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SOME PITFALLS IN PATTERN RECOGNITION FORECASTING

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1. Introduction

Two Fall 1988 upper Midwest snowstorms are examined to illustrate the pitfalls one can encounter when great emphasis is placed on synoptic pattern recognition; the first case proved to be just such a trap for the author. It is shown that when a given synoptic pattern displays (or conversely fails to display) key signatures associated with various events (i.e., heavy snowfall, severe thunderstorms, or cyclogenesis), a type of forecaster psychology (or mind set) may develop that sharply undermines an individual's ability to interpret new data and analyses objectively. This phenomenon can be termed pattern recognition syndrome. The forecast that is issued in these instances is usually some variation of the pattern the forecaster feels has been identified. The forecast results in these instances, all too often, come up far short of what was anticipated.

In the two situations reviewed, an examination of current and forecast low level moisture and temperature profiles would have alerted one that an "exception to the rule of thumb" was in the making. It is suggested that routine lower tropospheric analysis during snowfall situations may put a forecaster within reach of some very satisfying long shots.

2. Case 1

The synoptic situation of October 28, 1988, provides an exceptionally good example of how the atmosphere sometimes presents us with a seemingly easy "straight out of the book" forecast challenge. Oftentimes, however, the issued forecast often ends up being a complete disaster. In this particular situation, exceptionally strong dynamics proved to be the bait the forecaster could not resist.

The upper level charts and numerical model output on the morning of October 28, 1988 (through 9:30 a.m. CST) seemed to embody every feature one associates with heavy snowfall. The 500 mb chart (Fig. 1) showed a 150 meter 12 hour height fall center (HFC) over Bismarck. The continuity of this feature suggested it was transiting the long wave trough and would bottom out over

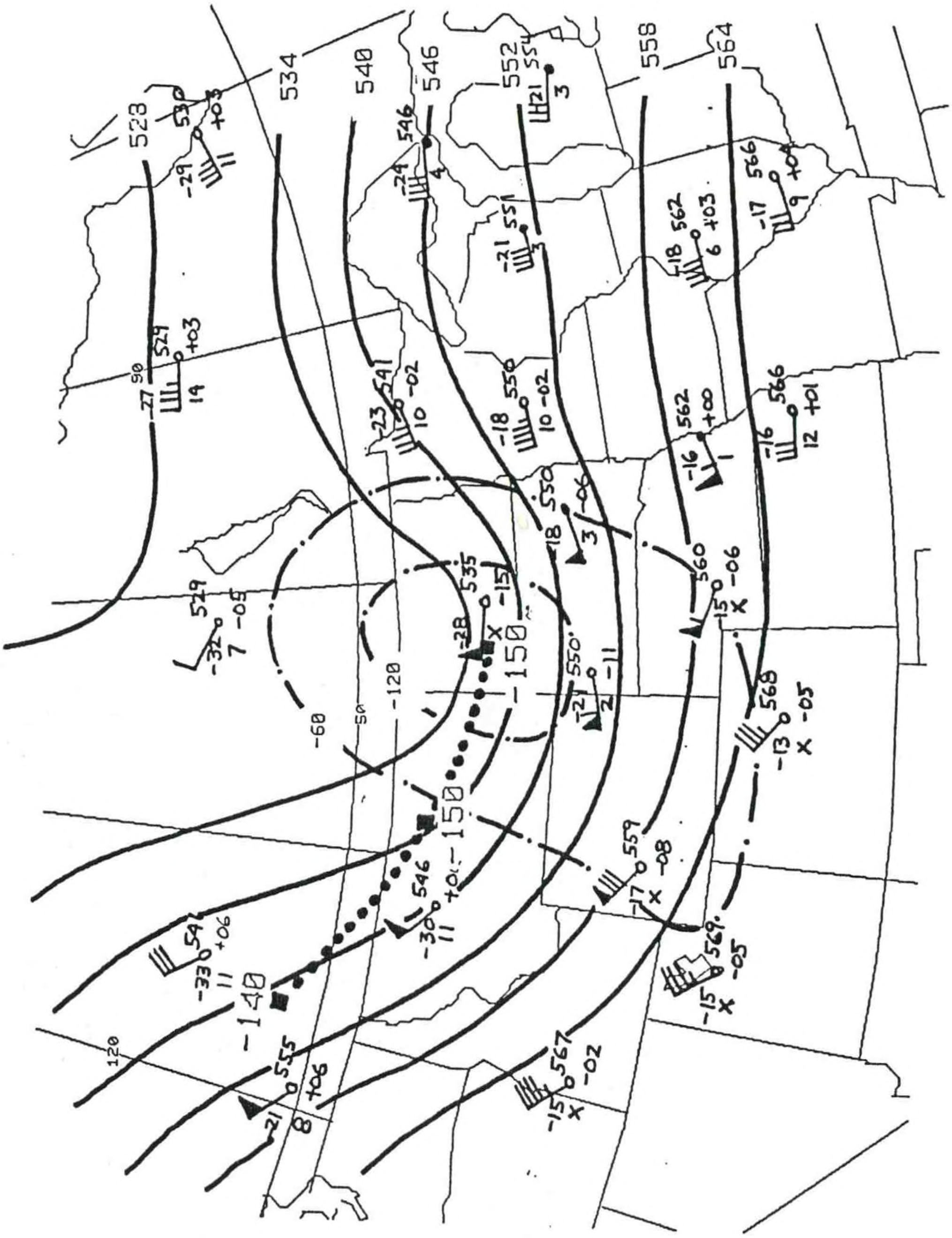

Fig. 1. 500 mb analysis for 1200GMT October 28, 1988. Solid lines - geopotential, dash-dotted - 12 hour height tendancy. Heavy boxes locate the 12 hour height fall center (HFC) locations with heavy dots providing continuity over previous 24 hours.

central Minnesota during the next 12 to 18 hours. Case studies by Weber (1979) show an affinity for significant snowfall just north of the path of the 500 mb HFC.

At jet stream level (300 and 250 mb charts not shown), the flow crossed strongly toward higher pressure west of the trough axis suggesting further deepening. Furthermore, northeast Minnesota was in the right rear quadrant of a downstream speed maxima at 300 mb. All this suggested an intensification of upper level trough and associated vorticity maxima. In situations like this, the mid-tropospheric vorticity maxima usually intensifies and drops sharply southeast.

Numerical model output seemed to confirm the above reasoning too. The 500 mb forecast for 0000 GMT, October 29 (NGM 24 hour prog not shown) placed a vorticity maxima of 26 near St. Cloud. However, the LFM 12 hour 500 mb forecast proved to be the final straw in terms of making a decision about the forecast. The normally weaker LFM placed a 24 vorticity maxima over the same location. The heavy snow and vorticity path relationships of Goree and Younkin (1966) came to mind and a winter storm warning for northeast Minnesota was confidently issued.

During the first few hours of the warning, hopes for verification were kept alive as a rain and snow mixture developed at Duluth. By 1:00 p.m. CST, Duluth returned to all rain and it then became apparent that the air mass over northeast Minnesota would remain too warm for snow. It also became obvious with time that dynamic cooling would not change the precipitation back to snow so the warning was dropped.

Later in the afternoon, just prior to afternoon zone forecast issuance, coordination with the Milwaukee forecast office revealed that they would be issuing a snow advisory for northern Wisconsin. Interestingly, the same reasons used only hours earlier for the busted northeast Minnesota forecast were used to lend support for the Wisconsin snow advisory. Clearly, it is not easy for many forecasters to pull back from a synoptic scenario once they have "locked in" on it, even after contradictory evidence is presented. This is pattern recognition syndrome in action, and it may explain many of the forecasts that bust. It provides the answer to the often asked question that follows a poor forecast: "Why didn't I see that?" The answer, of course, is that data that conflicts with a given synoptic scenario is easier to disregard than data that reinforces the forecaster's thinking.

3. Case 1: A Reevaluation

An examination of low level thermal and moisture fields on the morning of October 28, 1988, would have revealed that heavy snowfall was all but impossible for northeast Minnesota, irrespective of dynamic cooling considerations. A graphical approach to examining the thermal field during snow situations is provided by Umpenhoffer (1968). The mid-level (850-700 mb) and low level (1000-850 mb) thickness fields[1] are displayed in Figures 2a and b, respectively. Thickness lines were obtained by graphical subtraction of the AFOS height analyses.

The mid-level thickness analysis shows the favorable 1520 to 1540 meter heavy snow thickness band extending east of International Falls along the international border. This area is east of the thickness ridge and is, therefore, in a region of warm advection. Moreover, the orientation of thickness lines with respect to the closed 850 mb circulation over northwest Minnesota dictates a northeast track for the 850 mb low according to Sutcliffe's thermal steering term (Haltiner and Martin, 1957). In as much as heavy snow seldom falls south of the 850 mb low track, northeast Minnesota is virtually removed from such a threat. The low level thickness chart (Fig. 2a) provides additional evidence of the poor heavy snow potential for northeast Minnesota. The 1300 meter thickness, used as a rain-snow delineator, has pushed north of the area into Canada.

While the thickness analyses are useful in locating areas for heavy snow potential or the rain-snow line, only an examination of the lower tropospheric wet bulb structure really confirms the analysis. The St. Cloud and International Falls RAOB's (Figs. 3a and b) provide a reasonable framework for interpolating the wet bulb sounding across northeast Minnesota. It is seen that only near International Falls is the structure cold enough to maintain snowfall (this in the absence of further advective warming). This reasoning is confirmed by the snowfall analysis in Fig. 4 as the four inch contour cuts just south of International Falls.

A second snow case is reviewed in the following section. This case also illustrates a situation where pattern recognition proved to be misleading, but in this case, a seemingly benign situation yielded considerable snowfall over Minnesota. Happily, forecasters working on this day did not fall into the pattern recognition trap and anticipated a tricky snowfall over Minnesota.

4. Case 2

The snowfall of November 12, 1988, is perhaps one of the more pronounced examples of a misleading initial synoptic structure. In this case, most rules of thumb on snow forecasting all failed simultaneously. Figures 5a through f display familiar AFOS panels for the surface, 850 and 700 mb levels for both 0000 and 1200 GMT on November 12, 1988. These panels provide an effective summary of this synoptic situation. Twelve hour changes at each level can be viewed by scanning the figures from left to right.

Of particular interest in Fig. 5a is the initial location of the 540 thickness, a reference thickness that is often effective in separating rain and snow areas. The far northward position of this thickness together with the warm

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1 The 1000 mb height field can be estimated using the hypsometric equation and assuming the 1000 mb isobar on the surface chart is the 0 meter isoline. Then every 8 mb change in surface pressure is approximately a 6 meter change in height.

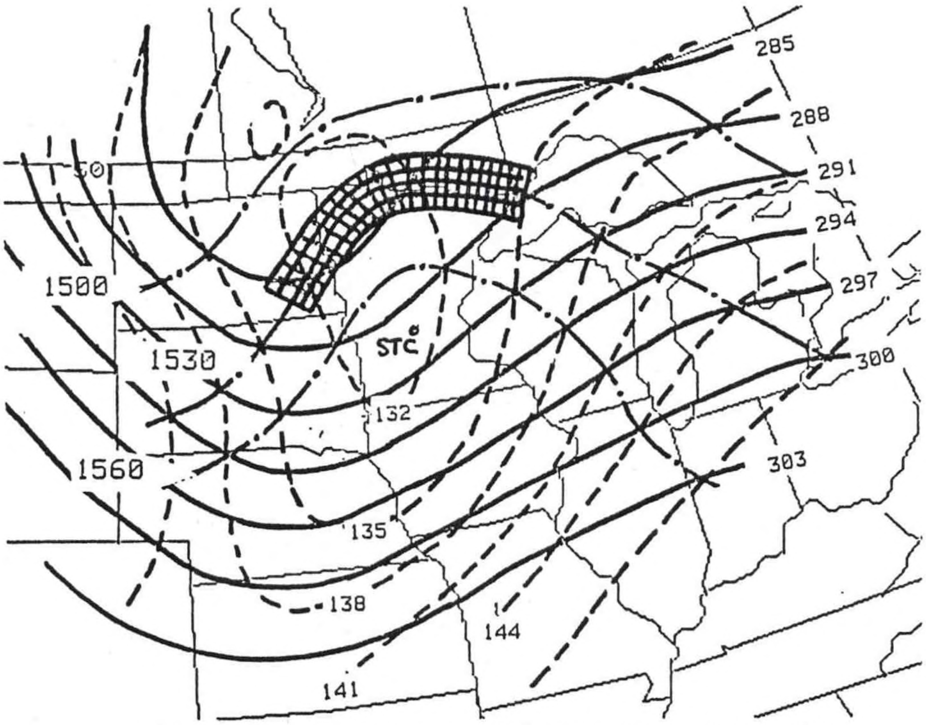

Fig. 2a. Middle-level thickness (700-850 mb) analysis for 1200 GMT October 28, 1988, obtained with graphical subtraction. Solid lines are 700 mb geopotentials and dashed lines are 850 mb geopotentials. Thickness lines are displayed as dash-dotted lines. The hatched area covers favorable 1520 to 1540 meter "snow" thicknesses.

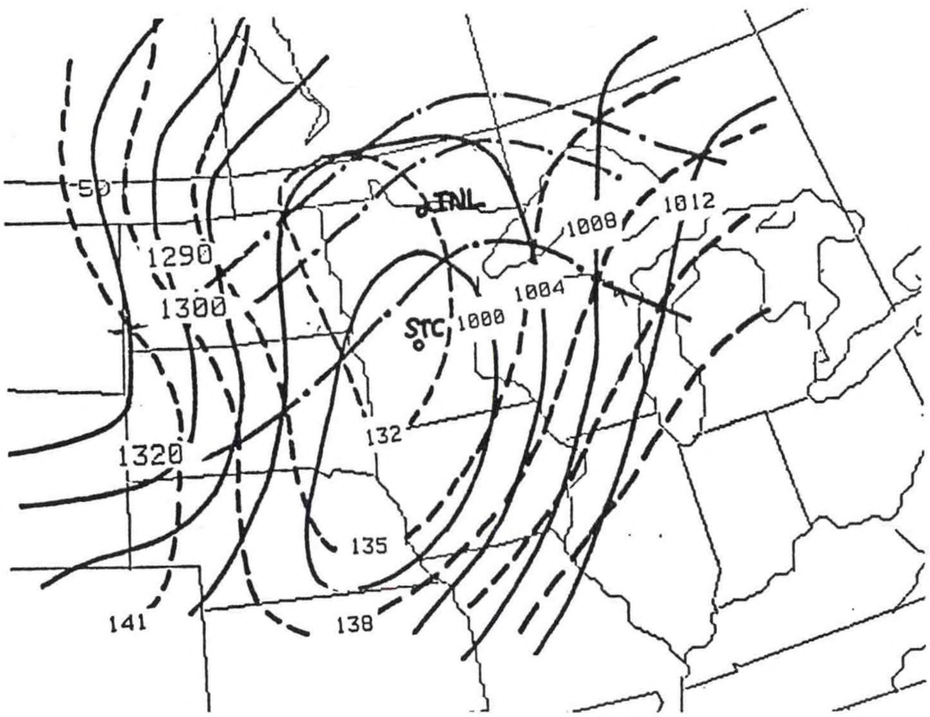

Fig. 2b. Low-level thickness (850-1000 mb) analysis for 1200 GMT October 29, 1988, obtained with graphical subtraction. Solid lines are surface isobars and dashed lines are 850 mb geopotentials. Thickness lines are displayed as dash-dotted lines.

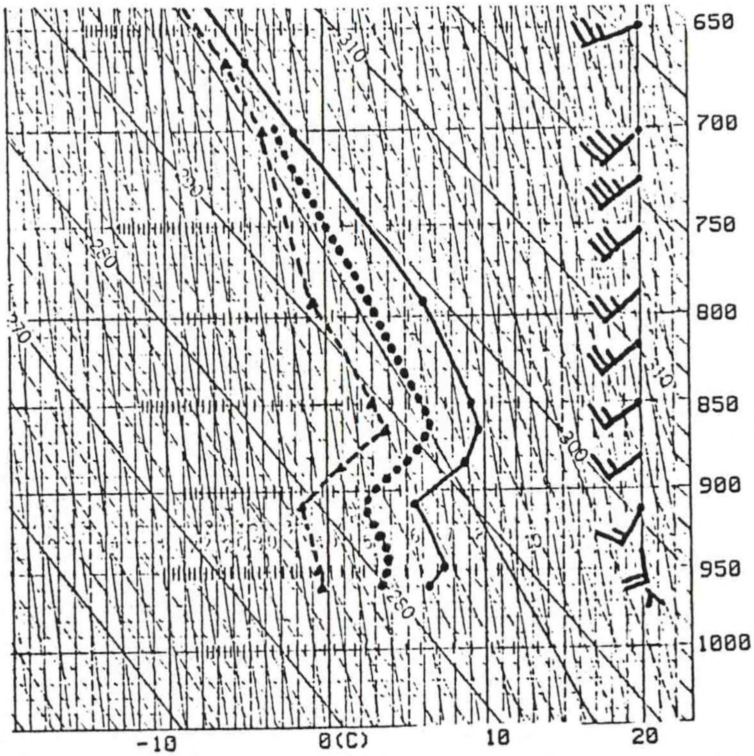

Fig. 3a. Saint Cloud raob for 1200 GMT October 28, 1988. Dotted line refers to wet bulb sounding.

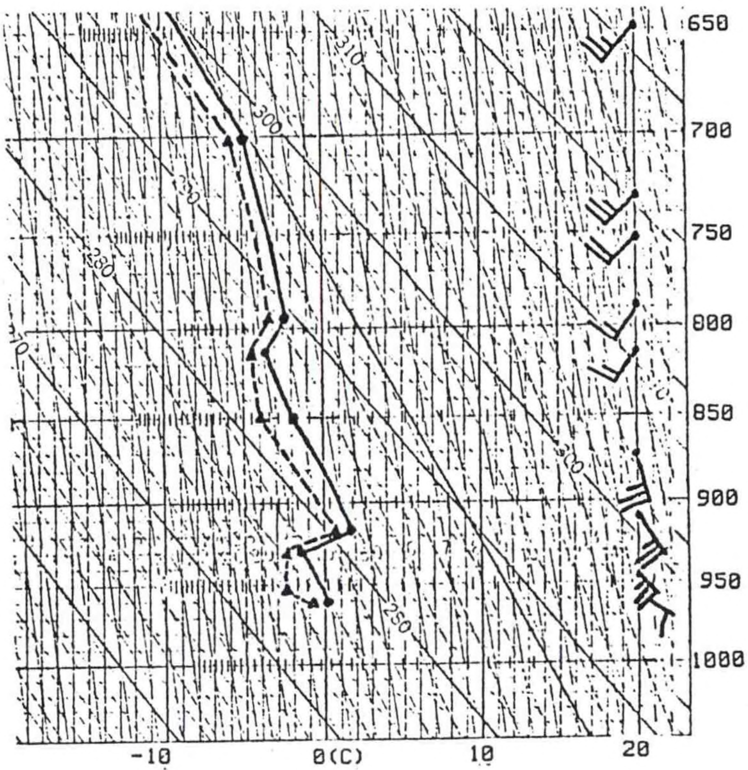

Fig. 3b. International Falls raob for 1200 GMT October 28, 1988.

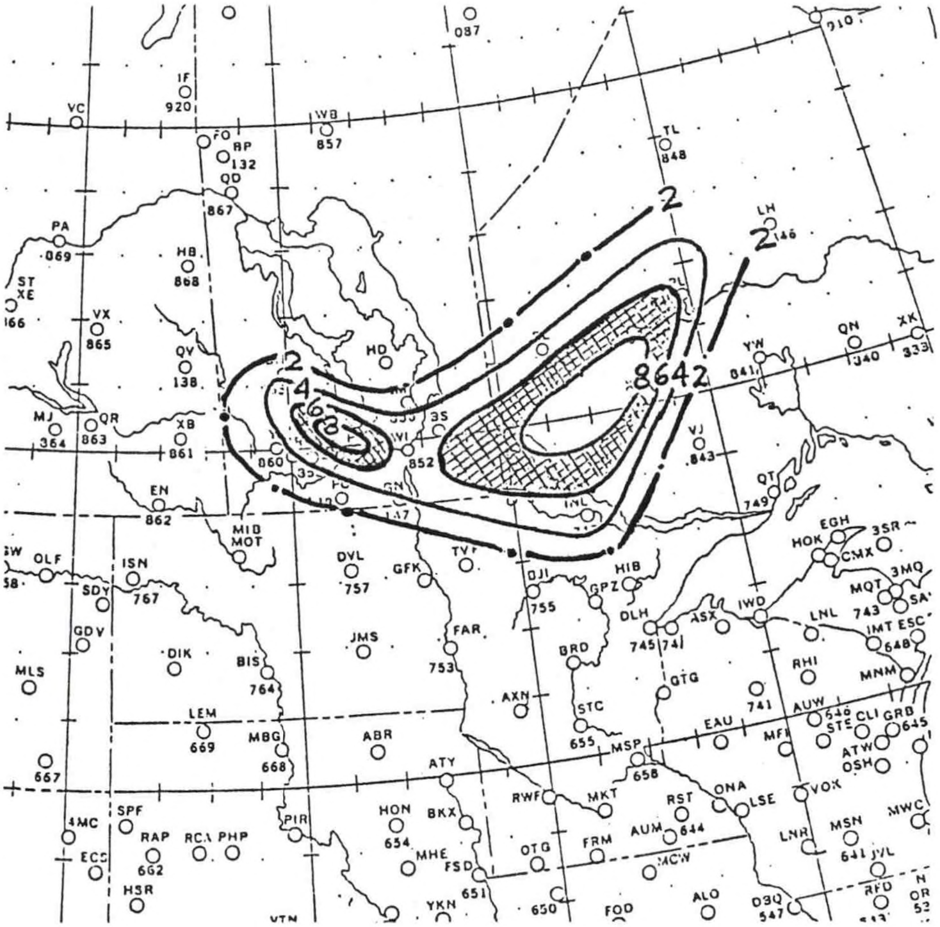

Fig. 4. Snowfall (inches) for October 28, 1988.

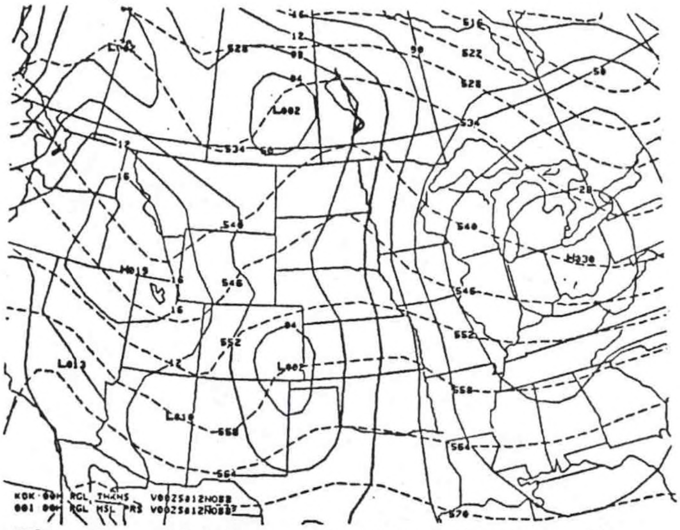

Fig. 5a. Thickness (1000-1500 mb) and surface isobars for 0000 GMT November 12, 1988.

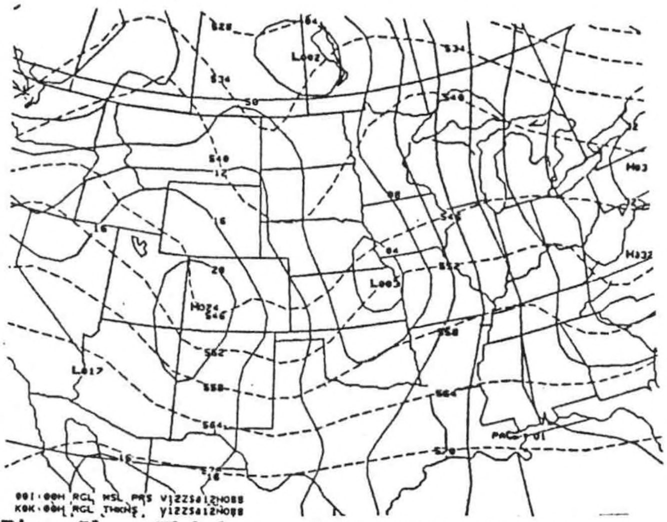

Fig. 5b. Thickness (1000-500 mb) and surface isobars for 1200 GMT November 12, 1988.

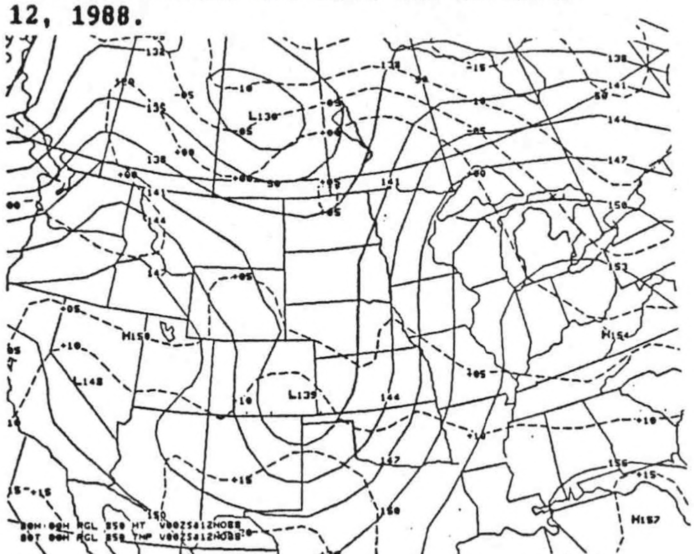

Fig. 5c. 850 mb analysis (geopotentials as solid coutours and isotherms as dashed) for 0000 GMT November 12, 1988.

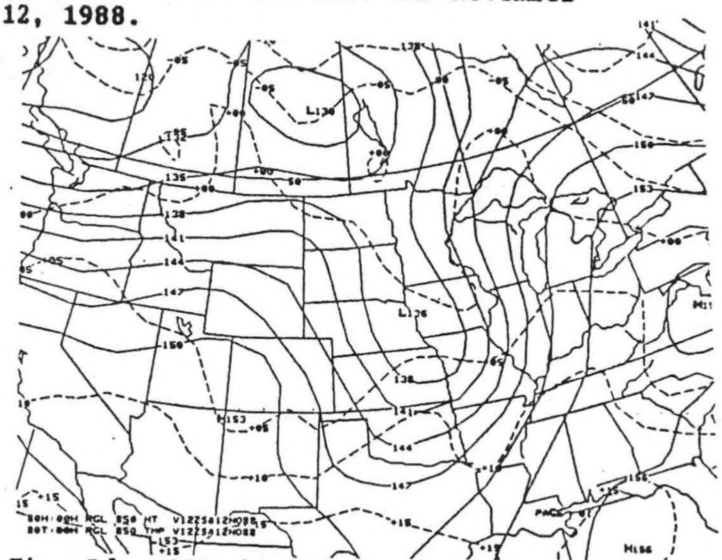

Fig. 5d. 850 mb analysis (geopotentials as solid coutours and isotherms as dashed) for 1200 GMT November 12, 1988.

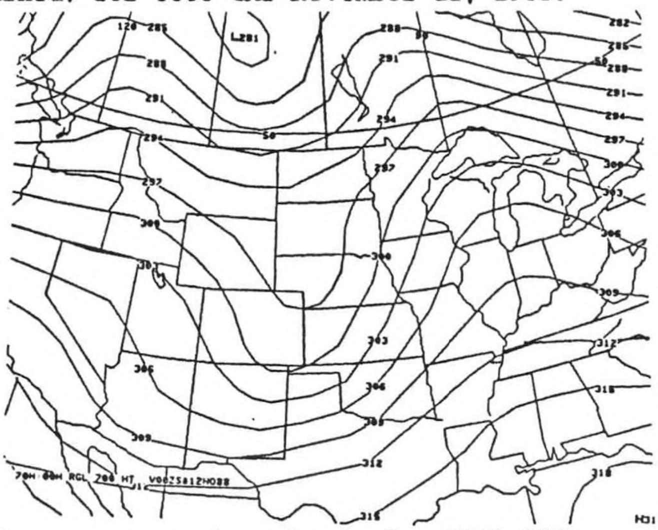

Fig. 5e. 700 mb analysis for 0000 GMT November 12, 1988.

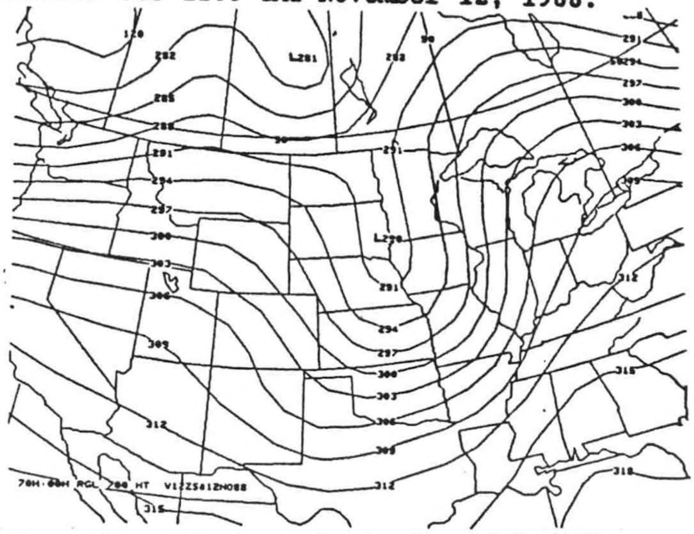

Fig. 5f. 700 mb analysis for 1200 GMT November 12, 1988.

advection across the area imply an impending rain event for most of Minnesota. The 850 mb analysis (Fig. 5c) throws even more doubt on the chance for snow over the area as the zero degree isotherm is located well north of the international border. In addition, the main area of implied lift is along a warm front that extends east of a closed low over central Saskatchewan.

The pattern does look favorable for precipitation as a sharp 700 mb trough is evident west of the region (see Fig. 5e). However, the first impression, or pattern recognition derived forecast one would obtain from these charts is one of widespread rainfall over the upper Midwest.

Figures 5b, d and e show the 1200 GMT November 12, 1988, surface, 850 and 700 mb charts, respectively. Of special interest is the zero degree isotherm for the 850 mb chart in Fig. 5d. Note how this isotherm now drops south of Canada across Minnesota. The cooling is probably accomplished by both evaporation and synoptic scale rising motion with evaporative cooling the primary contributor. In this case, evaporative cooling probably helped change an apparent rain event into a significant snowfall for Minnesota (see Fig. 6).

The dramatic 12 hour change that took place over central Minnesota in the lower tropospheric structure is graphically depicted in portions of St. Cloud RAOB's shown in Figures 7a and b. Note how the final thermal structure in Fig. 7b was essentially diagnosed by the initial wet bulb sounding in Fig. 7a. Obviously, the trick in these situations is to anticipate when and where cooling due to evaporation and synoptic scale rising motion will eventually balance any warm advection. Once this is determined, it becomes possible to lay out a rain-snow axis and attempt to forecast snowfall amounts.

It should be noted that the snow forecasting technique of Umpenhoffer proved to be ill-conditioned to the snow situation of November 12, 1988. The main problem area with Umpenhoffer's technique rested not so much with any failure of the technique, per se, but with the synoptic model upon which it is based. A brief discussion of this model is important to clarify this point.

The typical Midwest snowstorm features sharp low level baroclinity that can be distinctly portrayed as a thickness wave or thickness ribbon as termed by Umpenhoffer. The prime area of lift within such a structure is across the thickness ridge upwind (in a thermal wind sense) to a point of inflection in thickness curvature. The hatched area shown in the middle level thickness field (Figure 2a) depicts the prime lift area as described above. See Umpenhoffer (1968) for additional details.

The November 12, 1988 snowstorm not only displayed thicknesses that were too warm for snow over Minnesota, but also featured an essentially barotropic structure. Baroclinity on both middle and lower level thickness charts was situated over southern Canada very close to the 850 mb warm front noted in Figure 5c.

However, an assumption that vertical motion would be lacking over Minnesota on November 12, 1988, based on low level thickness arguments, would have proved completely erroneous. The lift in this synoptic situation is best viewed from an isentropic framework. However, in the absence of these charts, the reader

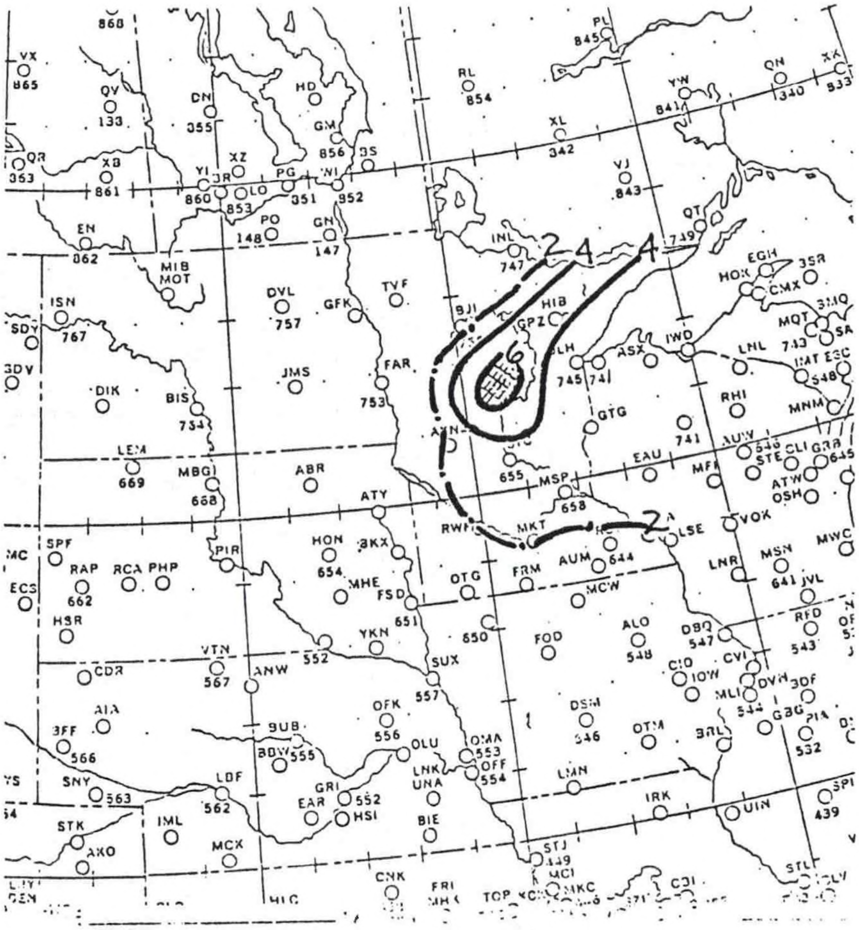

Fig. 6. Snowfall (inches) for November 12, 1988.

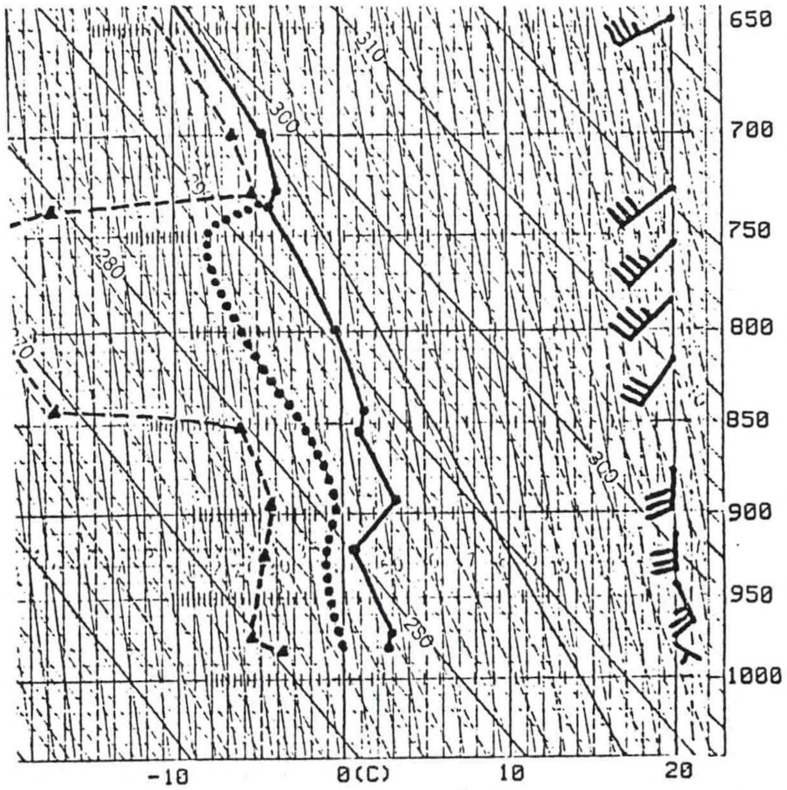

Fig. 7a. Saint Cloud raob for 0000 GMT November 12, 1988. Dotted line refers to wet bulb sounding.

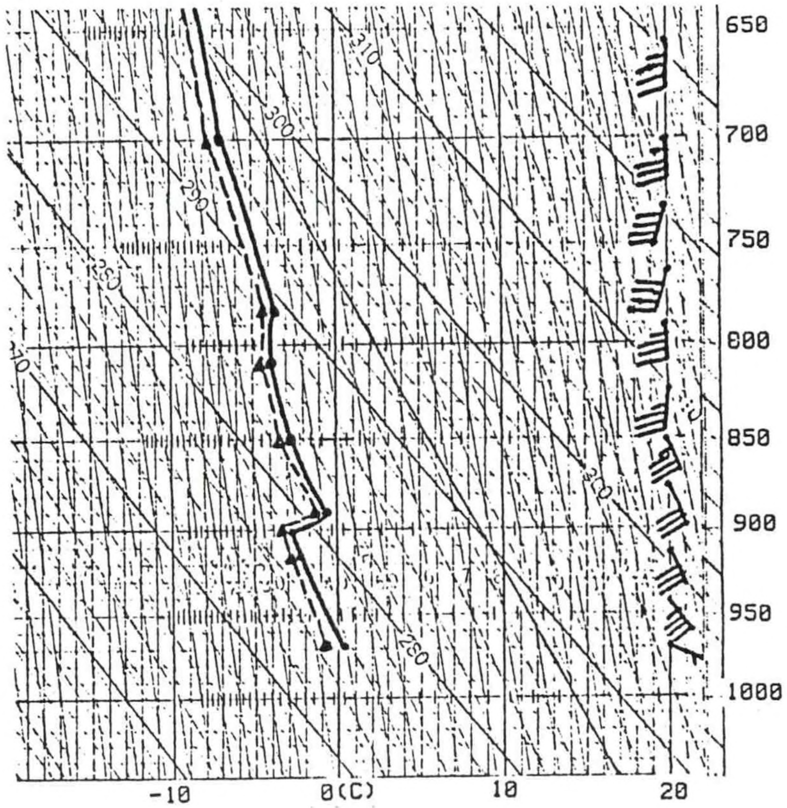

Fig. 7b. Saint Cloud raob for 1200 GMT November 12, 1988.

can still get a reasonable "feel for the situation" by once again reviewing Figures 5a through f. In the context of these figures, vertical motion is clearly evident as noted by the strong 850 mb warm air advection for trajectories from central Texas into the upper Midwest.

As mentioned previously, the NGM's forecast for low and middle level thickness fields did appear too warm for snowfall over Minnesota. However, the FRHT67 bulletin did indicate a close call. The T1T3T5 model output for MSP indicated marginal cooling below freezing through 1200 GMT on November 12, 1988. In addition, a vertical motion peak of 6 microbars per second was forecast during the night. This, together with a precipitation forecast of 0.44 inches through noon the following day, would have given a forecaster confidence in expecting strong evaporative cooling.

In spite of some conflicting numerical prediction output and an initial synoptic structure that suggested rain, forecasters at MSP did not succumb to pattern recognition syndrome. By evaluating various factors independently and not relying solely on any ill-conceived conceptional models, they were able to piece the forecast puzzle together. Their understanding of the synoptic situation was clearly evident in the state forecast discussion (SFD) issued at 0319 GMT on November 12, 1988:

> ITS A TOUGHIE ALL RIGHT. 02Z SFC WET BULB CHART SHOWS SFC WET BULB TEMP BLO FRZG NE OF A LINE FROM AXN TO FRM. PSEUDO AND DYNAMIC COOLG SHUD COOL THE AMS TO BLO FRZG GENLY NE OF THIS LINE. HIER TERRAIN CONSIDERATIONS ALSO SUG PSBL RIPS MIXTURE SW OF THIS LINE. SO WX ADVISORY FOR ALL OF MN. INDICATIONS OF WHAT IS/CUD HAPPEN SEEN ON REMOTE OF HON RADAR WITH VERY HI REFLECTIVITY LVLS (PROBABLY ALFT) INDICATING SLEET ALOFT. 12D FROM THE 12Z RUN OF THE RGL WAS RIGHT ON THE MONEY IN TERMS OF SAT IMAGERY. UNQUALIFIED POPS FOR THE REST OF TNGT S HALF WITH HI POPS FOR NRN MN ALSO. GIVEN STG MOISTURE INFLUX AT H8 AND H7 AT 00Z AND MASSIVE WAA AT H2 (ALA B.J. COOK) WE HAVE TO THINK DECENT SNOW CUD FALL IN THE NC AND NE.

5. Summary

Two Fall 1988 upper Midwest snowstorms are used to illustrate the grief forecasters can bring on themselves through overemphasis on simple conceptional forecast models. The concept of pattern recognition syndrome is introduced to describe how forecasters sometimes cripple their objectivity in a given forecast situation because of preconceived notions on various synoptic, pattern signatures. It is suggested that pattern recognition syndrome may explain numerous missed forecasts and is probably a major obstacle preventing most of us from improving.

6. References

Goree, P. A., and R. J., Younkin., 1966: Synoptic climatology of heavy snowfall over the central and eastern United States. Mon. Wea. Rev., 94, 663-668.

Haltiner, G. J., and F. L. Martin., 1957: Dynamical and Physical Meteorology. McGraw-Hill Book Company Inc., New York, NY, 470 pp.

Umpenhoffer, C. M., 1968: Low level thickness charts. Det. 42, 7th Weather Wing (MAC), Kansas City, Missouri. Unpublished report available from National Severe Storms Forecast Center, Kansas City, MO 64106.

Weber, E. M., 1979: Major Midwest Snowstorms. Technical Note 79-2, Third Weather Wing, Offutt AFB, NE 68113, 95 pp.