Comments on "A Winter Mesocyclone over the Midwestern United States"

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The paper by Mills and Wash (1988; hereafter referred to as MW88) describes a case that is of interest, at least in part, because it is an example of the apparently rich spectrum of cyclonic systems within polar airstreams; such systems sometimes are called "polar lows." The spectrum ranges from systems that are more or less purely baroclinic (e.g., Reed 1979; Reed and Blier 1986) to those that are more or less purely CISK-like (e.g., Rasmussen 1981). Most examples of cyclonic storms in polar airmasses combine both of these aspects to a varying degree (see the excellent review by Businger and Reed 1989). This event appears to be consistent with that view, since it arises on a frontal boundary and includes convection strong enough to produce thunder.

These comments are not an evaluation of the merits of these two prototypes for cyclones in polar airstreams, nor is the term "CISK-like" intended to imply any advocacy of CISK, per se, as the physical mechanism for such cyclonic storms. (For further information consult the references here and in MW88.) Rather, my purpose herein is to suggest that one can obtain a somewhat different interpretation of the case presented in MW88 by doing a careful surface isotherm analysis and a simple diagnosis of midtropospheric static stability.

Figure 1a–c shows a detailed isotherm analysis for the data presented in Fig. 2a–c of MW88. The omission of isotherm (and isodrosotherm) analyses from surface data often means that important details of the diagnosis are overlooked. In this case, it appears that there is a "bubble" or dome of cold air ahead of the main cold frontal surge, the origins of which are not clear from the data presented in MW88.

From microfilm copies of the operational surface and constant pressure level charts, I have looked at the event shown in MW88 and conclude that this cold air mass was drawn southward from Canada in the circulation around a cyclone that moved through the Great Lakes during the period from 0000 UTC 4 February 1984 through 0000 UTC 5 February, at which time MW88 pick up the analysis. At this latter time, a fresh surge of cold air already is moving through the Dakotas, having begun to move southeastward about 24-h earlier. The boundary of the cold airmass ahead of the fresh intrusion of polar air is an ordinary front. As this cold dome moves southeastward ahead of the new cold front, it apparently is being modified by moving over a relatively warm surface, as its boundary is undergoing frontolysis. Thus, by 1200 5 February (Fig. 1c), the old boundary has become relatively diffuse.

The small-scale low that is the topic of MW88 develops at or near the intersection of the new cold front with the western edge of this old cold dome. The operational analyses of the National Weather Service's National Meteorological Center depict a low at the intersection as early as 0300 UTC 4 February (See Fig. 2a). Such a system might be viewed as a cold season analog of the warm season mesoscale lows that develop at intersecting boundaries (e.g., Magor 1959; Purdom 1979). In this case, a significant 500 mb vorticity maximum is moving south-southeastward over the small surface cyclone (as seen in Fig. 3 from MW88). During the warm season, such features aloft may be subtle, and at least one of the intersecting boundaries may originate from convective outflow.

In the warm season, the amount of forcing required to produce upward vertical motion is reduced from that required in the cold season, owing to generally lower static stabilities in the warm season. Observe in Fig. 13 of MW88 that there is an elevated layer of low static stability [the possible significance of which is discussed in Mudrick (1987)] from Peoria, Illinois to Sault Ste. Marie, Michigan between 750 and 500 mb. Figure 3a–d depicts the temperature difference (Δt) between 700 and 500 mb (see Doswell et al. 1986) through the evolution of the event in MW88. For reference, at the temperatures indicated in Fig. 10 of MW88, between 700 and 500 mb a dry adiabatic lapse rate is associated with a Δt of about 22.5°C, whereas a Δt of 20°C is

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about equivalent to a pseudoadiabatic lapse rate. As seen in Fig. 3, there is a zone of relatively high lapse rates in the 700–500 mb layer that rotates around the large-scale cyclone, with stable lapse rates clearly associated with the fresh intrusion of polar air. Such an analysis confirms and enhances that of MW88, suggesting that "thundersnow" events are associated not only with strong advective forcing (as noted in MW88), but also with regions of reduced static stability.

These comments are intended to point out the advantages of doing a detailed surface isotherm analysis. My experience suggests that many analysts draw fronts along the windshift line rather than on the warm side

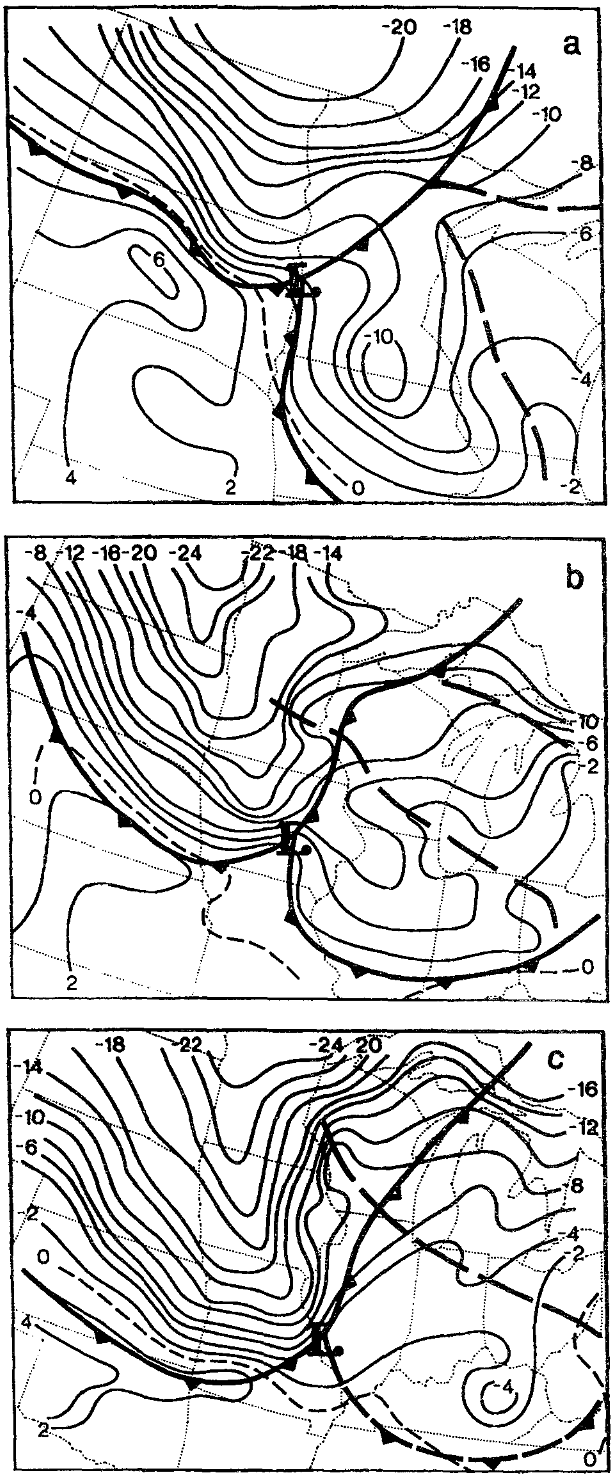

FIG. 1. Isotherms (°C) and feature analysis at (a) 0000, (b) 0600, and (c) 1200 UTC 5 February 1984, coinciding with Figs. 2a–c in MW88. Isotherms are thin solid lines, every 2°C, except the 0°C isotherm, which is thin dashed. Frontal symbols are conventional, and the heavy dashed line across Wisconsin depicts a quasistationary thermal ridge; in the northern Great Lakes in panels a and b, the heavy dashed line intersecting the cold front is a thermal boundary.

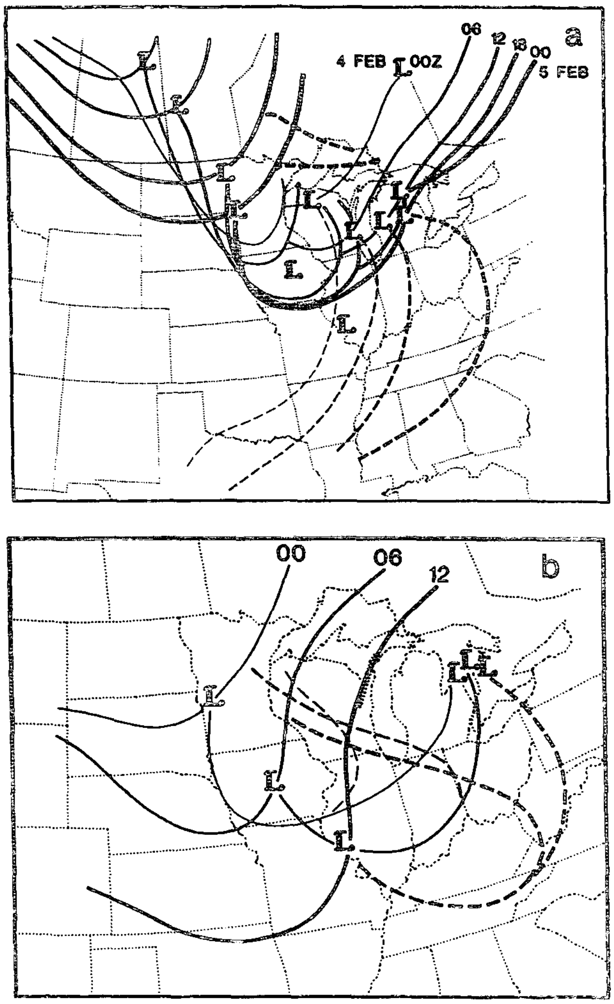

FIG. 2. Schematic history of the weather features from (a) 0000 UTC 4 February to 0000 UTC 5 February 1984, and (b) 0000 UTC 5 February to 1200 UTC 5 February 1984 [see Fig. 1], at 6-h intervals. Fronts are shown as solid lines, with dashed lines denoting troughs or thermal boundaries. The thickness of the lines increases with increasing time on both panels a and b. The lightly shaded *L* symbols in panel a show the positions of the cyclone discussed in MW88 at the last two times of (b), for purposes of continuity.

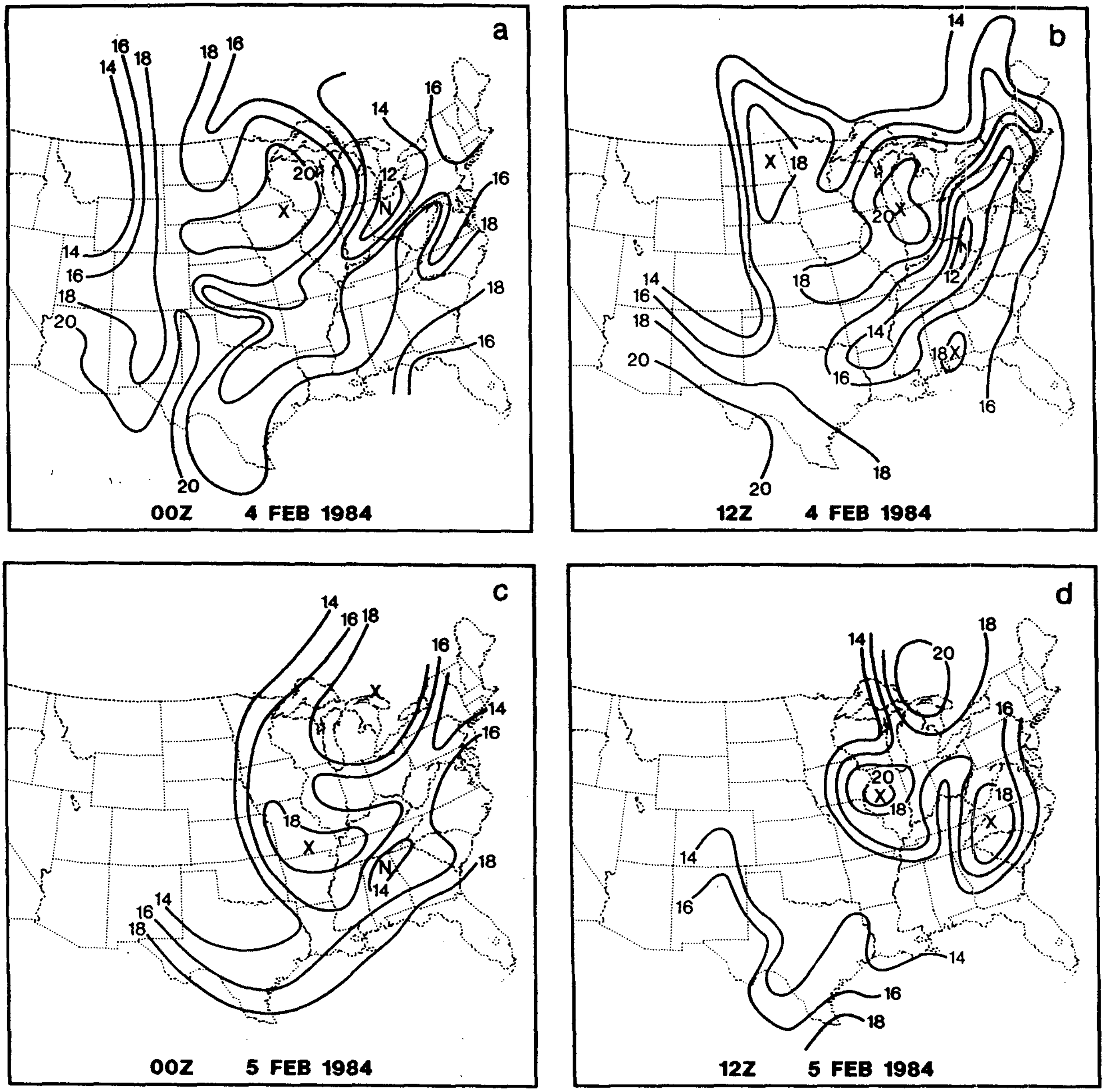

FIG. 3. Analysis of the temperature difference between 700 and 500 mb (°C) at (a) 0000 UTC 4 February, (b) 1200 UTC 4 February, (c) 0000 UTC 5 February, and (d) 1200 UTC 5 February 1984. Centers of closed maxima are denoted with *X*, while *N* depicts centers of closed minima. In panels c and d, no values below 14 are contoured even though they are present.

of the marked increase in the thermal gradient. Such a windshift line frequently precedes a cold front, so I naturally was inclined to examine the isotherms in MW88's data. This accidentally led to my seeing the cold dome ahead of the new polar intrusion. As shown in Fig. 2, a small-scale cyclone was present at the intersection of the two boundaries for quite an extended period. The 700–500 mb Δt analysis is such an easy way to examine the field of static stability that I use it frequently. When the resulting Δt pattern is combined with the cross section shown in MW88, a more complete diagnosis of the situation is possible than when doing only Δt or cross-sectional analyses alone.

This is an interesting and provocative case study. I certainly hope that the authors will examine a number of cyclones in polar airstreams over the continent, as a single case does not allow for much generalization. Finally, the authors are to be commended for including their data in their figures, which makes it possible for a reader to validate their analysis.

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