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USE OF MOS FORECAST PARAMETERS IN TEMPERATURE FORECASTING

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TABLE OF CONTENTS

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I. INTRODUCTION

Meteorological variables are highly interrelated. A forecaster frequently makes at least subjective forecasts of one or more additional parameters such as cloudiness or precipitation in the process of preparing a temperature forecast. Someone seeking to develop an objective forecast aid is confronted with the same problem. The availability of MOS-derived wind-and-cloud forecasts has opened new opportunities to field forecasters seeking to develop local forecast aids. In this paper, a minimum temperature forecast system is developed for Pocatello, Idaho, which uses MOS wind and cloud forecasts in a physically reasoned manner. The MOS or Model Output Statistics technique is described by Glahn and Lowry [1], and the development of MOS forecast wind and cloud amount is described by Technical Procedures Bulletins Nos. 98 [2] and 124 [3].

Overnight minimum temperatures are considered by many forecasters to be strongly related to the following variables: 1) Afternoon maximum temperatures; 2) Afternoon dew-point temperatures; 3) Length of night; 4) Cloud cover; 5) Wind speed and sometimes wind direction; 6) Thermal advection; and 7) Snow cover or condition of the ground. The approach used in this study is to present an existing clear, calm forecast equation which considers points 1, 2, 3, and 7, then to develop adjustments for winds and clouds using the MOS forecasts, and finally an adjustment for fog, dew or frost.

II. OLSEN MINIMUM TEMPERATURE FORECASTING AID

An excellent aid for forecasting minimum temperatures at Helena, Montana, under clear nights and calm winds was developed by Olsen [4]. This aid includes adjustments for depth and condition of snow cover and has been used continuously by the Boise forecast office since Dave Olsen joined the staff in 1972.

$$T_{min} = 3.92(T_{max}^{1/2})(T_{dp}^{1/4}) \ [1 + 0.015 \text{ SIN } \{\pi/180 \cdot (\text{date-Mar. } 21)\}] - Sd^{1/2}$$

where T_{min} = forecast minimum temperature, ^{o}k
T_{max} = afternoon maximum temperature, ^{o}k
T_{dp} = afternoon dew-point temperature, ^{o}k
d = snow depth, inches
S = snow condition, wet=1, crusty=2, dry=4, fresh or powdery=6.

The Olsen clear/calm equation was applied to 90 nights of development data from October 21, 1975, through January 19, 1976. The average forecast error was 12.9°F., with a very strong cold bias as might be expected.

III. WIND ADJUSTMENT

An unpublished local study by Plankinton [5], suggested that nighttime winds raise the minimum temperature by about one degree fahrenheit for every knot of wind speed up to at least 13 knots. Therefore, the average MOS forecast winds at 06Z and 12Z was added to the Olsen clear/calm forecast on each of the 90 nights. This step cut the average forecast error in half to 5.96°F., however, a cold bias of nearly four degrees persisted. During the same 90 nights the MOS objective forecast temperature [6] for the first period minimum temperatures attained an average error of 4.92°F. at Pocatello.

The nights with strong forecast winds were examined and found to have a nearly neutral temperature bias, and that further adjustments for clouds or other factors would degrade the forecast accuracy. After careful testing, it was determined to eliminate the cloud adjustment if the average MOS forecast winds exceeded 11 knots. The rational of this decision is that strong winds begin to dominate the synoptic situation and bring in air from other areas which may not be cooling at the same rate as local air might cool.

IV. CLOUD ADJUSTMENT

Next, the MOS cloud forecasts were examined. The best category value at the end of each forecast cloud group is determined by a procedure which seeks to minimize the forecast error evaluated with a contingency table. Therefore, the value tends to be biased toward the scattered or broken categories, and a decision was made not to use this best category value as a forecast variable. A weighted sum of the probabilities of each category was developed by multiplying the probability of each category by the tenths of cloud cover in the category. Thus, the probability overcast cloudiness is multiplied by 0.9, the probability of broken clouds by 0.7, and the probability of scattered by 0.3. The sum of these products forms a cloud parameter which varies from zero to 10 when rounded to the nearest integer, and was added to the previous minimum temperature estimate. This step reduced the average error for the 90 nights to 4.37, or about one-half degree better than the average MOS temperature error.

V. FOG ADJUSTMENT

An examination of the forecast error remaining after the cloud adjustment revealed that the forecast frequently erred on the cold side whenever the forecast minimum was more than a few degrees below the afternoon dew point. On many of these nights fog did develop and limited the rate of cooling. On other nights, no fog was reported on the observations, however, dew or frost or other phenomena may have occurred and limited the cooling. After close examination, it was decided to adjust the minimum temperature forecast upward if it were 5 or more degrees cooler than the afternoon dew point. The forecast minimum was adjusted upward by one degree for either 5 or 6 degrees of difference between it and the dew point; two degrees for 7 degrees of difference; three degrees for 8 degrees of difference; etc., up to a limit of 6 degrees of adjustment. Following the fog adjustment, the average error for the 90 days of development data was 3.88, for an average improvement over the MOS temperature guidance of 1.04°F.

Several forecast parameters for thermal advection were tested with only a slight improvement in the forecast accuracy. Therefore, this factor was not included in the forecast system.

VI. RESULTS AND CONCLUSIONS

The whole minimum temperature forecasting system can be written symbolically as follows:

$$T_{min} = T_{min(Olsen)} + \overline{MOSWND} + \underset{(\text{if } \overline{MOSWND} \leq 11)}{\overline{MOSCLD}} + \underset{(\text{if fcst min} \leq T_{dp} - 5°\text{F}).}{\text{FOG ADJUSTMENT}}$$

The system was applied to 25 nights of independent test data from January 20, 1975, through February 13, 1976, and resulted in an average forecast error of 4.12°F. compared to an average error of 5.04°F. for the MOS temperature guidance forecasts, which is very nearly the same one-degree improvement registered in the development data.

A brief period of 21 nights of data was available during the warm season from August 1975. The average forecast error from this period using the system developed in this paper was 5.67°F., compared to an average error of 4.19°F. for the MOS temperatures. However, a cold forecast bias amounting to 4.81°F. remained, providing the promise of significant improvement with the incorporation of additional forecast parameters. A promising additional factor may be the difference between the air temperature, and the soil temperature.

This minimum temperature forecast system has been programmed for use on the WANG programmable calculator and is used routinely by a few of the forecasters at Boise WSFO. The testing of the system on other forecast points within Idaho and for forecast periods beyond the first period at Pocatello is progressing. By including MOS predictors in this system, it is hoped that it will continue to improve as the numerical models improve, and that it will thus continue to show improvement over the MOS temperature forecast guidance.

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