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National Weather Service

A PROCEDURE FOR IMPROVING NATIONAL METEOROLOGICAL CENTER OBJECTIVE PRECIPITATION FORECASTS – WINTER SEASON

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Date: 11-19-73
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UNITED STATES DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE EASTERN REGION
Garden City, New York

NOAA TECHNICAL MEMORANDUM NWS ER-54

A PROCEDURE FOR IMPROVING NATIONAL METEOROLOGICAL CENTER OBJECTIVE PRECIPITATION FORECASTS - WINTER SEASON

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SCIENTIFIC SERVICES DIVISION
Eastern Region Headquarters
November 1973

A PROCEDURE FOR IMPROVING NATIONAL METEOROLOGICAL CENTER OBJECTIVE PRECIPITATION FORECASTS - WINTER SEASON

INTRODUCTION

A procedure for using the Limited-Area Fine-Mesh Model (LFM) (1) quantitative precipitation forecasts (QPF) to improve National Meteorological Center (NMC) objective probability of precipitation (PoP) forecasts in the summer was presented in NOAA Technical Memorandum NWS ER-49 (2). A similar procedure applied to winter data is now presented. The NMC objective PoP forecasts are derived using Primitive Equation and Trajectory Model Output Statistics (PEATMOS) (3).

The relative frequency of measurable precipitation ($\geq$.01 inch) in 12 hours was determined for cases with similar PEATMOS PoP values, for cases within specified ranges of LFM QPF, and for cases with similar PEATMOS PoP values stratified further according to LFM QPF. The PEATMOS PoP values were obtained from teletype messages, when available, and from facsimile maps when there was no teletype messages or for stations not included in the message. The LFM QPF's were obtained from facsimile maps. The forecasts of LFM QPF and PEATMOS PoP were examined for a 12-hour period ending 24 hours after the time of initial data used to prepare the forecasts. This 12-hour period is identical to the first 12 hours covered in the public weather forecasts released near 5 a.m. and 5 p.m. local time. Forecasts and observations valid for the 12-hour night period 0000Z to 1200Z were evaluated together with forecasts and observations valid for the 12-hour day period 1200Z to 0000Z. This combining of data could mask out any diurnal effects that may exist, but a preliminary evaluation of data indicates that diurnal variations are small.

Combined data for thirteen stations located in New Hampshire and Maine were used to preserve geographic homogeneity and at the same time yield sufficient cases from which to arrive at conclusions. The thirteen stations chosen were Lebanon, Wolfeboro, Jaffrey, Concord, and Portsmouth, New Hampshire; and Caribou, Houlton, Greenville, Bangor, Eastport, Augusta, Rumford, and Portland, Maine.

Dependent data were initially for the period October 14, 1972, to January 31, 1973. A test was conducted on independent data for February and March 1973. All data were then combined for the period October 14, 1972 to March 31, 1973, so as to have a bigger data base from which to arrive at a suggested technique for modifying the winter PEATMOS PoP.

RESULTS

Table 1 presents results for the initial dependent data period of October 14, 1972 to January 31, 1973. PEATMOS PoP, without stratification for LFM

QPF, perform well for the values of 0% and 70%. In the range of 20% to 60%, the PEATMOS PoP values were too high by about 10%. PEATMOS PoP values of 80% and 90% were too low. The LFM was correct in 92% of 1858 cases in which it forecast no precipitation (Table 1, bottom line). Measurable precipitation occurred in 74% of 482 cases when the LFM QPF was in the range of .01 to .49 inches and measurable precipitation occurred in all 147 cases in which the LFM forecast .50 inches or more.

Table 2 presents a modified winter PoP as a function of the PEATMOS PoP and LFM QPF. Some subjectivity was necessary in developing Table 2 from the data presented in Table 1, especially where little or no data were available. The modified winter PoP was tested and compared to the unmodified PEATMOS PoP using the dependent data and then independent data for the months of February and March 1973 (Table 3). On independent data the modified PoP had a 40% improvement in Brier score over the PEATMOS PoP and an 11% improvement over the 0.073 Brier score determined for PoP forecasts that were actually released to the public by forecasters on those days when the modified PoP was available to them as guidance. The PoP forecasts were also converted to categorical forecasts and verified (Table 3). In this conversion a PoP of $\geq$ 50% was treated as a categorical forecast of precipitation and a PoP of $\leq$ 40% was considered as a categorical forecast of no precipitation. Regardless of the score used, the modified PoP was superior to the PEATMOS PoP. Similar results were previously shown for the summer (2).

The independent data were combined with the dependent data to produce a larger data sample that could be used to modify the results presented in Tables 1 and 2. Table 4 is the relative frequency of observed measurable precipitation as a function of PEATMOS PoP and LFM QPF for the period October 13, 1972, to March 31, 1973. Table 5 gives the modified PoP as a function of PEATMOS PoP and LFM QPF, and is based on results in Table 4. Statistics in Table 6 show the skill of the PEATMOS PoP compared to the modified PoP based on Table 5. The statistics in Table 6 are for the larger dependent sample period October 13, 1972 to March 31, 1973. The modified PoP was superior to PEATMOS PoP in all scores except prefigurance. This exception was due to the PEATMOS PoP over-forecasting precipitation as shown by the bias statistic of 1.3.

PEATMOS PoP ERROR

Near the completion of this study, it was discovered that an error existed in the PEATMOS PoP program (4). The error occurred only in the months of November and December 1972, and January 1973. Consequently, three months of PEATMOS PoP data used in this study are of questionable validity. Corrected PEATMOS PoP values for two locations used here, Portland and Caribou, Maine, later became available, but only for the period November 1 to December 13, 1972. A comparison between the corrected and uncorrected data revealed that for the 121 cases examined, the difference in PEATMOS PoP (corrected versus uncorrected) exceeded plus or minus 10% in only 5 cases. This result, in addition to the fine results obtained with independent and correct February and March 1973 data (Table 3), indicates that errors in the questionable data had little effect on the results.

CONCLUSION

The results presented here are similar to those found using summer data (2). The PEATMOS PoP values should be modified by lowering them when the LFM QPF is zero, raising them when the LFM QPF is between .01 and .49 inches, and raising them significantly to 100% when the LFM QPF is $\geq$.50 inches. The conclusion presented in (2) is appropriate for quotation here:

"This study has developed a technique for improving precipitation forecasts by objectively using LFM 12-to 24-hour QPF to modify PEATMOS PoP. It is a pilot study which found a predictor that possessed independent information and improved upon the PEATMOS PoP. Even though the sample is small and for a particular area and season, it clearly points the way toward further studies. There is no a priori reason why this approach shouldn't show skill for other areas and seasons. The major contribution of the LFM QPF is in improving the resolution of the PEATMOS PoPs. Because numerical models and the PEATMOS PoP equations change and because the sample used in this study is small, the modified PoP should be continually verified to assure that they remain superior to the PEATMOS PoP."

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(3) National Weather Service, "Operational Forecasts Derived From Primitive Equation And Trajectory Model Output Statistics (PEATMOS)---No.3," *Technical Procedures Bulletin No. 78*, September 28, 1972.

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RELATIVE FREQUENCY OF PRECIPITATION

PEATMOS PoP	Without Stratification For LFM QPF	With Stratification for LFM QPF		
		LFM QPF = 0	LFM QPF .01" to .49"	LFM QPF ≥ .50"
0%	.01 (3/235)	.01 (2/234)	1.00 (1/1)	X
10%	.02 (14/671)	.01 (3/648)	.29 (5/17)	1.00 (6/6)
20%	.03 (11/326)	.01 (4/304)	.25 (5/20)	1.00 (2/2)
30%	.20 (55/277)	.13 (31/228)	.48 (23/48)	1.00 (1/1)
40%	.32 (51/160)	.19 (22/117)	.66 (27/41)	1.00 (2/2)
50%	.33 (57/171)	.19 (22/115)	.61 (33/54)	1.00 (2/2)
60%	.48 (106/220)	.23 (31/136)	.88 (66/75)	1.00 (9/9)
70%	.70 (143/203)	.39 (25/65)	.83 (96/116)	1.00 (22/22)
80%	.96 (175/183)	.70 (7/10)	.94 (80/85)	1.00 (88/88)
90%	.93 (38/41)	1.00 (1/1)	.88 (22/25)	1.00 (15/15)
100%	X	X	X	X
All Cases	.26 (653/2487)	.08 (148/1858)	.74 (358/482)	1.00 (147/147)

TABLE 1. *Relative frequency of observed measurable precipitation as a function of PEATMOS PoP and LFM QPF. Results are for the period October 13, 1972, to January 31. 1973. Numbers in parentheses are the number of precipitation cases over total cases. X indicates no cases.*

PEATMOS PoP MODIFIED FOR LFM QPF

PEATMOS PoP	LFM QPF = 0	LFM QPF .01" to .49"	LFM QPF ≥ .50"
0%	0%	30%	100%
10%	0%	30%	100%
20%	0%	40%	100%
30%	10%	50%	100%
40%	20%	60%	100%
50%	20%	70%	100%
60%	20%	80%	100%
70%	30%	80%	100%
80%	50%	90%	100%
90%	70%	90%	100%
100%	70%	100%	100%

TABLE 2. *Modified winter PoP as a function of PEATMOS PoP and LFM QPF. Period of data sample is October 13, 1972, to January 31, 1973.*

Scores	PEATMOS PoP Dependent Data	PEATMOS PoP Independent Data	Modified PoP Dependent Data	Modified PoP Independent Data
Brier Score	0.112	0.105	0.076	0.063
Bias	1.3	1.4	0.9	1.0
Prefigurance	0.79	0.83	0.77	0.83
Post Agreement	0.63	0.61	0.83	0.82
Threat Score	0.55	0.54	0.67	0.70
Percent Correct	83%	84%	90%	92%
Number of Cases	2487	1419	2487	1419

TABLE 3. *Comparison of skill of PEATMOS PoP and modified PoP forecasts for the dependent (October 13, 1972 - January 31, 1973) and independent (February 1 - March 31, 1973) data periods.*

Definitions of scores are as follows:

Brier Score: $1/N \left[\sum_{1}^{N}(F-O)^2\right]$

F = Forecast Probability for each case.
O = 1 (Rain) or 0 (No Rain) observed for each case.
N = Total number of cases.

Bias: $\dfrac{\text{Number of precipitation forecasts}}{\text{Number of precipitation cases}}$

Prefigurance: Fraction of precipitation cases correctly forecast.

Post Agreement: Fraction of precipitation forecasts which were correct.

Threat Score: Fraction of "expected" and observed precipitation cases which were correctly forecast.

Percent Correct: $100\% \times \dfrac{\text{Number of correct forecasts}}{\text{Number of forecasts}}$

RELATIVE FREQUENCY OF PRECIPITATION

PEATMOS PoP	Without Stratification For LFM QPF	With Stratification For LFM QPF: LFM QPF=0	LFM QPF .01" to .49"	LFM QPF ≥ .50"
0%	.01 (3/614)	.00 (2/613)	1.00 (1/1)	X
10%	.03 (22/894)	.01 (9/869)	.37 (7/19)	1.00 (6/6)
20%	.04 (18/474)	.02 (9/449)	.30 (7/23)	1.00 (2/2)
30%	.18 (73/412)	.11 (39/353)	.57 (33/58)	1.00 (1/1)
40%	.27 (71/259)	.15 (30/201)	.70 (39/56)	1.00 (2/2)
50%	.32 (80/251)	.17 (29/170)	.62 (49/79)	1.00 (2/2)
60%	.49 (157/321)	.20 (37/183)	.86 (111/129)	1.00 (9/9)
70%	.67 (192/288)	.35 (36/102)	.82 (134/164)	1.00 (22/22)
80%	.89 (232/260)	.38 (11/29)	.93 (125/135)	1.00 (96/96)
90%	.93 (118/127)	.38 (3/8)	.94 (58/62)	1.00 (57/57)
100%	.67 (4/6)	.00 (0/2)	1.00 (4/4)	X
All Cases	.25 (970/3906)	.07 (205/2979)	.78 (568/730)	1.00 (197/197)

TABLE 4. *Relative frequency of observed measurable precipitation as a function of PEATMOS PoP and LFM QPF. Results are for the period October 13, 1972, to March 31, 1973. Numbers in parentheses are the number of precipitation cases over total cases. X indicates no cases.*

PEATMOS PoP Modified for LFM QPF

PEATMOS PoP	LFM QPF = 0	LFM QPF .01" to .49"	LFM QPF ≥ .50"
0%	0%	40%	100%
10%	0%	40%	100%
20%	0%	40%	100%
30%	10%	50%	100%
40%	10%	60%	100%
50%	20%	70%	100%
60%	20%	80%	100%
70%	30%	80%	100%
80%	40%	90%	100%
90%	50%	90%	100%
100%	50%	100%	100%

TABLE 5. *Modified PoP as a function of PEATMOS PoP and LFM QPF. Data sample is for the period October 13. 1972, to March 31, 1973, for locations in Maine and New Hampshire.*

Scores	PEATMOS PoP	Modified PoP
Brier Score	0.110	0.065
Bias	1.3	1.0
Prefigurance	0.81	0.79
Post Agreement	0.62	0.83
Threat Score	0.55	0.68
Percent Correct	83%	91%
Number of Cases	3906	3906

TABLE 6. *Skill of PEATMOS PoP and Modified PoP for LFM QPF using Table 5. In converting a PoP to a categorical forecast, PoP ≥ 50% is a precipitation forecast. Results are for the dependent data period of October 13, 1972, to March 31, 1973.*

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