U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
OFFICE OF SYSTEMS DEVELOPMENT
TECHNIQUES DEVELOPMENT LABORATORY

TDL OFFICE NOTE 86-5

CONSISTENCY CHECKS FOR THE FOURTH PERIOD MOS MAXIMUM/MINIMUM TEMPERATURE FORECASTS

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December 1986

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1. INTRODUCTION

Since 1973, the Techniques Development Laboratory has used the Model Output Statistics (MOS) approach (Glahn and Lowry, 1972) to generate objective forecasts of the local maximum/minimum temperature (max/min). The max/min guidance is issued to National Weather Service forecasters for use in making public weather forecasts. On November 25, 1985, revised temperature forecast equations were implemented (Erickson and Dallavalle, 1986; National Weather Service, 1985). Equations are available to predict the daytime max and nighttime min at the station of interest. Forecasts are valid for four periods. The equations predict today's max, tonight's min, tomorrow's max, and tomorrow night's min from 0000 GMT data. During the 1200 GMT forecast cycle, guidance is available for tonight's min, tomorrow's max, tomorrow night's min, and the day after tomorrow's max. The max/min forecasts are valid for projections ending approximately 24, 36, 48, and 60 hours after 0000 or 1200 GMT. In addition to the max/min guidance, forecasts of the surface temperature are available and are valid at 3-h intervals from 6 to 51 hours after 0000 or 1200 GMT.

In daily operations, objective checks are used to ensure meteorological consistency between the first, second, and third period max/min temperature forecasts and the 3-h temperatures valid during the appropriate period. For example, the 3-h temperature forecasts valid from 27 to 39 hours after initial model time are compared to tonight's min (tomorrow's max) from 0000 GMT (1200 GMT). If any of the 3-h forecasts during that period are less (greater) than the min (max) guidance, then the forecast for the min (max) is set equal to the smallest (largest) 3-h temperature. In a similar fashion, today's max (tonight's min) from 0000 GMT (1200 GMT) is compared to the 3-h forecasts valid from 15 to 27 hours after initial cycle time; tomorrow's max (0000 GMT) or tomorrow night's min (1200 GMT) is compared to the 39- through 51-h temperature forecasts. Note that the 27- and 39-h temperature forecasts are compared to both max and min values for adjacent periods. As a result of all this checking, the first period max (min) will always be greater (less) than or equal to the second period min (max). Analogously, the second period min (max) will always be less (greater) than or equal to the third period max (min). Thus, meteorological consistency among the max/min guidance for the first three periods and the 3-h temperature forecasts is guaranteed.

In contrast, the fourth period max/min temperature forecast does not have a consistency check because a series of appropriate 3-h temperature forecasts is not available. As a result, inconsistencies between the third and fourth period max/min forecasts are occasionally observed (Fig. 1). A consistency check between the 51-h temperature forecast and the fourth period max/min forecast would eliminate these inconsistencies. In this paper, we discuss the test of one such algorithm.

2. APPROACH

While a comparison between the third and fourth period max/min is the most direct method of ensuring consistency between the two forecasts, the 51-h temperature forecast could still be inconsistent with the fourth period max or min. A more efficient approach is to check the 51-h temperature forecast against the fourth period max/min. As mentioned earlier, because of existing checks, the third period min (max) is never greater (less) than the 51-h temperature. Consequently, a consistency check between the fourth period max/min and the 51-h temperature guarantees consistency of the former with both the third period min/max and the 51-h temperature.

To determine the magnitude of the inconsistency problem, we calculated the number of times that the predicted fourth period max (min) was less (greater) than the 51-h temperature forecast at 93 stations during a cool season (November 25, 1985-March 31, 1986) and a warm season (April 1, 1986-June 30, 1986). The 93 stations were distributed throughout the conterminous United States and so represented a reasonable sample. In addition, we verified the fourth period max/min temperature forecasts modified by a suitable consistency check. Consistency was achieved by simply setting the fourth period max/min forecast equal to the 51-h temperature forecast when the two predictions were meteorologically inconsistent. Verifying observations were obtained from the NWS National Verification Program (Dagostaro, 1985) archive. Forecasts were verified for the same cool and warm seasons described earlier.

3. RESULTS

Inconsistencies between the 51-h temperature and the fourth period max/min occurred in less than 1 percent of the cases during the cool season and less than 0.1 percent of the time in the warm season (Table 1). Correspondingly, the fourth period max/min and 51-h temperature consistency check had little effect on the verification results (Table 1). Note that the mean absolute error did not change when consistency was ensured. However, the distribution of the fourth period max/min forecast changes in the cool season (Table 2) did show some impact from the consistency check. Changes in the max temperature forecasts were evenly distributed between improved and degraded forecasts. The min temperature change distribution showed, however, that the consistency check caused more correct changes in the forecasts than erroneous ones. Notice that all changes greater than 6 degrees were in the correct direction.

4. DISCUSSION AND CONCLUSIONS

We've found that inconsistencies between the fourth period max/min and the 51-hour temperature forecasts occur infrequently during the cold months of the year and are extremely unusual in the warmer months. Logically, a check between the 60-h max/min and 51-h temperature is the best method to ensure consistency in the MOS guidance. In our experiments, we found that such a procedure did not change the overall mean absolute error of the max/min forecasts. When the changes in the fourth period min forecasts were large, in fact, the objective forecasts were slightly improved. For both the max and the min, the consistency algorithm appears to have no adverse impact on the temperature forecasts. Moreover, an operational check such as the one tested here has the benefit of producing a coherent package to the user without any loss in skill.

Our findings were presented to the Committee on Analysis and Forecast Techniques Implementation (CAFTI) in November 1986. CAFTI recommended approval, and the consistency check was implemented in early December 1986.

REFERENCES

Dagostaro, V. J., 1985: The national AFOS-era verification data processing system. TDL Office Note 85-9, National Weather Service, NOAA, U.S. Department of Commerce, 47 pp.

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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.

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Table 1. Mean absolute errors (MAE), mean algebraic errors (ME), and root mean square errors (RMSE) for the fourth period max/min local (LCL), operational MOS (OPER), and modified MOS (MOD) temperature forecasts. The forecasts were modified by making a consistency check against the 51-h temperature. The number of inconsistencies (INCONS) indicates how often the 51-h temperature guidance was greater (less) than the fourth period max (min). Forecasts were verified for 93 stations for the November 25, 1985-March 31, 1986 (cool season) and the April 1, 1986-June 30, 1986 (warm season) periods. All errors are in ^{o}F.

Forecast	Score	Cool Season			Warm Season		
		LCL	OPER	MOD	LCL	OPER	MOD
MIN	MAE	5.0	5.2	5.2	3.5	3.5	3.5
	ME	-0.3	-0.3	-0.3	-0.4	-0.2	-0.2
	RMSE	6.5	6.8	6.8	4.7	4.6	4.6
	INCONS	-	88	-	-	7	-
	CASES	10159	10159	10159	7773	7773	7773
MAX	MAE	4.9	5.4	5.4	4.2	4.3	4.3
	ME	-0.6	-0.3	-0.2	0.0	0.2	0.2
	RMSE	6.5	7.1	7.2	5.6	5.6	5.6
	INCONS	-	85	-	-	7	-
	CASES	10262	10262	10262	7768	7768	7768

Table 2. Distribution of temperature changes (^{o}F) in the fourth period max/min forecast when a consistency check with the 51-h temperature forecast is made. These values were taken from the verifications for 93 stations for the November 25, 1985-March 31, 1986 period.

Forecast	Number of Changes in Correct Direction				Number of Changes in Wrong Direction				No Change in Error	Missing Obs	Total
	Size of Change (^{o}F)				Size of Change (^{o}F)						
	1-2	3-4	5-6	>6	1-2	3-4	5-6	>6			
MIN	41	9	0	3	28	2	0	0	2	3	88
MAX	31	9	1	0	30	3	4	0	1	6	85

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HDNG FOUS12 LFM-MOS GUIDANCE      12/23/85   1200 GMT

DY/HR    23/18   24/00   24/06   24/12   24/18   25/00   25/06   25/12   26/00
NMCFPCEWR
FOUS12 KWBC 231615
EWR  E
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.
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MN/MX                                 33              46              26       25
TEMP     39 40   38 37   36 36   37 39   43 43   41 38   35 31   28 28
DEWPT    27 27   28 29   31 32   33 34   34 34   33 31   26 21   18 14
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NMCFPCJFK
FOUS12 KWBC 231615
JFK EC
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MN/MX                                 33              45              30       28
TEMP     39 39   37 37   37 37   38 40   44 43   42 41   38 35   32 32
DEWPT    29 29   30 30   31 33   34 35   36 36   36 34   29 25   22 21
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NMCFPCLGA
FOUS12 KWBC 231615
LGA EC
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.
MN/MX                                 34              46              29       26
TEMP     41 41   40 38   38 37   38 40   43 43   42 41   37 34   31 31
DEWPT    29 29   29 29   29 30   30 32   34 34   34 32   27 23   20 19
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Figure 1. A portion of the MOS guidance issued from 1200 GMT data on December 23, 1985 for Newark (EWR), Laguardia (LGA), and Kennedy (JFK) Airports. The forecast for tomorrow night's min is indicated by a circle; the forecast for the day after tomorrow's max by a square.