 12 hours. However, the forecaster at issuance time (22Z, November 18) could not have known that by 00Z, November 18, the 288°K isentrope would have moved north. Such information would have significantly improved the forecast. Such information could be available if numerical model-based forecast isentropic cross sections were available to the field. Perhaps gridded model data sent to WSFO's combined with local application programs could produce such cross sections. Thus, a key point of this paper is this: ISENTROPIC CROSS-SECTIONS FROM NWP MODELS SHOULD BE MADE AVAILABLE TO FIELD FORECASTERS. Moore (1988) has detailed the need for this. The author presents this paper as additional documentation for this request.

Finally, another clue that would have kept the forecaster from forecasting snow south of St. Cloud was not assessed properly. The 12-hour RGL valid for 00Z, November 19, forecast a weak vorticity maximum to move northeastward into eastern South Dakota. SWIS and radar loops hinted during November 18 that this

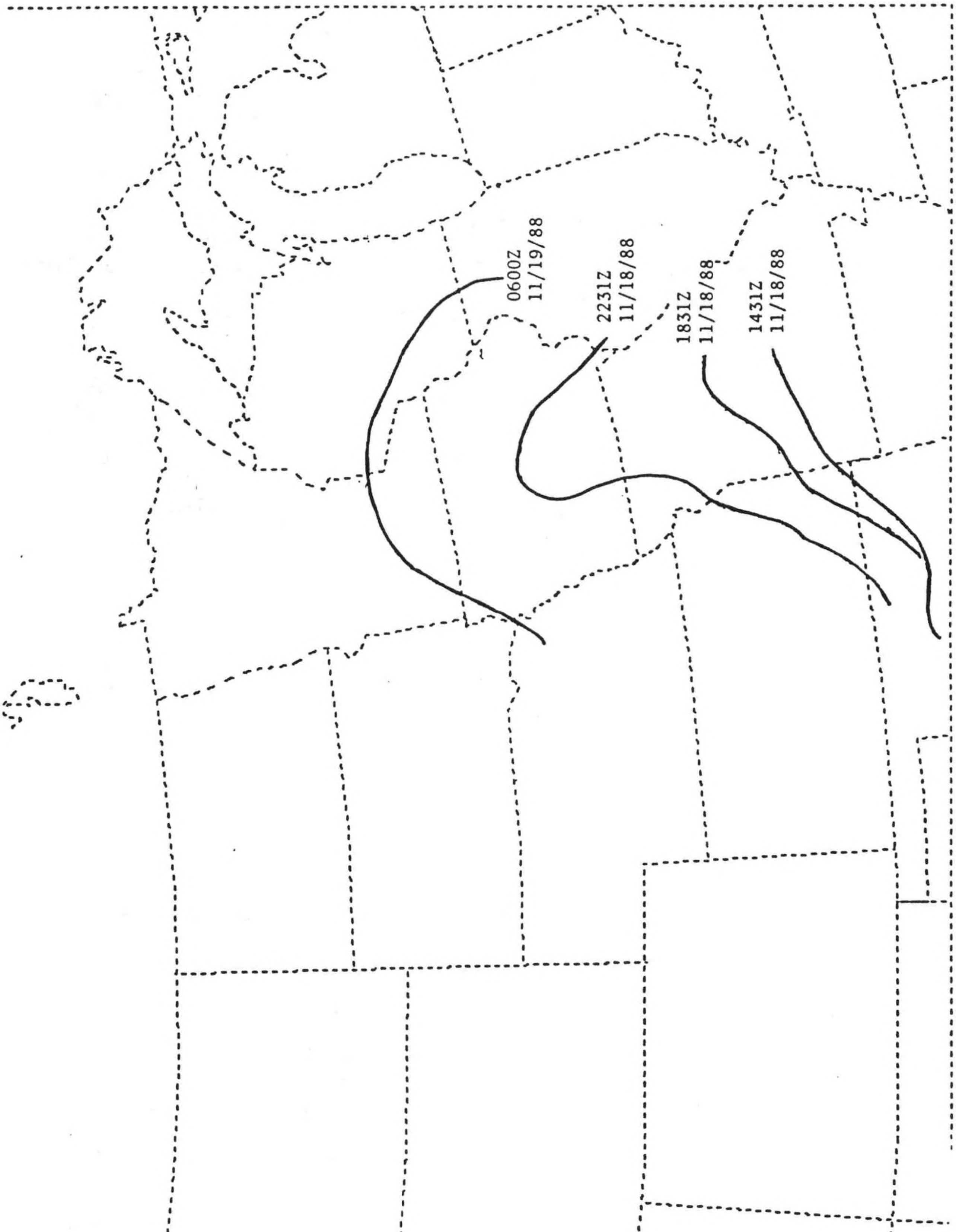
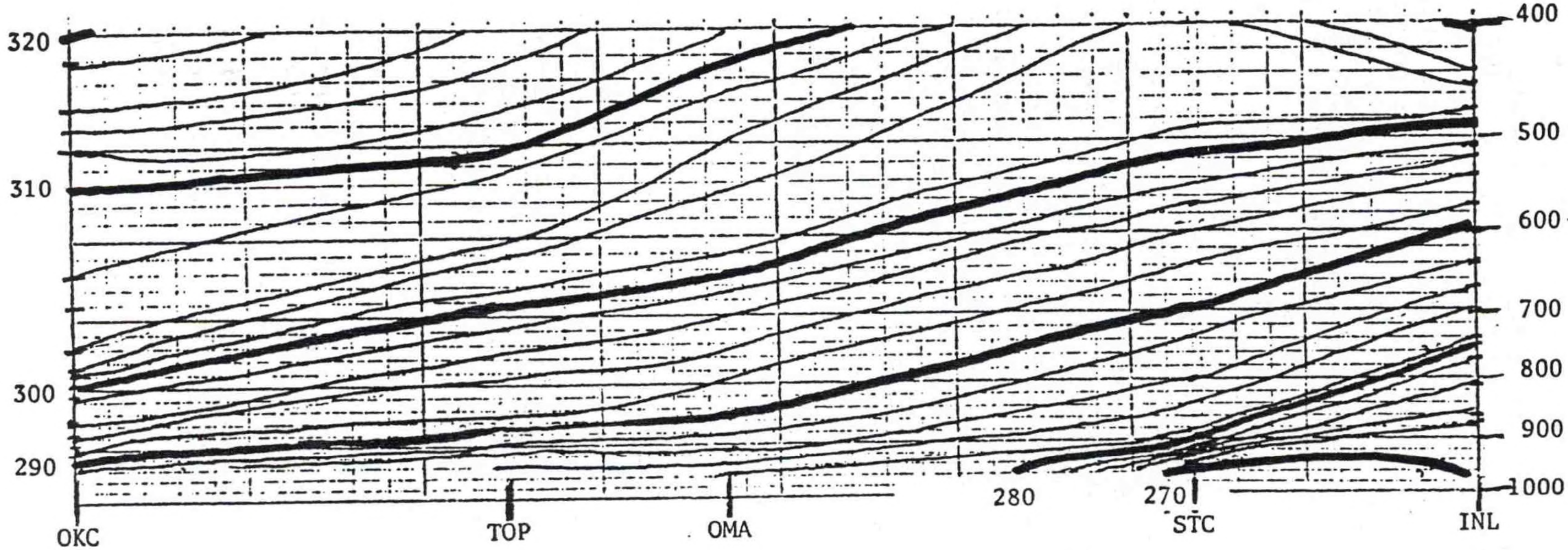


Fig. 11. Isochrones of the leading edge of Gulf of Mexico moisture induced stratus, constructed from SWIS images.



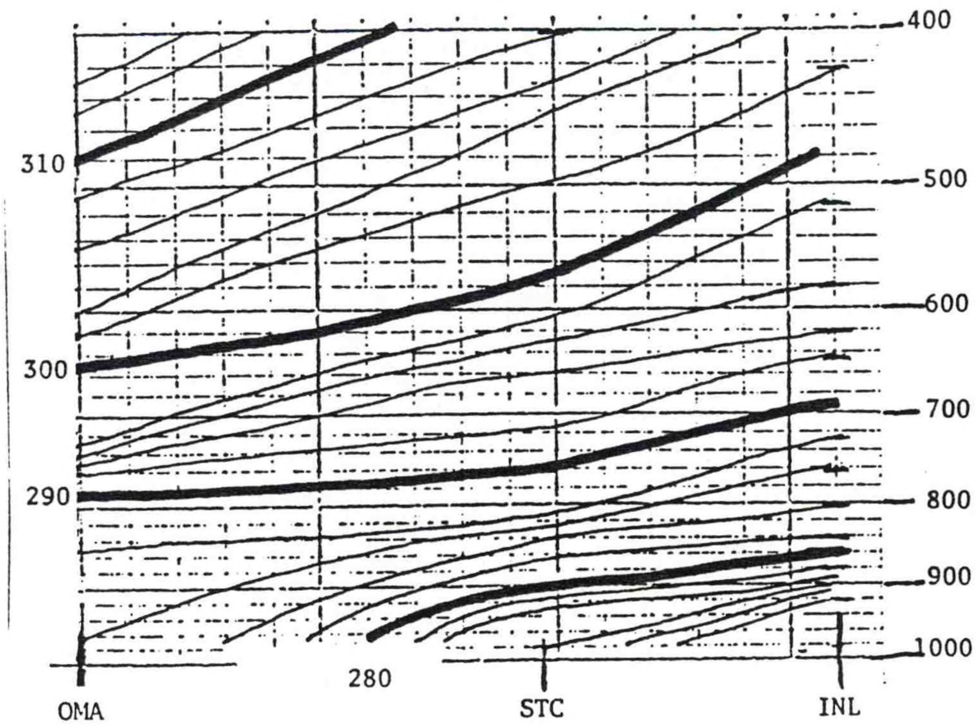


Fig. 12. (above). Observed cross-section OKC-TOP-OMA-STC-INL for 12Z, 11/18/88. Isentropes in degrees K (solid lines, with multiples of 10 degrees in bold lines).

Fig. 13. (right). Observed cross-section OMA-STC-INL for 00Z, 11/19/88. Isentropes in degrees K (solid lines, with multiples of 10 degrees in bold lines).

vorticity max did exist. Goree and Younkin (1966) have shown that significant snowfall often occurs downstream and 2.5 degrees latitude to the left of the 500 mb vorticity maximum track. The converse is quite possibly true: sinking occurs to the right of the track of the vorticity maximum. (See Weldon, 1983 for an excellent discussion on this.) So, in this case, the South Dakota vorticity maximum could well have been counted on to cause a dry slot to push into southern Minnesota; this should have suggested that snow would not occur south of St. Cloud. Thus, another key point is this: IF AN NWP MODEL, PARTICULARLY THE RGL, SHOWS A DRY SLOT FORMING TO THE RIGHT OF A VORTICITY MAX THAT CAN BE CONFIRMED BY SWIS OR RADAR LOOPS, BELIEVE IT. DON'T EXPECT ADDITIONAL MOISTURE TO EASILY SATURATE THE DRY SLOT.

8. Summary

Care should be taken in subjectively modifying NWP forecasts. In the forecast challenge presented in this paper, the forecaster attempted to subjectively add low level moisture to the RGL forecast for Minnesota. In doing so, the forecaster improved measurably over the RGL in the precipitation volume, but the location was to a large extent inaccurate. Even if the observed cross section had been used, the location of the snowfall would still have been inaccurate. Had the forecaster believed in the RGL forecast dry slot moving into southern Minnesota, then he could have eliminated that part of southern Minnesota from the snow forecast; in essence getting both the location and amount of precipitation correct. The correct modification to the RGL probably would have been much more apparent, if access to NWP forecast isentropic cross sections had been available to field forecasters. Hopefully, this paper serves as a document for that need.

9. References

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