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THE JANUARY 1986 DAKOTAS' BLIZZARD FIZZLE: APPLICATION OF A CHECKLIST FOR ARCTIC OUTBREAKS AND "GALE" PROJECT DATA

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1. Introduction

During the 24 hours preceding 00Z January 26, 1986, the upper air pattern over western Canada featured an intensifying jet streak propagating through the top of a ridge on course toward the Dakotas. Any jet streak with these characteristics serves as a "flag" for potential blizzard conditions over the Dakotas, depending on surface and lower atmospheric conditions. This late January 1986 synoptic situation failed to produce widespread blizzard conditions over the Dakotas. The reasons will be investigated in this paper, making use of a checklist for Arctic outbreaks. What makes this case unique was the concurrent 1986 "GALE" winter season project, which provided three-hourly upper air soundings from Huron, SD. Isentropic time sections utilizing this date will help highlight the factors which led to the January 1986 Dakotas' blizzard "fizzle".

2. Synoptic Situation

An intensifying jet streak centered between 300 and 200 mb, and associated short wave trough, propagated through the top of a ridge over western Canada during the 24 hours ending at 00Z January 26, 1986. Fig. 1 shows the 300 mb isotach analysis at 00Z January 26, 1986, while Figs. 2, 3, 4, and 5 show the 500 mb, 700 mb, 850 mb, and surface analyses, respectively. Maximum winds in the jet streak had increased from 130 to at least 170 kts. Note that a short wave trough at 500 mb was passing through the Dakotas with the surface trough out ahead of it.

Three hour pressure rises of 4 to 6 mb were found behind the surface trough and 1/2 to two inches of loose snow was on the ground over the eastern Dakotas. In addition, Fargo ND reported visibilities of 3/4 mile and a 36 kt wind gust at 2208Z January 25, 1986. Huron SD reported a 3/4 mile visibility in a snow burst at 0050Z January 26, 1986, along with a 36 kt wind gust.

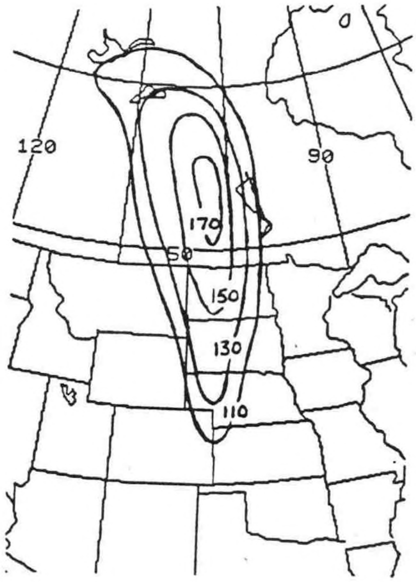

FIG. 1. NWS ISOTACH ANALYSIS (KNOTS) AT 300 MB FOR 00Z 26 JAN 1986

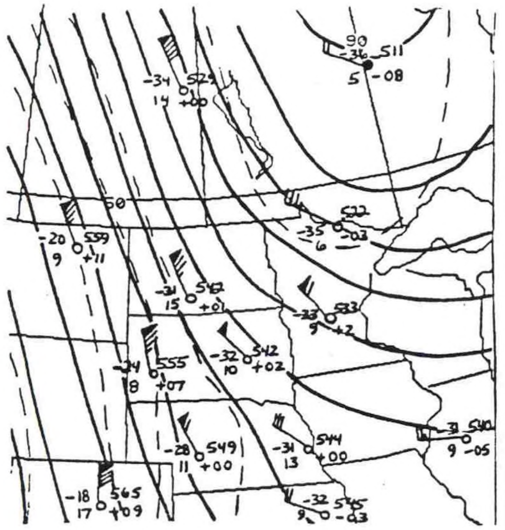

FIG. 2. NWS 500 MB ANALYSIS FOR 00Z 26 JAN 1986

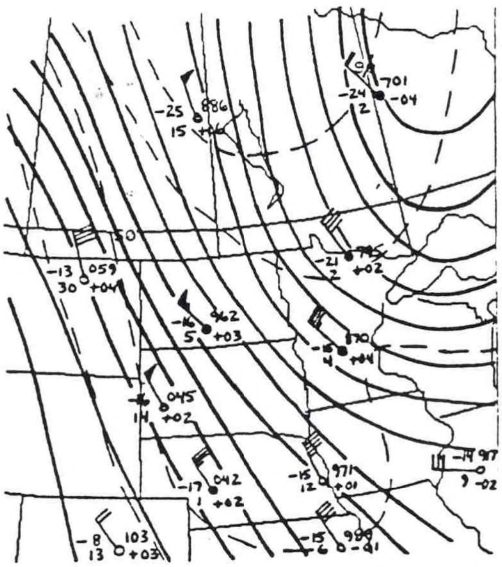

FIG. 3. NWS 700 MB ANALYSIS FOR 00Z 26 JAN 1986

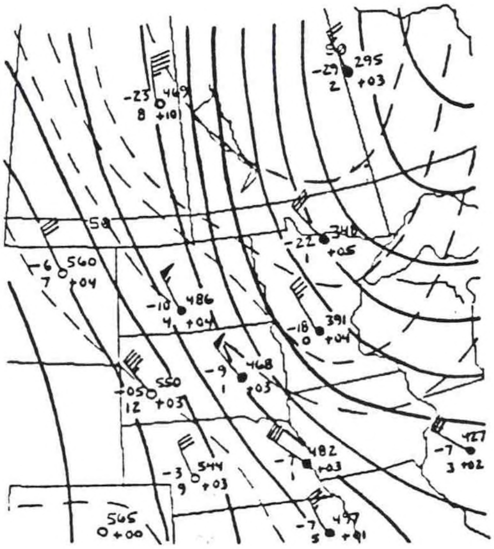

FIG. 4. NWS 850 MB ANALYSIS FOR 00Z 26 JAN 1986

A hand drawn sketch of the GOES satellite picture at 00Z January 26, 1986 is shown in Fig. 6. A "wedge" of clearing skies was evident behind the mid-level shortwave with the axis of clearing pointed to northern Minnesota. The position of the mid-level vorticity maxima is marked with a "X". Fig. 7 depicts the NMC analysis of the 500 mb height contours and vorticity at 00Z January 26, 1986. In Fig. 8 are shown the surface pressure analysis and the surface-500 thickness lines. The geostrophic wind chart in Fig. 9 reveals the surface geostrophic wind field at the same time.

3. The Evening Forecast on January 25, 1986, and Observation Results

Based on the synoptic weather situation mentioned above, the author at WSFO Sioux Falls SD issued a "Weather Advisory for Travelers" for northeastern South Dakota for the remainder of the "tonight" period. The possibility of near blizzard conditions in open areas was incorporated into the forecast text of the northeastern zones.

After the 9:20 p.m. evening forecast was issued, the lowest reported overnight visibilities at Huron and Aberdeen, SD, were in the two to three mile range, with wind gusts to 25 to 30 kts. Conditions were likely worse in the open country, but probably not in the 1/4 mile and 50 kt category. However, Fargo, ND, reported steady winds of 25 to 30 kts with gusts to 35 kts from 7:00 p.m. CST to around midnight. Blowing snow reduced their visibility at midnight to 3/4 mile. Thus, worse conditions existed at times from the Red River Valley into northwestern Minnesota.

4. Applying a Checklist for Arctic Outbreaks

A checklist for Arctic outbreaks was developed by Van Ess (1985) which assesses the strength of various meteorological parameters in producing blizzard conditions. This checklist is repeated in Fig. 10, with the first ten parameters "blocked off" according to their observed or estimated strength over the eastern Dakotas at 00Z January 26, 1986.

Note that most of the parameters were rated moderate, and a few were strong. The high level jet winds were rated strong as were the 850 mb winds. The "20" vorticity center was rated moderate since the NGM tends to assign higher numerical values to vorticity maxima (checklist was based on LFM). More important, though, the lapse rate was initially adiabatic from the surface to only about 750 mb. Above this an inversion at 750 mb in the Huron sounding (see Fig. 11) most likely served as a "cap" to cut off the strong winds aloft.

The best surface pressure rises were in Canada just north of Minnesota as shown in Fig. 8. This pressure rise "bubble" was moving southeast, away from the eastern Dakotas, taking with it the best isallobaric wind contributions.

Additional negative points, suggested by the vorticity pattern in Fig. 7 most likely subtracted from the potential blizzard conditions over the eastern Dakotas. The vorticity pattern was initially elongated and took 12 hours to transform into a well defined center over northeastern Minnesota. By 1200Z January 26, 1986 the vorticity maxima was then over northeastern Minnesota and had a more concentrated pattern (not shown). Therefore, the best associated

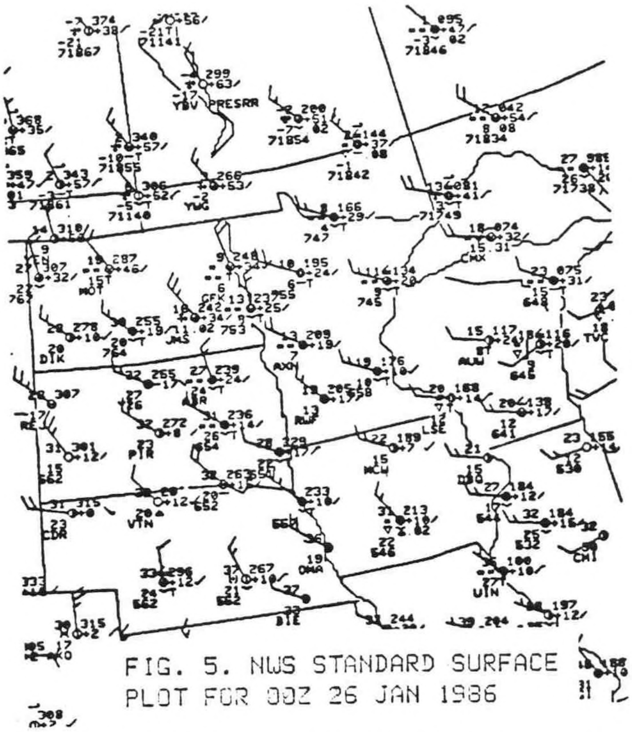

FIG. 5. NWS STANDARD SURFACE PLOT FOR 00Z 26 JAN 1986

FIG. 6. GOES IR IMAGERY (HAND DRAWN) FOR 01Z 26 JAN 1986. SOLID LINES ARE HIGH LEVEL CLOUDS. SCALLOPED LINES ARE LOW TO MID LEVEL CLOUDS. 500 MB VORTICITY MAXIMA IS MARKED WITH AN "X".

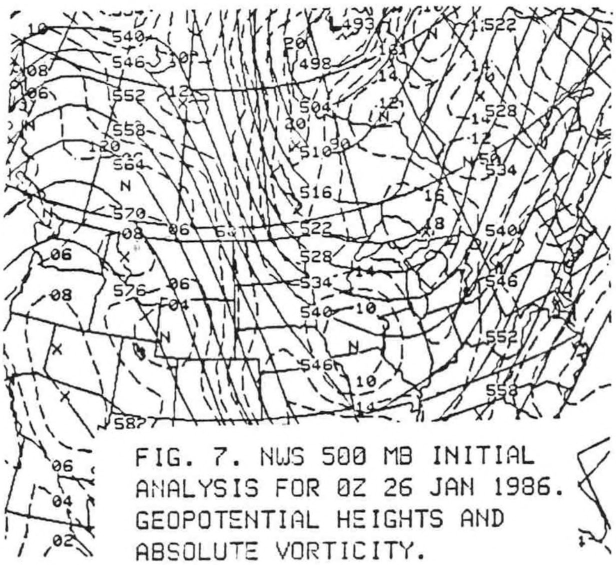

FIG. 7. NWS 500 MB INITIAL ANALYSIS FOR 0Z 26 JAN 1986. GEOPOTENTIAL HEIGHTS AND ABSOLUTE VORTICITY.

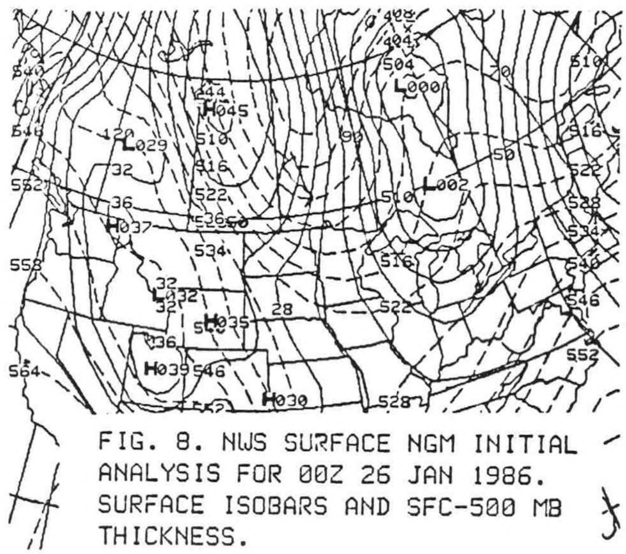

FIG. 8. NWS SURFACE NGM INITIAL ANALYSIS FOR 00Z 26 JAN 1986. SURFACE ISOBARS AND SFC-500 MB THICKNESS.

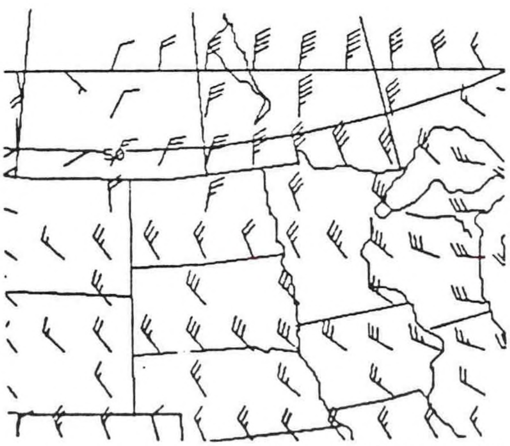

FIG. 9. SURFACE GEOSTROPHIC WINDS FOR 00Z 26 JAN 1986.

NVA-subsidence zone was located over Minnesota, and not over the eastern Dakotas, where the strongest wind in the 850 to 300 mb layer was found. The subsidence is shown by the clearing taking place from Lake Winnepeg to northern Minnesota in in Figs. 6 and 12.

Likewise, the axis of the strongest cold air advection in the 850 to 500 mb layer was located over Minnesota. Cold air advection in this layer would help prolong an adiabatic lapse rate to levels above 850 mb. This process is seen in the 850 mb chart as a thermal trough pointing into northern Minnesota. Cold air advection in this layer would help prolong an adiabatic lapse rate to possibly the 700 or even 500 mb level. Consequently, the eastern Dakotas only received a "glancing blow" from the January 26, 1986 storm.

5. The GALE Project and Isentropic Cross-sectional Analysis

The 1986 winter season "GALE" project, which the National Weather Service participated in, provided a unique opportunity to apply three-hourly radiosonde data to this case study. Time cross-sections, utilizing this data from Huron, SD were constructed, and the isentropic, isotach, and moisture fields were analyzed. These time sections covered the period from 00Z January 26 to 00Z January 27, 1986. Unfortunately, several balloon runs were terminated around 400 mb, and one launch was totally unsuccessful. These problems were likely related to the strong winds.

Fig. 13 depicts the subjective isentropic and isotach analyses superimposed. Two isotach maxima are readily apparent. However, more noteworthy was the significant warming taking place between 650 and 400 mb as indicated by lowering of these isentropes with time between 00Z and 09Z January 26, 1986. Also revealed was the gradual erosion of the low level adiabatic lapse rate from 00Z to 12Z January 26, 1986. These lower and middle level changes combined to "cut off" the boundary layer air from the stronger winds aloft. It must be remembered that strong cold air advection in the surface-500 mb layer is crucial for maintaining an adiabatic lapse rate (or nearly so) in the lower atmosphere. This in turn, allows mixing and subsidence to transfer to the surface some of the higher momentum of the stronger winds aloft.

The analyses in Fig. 13 also reveal that there was very little change in wind speed after 06Z along any given isentrope between 273 and 293 degrees. This would indicate that higher momentum air was not being mixed/ejected toward the boundary layer. The reasons were mentioned above.

In Fig. 14 the moisture field is shaded where the temperature-dewpoint spread was 5^{o}C or less. Overlaid are the low level inversions and the tropopause. One can see that the "dome" of moisture gradually broke down due to the subsidence/sinking taking place just above 700 mb between 00Z and 12Z January 26, 1986. The development of an area with a temperature-dewpoint spread less than 5^{o}C occurred between 550 mb and 350 mb around 12Z January 26, 1986. This feature was related to the propagation of our subject jet streak with it's associated indirect circulation and induced upward vertical motion. The circulation is indicated by the alternate splaying and then convergence of the 303, 313, and 323 theta surfaces between 06Z and 12Z January 26, 1986. Refer to an

		WEAK	MODERATE	STRONG
1.	Q: MAGNITUDE OF 500 MB VORT MAX?	<16	16-19	20+
2A.	Q: HOW STRONG IS SUBSIDENCE (NVA)?	WEAK	MODERATE	STRONG
2B.	Q: WHAT IS FORECAST RH IN DRY SLOT	70+	50-70%	<50%
3.	Q: IS VORTICITY COMMA AND DRY SLOT EVIDENT ON SATTELITE?	NO	YES	VERY APPARENT
4A.	Q: HOW FAST IS 3HR PRESSURE RISING?	2-4MB	4-6MB	6-10MB
4B.	Q: TOTAL CONTRAST IN PRESSURE RISE-FALL COUPLET?	3-5MB	6-8MB	9-12MB
5.	Q: TO WHAT LEVELS ARE THE WINDS HOOKED UP?	SFC-850MB	SFC-500MB	SFC-300MB
6.	Q: HOW STRONG IS JET?	<70KTS	70-90KTS	100KTS +
7A.	Q: HOW CLOSELY ARE THICKNESS LINES PACKED?	LOOSE	MODERATE PACKED	TIGHTLY PACKED
7B.	Q: WHAT ANGLE DO ISOBARS CROSS THICKNESS LINES?	0 TO 30	30 TO 60	60 TO 90
8A.	Q: HOW STRONG IS 850MB WIND	WEAK (30KTS)	MODERATE (30-40KTS)	STRONG (40KTS+)
8B.	Q: WHAT IS 850 MB TEMP DIFFERENCE BETWEEN BEGINNING AND END OF ADVECTION	<10.	10 TO 18	18+
9.	Q: WHAT IS WIND SPEED ON GEOSTROPHIC (SANGSTER) CHART.	30 KTS	35 TO 45 KTS	45 TO 60 KTS
10.	Q: HOW MUCH SNOW IS AVAILABLE IN STATE AND UPSTREAM	HARD PACKED OR ICE COVERED	1-2 INCH LOOSE	3 PLUS INCHES

11. Q: HOW LONG WILL STRONG WINDS LAST? THIS IS A TOUGHER QUESTION AS USUALLY THE WINDS WILL BLOW LONGER THAN PLANNED. TWO FACTORS ARE APPARENT.
    1. WINDS SHOULD SUBSIDE AFTER LARGER SURFACE PRESSURE RISE AREA PASSES THROUGH.
    2. WINDS SHOULD SUBSIDE AFTER 850 MB COLD ADVECTION ENDS.

FIG. 10. ARCTIC OUTBREAK CHECKLIST (SEE VAN ESS 1985 FOR DETAILS.

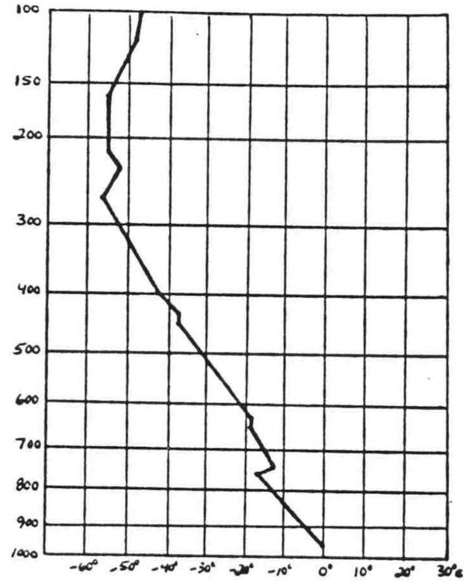

FIG. 11. RADIOSONDE OBSERVATION FROM HURON, SD FOR 00Z 26 JAN 1986

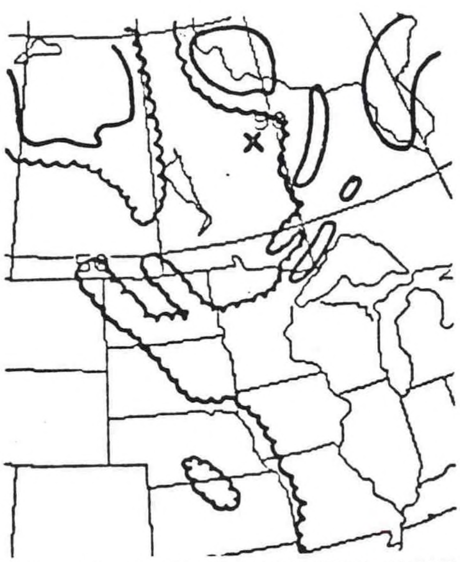

FIG. 12. GOES IR IMAGERY (HAND DRAWN9 FOR 03Z 26 JAN 1986. SAME SYMBOLS AS IN FIG. 6.

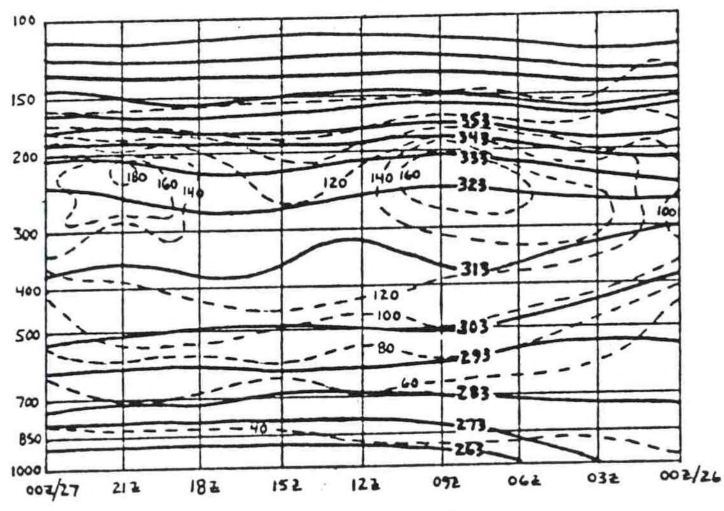

FIG. 13. VERTICAL TIME SECTION FOR HURON, SD. POTENTIAL TEMPERATURES (SOLID) IN K ANDN ISOTACHS (DASHED) IN KNOTS.

excellent paper by Uccellini and Johnson (1979) for information on jet streaks and associated indirect circulations, mass adjustments, and vertical motions.

Fig. 15 shows the 1231Z January 26, 1986 GOES satellite photograph (hand drawn). Our upper level jet streak impulse and associated clouds were quite evident over eastern South Dakota.

Another feature shown in the time section was the gradual rising of the top of the low level inversion/isothermal layer with time. This change was consistent with the overall warming that took place between 650 and 400 mb. In addition, the tropopause rose from 275 mb to near 200 mb.

To further highlight the changes that occurred during this time section, the 09Z January 26, 1986 Huron, SD sounding is shown in Fig. 16. This sounding greatly contrasts with the 00Z January 26, 1986 sounding in Fig. 11. Note the destruction of the low level adiabatic lapse rate and the significant warming that took place between 650 and 400 mb. As detailed before, these changes were partially responsible for the January 1986 Arctic outbreak becoming a fizzle rather than a blizzard.

6. Summary

During the winter months many northwest flow systems can appear to be potential wind producers for the northern plains. A few become the strong systems that generate significant winds to generate ground blizzard conditions, or worse. In this case study, a few key ingredients were weak or geographically displaced, even though the overall system appeared to be potent for strong winds.

This system had very strong winds aloft over the Dakotas while a short wave trough and a developing vorticity maxima moved through the north-central states. This development proved to be slow and too far east to generate significant subsidence over the Dakotas. Also, the best cold air advection from 850 to 500 mb was pointed at Minnesota. The end result was the destruction of a low level adiabatic lapse rate which prevented the downward transfer of momentum associated with the stronger winds aloft. In addition, there was very little isallobaric wind contribution to the surface winds over the Dakotas. Admittedly, some of these points are hindsight, although some clues were available for the evening zone forecast update. Overall, the eastern Dakotas only received a small amount of this system's total energy.

Strong surface winds over the northern plains in the late fall, winter, and early spring seasons can result in widespread or localized blizzard conditions which can be fatal to unprepared travelers. The need to forecast these winds in an accurate and timely manner is extremely important. As seen in this case study, many ingredients can be present to generate strong winds with blizzard conditions. However, the system can still become a fizzle during the forecast period due to some unforeseen change in a meteorological parameter. Soundings, and time or cross sections on a three-hourly basis would obviously help in recognizing some of these changes taking place.

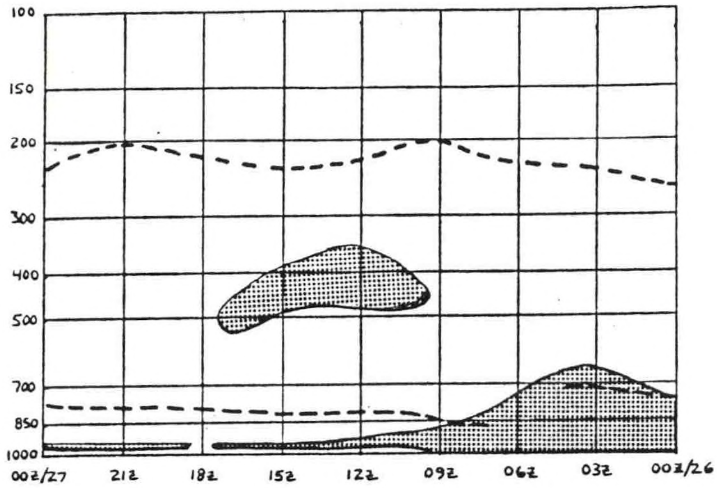

FIG. 14. VERTICAL TIME SECTION FOR HURON, SD. TROPOPAUSE AND LOW LEVEL INVERSIONS (DASHED) AND AREAS WITH TEMP/DEWPT SPREADS OF 5 C OR LESS (SHADED).

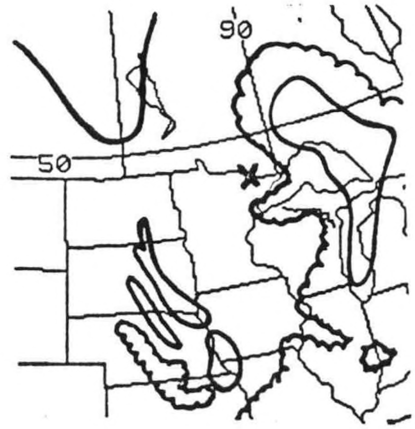

FIG. 15. GOES IR IMAGERY (HAND DRWAN) FOR 1230Z 26 JAN 1986. SAME SYMBOLS AS IN FIG. 6.

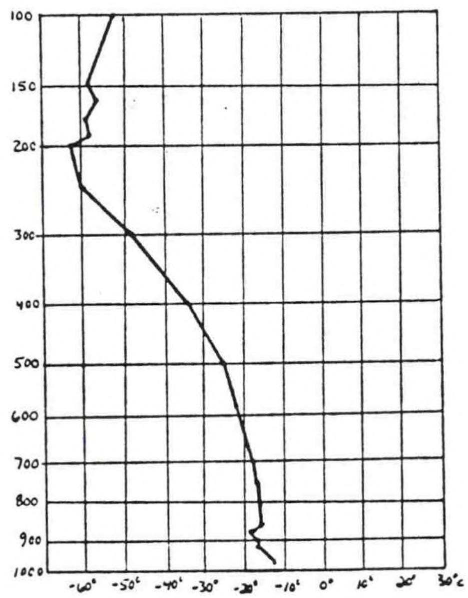

FIG. 16. RADIOSONDE OBSERVATION FROM HURON, SD FOR 09Z 26 JAN 1986.

The authors will combine efforts during the 1987-88 winter and spring season to update the checklist for Arctic outbreaks. The updated checklist will be based on the NGM and will better define crucial parameters, such as the adiabatic lapse rate that was very important in this case study. The rating system used in the checklist will be refined using all available analysis and prognostic tools, including SWIS.

As a final point, the checklist and ideas used in this paper work best under wintertime Arctic outbreaks. But they are also very useful in predicting strong wind episodes during the fall and spring transitional seasons.

7. References

Uccellini, L. W., and D. R. Johnson, 1979: The Coupling of Upper and Lower Tropospheric Jet Streaks and Implications for the Development of Severe Convective Storms. Mon. Wea. Rev., 107, 682-703.

Van Ess, R., 1985: Forecasting Ground Blizzards. National Weather Service Central Region, Scientific Services Division, Tech. Attach. 85-22.