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EVALUATION OF AN OBJECTIVE RADAR TECHNIQUE FOR UPDATING NUMERICAL PRECIPITATION GUIDANCE

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EVALUATION OF AN OBJECTIVE RADAR TECHNIQUE FOR UPDATING NUMERICAL PRECIPITATION GUIDANCE

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ABSTRACT

An objective technique which incorporates radar data in updating the National Meteorological Center's (NMC) precipitation probability guidance for Atlanta was evaluated for the period December 1972 through February 1973. The results indicate that this technique produced precipitation forecasts substantially superior to those issued both by NMC and by forecasters at the Weather Service Forecast Office at Atlanta. In addition, the technique was easily used in routine operations and required only a small amount of time for completion of the computations.

INTRODUCTION

During the past several years the introduction and improvement of a variety of numerically-produced guidance products from the NMC has been largely responsible for significant improvement in accuracy of National Weather Service forecast products. This has been well documented by the results of Cooley and Derouin (1972) and others. The introduction of such guidance material is bringing about a significant change in the forecasting techniques used by meteorologists. The forecaster's reliance on subjective forecasting methods, climatology, empiricism, and classical statistical models was very great prior to the mid 1960's. *Today, after about a decade of transition, the role of the forecaster is rapidly becoming one in which his greatest efforts are made in the area of modifying objectively produced guidance.* However, forecasters usually approach this problem in a rather subjective manner. The results of the evaluation of the method examined in this paper suggest that further improvement in the accuracy of forecast parameters lies with the use of objective techniques for updating guidance.

One of the most promising avenues which should aid forecasters in improving NMC guidance, as pointed out by Moore and Smith (1972), is that of objectively utilizing data not used as input into the numerical model, and data extracted from observations made after those used in the NMC guidance products.

They demonstrated the potential of radar data for such applications and developed a procedure to modify PEATMOS PoP (*P*rimitive *E*quation and *T*rajectory *M*odel *O*utput *S*tatistics *P*robability of *P*recipitation) guidance prepared at NMC. Two equations, designated PoPup1 and PoPup2, were developed for use in updating PoP guidance for Atlanta, the decision as to which of the equations to use depending primarily on the form in which the radar information was available. The second of these was used in the operational test described here. The equations are applicable to the first period and employ radar data taken approximately 9 hours after the standard 0000GMT and 1200GMT Primitive Equation Model data times and prior to the public forecast release times of about 1000GMT and 2200GMT. This is shown schematically in Fig. 1.

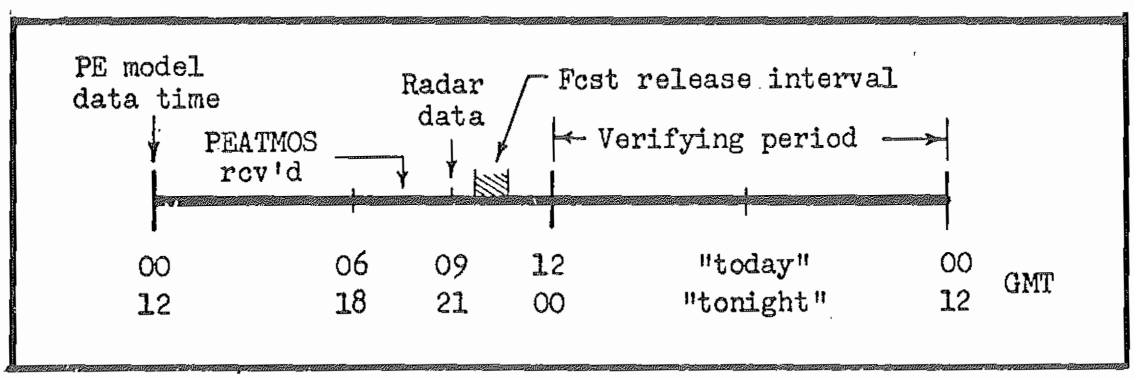

Fig. 1. Temporal relationship of predictors (PEATMOS PoPs and radar data) and predictand (precipitation in 00-12 GMT or 12-00 GMT periods).

Fig. 2 indicates the area from which radar information was used for the derivation and application of the following equation at Atlanta:

$$PoPup2 = -0.01 + 0.33(PCT_{II}) + 0.51(PEATMOS\ PoP) + 0.16(E_{I}) + 0.17(E_{III})$$

where PCT_{II} = % of grid squares in Area II with echoes

PEATMOS PoP = Probability obtained from guidance forecast for first 12-hour period

E_{I} = Presence or absence of an echo in Area I (Echo present, E_{I} =1; Echo absent, E_{I} = 0)

E_{III} = Same as E_{I} but for Area III

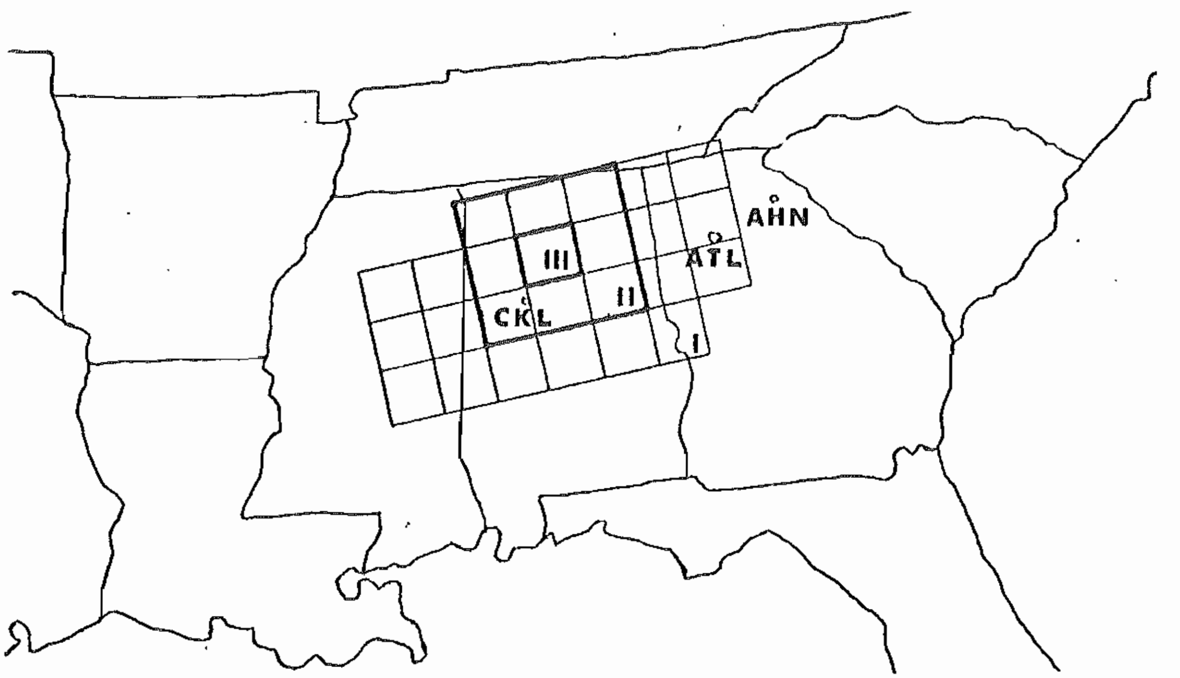

Fig. 2. PoPup2 Radar Plotting Chart for Atlanta.

For operational testing the following procedure was followed:

1. The source of radar information at 0840GMT or 2040GMT was the RADU radar echo depiction chart (a facsimile product) or plotted hourly reports.*

2. The areas of interest on the radar charts were delineated with the aid of a transparent overlay.

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* Ed. note: Radar data are now available in digital form on a grid which matches that used in the development of the PoPup equations. The manual radar digitization program began in July 1973.

3. The PEATMOS PoP guidance value for the first 12-hour period was obtained from the teletype message.

4. A verification form was kept on which were recorded the PEATMOS PoP, PoPup2 (rounded to the nearest 10 percent), and observed precipitation (either 0 or 1).

EVALUATION

PoPup2 was evaluated for its skill and operational utility for the period December 1972 through February 1973. "Updated" forecasts were compared to both FP and PEATMOS forecasts. Forecasters rarely used the update equation in preparing FP forecasts.

Several verification techniques were considered, but the obvious choice was the Brier Score. There are two reasons for this. First, the Brier Score is a combined measure of a forecaster's skill in both resolution and reliability. Second, it is well known to all NWS Forecasters since it is the primary statistical measure used in the NWS Verification Program for precipitation probability forecasts.

The improvement of PoPup2 forecasts over both raw PEATMOS guidance forecasts and WSFO Atlanta forecasts (FP forecasts) was also examined. In addition, bias for all three sets of forecasts was computed and resolution examined. Nomenclature and equations used in all computations are given in Table 1.

Table 1. Equations used in statistical analysis.

$$\text{Bias} = \frac{1}{N}\sum_{i=1}^{N}(F_i - O_i)$$

$$\text{Brier Score, BS} = \frac{1}{N}\sum_{i=1}^{N}(F_i - O_i)^2$$

$$\text{Improvement, } I_{a/b} = \frac{BS_b - BS_a}{BS_b} \times 100$$

F = Precipitation probability forecast (percent)

O = Observed precipitation: O = 0(no rain) or 1(rain)

N = Number of cases

a,b = Forecasts made by different techniques

Statistical Evaluation. Data were missing for 23 events so that the sample included 157 cases (two cases per day). The Brier Scores, bias, improvement of one forecast echelon over another, and an analysis of resolution may be found in Tables 2-4.

The Brier Scores computed for the combined sample of 157 cases indicate PoPup2 is substantially better than either the PEATMOS guidance or FP forecasts. This is shown in Table 2. However in Table 3 it is interesting to note that all forecast echelons exhibit only a slight positive bias. The update procedure performed better in comparison to the other forecasts for December and January than in February. The equation was developed from December and January data, and our results indicate that it is best tuned to weather regimes for those months.

Table 2. Brier Scores and Improvement.

PD / FCST	0000 - 1200 GMT			1200 - 2400 GMT			Combined Periods			ALL FCSTS
	Dec	Jan	Feb	Dec	Jan	Feb	Dec	Jan	Feb	
PoPup2	.102	.120	.035	.129	.063	.071	.116	.091	.053	.086
FP-ATL	.162	.140	.030	.102	.110	.070	.130	.125	.050	.103
PEATMOS	.122	.140	.034	.160	.070	.064	.142	.105	.050	.099
IMPVT	$I_{\frac{PoPup2}{PEATMOS}} = +13\%$						$I_{\frac{PoPup2}{FP}} = +17\%$			

Table 3. Bias.

PD / FCST	0000 - 1200 GMT			1200 - 2400 GMT			Combined Periods			ALL FCSTS
	Dec	Jan	Feb	Dec	Jan	Feb	Dec	Jan	Feb	
PoPup2	.129	-.037	.020	.037	.054	.112	.080	.009	.067	.051
FP-ATL	.054	-.056	.016	-.007	.032	.050	.022	-.011	.033	.014
PEATMOS	.133	-.048	.092	-.030	.014	.058	.047	-.016	.075	.034

These results suggest that the Brier Score for PoPup2 was influenced by good resolution. An analysis of resolution is shown in Tables 4a and 4b. The most striking result of this analysis is the apparent ability of PoPup2 to forecast a high probability for precipitation events, a very desirable characteristic. However Table 4 indicates only small differences in resolution for the three types of forecasts for no precipitation events.

Table 4a. Frequency of Forecast Probability Classes for the 34 Precipitation Events. Classes were selected to be consistent with NWS Operations Manual Ch. C-91.

Class / FCST	≤Slgt Chc 00 - 20%	Chc-Lkly 30 - 70%	Unqualified 80 - 100%
PoPup2	.06	.29	.65
FP-ATL	.18	.38	.44
PEATMOS	.09	.59	.32

Table 4b. Frequency of Forecast Probability Classes for the 123 No Precipitation Events.

Class FCST	Sigt Chc 00 - 20%	Chc-Lkly 30 - 70%	Unqualified 80 - 100%
PoPup2	.81	.16	.03
FP-ATL	.85	.11	.04
PEATMOS	.78	.20	.02

Operational Evaluation. *No difficulty was encountered in the use of PoPup2.* Even when time was limited the update technique could be used by making the computation an hour earlier by extrapolating the movement of radar echoes. Little time was required for the operation when no precipitation was present in the gridded area, and only 5 to 10 minutes was required when precipitation was present.

While this technique was used to adjust the point probability at Atlanta, the indicated adjustment was usually reflected in forecasts for other zones in the state, and to some extent in succeeding forecast periods. For example, if high probabilities were forecast by PEATMOS for much of the state and PoPup2 significantly lowered the point probability for the first period at Atlanta, the probability for a number of zones was frequently adjusted downward. Or, if the first period PEATMOS probabilities were lowered by PoPup2, the second period PEATMOS might be subjectively increased when it appeared that the PEATMOS adjustment reflected a change in the timing of a precipitation-producing event. It would probably be more accurate to shift the radar "boxes" and re-determine the parameters of the PoPup2 equation for each location for which a forecast is made. PEATMOS guidance is easily interpolated for intermediate locations. Such an application of a PoPup2-type equation is discussed by Moore and Smith.

For the short period studied we found little evidence to suggest that PoPup2 forecasts may be subjectively modified to further improve the final probability forecast issued in the FP forecasts. There are several reasons for this. First, only a slight positive bias is exhibited by the sample evaluated in this paper, and no bias was evident in the sample examined by Moore and Smith. Second, in the cases when no precipitation occurred little difference in skill is implied by the figures in Table 4b. In the cases when precipitation did occur, PoPup2 demonstrated far greater skill than either FP or PEATMOS forecasts. This is evident in the values shown in Table 4a. It is to be hoped, however, that just as the FP forecasts improve, in the mean, on the PEATMOS guidance, routine use of the update equation to produce better guidance will in turn result in even better FP forecasts.

In addition to the purely statistical evaluation, those cases when PoPup2 forecasts were considered poor were subjectively evaluated to determine whether there might be any easily identifiable meso- or synoptic scale meteorological pattern which could be associated with these forecasts. No such patterns were determined.

CONCLUSION

The positive result of the statistical evaluation lends credence to the philosophy that objective use of data not used as direct input, or the use of data that is obtained after that used in the numerical guidance, is one of the most promising avenues of approach to improve forecasting in the National Weather Service. From a purely operational standpoint at WSFO, Atlanta, it is evident that PoPup2 is an excellent means for updating the numerically produced PEATMOS guidance forecasts, at least during the winter months. Therefore, it is recommended that considerable effort be made by forecasters to utilize this promising new precipitation guidance updating technique.

REFERENCES

1. Cooley, D.S., R.G. Derouin, 1972: Long-term Verification Trends of Forecasts by the National Weather Service. NOAA Technical Memorandum NWS FCST-18, 11 pp.

2. Moore, Paul L. and Daniel L. Smith, 1972: Updating of Numerical Precipitation Guidance. J. Appl. Meteor., 11, 1293 - 1298.