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MID-WINTER BIAS OF LFM-BASED MOS AND NGM PERFECT PROG TEMPERATURE FORECAST

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1. Introduction

The Model-Output-Statistics (MOS) maximum temperature forecasts have exhibited a marked warm bias in mid-winter synoptic situations in which there exists a shallow cold air mass near the surface. This condition is frequently observed in the Rockies in association with intrusions of intense but shallow Arctic air masses on the High Plains east of the Continental Divide. It is also observed in regions of trapped cold air in high western slope valleys. This paper will present recent examples of this phenomenon.

2. Data

The MOS temperature forecasts are based, in large part, on the thickness prognostications. The thickness is, in fact, one of the most heavily weighted terms in the MOS equations. Derived from the hypsometric equation, thickness is proportional to the mean temperature in the layer. It follows then that in the case of shallow surface-based cold air masses, thickness becomes a poor representation of surface temperatures, and temperature forecasts based on thickness (and height) will be prone to error. The following examples illustrate this;

A. February 5, 1988, Denver

LFM MOS 3rd pd maximum temp forecast............30
observed......15
NGM perfect prog 3rd pd maximum temp forecast...38

Little improvement was noted even in the first period forecast for this day. Slightly smaller errors were observed for the day at Colorado Springs (COS) and Pueblo (PUB) where the Arctic air mass was even shallower and later in arriving.

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B. February 10, 1988, Denver

LFM MOS 4th pd maximum temp forecast............39
NGM perfect prog 4th pd maximum temp forecast...42
observed......21

LFM MOS 3rd pd maximum temp forecast............35
NGM perfect prog 3rd pd maximum temp forecast...37

It is interesting to note that while the MOS temperature forecasts performed very poorly on both these days, corresponding height and thickness progs verified quite well. Indeed, had the vertical lapse rate more closely approached dry adiabatic, the temperature forecast would have been quite reasonable based on the forecast height and thickness. This was far from the case as is obvious in the observed vertical profiles of the day (Fig. 3). The 48H LFM and NGM MSL pressure and thickness progs were suggestive of an Arctic air mass moving southward along the eastern slopes of the Rockies (Fig. 1). Since the main thrust was to be through the Central Plains states, the air mass would likely be quite shallow, not extending west of the Continental Divide. The vertical profiles of the day showed this to be true with the Arctic air mass less than 3 km deep. The 48H 500 mb, MSL pressure, and thickness progs as well as the 700 mb temperature prog all verified quite well. In spite of this, the MOS temperature forecasts were essentially "blind" to the presence of a shallow Arctic air mass.

Similarly, problems arise with the MOS temperature forecasts on the western slope of Colorado when a persistent shallow cold air mass is trapped in high valleys, undergoing little mixing or modification with time. This problem is most prevalent during mid-winter low-sun when there is a snow cover.

The results of a local study (Markkanen, 1988) have shown a strong warm bias of the LFM MOS temperature forecasts at Grand Junction (GJT) for all the month of January 1988. The average error was 7.1 degrees for all periods, and a whopping 9.1 for just the 4th period. This is extraordinary for a station whose temperature normally changes little from day to day. (January 1988 was no different than normal, the average day-to-day change in maximum temperature was 3.7 degrees.) This month was unusual for Grand Junction in that there was snow cover throughout the month. Snow cover in the high valleys of western Colorado tends to enhance low level inversions and these trapped pools of cold air undergo little vertical mixing or diabatic modification in mid-winter as long as snow cover persists. Daily rawinsondes at GJT revealed a shallow surface-based inversion which persisted through much of the month. Even moderately strong Pacific frontal systems seemed to have little effect. MOS equations are not available for the 12Z model runs, but the 00Z equations only use snow cover for the 1st period maximum. There is no snow cover in the 3rd period. Previous days maximum also appears in the 1st period maxima from the 00Z run but not in the 3rd period. Observed temperatures appear twice in 1st period maxima and only once in the 3rd period maxima. Thus, it is obvious that with increasing time projection, the effects of the unusual prevailing conditions have less and less influence in the MOS forecasts.

The temperature bias in these mid-winter situations is further exacerbated by model terrain characteristics. Figure 4 represents the initialized NGM terrain for a particular day in September 1988. Note that the difference between the actual station pressure and terrain pressure height at both DEN and GJT is 56 mb and 70 mb, respectively. That means that in this situation the lowest 56 to 70 mb of the atmosphere is essentially "underground" as far as the model is concerned and doesn't exist. This was a day in which the MSL pressure gradient was quite weak. In a typical winter situation the discrepancy can be much greater, and a shallow surface-based cold air mass could go largely undetected in model initialization.

3. Conclusions

There appears to be little hope of genuine improvement with regard to LFM-based MOS temperature forecasts in these situations. However, we have recently received word (Dallavalle, 1988) regarding the future of NGM-based MOS temperature guidance. It has been stated at NWSH with reference to Denver MOS and perfect prog forecasts;

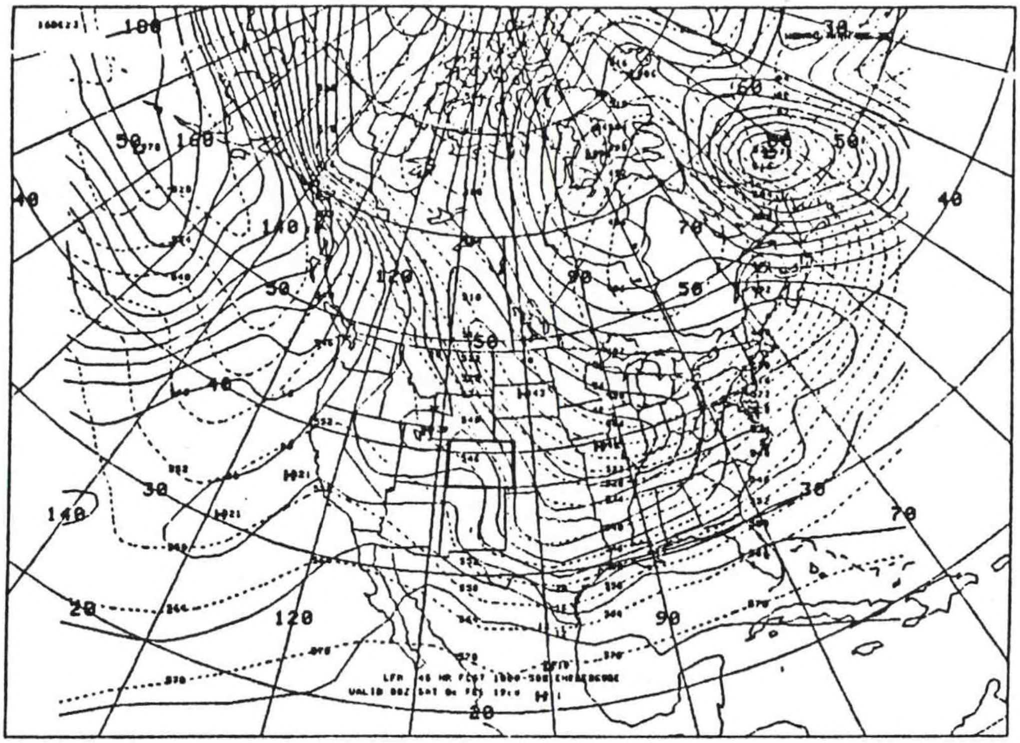
> "The large errors produced by the perfect prog guidance during the cool season definitely concern us. We're now beginning a project to improve these forecasts. If we are successful, you should see better perfect prog guidance sometime during the 1988-89 winter. In addition, we are working to produce NGM-based MOS guidance by the summer of 1989. To accomplish this goal, we will need to run the NGM on historical data. Whether we will be able to do this and then derive reliable MOS forecast equations is still an unanswered question."

Until there are definitive answers to that and other questions, the repeated occurrence of these two situations in mid-winter; Arctic intrusions on the High Plains and trapped cold air on the western slope, present a unique and continuing opportunity for significant improvement by the forecaster over numerical guidance.

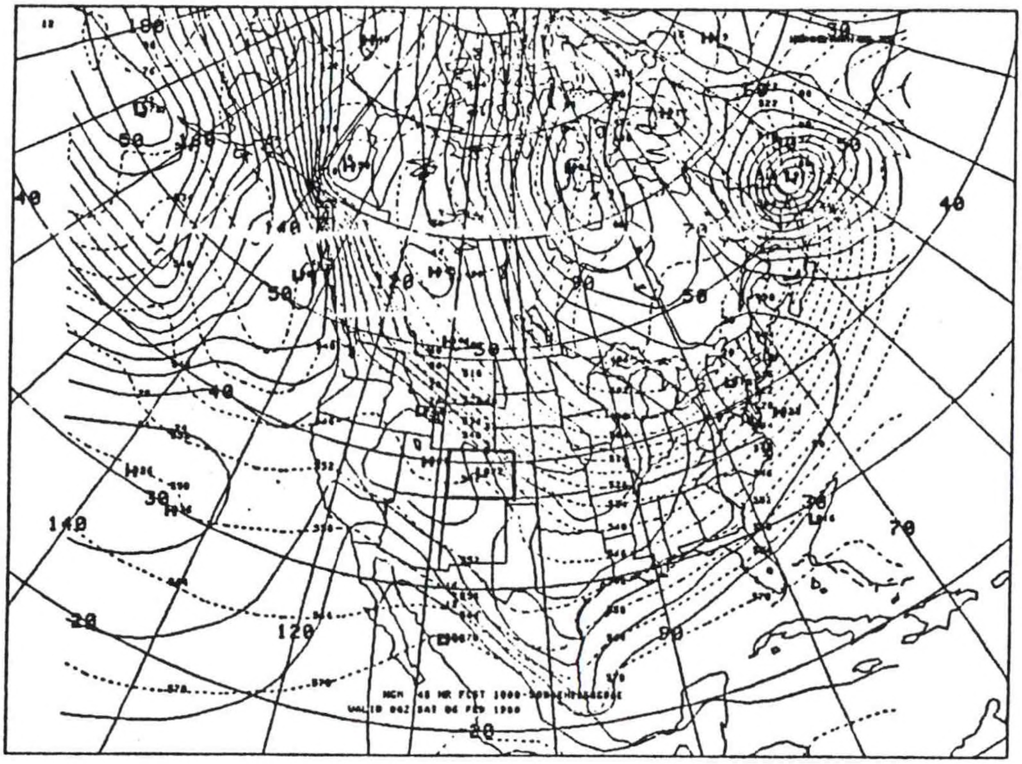
4. Reference

Markkanen, S. E., 1988: January Temp/Pcpn Verification for DEN/COS/PUB/GJT. Unpublished inter-office memorandum, available from National Weather Service Forecast Office, Denver, Colorado.

Dallavalle, J. P., 1988: Personal communication. Office of Systems Development, National Weather Service Headquarters, Washington, D.C.

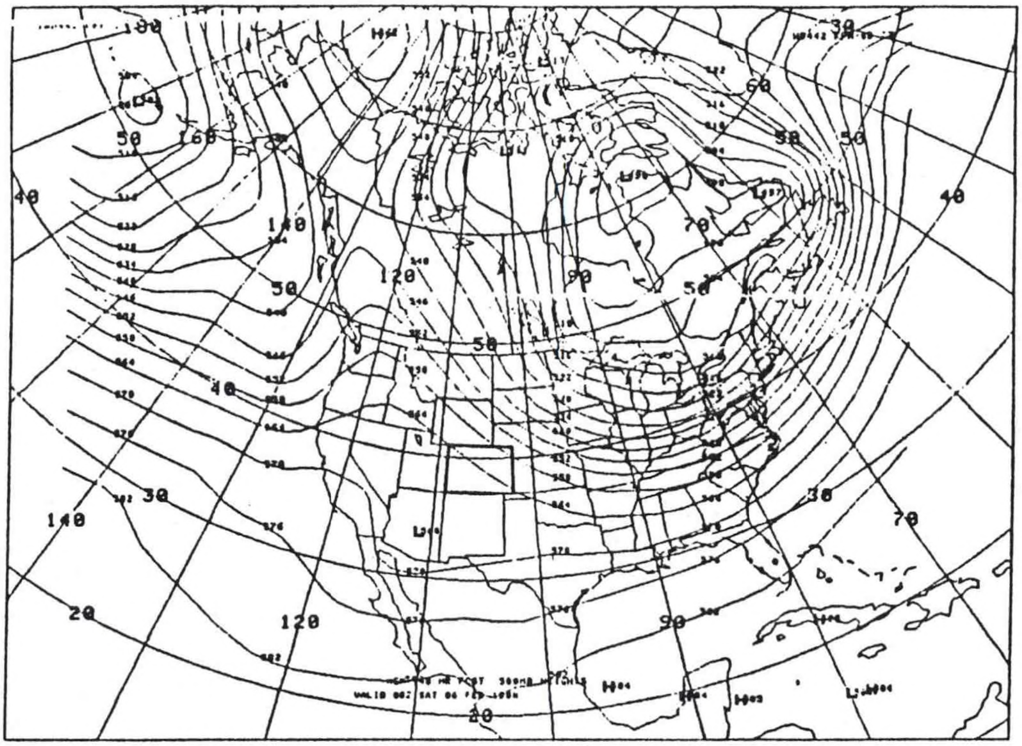


0400 K83: 48h LFM Thickness v Sat 06-FEB-1988 00:00
0400 084: 48h LFM Surface Pressure v Sat 06-FEB-1988 00:00



0400 K8K: 48h NGM 1000-500mb Thickness Forecast v Sat 06-FEB-1988 00:00
0400 08I: 48h NGM Surface Pressure Forecast v Sat 06-FEB-1988 00:00

Fig. 1



0400 58H: 48h NGM 500mb Height Forecast v Sat 06-FEB-1988 00:00

Fig. 2

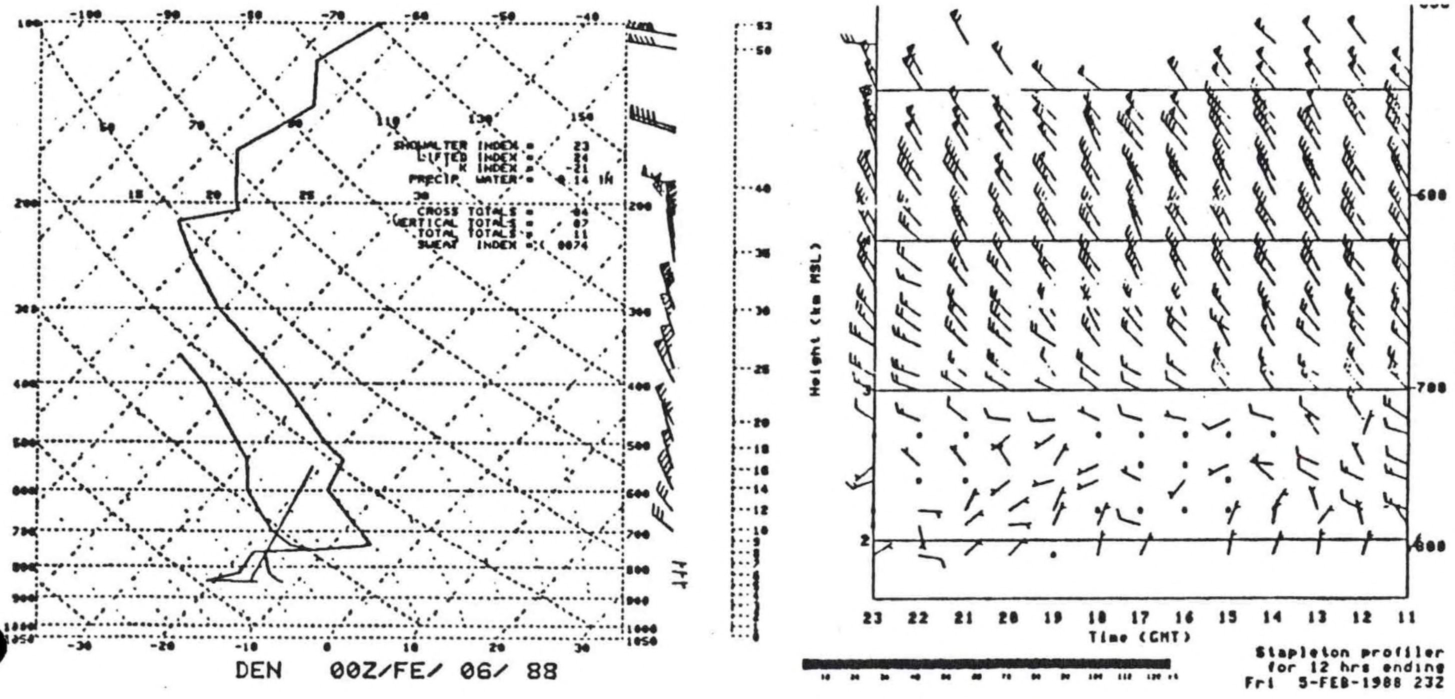
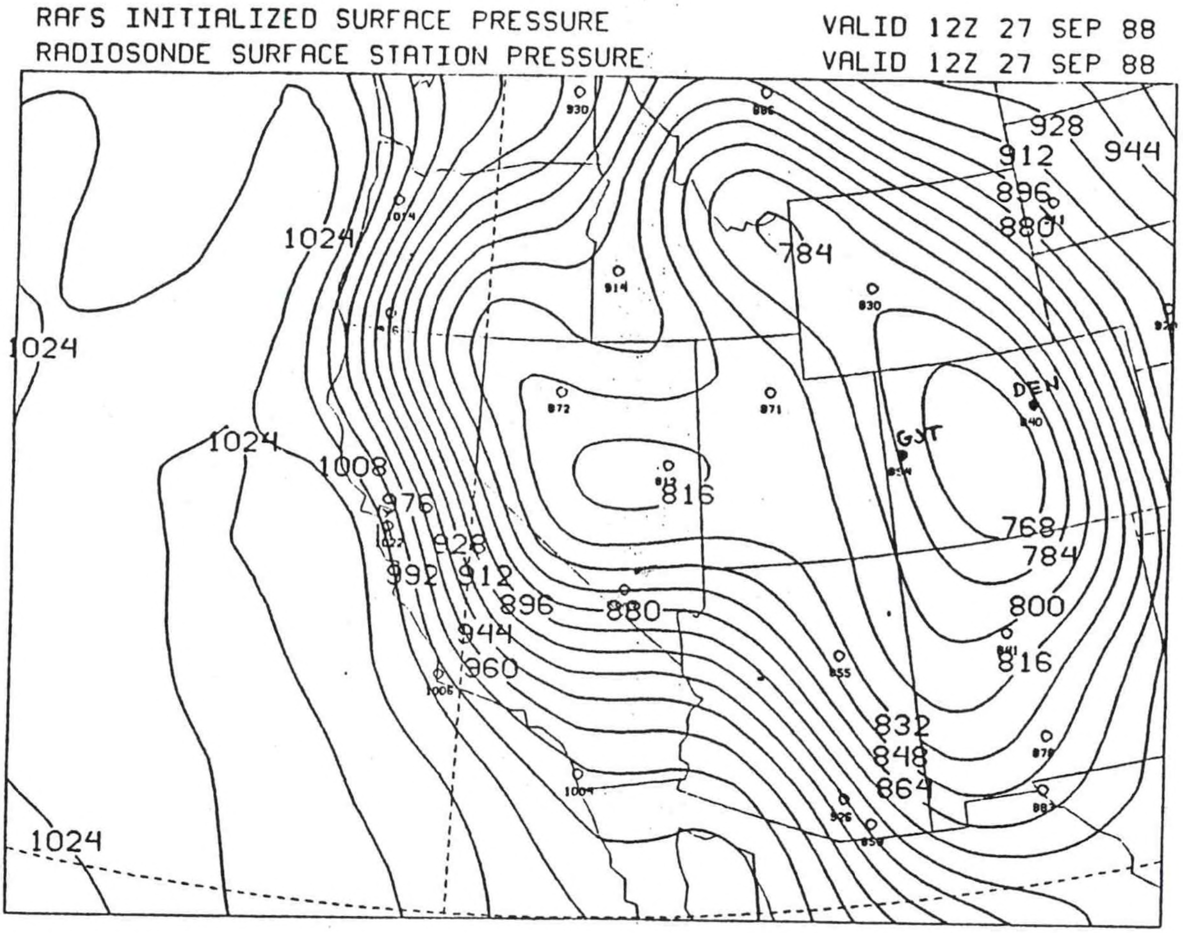


Fig. 3


RAFS INITIALIZED SURFACE PRESSURE
RADIOSONDE SURFACE STATION PRESSURE
VALID 12Z 27 SEP 88
VALID 12Z 27 SEP 88
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1008
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992
928
912
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880
944
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816
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DEN
GJT
768
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800
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832
848
864

Fig. 4