CENTRAL REGION TECHNICAL ATTACHMENT 94-17

THE USE OF 925 MB TEMPERATURE DATA IN DIAGNOSING WINTER PRECIPITATION TYPE

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1. Introduction

In early 1992, the National Weather Service (NWS) began including the 925 mb level in the mandatory level coding sent from NWS rawinsonde stations. Although 925 mb data cannot often be determined for stations in the West, it is always readily available for stations in the eastern-half of the United States, including those stations in the Appalachian Mountains.

In this paper, the correlation between 925 mb temperature and winter precipitation type is examined. Comparisons of 925 mb temperature and associated precipitation type to 850 mb temperature are also made. Using a pressure-level temperature as a precipitation indicator has shortcomings, the most important of which is that only one level is analyzed and vertical structure is ignored (McNulty, 1991). However, a positive correlation between 925 mb, or a combination of 925 mb and 850 mb temperature to precipitation type, would result in a valuable tool for operational meteorologists.

2. Method

From December 1992 through the middle of April 1993, analyses were made of the 925 mb level over roughly the eastern two-thirds of the United States. Weather depiction charts were also analyzed, which provided a quick method for determining precipitation location and type. In addition, surface analyses were done, and 850 mb charts were collected for comparison with the 925 mb analyses.

Overall, 53 cases were analyzed during the period of study. Sixteen of these were removed for a variety of reasons. Some of these were that precipitation was located too far into the warm or cold air mass, only one type of precipitation existed, and lack of Canadian data affected the quality of the analysis.

The study focused on two items. First, precipitation types were compared to 925 mb temperature. Second, the results of the analyses at 925 mb were compared to both the 850 mb zero-degree isotherm and 850 mb temperatures ranging from -5 to +5.

3. Results

Using 925 mb data alone, the results of the study were not very encouraging. The study did show that most of the stations located in areas colder than 0°C were in a snowfall regime, and most of those stations located in areas warmer than zero were in rainfall. Of the 37 cases, 13 showed no identifiable 925 mb isotherm as a demarcation line between precipitation types. The remaining 24 cases showed some evidence of differentiation between precipitation types along a particular isotherm. However, considerable variability existed among the 925 mb temperatures at which this differentiation occurred (Figure 1).

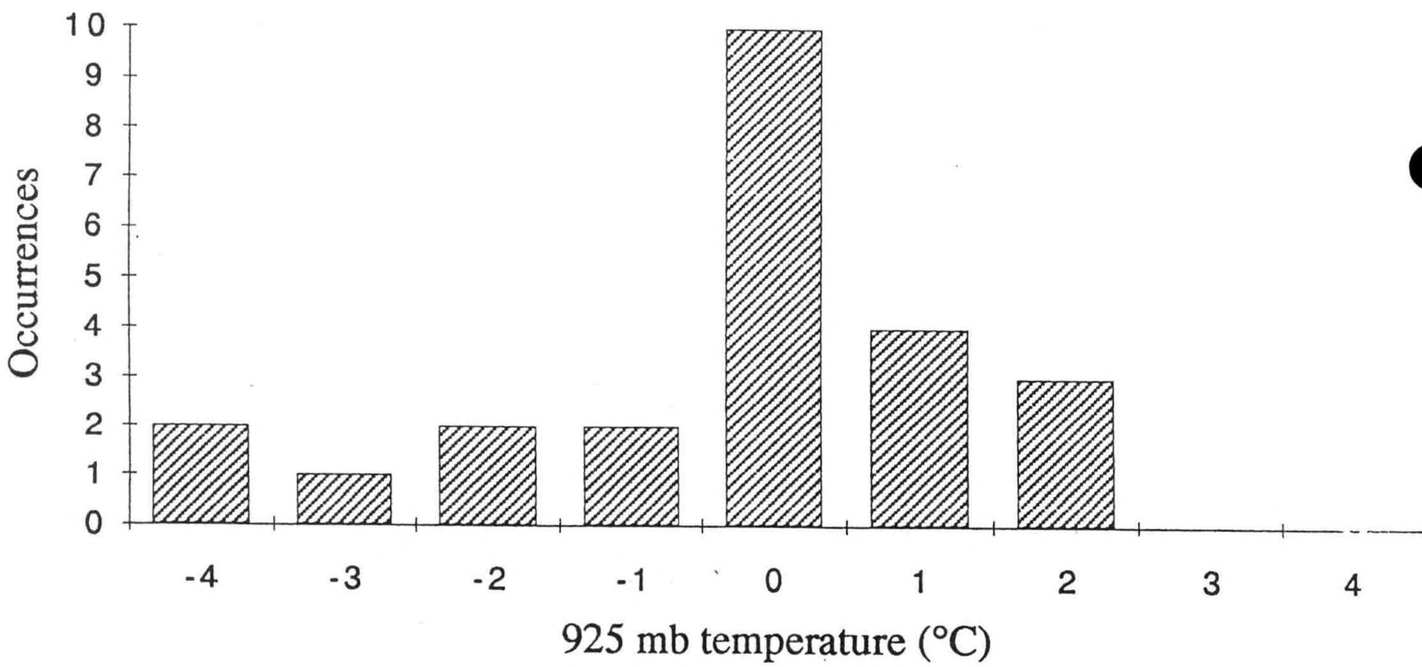

Figure 1. Number of times a 925 mb temperature provided demarcation between precipitation type.

The overall variability of the sole use of 925 mb data to determine precipitation type is also shown in the weather depictions of Figures 2 through 4. In each figure, an "overrunning" synoptic regime existed in the Great Lakes and the Upper Mississippi Valley. Superimposed on the weather depictions are isotherms for 925 mb and 850 mb.

Figure 2 (0000 UTC, January 13, 1993) is an example of a case where no particular 925 mb isotherm differentiated between precipitation types. Over eastern Iowa, the demarcation between freezing rain and snow was close to the -5°C isotherm. Farther east into Wisconsin however, the same differentiation occurred around -3°C. The change from rain to freezing rain occurred around -3°C over extreme northwest Illinois, but the same change occurred near 0°C over extreme southeast Lower Michigan.

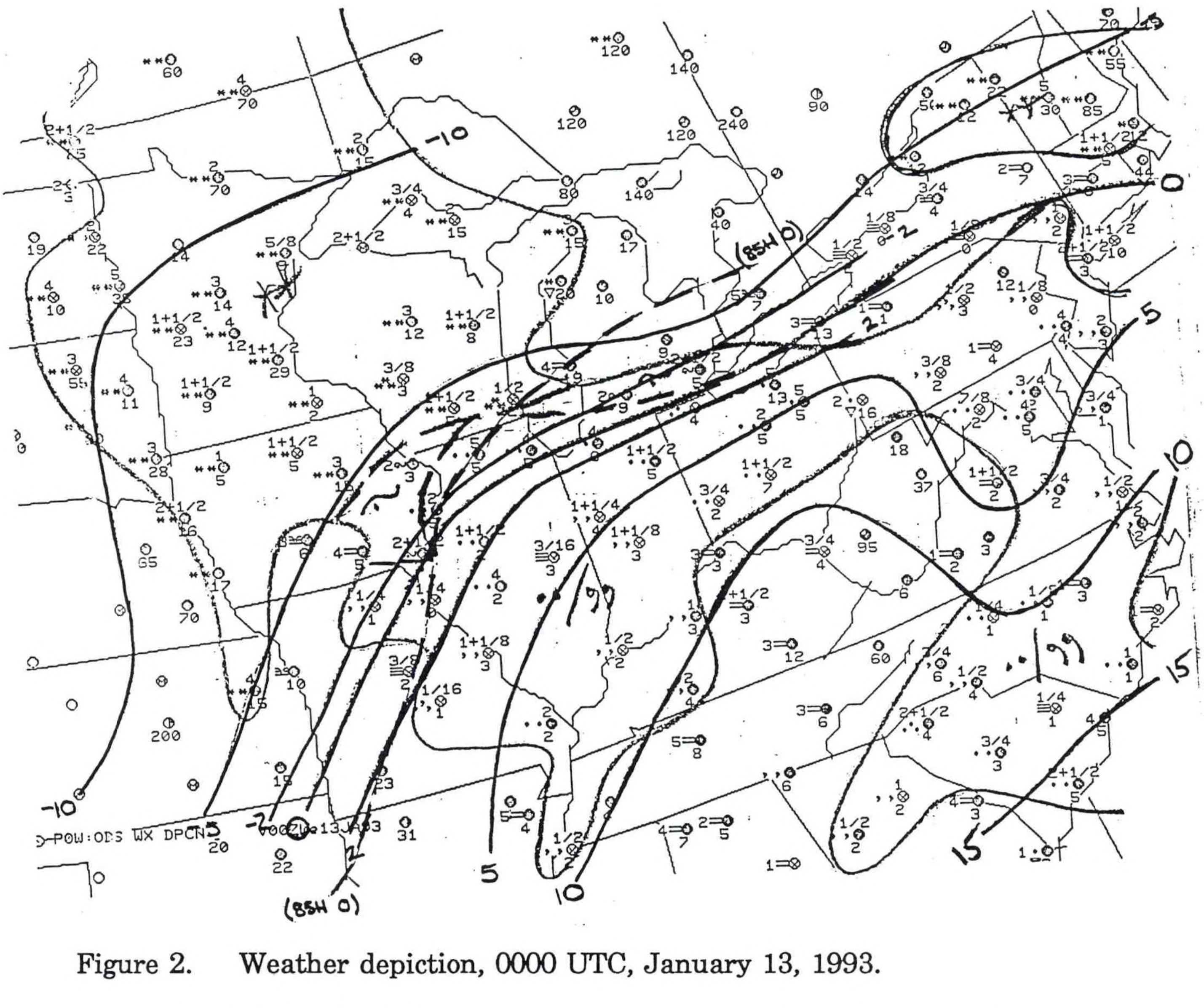

Figure 2. Weather depiction, 0000 UTC, January 13, 1993.

Figure 3 (1200 UTC, February 21, 1993) is an example where a particular isotherm, other than 0°C, marked a boundary between differing precipitation types. The separation of rain and freezing rain occurred along the -2°C 925 mb isotherm, and the demarcation between freezing rain and snow occurred near -4°C. In Figure 4 (1200 UTC, March 22, 1993) there was a close correlation of the rain/snow line with the 925 mb 0°C isotherm.

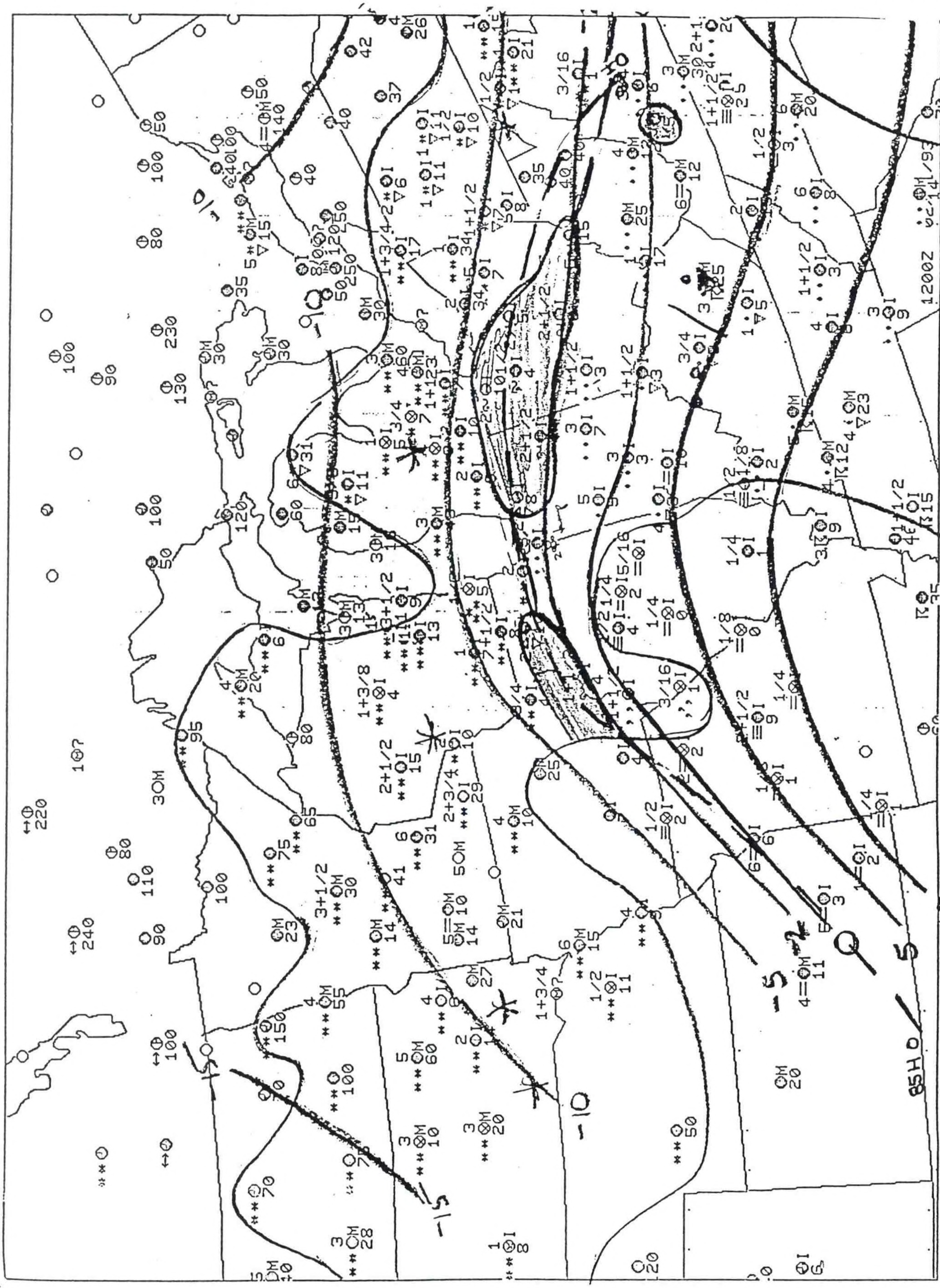

Figure 3. Weather depiction, 1200 UTC, February 21, 1993.

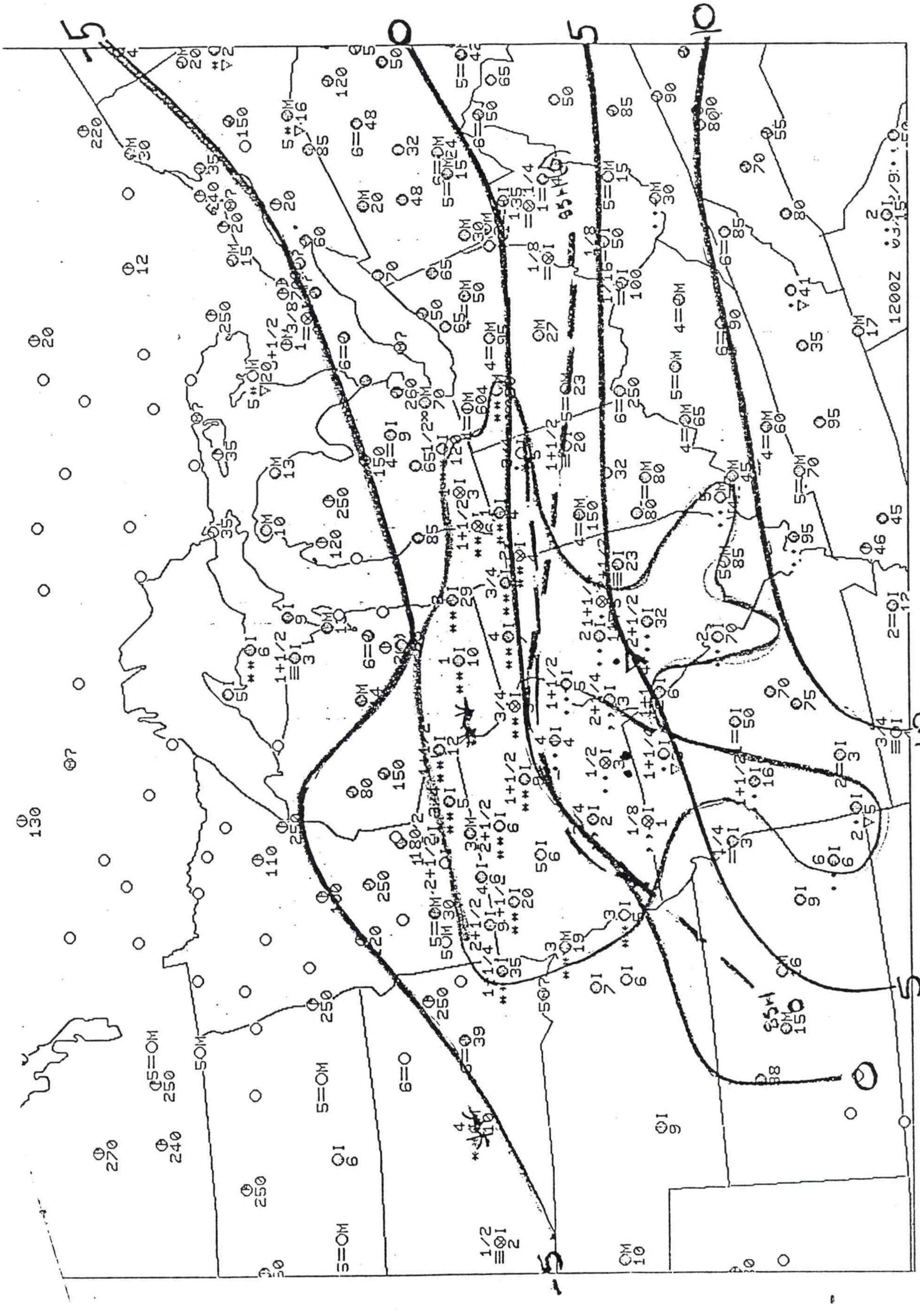

Figure 4. Weather depiction, 1200 UTC, March 22, 1993.

Figures 2 through 4 demonstrate that 925 mb temperature alone does not give an accurate indication of precipitation type. In each case, the surface patterns were similar, the precipitation was of an "overrunning" type, and the geographical area of interest was nearly identical. However, attempts to use 925 mb temperature analyses to determine precipitation type produced inconsistent results.

This haphazard quality of 925 mb temperature as a predictor of precipitation type was evident throughout much of the study. Depending on geography alone, few cases in any portion of the eastern U.S. showed any similarities in terms of a correlation of 925 mb temperature to observed precipitation type, even in similar synoptic situations. Additionally, ignoring geography and categorizing the results in terms of synoptic features alone produced equally inconsistent results.

However, a pair of noteworthy, positive aspects did become apparent from the analyses. Rain was never observed in areas where the 925 mb temperature was colder than -3°C. Snow was never observed in areas with a 925 mb temperature warmer than +3°C.

Freezing rain was associated with the widest range of 925 mb temperatures, from as cold as -7°C to warm as +4°C. In Figure 2 alone, note that freezing rain was observed with a 925 mb temperature as cold as near -5°C and as warm as 0°C.

4. Comparison with 850 mb Data

A. 850 mb Zero-Degree Isotherm

The 850 mb zero-degree isotherm was compared to the 925 mb zero-degree isotherm to determine which was more reliable in determining precipitation type. Overall, neither zero-degree isotherm performed better than the other. In 18 cases, the 925 mb zero-degree isotherm was a better indicator of the change or type of precipitation. In 16 cases, the 850 mb zero-degree isotherm was better, and in 13 cases, neither took precedence.

However, the 850 mb zero-degree isotherm was almost always as good as or better than the 925 mb zero-degree isotherm in areas of freezing rain. In 12 cases of freezing rain occurrence, eight were better predicted by the 850 mb zero-degree isotherm. The remaining four cases were equally characterized by the zero-degree isotherms of both 925 mb and 850 mb. An example of this is shown in Figure 5 (0000 UTC, December 29, 1992). This case was signified by a strong, shallow cold front located over the central Plains south of the area of precipitation. The entire area of freezing rain was located south of the 850 mb zero-degree isotherm, and north of the 925 mb zero-degree isotherm. This example, typical of most of those with freezing rain, shows that the 850 mb zero-degree isotherm location tends to correlate better with the occurrence of that type of precipitation.

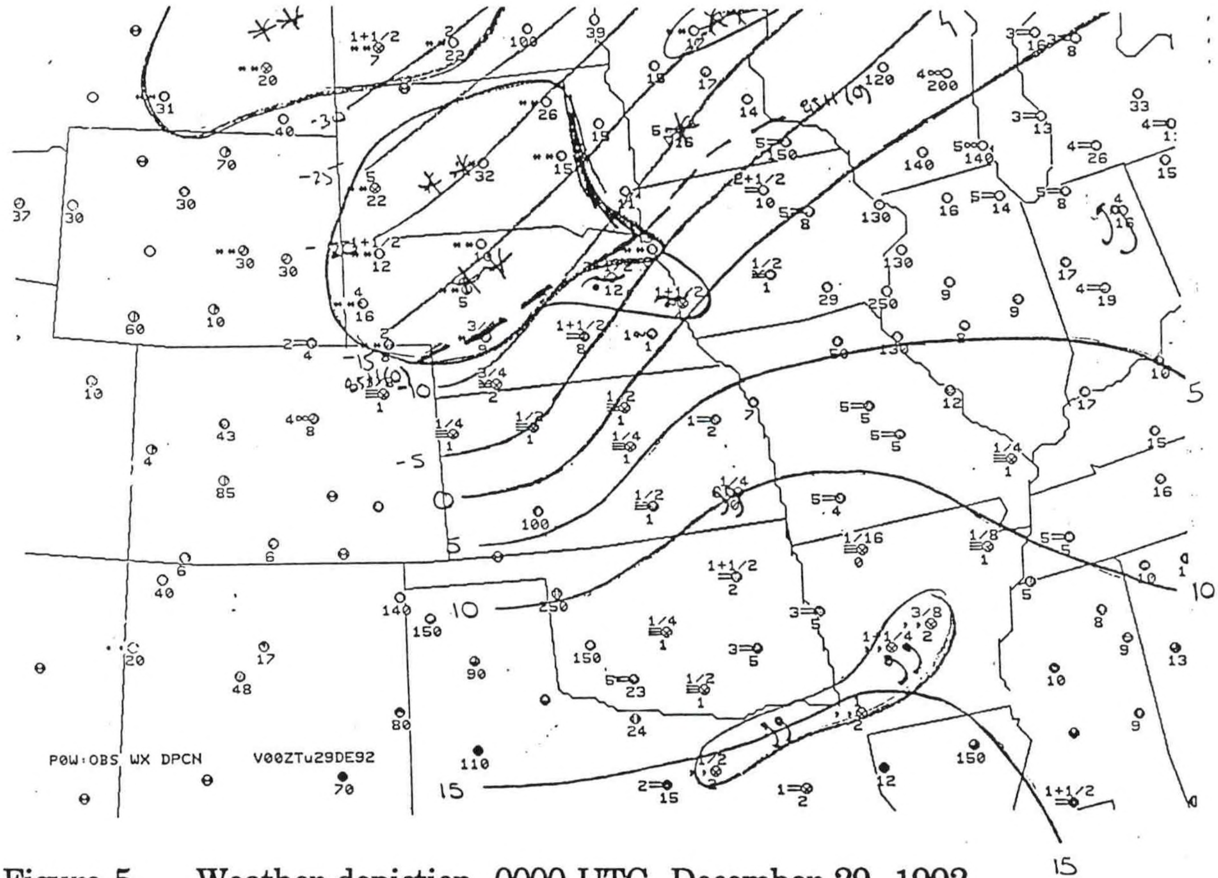

Figure 5. Weather depiction, 0000 UTC, December 29, 1992.

Comparison of other 925 mb isotherms to the 850 mb zero-degree isotherm and various precipitation types provided little additional information. For example, in Figure 5 the freezing rain orientation over east-central Nebraska and extreme western Iowa was essentially perpendicular to the 925 mb isotherms. This scenario offered no correlation to the occurrence of freezing rain.

B. 850 mb Isotherms of -5 to +5

An expanded comparison of 925 mb temperature data and precipitation type to 850 mb temperature was performed using a range of temperatures for both levels from -5°C to +5°C. If a weather depiction showed precipitation at a particular location, the type of precipitation was placed on a scatter diagram. Figure 6 shows the distribution of precipitation types for all cases. Figure 6 will be referenced with regard to the following temperature quadrants:

Quadrant	850 mb temperature	925 mb temperature
1	0 <= T <= 5	-5 <= T < 0
2	0 <= T <= 5	0 <= T < 5
3	-5 <= T < 0	-5 <= T < 0
4	-5 <= T < 0	0 <= T <=5

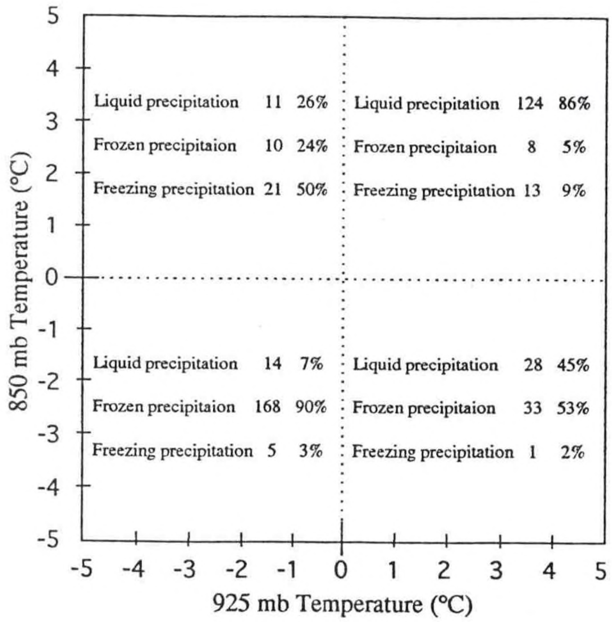

Figure 6. Distribution of precipitation types for each 850 mb/925 mb temperature quadrant (all cases).

Not surprisingly, given that temperatures at 850 mb tend to be correlated with temperatures at 925 mb, most precipitation data points tended to be located in quadrants two and three. It is when temperature profiles resemble those found in quadrants one and four, however, that meteorologists are most challenged with respect to forecasting precipitation type.

The "cold" quadrant three indicated predominately snow. In quadrant two, 86% of the stations on analyzed weather depictions reported liquid precipitation. Of the eight frozen events in quadrant two, half were located in the cold west-to-northwest part of a surface low pressure center.

In quadrant one, half of the stations reported freezing precipitation. The other half were equally divided between frozen and liquid types. This shows the potential for a forecast leaning toward freezing precipitation, or at least freezing precipitation mixed with other types, when the atmospheric temperatures are as those described in quadrant one. Finally, quadrant four showed only one freezing precipitation case, with the rest almost equally divided liquid and frozen events. Even though the data sample in this quadrant was small, results indicate a low probability of occurrence of freezing precipitation in that environment.

5. Summary and Conclusion

Sole use of 925 mb temperature to forecast precipitation type does not appear very practical. Considerable variability existed among the 925 mb temperatures at which differentiation between precipitation types occurred. In some cases, a precipitation-type demarcation would occur along the zero-degree isotherm. In others, a precipitation-type demarcation line would be aligned along a colder 925 mb isotherm, or perhaps not along any 925 mb isotherm.

Some noteworthy, positive aspects were discovered, primarily in terms of the coldest (warmest) 925 mb temperature at which rain (snow) was observed. Rain was never observed below -3, and snow was not indicated above +3. Knowing this, should other data (such as thicknesses) provide for an inconclusive result regarding precipitation type, 925 mb temperature data may indeed assist forecasters.

Comparisons with 850 mb data show that the use of the 925 mb zero-degree isotherm is at least as useful as the 850 mb zero-degree isotherm. The shallower depth of atmosphere at 925 mb seems to make little difference.

However, comparing ranges of temperatures at 925 mb and 850 mb to precipitation type provided a potential application to winter weather forecasting. In an atmosphere where 850 mb temperatures were at or above zero, and 925 mb temperatures were below zero, the predominant precipitation type found in this study was freezing rain. (Though sleet is another type of precipitation found in this environment, very few stations on the weather depictions gathered for this study had sleet as a precipitation type. Thus, sleet was not handled in this study.) If the temperature at both levels was warmer than zero, precipitation type was usually rain. If the temperature at both levels was colder than zero, frozen precipitation was predominant. Lastly, very few freezing rain events occurred when 850 mb temperatures were below zero and 925 mb temperatures were at or above zero. These results show potential for the usefulness of a combination of 850 mb and 925 mb temperatures when attempting to make precipitation-type forecasts. Further study on this application may shed more conclusive light on its practicality, possibly even providing more information on the predominance of snow or rain when 925 mb temperatures are warmer than 0°C and 850 mb temperatures are cooler.

6. Acknowledgements

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7. References

McNulty, R.P., 1991: Winter Weather Precipitation Type (lesson notes - August), NOAA, NWS Training Center, Kansas City, MO.