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VERIFICATION OF OBJECTIVE SNOW AMOUNT GUIDANCE (OCTOBER 1982-MARCH 1983)

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1. INTRODUCTION

During the month of September 1982, the Techniques Development Laboratory implemented a new probability of snow amount (PoSA) forecast system described in Technical Procedures Bulletin No. 318 (National Weather Service, 1982a) and Bocchieri (1983). This new system provides both probabilistic and categorical forecasts for 195 stations in the conterminous United States for three categories of snow amount ($\geq$2, $\geq$4, and $\geq$6 inches) for 12-24 h periods after both 0000 and 1200 GMT. The previous snow amount guidance, called the probability of heavy snow (PoSH), provided categorical forecasts of snow $\geq$4 inches only, and is described in Technical Procedures Bulletin No. 246 (National Weather Service, 1978). The new PoSA system is based on equations developed through application of the Model Output Statistics (MOS) technique (Glahn and Lowry, 1972) and uses forecast output from the Limited-area Fine Mesh (LFM) model (National Weather Service, 1977; Newell and Deaven, 1981).

This report briefly describes the development of the PoSA system and presents verification statistics for the cool season months of October 1982 through March 1983. This was the first season for which the PoSA system provided operational forecasts. Hence, the results were not compared to those from previous cool seasons.

2. DEVELOPMENT

The Regression Estimation of Event Probability (REEP) screening technique (Miller, 1964) was used to develop the PoSA forecast equations. This technique objectively selects a subset of effective predictors from a larger set of potential predictors to use in multiple linear regression equations. The equations give estimates of the probabilities of occurrence of a given set of binary predictands. For the PoSA equations, snow amount was categorized into three, cumulative, binary predictands: $\geq$2, $\geq$4, and $\geq$6 inches. The predictand is called binary because in the developmental phase it was assigned a value of 1 or 0 for a given case depending, respectively, upon whether or not that particular snow amount category occurred. A good description of the screening procedure can be found in Glahn and Lowry (1972).

Conditional PoSA equations were derived for each of several geographic regions (see Fig. 1) by combining data from all stations within the region. The equations are conditional because only "pure snow" events were included in the developmental sample which consisted of nine cool seasons from 1972-73 through 1980-81. A pure snow event is defined as the occurrence at a station of $\geq$0.1 inches of snow and/or sleet, and no other type of precipitation, during a 12-h period.

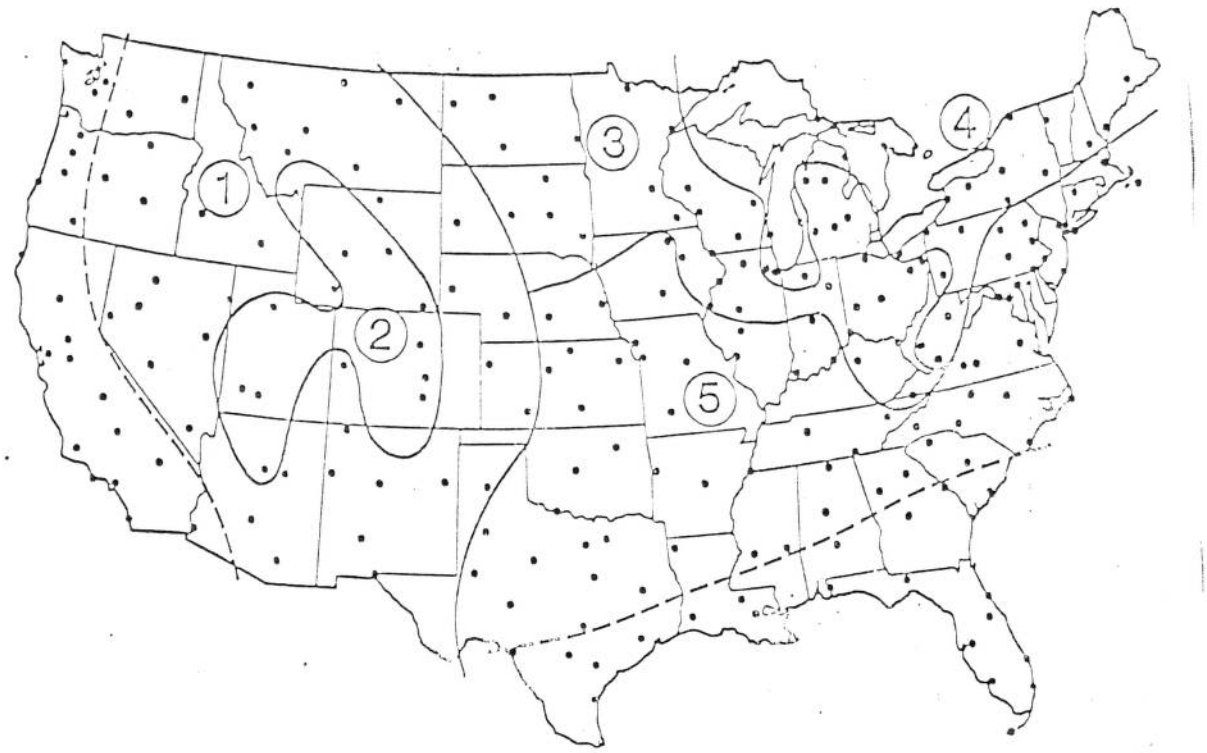

Figure 1. The five regions used in the development of the conditional probability of snow amount equations. Stations south and west of the dashed lines were not included in the development.

To produce unconditional PoSA forecasts, PoSA(U), the conditional PoSA forecast, PoSA(C), for each snow amount category is multiplied by the probability of precipitation (PoP) (National Weather Service, 1980) for the corresponding 12-h period and the average conditional probability of frozen precipitation ($\overline{\text{PoF}}$) (National Weather Service, 1982b) for the same 12-h period. To obtain $\overline{\text{PoF}}$, the 12-, 18-, and 24-h PoF forecasts are averaged; in this scheme, the 18-h forecast is weighted twice as much as the 12- and 24-h forecasts. For instance, the unconditional probability of the $\geq$2 inch category is estimated by:

$$\text{PoSA(U)}(\geq 2 \text{ inches}) = \text{PoSA(C)}(\geq 2 \text{ inches}) \times \text{PoP} \times \overline{\text{PoF}}.$$

In order to make categorical snow amount forecasts from the unconditional probability forecasts, threshold values were developed for each snow amount category, for each region, and for both 0000 GMT and 1200 GMT. The thresholds were obtained in an iterative manner by computing verification scores for categorical snow amount forecasts based on differing sets of threshold probabilities. The threshold chosen was the one which produced the best verification scores on the developmental sample.

Operationally, conditional, unconditional, and categorical forecasts are all transmitted on the FOUS12 bulletin (National Weather Service, 1983). Further details regarding the development of the PoSA system may be found in Bocchieri (1982a, 1982b, and 1983).

3. VERIFICATION RESULTS

We verified the categorical forecasts by calculating the bias, threat score, and post-agreement[1] for each category of snow amount for the 12-24 h forecast periods from 0000 and 1200 GMT for October 1982 through March 1983. Table 1 shows the scores for both cycles for all 195 stations combined. Also included for purposes of comparison are the verification results from forecasts made on the developmental sample (October 1972-March 1973 through October 1980-March 1981).

Table 1. The bias, threat score, post-agreement, and number of cases for categorical snow amount forecasts for 195 stations combined. These scores were calculated for the operational forecasts (I) made from October 1982 through March 1983, and for forecasts made from the developmental sample (D) which included nine cool seasons of data from 1972-73 through 1980-81. The results are shown for 0000 and 1200 GMT.

Snow Amount Category (inches)	Bias		Threat Score		Post-Agreement (%)		Number of Cases	
	I	D	I	D	I	D	I	D
0000 GMT								
≥2	1.13	1.12	.26	.27	38.5	40.7	420	4716
≥4	1.08	1.09	.20	.20	31.6	31.9	126	1300
≥6	0.72	0.88	.16	.17	26.7	31.1	43	399
1200 GMT								
≥2	1.06	1.09	.27	.29	41.4	43.1	444	4987
≥4	1.07	1.16	.24	.21	36.9	32.7	122	1298
≥6	0.90	0.89	.17	.17	31.1	30.6	50	395

The verification results indicate that, in general, the 1200 GMT forecasts were slightly better than the 0000 GMT forecasts for the 1982-83 cool season. The bias scores reveal a tendency to slightly overforecast the ≥2 and ≥4 inch categories and to underforecast the ≥6 inch category. Of course, it is desireable to overforecast snow amounts to some extent. The post-agreement indicates that, when the PoSA system forecasts a category to occur, it is correct approximately 40% of the time for the ≥2 inch category, and about 30% of the time for the ≥6 inch category. Table 1 also shows that the scores for the 1982-83 cool season are similar to those obtained on the developmental sample.

[1]The bias = B/C, the threat score = A/(B+C-A), and the post-agreement = A/B, where A, B, and C are the number of correct forecasts, the total number of forecasts, and the number of observations of the event, respectively.

4. SUMMARY

The new PoSA system was implemented operationally during September of 1983. It provides probability and categorical forecasts for 195 stations in the conterminous United States for the three categories of snow amount ≥ 2, ≥ 4, and ≥ 6 inches, for 12-24 h periods after both 0000 and 1200 GMT. The new PoSA system replaced the PoSH system which only forecast the occurrence of snow ≥ 4 inches.

Verification results from the first cool season of operational use of the PoSA system (October 1982 through March 1983) indicate that the PoSA system performed as expected based on previous verification results of forecasts produced from the developmental sample.

5. ACKNOWLEDGEMENTS

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REFERENCES

Bocchieri, J. R., 1982a: Recent experiments in the use of Model Output Statistics for forecasting snow amounts. TDL Office Note 82-2, National Weather Service, NOAA, U.S. Department of Commerce, 7 pp.

_____, 1982b: Further development and testing of an automated system to forecast snow amounts. TDL Office Note 82-7, National Weather Service, NOAA, U.S. Department of Commerce, 19 pp.

_____, 1983: Automated guidance for forecasting snow amount. Mon. Wea. Rev., 111, 2099-2109.

Glahn, H. R., and D. A. Lowry, 1972: The use of Model Output Statistics (MOS) in objective weather forecasting. J. Appl. Meteor., 11, 1203-1211.

Miller, R. G., 1964: Regression estimation of event probabilities. Tech. Rep. No. 1, Contract CWB-10704, The Travelers Research Center, Inc., Hartford, Conn., 153 pp. [NTIS AD 602037].

National Weather Service, 1977: High resolution LFM (LFM-II). NWS Technical Procedures Bulletin No. 206, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 6 pp.

_____, 1978: The use of Model Output Statistics for predicting the probability of heavy snow. NWS Technical Procedures Bulletin No. 246, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 10 pp.

_____, 1980: The use of Model Output Statistics for predicting probability of precipitation. NWS Technical Procedures Bulletin No. 289, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 13 pp.

_____, 1982a: The use of Model Output Statistics for predicting snow amount. NWS Technical Procedures Bulletin No. 318, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 14 pp.

_____, 1982b: Operational probability of precipitation type forecasts based on Model Output Statistics. NWS Technical Procedures Bulletin No. 319, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 13 pp.

_____, 1983: The FOUS12 (FO12) bulletin. NWS Technical Procedures Bulletin No. 325, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 12 pp.

Newell, J. E., and D. G. Deaven, 1981: The LFM-II model--1980. NOAA Technical Memorandum NWS NMC-66, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 20 pp.