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USING MID-LEVEL RADAR ECHOES AS A CLUE TO SEVERE STORM MOVEMENT

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1. INTRODUCTION

The "First Echo Aloft" signature (Lemon, 1977) has been a good indication of developing severe weather, and a good guide to potential storm severity. The higher above the freezing level the first echo appears, the stronger the return, the higher the likelihood of surface severe weather.

The AFOS applications program MESOS has been a useful tool for short term forecasting of convective weather. Persistent areas of moisture and wind convergence (SMC/SWC), coupled with warm advection, are good for pinpointing spots where convection will develop and track.

When combined with the "First Echo Aloft" (see Lemon, 1977), persistent surface convergence and low level warm (theta-STA) advection identify regions of potential surface severe weather occurrence. The purpose of this paper is simply to inform radar operators and severe storm coordinators of another combination of existing conventional techniques that may aid in short term severe storm forecasting.

2. CASE EXAMPLE

As an example, consider the evening and early morning hours of July 22-23, 1987. Moist, unstable air (surface dew points 65 to 70 and surface LI's of -5 to -8) covered the tri-state region, especially just north of a weak east-west stationary front. Moderate to strong surface wind convergence (30 to 40 $*10^{-6}$/sec), moisture convergence (20 to 30 G Kg^{-1} hr^{-1}) and warm theta advection (.8^{O} to 1.8^{O}F hr^{-1}) persisted from north central South Dakota into northern Minnesota (Fig. 1a). The National Severe Storms Forecast Center (NSSFC) issued severe thunderstorm watch number 418 in anticipation of severe convection along the frontal axis.

Intense convection was in progress at 00Z (7:00 p.m. CDT) between two areas of moderate wind and moisture convergence, and warm advection maxima. This convection tracked due east into the stronger convergence/advection zones. The mean wind vector was 230/35, while the low level surface flow (not shown) was perpendicular to and overriding the frontal boundary.

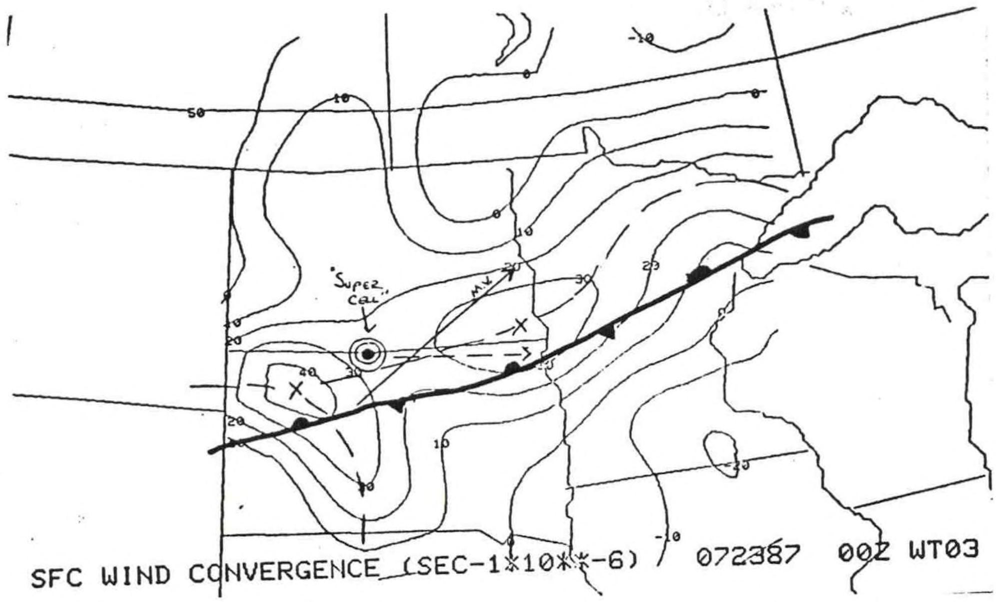

Fig. 1a. AFOS graphic SWC for 00Z, July 23, 1987, with the synoptic scale stationary front overlayed. Ongoing severe supercell position marked by "bullseye." Dashed line from cell indicates movement; solid line to northeast marked M.V. denotes SELS mean wind vector. SWC maximum and axes marked.

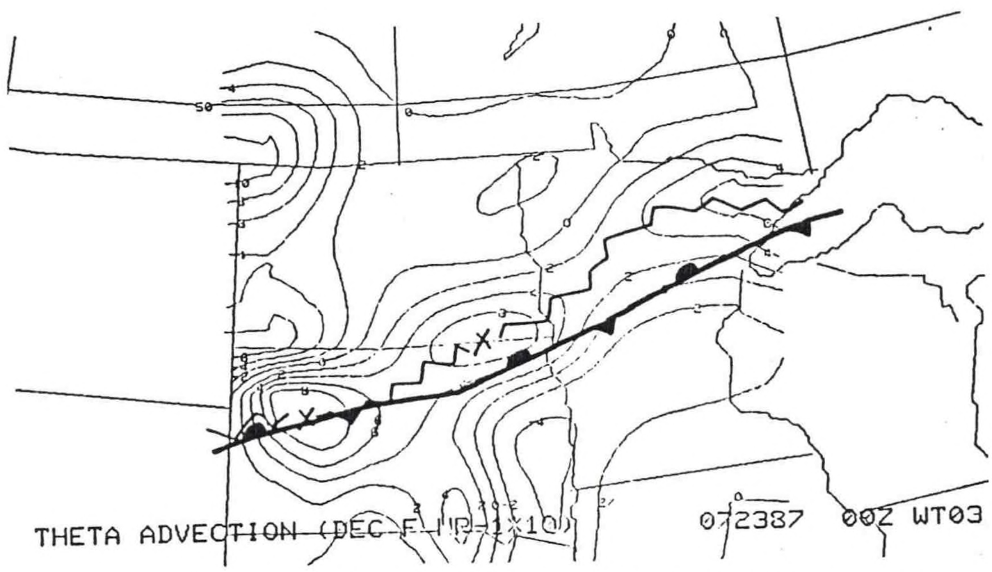

Fig. 1b. AFOS graphic STA for 00Z, July 23, 1987, with the stationary front marked. Theta warm advection centers and axes marked.

At 05Z (11:00 p.m.) the MESOS SWC/SMC/STA maximum values had shown little change in either position or strength since 00Z (Figs. 2a and b). This would indicate a well developed region or "channel" of upward vertical motion in place ahead of the strongest cells (Fig. 3) for an extended period of time.

At 0430Z, radar indicated a line of one and two level convection, based in the mid-levels (10,000-15,000) developing parallel and about 75 miles upwind from these axes. This area of convection aloft appeared to remain stationary as the stronger South Dakota convective cluster approached. The South Dakota cluster weakened between 05 and 0530Z as intense convection began to develop along the line laid out by the aloft convection. Between 0630Z and 0930Z, convection moved east-northeast along the axes of the STA/SWC/SMC maximum, producing surface severe weather along its path (Fig. 4).

This type of event has been noted several times before in conjunction with severe weather. Strong SWC/SMC and low stability indices without the "First Echo Aloft" signature lead to little or no severe weather. Yet every observed occurrence of "First Echo Aloft" associated with this type situation (surface boundary, moderate to strong SWC/SMC, low LI's, etc.) lead to severe weather. In addition, the placement of the storm track and severe events has been similar.

3. CONCLUSIONS

Both of the techniques described here are certainly not new. Yet together they seem to point out a path of (high) potential severe weather. As with any subjective analysis technique, this one needs adjustment from location to location. "Strong" in reference to moisture/wind convergence or "high" in reference to moisture availability is different from Oklahoma to North Dakota. While surface dew points in the 70's are common in the Southern and Central Plains during the summer, dew points in the 50's and 60's are sufficient for severe storm development in the Dakotas. Consequently, "First Echo Aloft" signatures that would be common place, or at best weak, in the Southern Plains could be significant in North Dakota.

4. NOTES

(1) If MESOS is available, concentrate looking for the first echo aloft signature "upwind" of the maximum SWC/SMC/STA axes.

(2) Number (1) above seems enhanced when the area is between two active clusters of convection separated by 200 miles or more.

(3) Fine lines have been noted to develop in/near the SWC maximum axis.

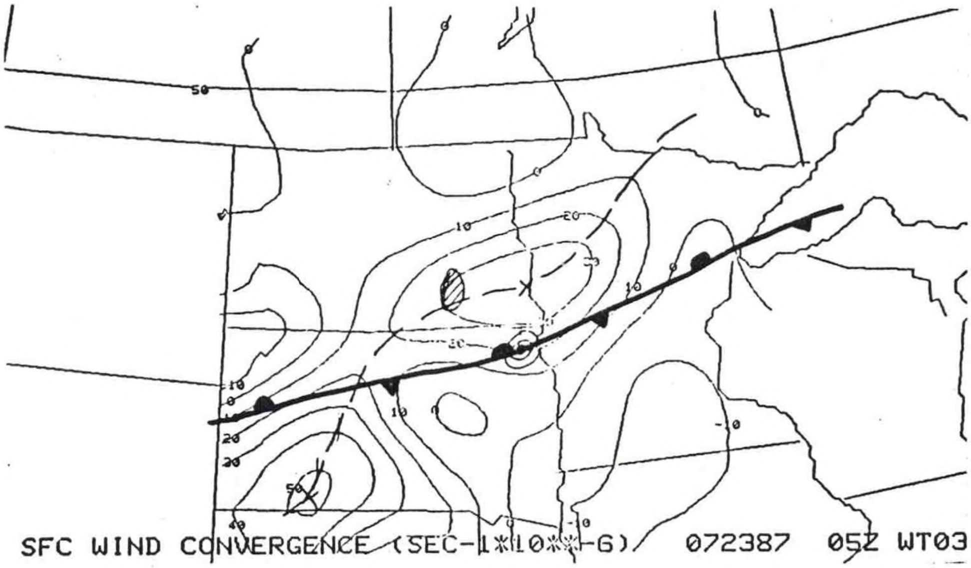

Fig. 2a. Same as Fig. 1a except for 05Z, July 23, 1987. Stippled area in southeast North Dakota locates developing severe storm. Older supercell denoted by "bullseye."

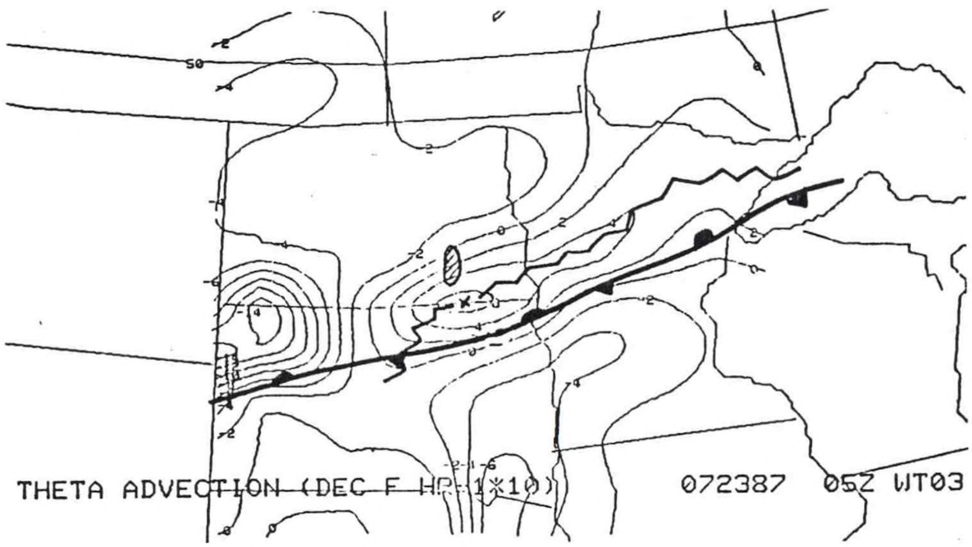

Fig. 2b. Same as Fig. 1b except for 05Z, July 23, 1987.

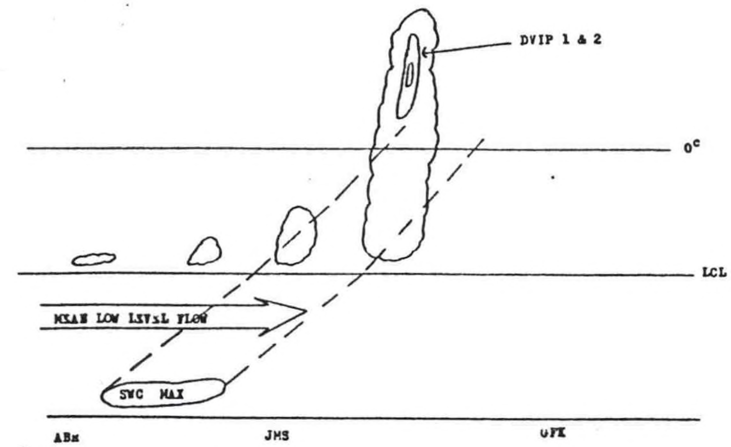

Fig. 3. Authors conception of vertical motion, caused by strong surface wind convergence, being channeled by the mean low level wind flow. Clouds develop above the LCL; radar echoes develop above the 0°C isotherm. Slope would be relative to the strength of the mean flow.

Fig. 4. Composite of the surface wind convergence maximum axis (alternate dash x dash line), theta warm advection maximum axis (zig-zag line) and the first echo aloft position (dashed line). Time frame is 0430Z to 0630Z, July 23, 1987. Triangles denote the reported surface severe weather which was primarily damaging straight line winds over 70 mph. The time frame is 0430Z to 0930Z, same date.

5. REFERENCES

Lemon, L. R., 1977: Severe Thunderstorm Identification Techniques and Warning Criteria: A Preliminary Report. NOAA Technical Memorandum NWS NSSFC-1 (see also NOAA Technical Memorandum NWS NSSFC-3, April 1980).