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ON THE USE OF LFM PREDICTORS IN PE-BASED PoPA EQUATIONS

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1. INTRODUCTION

Recently, significant model changes have occurred at the National Meteorological Center. A limited area fine mesh model with a smaller gridlength (LFM-II) (Brown, 1977a) has replaced the original model (LFM-I) (Gerrity, 1977); the former's gridlength is about 2/3 that of the latter's. In addition, a 7-level primitive equation model (7LPE) (Brown, 1977b) has replaced the 6-level primitive equation model (6LPE) (Shuman and Hovermale, 1968). The 7LPE has a gridlength 1/2 that of the 6LPE or the same as that of the LFM-I.

To accommodate these changes, PoPA equations (Bermowitz and Zurndorfer, 1978), developed with the MOS technique (Glahn and Lowry, 1972) and based on forecasts from the LFM-II and 7LPE models, should be derived to replace those based on models that no longer exist. At present, however, it is not possible to do this since an adequate sample of output from these new models has not been archived. Until such time that a large enough sample exists, we must use either LFM-I or 6LPE-based equations (from now on in this paper referred to as LFM-I and 6LPE equations, respectively) with LFM-II forecasts as input for our early guidance product and 6LPE equations with 7LPE fields as input for our final guidance product. An alternative for the final guidance is to use LFM-I equations with 7LPE input where LFM-I equations can be or already have been derived.

Since we must now use predictors from a model that is different from the one upon which the equations were developed, it would be desirable to know the effect this has on the quality of the resulting PoPA forecasts. Dallavalle and Hammons (1976) have shown that there is little deterioration in maximum and minimum temperature forecasts when LFM-I fields are substituted into 6LPE equations. To determine the effect here, we performed a comparative verification of probability and categorical forecasts of precipitation amount generated from operational, 6LPE equations with 6LPE forecasts as input against those produced with the same equations but with LFM-I forecasts as input. The results of this verification should indicate the effect of substituting 7LPE forecasts into 6LPE equations and perhaps the effect of substituting LFM-II fields into either 6LPE or LFM-I equations.

2. VERIFICATION PROCEDURE

To perform the verification, forecasts for the periods 12-36, 36-60, 12-24, 24-36, and 36-48 h after 0000 GMT were compared for the 1976-77 cool season (October-March) and the 1977 warm season (April-August). September 1977 was excluded from the warm season verification since the LFM-I was replaced with the LFM-II as of the 1200 GMT run on August 31, 1977. Brier P-scores, expressed as improvement over climatic forecasts[1], threat scores, and

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[1]Climatic forecasts are seasonal 6-monthly relative frequencies at each of 233 cities of $\geq .25$, $\geq .50$, and ≥ 1.0 inch previously developed on five years of data for use in developing PoPA equations.

categorical biases were computed at 233 cities over the conterminous U.S.

Results for 24-h period forecasts were also broken down by National Weather Service (NWS) region since these forecasts are used operationally by the field forecasters. Verification of the forecasts for 12-h periods was performed to better define when deterioration, if any, would begin when LFM-I predictors are used in 6LPE equations.

3. RESULTS AND CONCLUSIONS

Results for the cool season are shown in Tables 1-5. For both warm and cool seasons the improvement over climatic forecasts was not computed for ≥ 2.0 inches since a relative frequency for this category was not available. In addition, we did not compute threat scores and biases for ≥2.0 inches for 12-h periods because too few cases frequently precluded development of regionalized equations for this category.

Cool season results for the conterminous U.S. (Table 1) indicate no deterioration of the forecasts during the 12-24 and 12-36 h periods when LFM-I predictors were used. However, beyond these projections all the scores indicate some deterioration.

A breakdown by NWS region for the cool season is shown in Tables 2-5. In the Eastern Region the results indicate that there was some improvement in the forecasts during the 12-36 h period, but some deterioration during the 36-60 h period with use of LFM-I predictors. Results in the Southern and particularly the Central Region are similar to those for the conterminous U.S.; that is, no deterioration of the forecasts during the 12-36 h period but some during the 36-60 h period. In the Western Region, results indicate deterioration of the forecasts during both 24-h periods when LFM-I predictors were used. The negative improvement over climatic forecasts for the category ≥ .25 inch and the relatively high improvement for the category ≥1.0 inch in the Western Region could be partially attributed to the abnormally dry cool season 1976-77.

Results for the warm season are shown in Tables 6-10. For the conterminous U.S. (Table 6), the results indicate no deterioration of the forecasts for all periods except 36-48 h when a slight deterioration occurred when LFM-I predictors were used. In fact, some improvement is evident for the periods 12-36, 12-24, and 24-36 h. These results differ somewhat from those of the cool season where some deterioration of all forecasts beyond 24 h made with LFM-I predictors was evident. A possible explanation is that smaller scale systems, which are more likely to be significant precipitation producers in the warm than the cool season, are maintained longer and predicted better by the LFM-I than by the 6LPE.

A regional breakdown shown in Tables 7-10 indicates that in the Eastern, Southern, and Central Regions results are similar to those over the conterminous U.S.; that is, some improvement of the forecasts for the 12-36 h period and no deterioration for the 36-60 h period when LFM-I predictors were used. In fact, some improvement is noted in the Southern and Central Regions for 36-60 h forecasts. In the Western Region, no deterioration is apparent for the 12-36 h forecasts, but some is apparent for the 36-60 h forecasts.

As in the cool season, the negative improvements over climatic forecasts for the lower categories and the relatively large improvement for the category ≥2.0 inches could be attributed to the abnormal dryness during the 1977 warm season.

In summary, during the cool season, the results indicate that use of 7LPE forecasts in 6LPE equations will not deteriorate the final guidance PoPA forecasts during the 12-36 h period except in the Western Region. However, during the 36-60 h period, indications are that some deterioration in the forecasts will occur in all regions. During the warm season, it appears that the final guidance forecasts will hold up longer than during the cool season when 7LPE forecasts are used in 6LPE equations. Indications are that there will be no deterioration of the forecasts for all projections--some improvement may even occur--except in Western Region during the 36-60 h period.

It should be pointed out that the operational forecasts in the Western Region could be better than indicated here in both seasons. It is possible that the poorer results in the West are caused by the LFM-I's western boundary. If this is so, use of the 7LPE, which does not have this boundary, should improve the forecasts.

A more general conclusion is that a change in model does not completely invalidate the MOS equations. Therefore, for the early guidance, it is likely that LFM-II forecasts can be substituted in 6LPE or LFM-I equations without significant deterioration of the forecasts.

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Table 1. Comparative verification of 24- and 12-h probability and categorical forecasts of precipitation amount produced with use of 6LPE predictors in 6LPE equations (PE) and LFM-I predictors in 6LPE equations (LFM). P-scores are expressed as improvement over climatic forecasts (Impr.) in %. Sample consisted of forecasts for 233 stations over the U.S. for period October 1976 - March 1977.

Forecast Projection (h)	Verification Score	Category (inch)							
		≥ .25		≥ .50		≥ 1.0		≥ 2.0	
		PE	LFM	PE	LFM	PE	LFM	PE	LFM
12-36	Impr.	36.91	36.73	27.39	27.40	23.91	23.91	--	---
	Threat Score	.413	.404	.319	.312	.216	.208	.045	.07[illegible]
	Bias	1.44	1.34	1.72	1.63	1.91	1.56	1.83	2.13
	No. Obs.	2988		1608		591		99	
36-60	Impr.	18.36	15.46	12.33	10.07	16.02	14.29	--	---
	Threat Score	.281	.250	.204	.194	.119	.096	.016	.01[illegible]
	Bias	1.48	2.00	1.58	2.04	1.33	1.81	1.69	1.49
	No. Obs.	2865		1541		564		93	
12-24	Impr.	30.30	30.23	22.37	23.13	24.31	25.02	--	---
	Threat Score	.340	.333	.247	.250	.149	.160	--	---
	Bias	1.65	1.52	2.10	1.78	2.19	2.10	--	---
	No. Obs.	1568		735		225			
24-36	Impr.	22.37	20.63	15.69	14.21	25.39	25.05	--	---
	Threat Score	.271	.249	.190	.174	.100	.087	--	---
	Bias	1.63	1.61	1.78	1.70	1.70	1.91	--	---
	No. Obs.	1595		765		233			
36-48	Impr.	14.42	12.39	11.77	9.61	18.59	18.32	--	---
	Threat Score	.210	.197	.137	.125	.039	.039	--	---
	Bias	1.72	2.14	1.72	2.32	1.19	2.11	--	---
	No. Obs.	1502		707		221			

Table 2. Same as Table 1 except for only 24-h periods for 56 stations in the Eastern Region.

Forecast Projection (h)	Verification Score	Category (inch) ≥ .25 PE	≥ .25 LFM	≥ .50 PE	≥ .50 LFM	≥ 1.0 PE	≥ 1.0 LFM
12-36	Impr.	43.85	45.77	31.69	34.70	17.76	19.04
	Threat Score	.488	.493	.359	.380	.244	.265
	Bias	1.35	1.23	1.70	1.58	1.71	1.39
	No. Obs.	1080		570		232	
36-60	Impr.	21.17	18.17	13.33	10.18	7.54	4.85
	Threat Score	.310	.283	.202	.201	.133	.070
	Bias	1.52	1.99	1.68	1.97	1.10	1.35
	No. Obs.	1050		557		227	

Table 3. Same as Table 2 except for 57 stations in the Southern Region.

Forecast Projection (h)	Verification Score	Category (inch) ≥.25 PE	≥.25 LFM	≥.50 PE	≥.50 LFM	≥1.0 PE	≥1.0 LFM
12-36	Impr.	35.59	33.63	26.91	25.82	17.41	17.75
	Threat Score	.407	.409	.328	.331	.214	.208
	Bias	1.38	1.15	1.65	1.34	1.99	1.39
	No. Obs.	1007		605		258	
36-60	Impr.	19.26	18.74	12.83	12.89	9.59	9.40
	Threat Score	.307	.293	.225	.217	.108	.120
	Bias	1.41	1.49	1.44	1.86	1.45	2.13
	No. Obs.	959		577		242	

Table 4. Same as Table 2 except for 69 stations in the Central Region.

Forecast Projection (h)	Verification Score	Category (inch)					
		≥ .25		≥ .50		≥ 1.0	
		PE	LFM	PE	LFM	PE	LFM
12-36	Impr.	33.94	34.70	24.92	24.43	18.83	19.07
	Threat Score	.391	.397	.316	.298	.205	.205
	Bias	1.38	1.18	1.50	1.45	2.33	1.81
	No. Obs.	526		272		67	
36-60	Impr.	16.20	10.59	11.75	10.38	13.15	13.48
	Threat Score	.240	.196	.190	.204	.140	.148
	Bias	1.33	2.61	1.56	2.17	1.55	1.30
	No. Obs.	489		247		64	

Table 5. Same as Table 2 except for 51 stations in the Western Region.

Forecast Projection (h)	Verification Score	Category (inch)					
		≥ .25		≥ .50		≥ 1.0	
		PE	LFM	PE	LFM	PE	LFM
12-36	Impr.	9.77	9.66	18.71	14.49	34.16	26.99
	Threat Score	.299	.260	.202	.164	.099	.047
	Bias	1.96	2.36	2.48	3.24	1.94	3.62
	No. Obs.	375		161		34	
36-60	Impr.	-6.54	-6.97	13.93	6.09	37.16	28.59
	Threat Score	.201	.176	.167	.105	.079	.028
	Bias	1.71	2.55	1.75	2.67	1.65	3.74
	No. Obs.	367		160		31	

Table 6. Same as Table 1 except for the period April - August 1977.

Forecast Projection (h)	Verification Score	Category (inch)							
		≥ .25		≥ .50		≥ 1.0		≥ 2.0	
		PE	LFM	PE	LFM	PE	LFM	PE	LFM
12-36	Impr.	12.08	14.02	7.66	9.11	6.92	7.91	--	--
	Threat Score	.250	.246	.175	.185	.093	.102	.024	.030
	Bias	1.88	1.75	1.91	1.71	1.78	1.54	1.60	1.37
	No. Obs.	3433		1904		751		130	
36-60	Impr.	5.42	5.98	3.36	3.43	5.12	5.24	--	--
	Threat Score	.197	.202	.134	.136	.067	.068	.021	.030
	Bias	2.10	2.11	2.30	2.39	2.14	2.76	2.00	4.81
	No. Obs.	3460		1918		769		128	
12-24	Impr.	8.16	10.03	4.52	5.61	17.89	18.48	--	--
	Threat Score	.188	.193	.113	.117	.040	.039	--	--
	Bias	1.75	1.46	1.56	1.33	1.21	1.30	--	--
	No. Obs.	1876		932		315		--	
24-36	Impr.	6.29	7.56	4.38	5.04	11.13	11.45	--	--
	Threat Score	.154	.160	.106	.119	.049	.059	--	--
	Bias	1.60	1.77	1.79	1.84	1.53	1.55	--	--
	No. Obs.	1701		889		314		--	
36-48	Impr.	4.36	3.85	2.86	2.39	18.20	17.96	--	--
	Threat Score	.150	.139	.093	.081	.043	.030	--	--
	Bias	2.15	2.24	2.45	2.48	2.22	1.83	--	--
	No. Obs.	1906		948		324		--	

Table 7. Same as Table 6 except for only 24-h periods for 56 stations in the Eastern Region.

Forecast Projection (h)	Verification Score	Category (inch) ≥ .25 PE	≥ .25 LFM	≥ .50 PE	≥ .50 LFM	≥ 1.0 PE	≥ 1.0 LFM
12-36	Impr.	17.53	18.82	10.92	12.45	4.68	6.19
	Threat Score	.302	.295	.201	.213	.103	.118
	Bias	1.66	1.45	1.92	1.58	1.89	1.72
	No. Obs.	1047		577		212	
36-60	Impr.	7.75	7.97	4.44	3.09	1.51	1.35
	Threat Score	.223	.237	.148	.150	.058	.071
	Bias	1.97	1.99	2.21	2.62	2.20	3.75
	No. Obs.	1066		582		217	

Table 8. Same as Table 7 except for 57 stations in the Southern Region.

Forecast Projection (h)	Verification Score	Category (inch) > .25 PE	> .25 LFM	≥ .50 PE	≥ .50 LFM	≥ 1.0 PE	≥ 1.0 LFM
12-36	Impr.	8.86	11.14	6.66	8.01	4.34	5.33
	Threat Score	.221	.229	.167	.181	.112	.119
	Bias	2.45	1.93	2.44	1.89	1.99	1.70
	No. Obs.	874		541		253	
36-60	Impr.	4.89	6.51	3.65	5.23	2.40	2.98
	Threat Score	.199	.198	.148	.153	.087	.098
	Bias	2.68	1.88	3.14	1.87	2.79	2.18
	No. Obs.	883		547		256	

Table 9. Same as Table 7 except for 69 stations in the Central Region.

Forecast Projection (h)	Verification Score	Category (inch) ≥.25 PE	≥.25 LFM	≥.50 PE	≥.50 LFM	≥1.0 PE	≥1.0 LFM
12-36	Impr.	10.71	12.92	6.48	8.04	2.14	2.97
	Threat Score	.245	.249	.175	.183	.067	.076
	Bias	1.63	1.71	1.50	1.51	1.58	1.23
	No. Obs.	1251		679		253	
36-60	Impr.	4.88	5.89	2.84	3.54	1.11	1.16
	Threat Score	.193	.204	.121	.134	.054	.049
	Bias	1.87	2.27	1.81	2.48	1.69	2.64
	No. Obs.	1246		679		261	

Table 10. Same as Table 7 except for 51 stations in the Western Region.

Forecast Projection (h)	Verification Score	Category (inch) ≥.25 PE	≥.25 LFM	≥.50 PE	≥.50 LFM	≥1.0 PE	≥1.0 LFM
12-36	Impr.	10.46	12.11	4.62	5.17	18.71	18.24
	Threat Score	.204	.162	.083	.110	.047	.024
	Bias	2.03	2.56	1.79	2.78	1.03	1.61
	No. Obs.	261		107		33	
36-60	Impr.	3.21	-0.34	1.56	-2.07	18.64	17.69
	Threat Score	.107	.100	.035	.034	0.0	0.0
	Bias	1.69	2.52	1.68	3.14	0.34	1.71
	No. Obs.	265		110		35	