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A LOCAL VERIFICATION OF LFM AND NGM QUANTITATIVE PRECIPITATION FORECASTS FOR MAINE AND NEW HAMPSHIRE

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INTRODUCTION

Quantitative precipitation forecasts (QPF) have become an important tool for the National Weather Service's forecast and warning programs (National Weather Service 1977, 1989a, and 1989b). QPF is routinely used by many Weather Service Forecast Offices (WSFO's) and River Forecast Centers (RFC's) in issuing river forecasts as well as flood watches, warnings and outlooks.

In order to accurately predict river levels, we need more accurate methods of predicting rainfall amounts out to 24 hours, and beyond. The state of the art is limited, though dynamic models (LFM and NGM), Model Output Statistics (MOS) and National Meteorological Center (NMC) QPF forecasts provide valuable input. Since WSFO's issue QPF for their forecast area, improved local methods of predicting QPF are needed to enhance the national guidance (in particular, the NMC QPF).

DISCUSSION

This study was performed as an aide in producing local QPF forecasts at a WSFO for use by the RFC in preparing river forecasts. Traditionally river forecasts did not contain QPF and would maintain a status quo on the predicted river levels at all river forecast points. That is, either the river level would be forecast to remain the same, or in many cases forecast to drop, even if heavy rain was predicted for the particular river basin(s).

By incorporating basin-average QPF in river forecasts, river levels would be more accurately depicted as rising when forecasts called for a significant rainfall event. QPF amounts over a 24-hour period of less than 0.25 inch, or a forecast of frozen precipitation, would have little affect on river levels, since run-off would be insignificant, if any.

Studies (Junker et al., 1989 and Keyser 1988a, 1988b, and 1988c) have shown a bias in the LFM to overforecast QPF, with an underforecast for the NGM. This study compares the model output of QPF for Maine and New Hampshire for both the LFM (FOUS) and the NGM (FOUE) output. This paper also addresses the important question of when to issue a heavy rain forecast of 1 inch or more.

The LFM QPF was also compared to half the LFM QPF output, since inherent errors in the model produce about twice the actual forecast of QPF (Carr, 1988). Still, there are events where the original LFM QPF is a good forecast, and the overall threat scores have been shown to be better than those for the NGM (Junker et al., 1989). This raises the question: should forecasters routinely cut LFM QPF in half, or should they use the output as provided in the FOUS bulletins? This study also looks into this question.

Routine daily QPF forecasts cover the 24 hour period from 1200 to 1200 UTC the following day and are based on the 0000 UTC cycle model output. This study will therefore be limited to output from this cycle only, and for the period out to 12 to 36 hours from initialization time. Since FOUS/FOUE output is only available on a point by point basis, data from the convective season (May through September for northern New England), when areas of precipitation are much less uniform, were not used. It should be kept in mind that the daily QPF forecasts are amounts averaged over an entire basin, while the model FOUS/FOUE output is a point forecast.

Verification was completed for the cool season, October through April for both 1988-89 and 1989-90 for Portland, ME (PWM), Bangor, ME (BGR), Caribou, ME (CAR) and Concord, NH (CON). These locations cover most of the forecast area of Maine and New Hampshire, though they do not account for the full spectrum of local effects such as orographic influences.

Four categories for QPF and observed precipitation were selected for this study to correspond with the RFC requirements. The first category coincides with the default forecast of no precipitation, which is less than 0.25 inch. The second category ranged from 0.25 inch to 0.49 inch, the third category from 0.50 inch to 0.99 inch, and the final category of 1.00 inch or more, which would be considered a significant rainfall event. Since individual results showed no substantial differences, data for all four stations were combined.

RESULTS

The NGM QPF outperformed the LFM QPF, but showed very similar results to the "1/2-LFM" QPF. Results are shown in Table 1. The NGM categorical forecasts were correct 83.7% of the time, compared to 83.1% for the 1/2-LFM and 76.4% for the LFM. Notice that the LFM output was substantially higher (19.5%) in regard to overforecasting QPF than the 1/2-LFM and NGM forecasts (both around 10%).

	CORRECT	OVER FORECAST	UNDER FORECAST
LFM	76.4%	19.5%	4.1%
1/2 the LFM	83.1%	10.1%	6.8%
NGM	83.7%	10.0%	6.3%

TABLE 1. Comparison of model QPF output vs observed precipitation for 1988-89 and 1989-90 cool seasons for all four stations and all four categories combined.

Looking at heavy rainfall events, that is verifying the 1.00 inch or more category, the results were very similar to the findings for all categories combined. These results are displayed in Table 2.

For 1.00 inch or more the NGM forecasts were correct in 22.7% of the cases, while the LFM was correct only 12.5% of the time. The 1/2-LFM displayed the best results with a 36.4% accuracy. Again, the original LFM QPF by far outdistanced the other forecasts in overforecasting precipitation amounts. This can also be illustrated by computing the bias for each model (discussed later).

	CORRECT	OVERFORECAST
LFM	12.5%	87.5%
1/2 the LFM	36.4%	63.6%
NGM	22.7%	77.3%

TABLE 2. Same as Table 1, except only for the forecast category of 1.00 inch or more.

A closer look at the data reveals that by cutting the LFM QPF in half: 1) the number of forecasts of 1.00 inch or more decreased from 112 to 11 (the NGM produced 22 such forecasts of heavy rain);

2) the number of forecasts of 1.00 inch or more, when less than 0.25 inch was observed, decreased from 58 to zero (the NGM produced 2); and 3) the number of forecasts of 1.00 inch or more, when from 0.25 to less than 1.00 inch was observed, decreased from 40 to 7 (the NGM produced 15).

On the other hand, by cutting the LFM QPF in half: 1) the number of forecasts of less than 0.25 inch, when 1.00 inch or more was observed, increased only slightly from 3 to 5 (the NGM was 3); 2) the number of forecasts less than 0.25 inch, when 0.25 inch to under 1.00 inch was observed, increased from 54 to 78 (the NGM was 76); and 3) for the 22 observed heavy rain events of 1.00 inch or more, the number of correct forecasts decreased from 14 to 4 (the NGM was 5).

Bias and threat scores were computed for heavy rain events of 1.00 inch or more, and for all operationally significant rain events of 0.25 inch or more. The results are shown in Table 3. The bias (B) is computed as follows:

$$B = F/O \text{ where}$$

F is the number of forecasts exceeding the given threshold (in this study 1.00 inch and 0.25 inch) and O is the number of observations exceeding the threshold. A bias of less (greater) than one means the model is underforecasting (overforecasting) the given threshold of precipitation.

The threat score (T) is computed as follows:

$$T = H/(F + O - H) \text{ where}$$

F and O represent those values described for the bias, while H is the number of correct forecasts. Threat scores range from a perfect score of 1 to a score of 0 when no stations are correctly forecast.

For 1.00 inch or more, the unmodified LFM output had the lowest threat score and displayed a very strong bias to overforecast QPF. The 1/2-LFM QPF scored the best threat score while showing a tendency to underforecast QPF. The NGM showed no bias in forecasting heavy rain of 1.00 inch or more.

For all forecasts of 0.25 inch or more, the LFM had the strongest tendency to overforecast, with a bias almost double the 1/2-LFM and the NGM. Here, the 1/2-LFM again had the best threat score, with the unmodified LFM and NGM essentially scoring the same.

There were 1676 forecasts available from the NGM and 1684 from the LFM. Of the 1684 (verifiable) observed 24 hour rainfall amounts, the breakdown, by category, was as follows: 22 events (1.3%) were 1.00 inch or more, 61 events (3.6%) were 0.50 to 0.99 inch, 106 events (6.3%) were 0.25 to 0.49 inch, and 1495 events (88.8%) were less than 0.25 inch. (Note that precipitation at any of the four stations was considered a separate event from the other stations.)

	1.00 INCH OR MORE		0.25 INCH OR MORE	
	Bias	Threat score	Bias	Threat score
LFM	5.09	0.117	2.08	0.098
1/2 the LFM	0.50	0.138	1.32	0.120
NGM	1.00	0.128	1.25	0.102

TABLE 3. Bias and threat scores for QPF output for forecasts of 1.00 inch or more and 0.25 inch or more.

CONCLUSIONS

Overall the NGM and the 1/2-LFM QPF provided better guidance in this study for limited stations for the cool season. However, comparisons of the NGM and 1/2-LFM cool season forecasts did not show one model to be significantly superior to the other. The NGM was less biased while the 1/2-LFM showed a better threat score.

It is evident that original LFM QPF substantially overforecasts. Also, by dividing LFM QPF guidance in half the forecaster is less likely to forecast the rare (occurring only 1.3% of the time in this study) heavy rainfall event. Other data, analyses, and guidance should key the forecaster into predicting an unusually heavy rainfall event. He/she should not be relying solely on the LFM (or NGM) QPF output. If the forecaster determines that a heavy rainfall is likely, then the original LFM QPF would not have to be divided by two.

These tendencies for the models to overforecast should be kept in mind when preparing QPF, especially when the forecasts are basin-average QPF. High individual point forecasts are often substantially reduced by averaging over an entire basin, especially in non-uniform rainfall events. Adjusting model or other QPF guidance to account for this will enable the RFC to generate a much improved river forecast, showing the proper tendencies in a rising, or falling, river. If the forecaster feels the potential exists for heavier rainfall than otherwise indicated, contingency forecasts (that is, a "what if" forecast) can be quickly run by the RFC to provide in-house guidance to hydrologists and forecasters as to how a particular river would react if heavier rainfall should occur.

By using this approach, forecasters will be less likely to overforecast an event, thus leading to the problem of forecasting a river to exceed flood stage, possibly leading to the issuance of unneeded flood watches and warnings.

FINAL REMARKS

This study does not account for time or spatial errors. That is the QPF may have been accurate but missed the time frame, for example, by 6 or 12 hours, or may have forecasted the maximum rainfall to be too far east or west.

References

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