FORECASTING

THE POSSIBLE INFLUENCE OF AN EXISTING SNOW FIELD ON THE TRACK OF A SURFACE LOW PRESSURE CENTER—A CASE STUDY

By Todd R. Morris (1)

NOAA/NWSFO
Milwaukee, WI 53207

ABSTRACT

One of the challenges for meteorologists who deal with winter storms is accurately forecasting the position and track of the surface low-pressure center. This can help determine not only precipitation type but also where the greatest amount of precipitation will fall. A case study was examined which fit an "old and unwritten" rule of thumb. This theory is that the surface low-pressure center will track along the southern edge of an existing snow field. The case study fit perfectly, physical reasoning is included, and further investigations are encouraged.

1. INTRODUCTION

The forecaster, in making a forecast, is always interested in the position and track of the surface low-pressure center (SLPC). It is one of the key elements in determining precipitation type and, more importantly, where the greatest amount of precipitation, be it rain or snow, will fall (Goree and Younkin, 2) (Weber, 3). Many atmospheric factors play a role, either directly or indirectly, in the eventual SLPC track. Some obvious or well-known ones include the forecast position and orientation of the 500-mb Low or trough, the location and track of the 500-mb height-fall center (HFC), the location of the jet stream, and the strength and orientation of the low-level thermal pattern, to name a few. Another possible, but less obvious, factor is the influence of an existing snow field.

2. BACKGROUND AND CONCEPT

An existing snow field, if large enough, will not only have a cooling effect on surface temperatures directly over the snow but also a short distance downstream and even further aloft. This is seen many times when warm air, at the surface, blows over a snow field with little effect on temperatures or where temperatures are cooled or modified by upstream air blowing over a snow field. The effect on temperatures in the vertical can be seen on an isentropic cross section. To conserve potential temperature, a cross section will typically show a cold dome directly above a snow field (Moore, 4) if the snow field is influencing the airmass immediately above ground. This effect can sometimes even be identified by close examination of temperatures at 850 mb. Here, a cold pool also will be evident directly over a snow field.

This influence of a snow field on the track of a SLPC appears to be the greatest when the low-level thermal gradient is relatively weak. This allows the snow field (or the cold air over it) to enhance what thermal boundary already exists.

It is widely accepted in the meteorological community and has been proven physically, using the Omega Equation, the theory of Dines Compensation, and the Pressure Tendency Equation (Pettersen, 5; Holton, 6; Zwack and Babin, 7), that the SLPC will most often favor a track right along the best thermal boundary. This study examines the track of a SLPC along the edge of a snowfield.

3. CASE STUDY—DECEMBER 19–20, 1987

Figure 1 depicts: (a) The NMC 500-mb trough positions 24 hr before the event, 1200 UTC 18 December 1987, and (b) The Nested Grid Model (NGM) forecast trough positions for 24, 36, and 48 hr., valid 1200 UTC 19 December, 0000 UTC 20 December, and 1200 UTC 20 December, respectively. Synoptically, one short-wave trough is forecast to push into the Pacific Northwest and across the Rockies while a second short-wave trough pushes eastward out of the southwest United States. The northern short-wave trough is forecast to become the dominant long-wave trough while the second southern short-wave trough ejects northeastward across the mid-Mississippi Valley into the Great Lakes.

Figure 2 depicts: (a) The NGM forecast 500-mb HFC track through 48 hr beginning with 1200 UTC 19 December and (b) The NGM forecast SLPC track through 48 hr. The forecast 500-mb HFC's were not readily available and had to be calculated manually for all RAOB sites east of 110°W and west of 80°W.

The overall forecast package was a reasonable solution given the concept that the SLPC most often tracks parallel to the 500-mb HFC track (Weber, 3) and that a southern short-wave trough typically will eject rapidly northeastward out of a developing longer wave trough position.

Figure 3 depicts the verifying upper trough, SLPC, and HFC positions for 1200 UTC 19 December. The 300-mb jet axis also is superimposed. Overall, the NGM run from 1200 UTC 19 December was verifying quite well up to this point.

Figure 4 is the observed snow cover map for 1200 UTC 19 December. Note the extensive snow cover stretching from the Panhandle of Texas northeast across Missouri into the western Great Lakes.

The effect of the snow field on temperatures in the vertical can be seen in the 850-mb analysis for 12 UTC 19 December (Fig. 5). Note the cold pool that lies directly over the snow field. Also note how weak the thermal contrast is overall, north and south, across the mid Mississippi Valley. There is only an 8°C temperature difference between Huron, SD (HON) and Monett, MO (UMN) and only 9°C between St. Cloud,

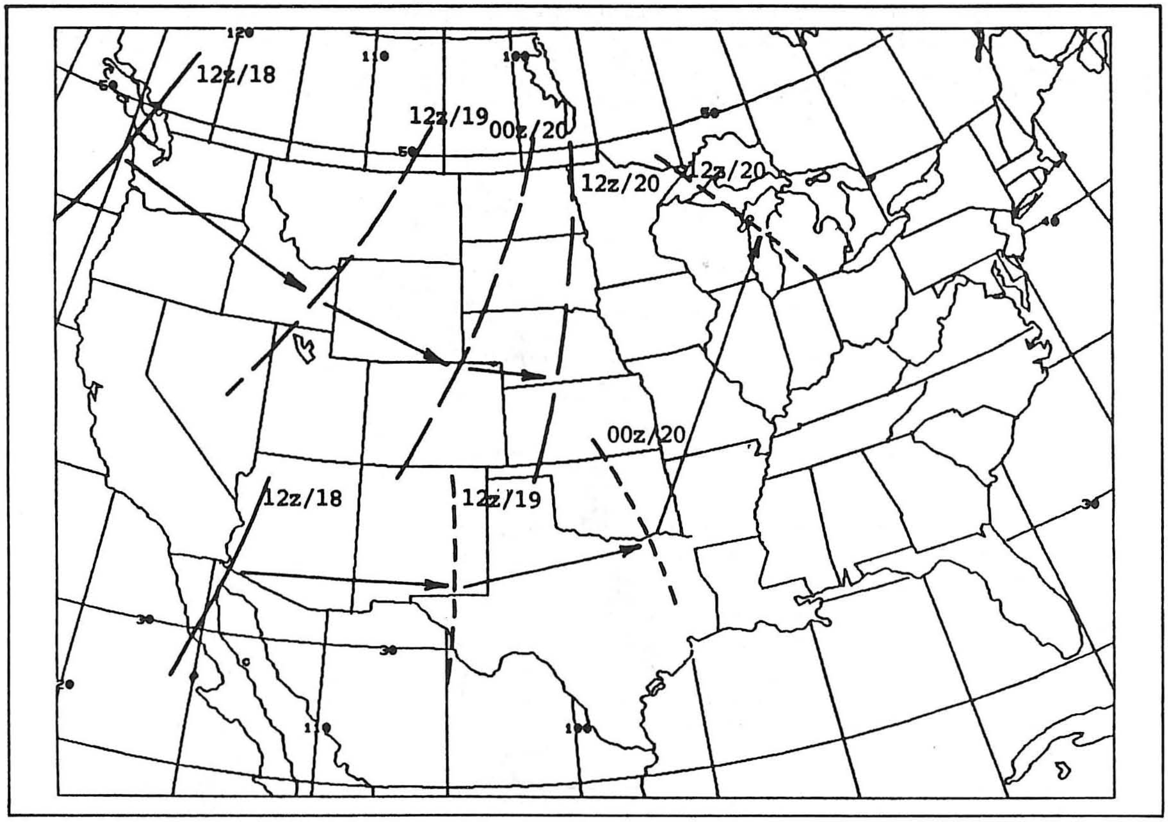


Fig. 1. NMC 500-mb trough positions for 1200 UTC 18 December 1987 (solid lines) and forecast positions for 24, 36 and 48 hr (dashed lines).

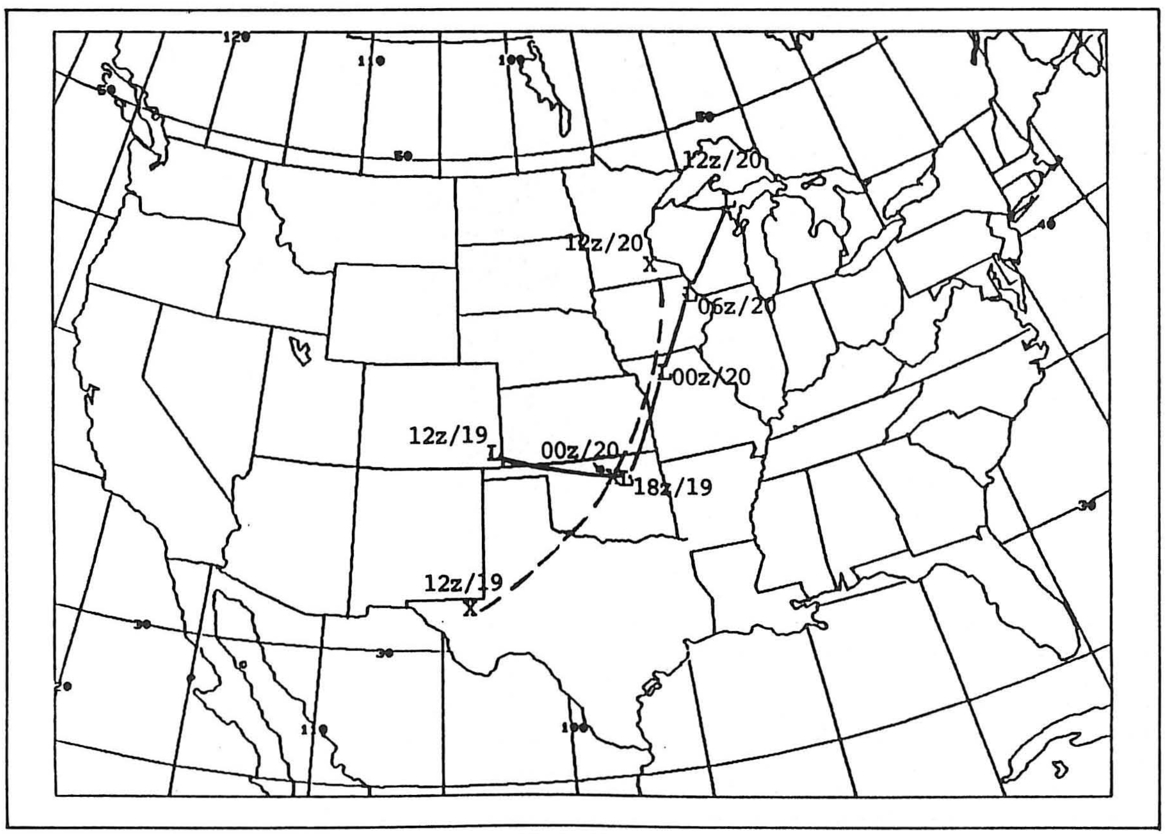


Fig. 2. NGM forecast of 500-mb height fall centers (dashed lines) and forecast of surface low pressure centers.

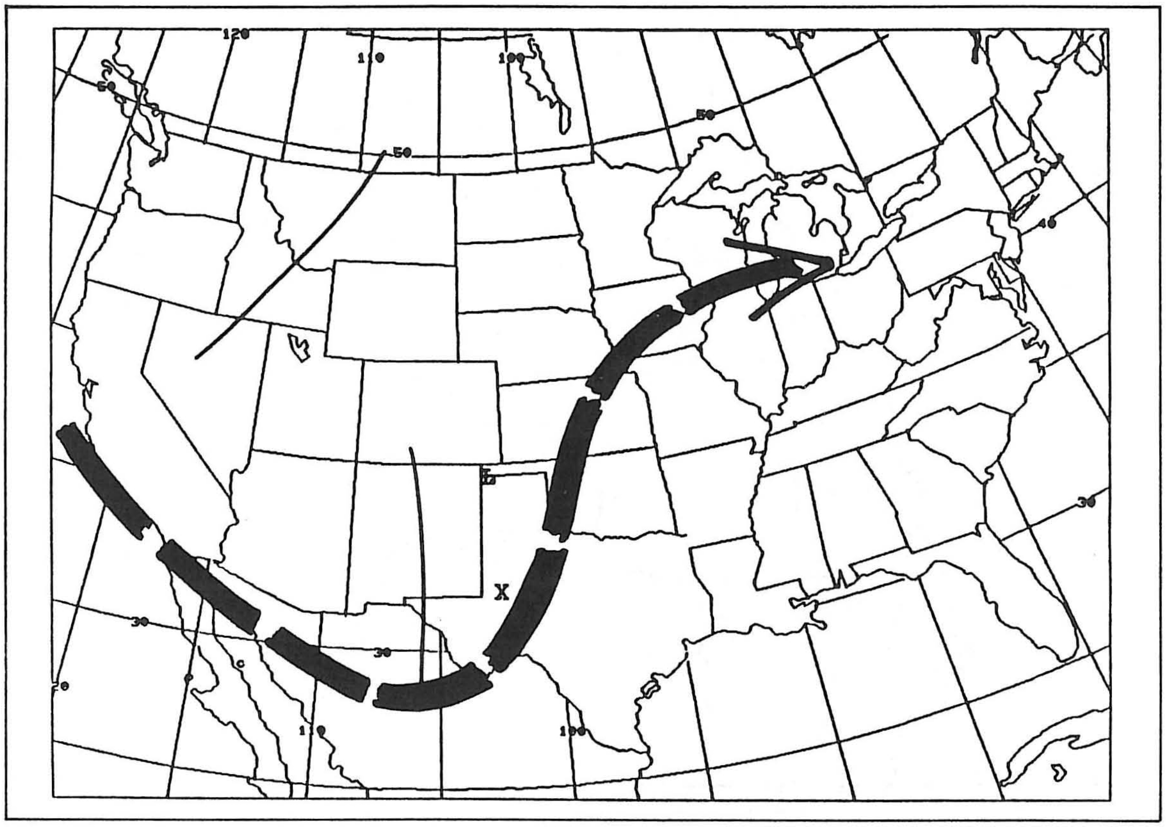


Fig. 3. Verifying 500-mb trough positions (solid lines); surface low pressure center (L); 500-mb height fall center (x); and 300-mb jet at 1200 UTC 19 December 1987.

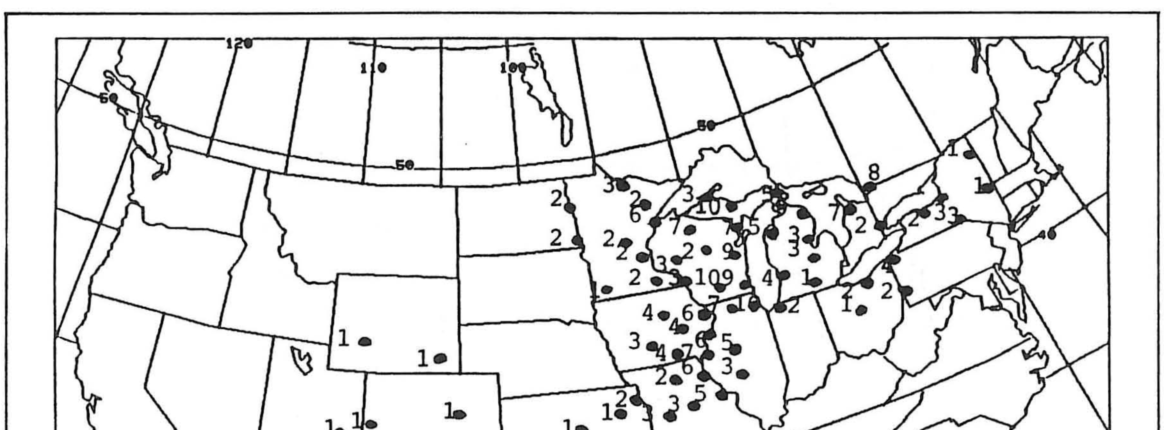


Fig. 4. Observed snow cover 1200 UTC 19 December 1987.

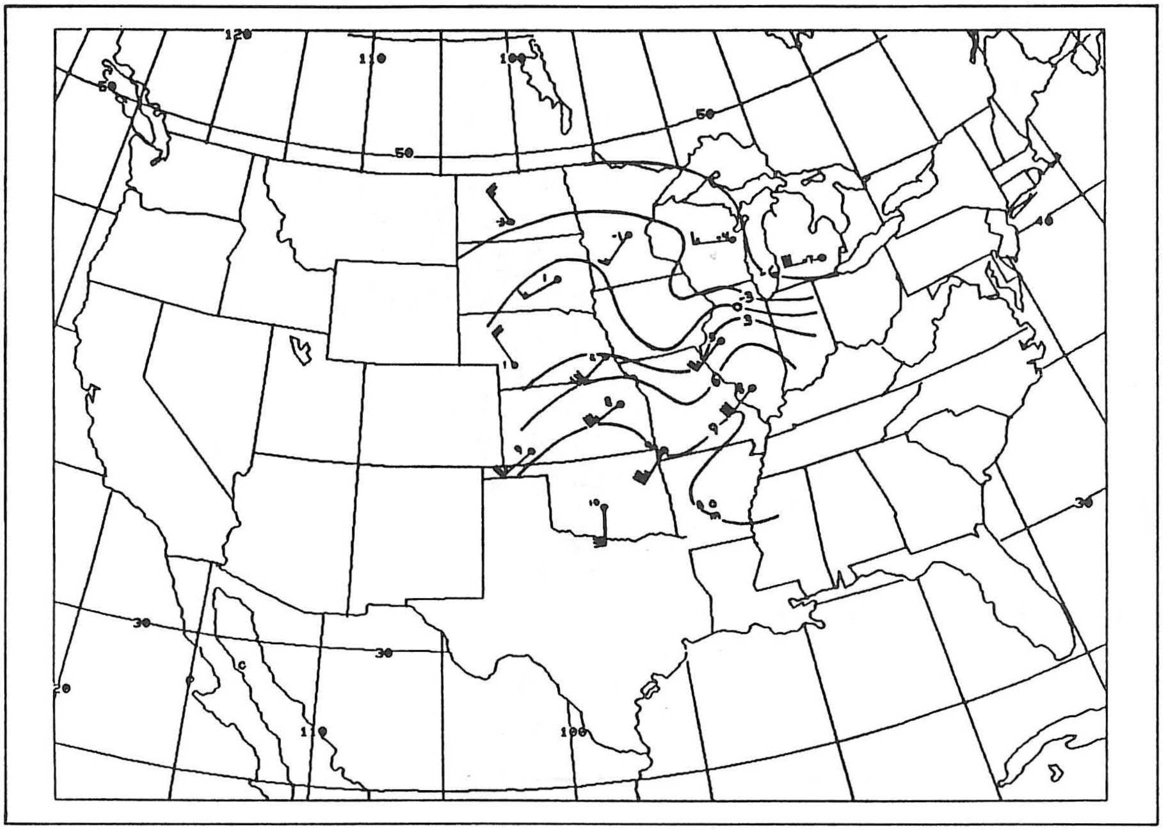


Fig. 5. 850-mb temperature analysis for 1200 UTC 19 December 1987.

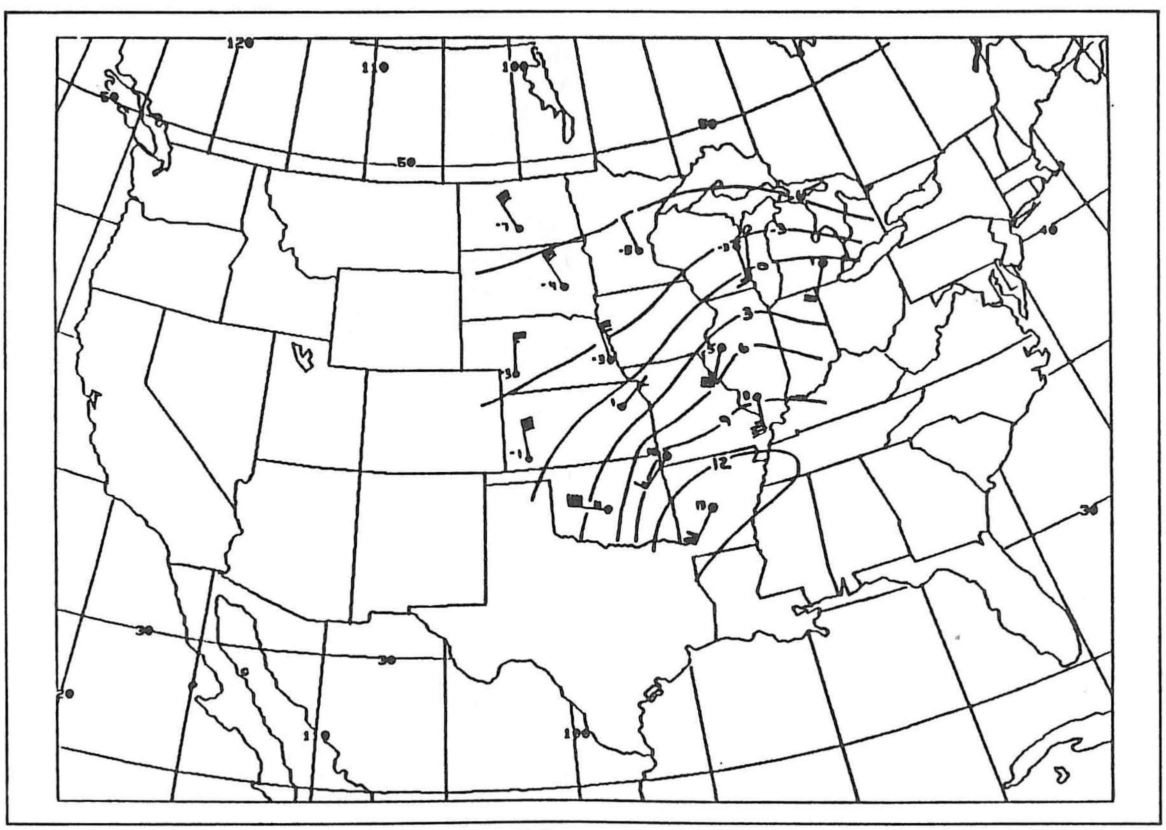


Fig. 6. 850-mb temperature analysis for 0000 UTC 20 December 1987.

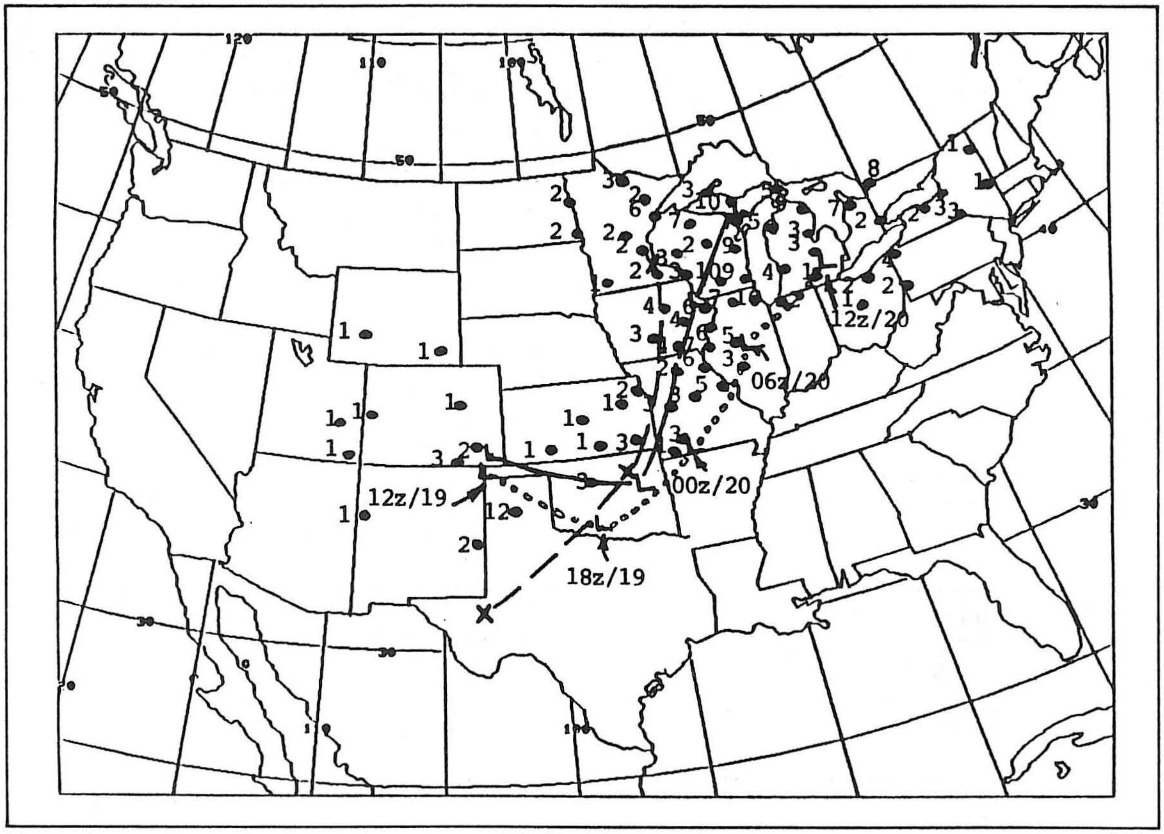


Fig. 7. Composite chart—observed snow cover 1200 UTC 19 December 1987; HFC track (dashed); forecast SLPC track (solid); and actual SLPC track (circles).

MN (STC) and Salem, IL (SLO). It is suggested here that this weak thermal contrast allowed the cold pool (i.e., the snow field) to play a greater role in establishing a low-level thermal boundary upon which the SLPC tracked.

Also, it is suggested here that the cold pool (i.e., the snow field) affected the overall dynamics of the situation by forcing air parcels, caught in the warm air advection (WAA), up and over the isentropic cold dome. This can be supported by the 850-mb analysis for 0000 UTC 20 December (Fig. 6). Note here how the temperature at Peoria, IL (PIA), Green Bay, WI (GRB), and SLO, all downstream of the snow field, hr remained essentially unchanged despite WAA for 12 continuous hr. On the other hand, note how Little Rock, AR (LIT), and Flint, MI (FNT), both essentially unaffected by a snow field, showed considerable warming. We can then assume, given:

WAA = VERTICAL MOTION + AIRMASS WARMING

that over PIA, GRB, and SLO, WAA went strictly into vertical motion at low levels as a result of the existing snow field. Assuming then that Dines Compensation is satisfied in a hydrostatic atmosphere, mass convergence must be taking place at low levels. This mass convergence using the Pressure Tendency Equation (Holton, 6) implies decreasing atmospheric pressure with respect to time. This decreasing atmospheric pressure then helped direct the track of the SLPC.

Figure 7 is a composite chart of: (a) The existing snow field; (b) The forecast HFC track; (c) The forecast SLPC track and (d) The actual 6-hr SLPC track from 1200 UTC 19 December to 1200 UTC 20 December 1987. Note here how the actual SLPC track veered to the right upon encountering the existing snow field and how this differs from the NGM forecast track.

4. CONCLUSIONS

Further case studies are needed to establish the influence of a snow field on the eventual movement of the SLPC. However, it does seem physically reasonable that if an existing snow field lies in the path of an approaching SLPC and the low-level thermal pattern is weak in contrast, the track of the SLPC may be influenced by the existing snow field, and the forecaster should consider this.

NOTES AND REFERENCES

1. Todd R. Morris is a Meteorologist with the National Weather Service in Milwaukee, Wisconsin. He received his B.S. in Meteorology from the University of Wisconsin-Madison in 1982.

2. Goree, P. A., and Younkin, R. J., 1966: Synoptic Climatology of Heavy Snowfall over the Central United States. Mon. Wea. Rev., Vol 94, No 11, November, 1966. pp 663–668.

3. Weber, E. M., 1978: Major Midwestern Snowstorms. AMS Conference on Weather Forecasting and Analysis and Aviation Meteorology, Preprints, October 16–19, 1978. pp 30–37.

4. Moore, J. T., 1988: Isentropic Analysis and Interpretation: Operational Applications to Synoptic and Mesoscale Forecast Problems, 1988, St. Louis University, 84 pp.

5. Petterssen, S., 1956: Weather Analysis and Forecasting, Volume I. 2nd Edition, McGraw-Hill, New York, 429 pp.

6. Holton, J. R., 1979: An Introduction to Dynamic Meteorology, 2nd Edition, 1979, Academic Press, New York, 391 pp.

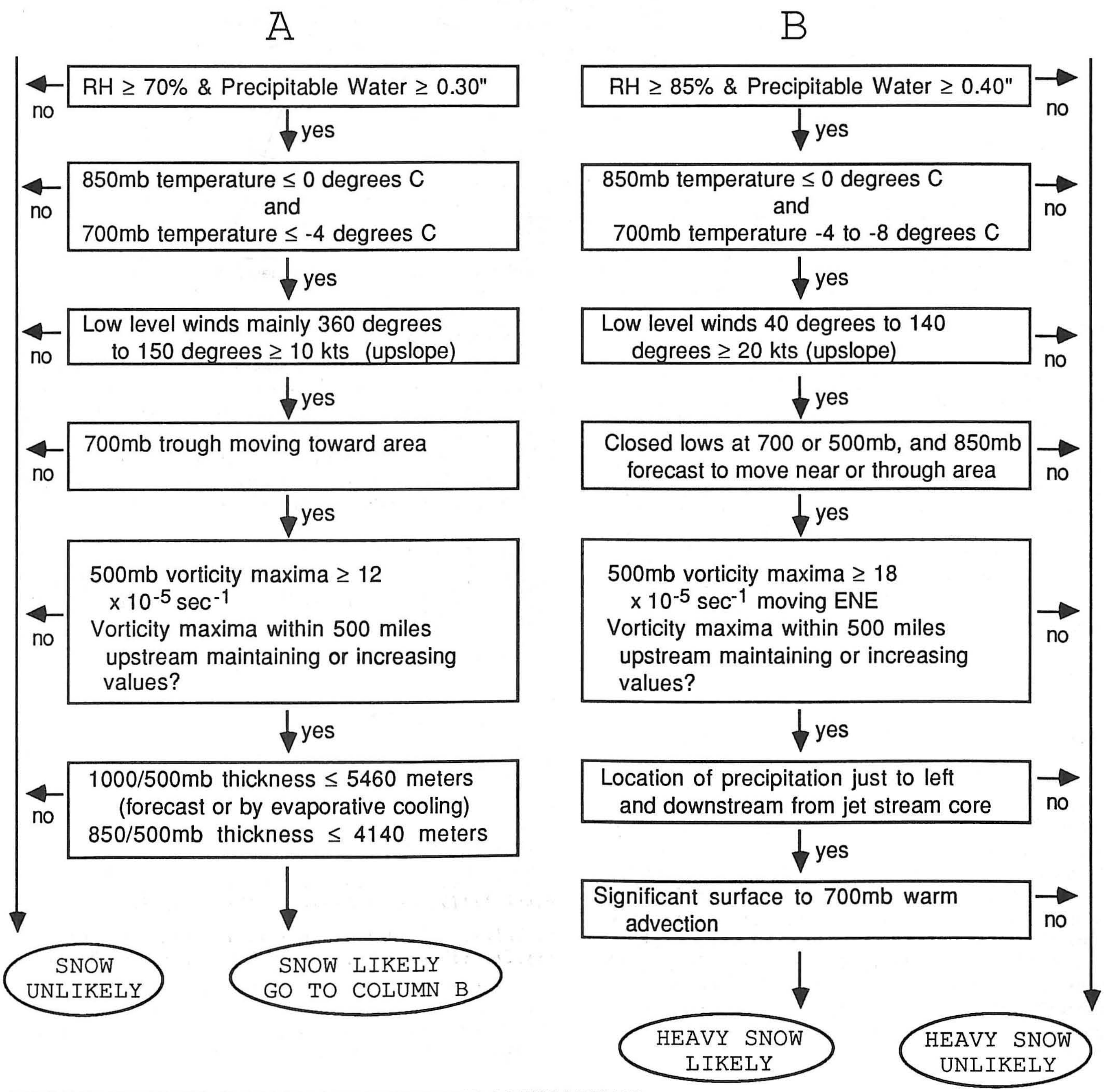
7. Zwack, P. and Babin, G., 1984: Using Quasi-Geostrophic Theory to Understand Lower Troposphere Synoptic Scale Vertical Motion. AMS 10th Conference on Weather Forecasting and Analysis, Preprints, June 25–29, 1984. pp 256–264.

FORECASTING

DECISION TREE FOR SNOW/HEAVY SNOW IN WEST TEXAS

- Use observed and/or computer model forecast values, as appropriate
- Use the following legend to highlight lines and areas on a sectional chart

RED LINE	- FORECAST AREA OF CLOSED LOW-LEVEL WARM ADVECTION SOLENOIDS (THICKNESS)
BROWN AREA	- FORECAST OF MEAN 1000/500MB RELATIVE HUMIDITY ≥70%.
PURPLE	- OUTLINE FORECAST AREA OF PVA SOLENOIDS (NOT VORT CENTER)
BLACK(dashed)	- FORECAST 5460 METER 1000/500MB THICKNESS LINE
BLUE	- JET (e.g., ≥ 50kts at 500MB or ≥ 70kts at 300MB)
GREEN LINES	- FORECAST SNOWFALL AMOUNTS(QPF)



ESTIMATE SNOWFALL AMOUNT & LOCATION USING COOK'S METHOD
(NWS Southern Region Technical Memorandum #93 - October 1977)

FH#6: CHKLST 3-S (11/89)--LBB