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TESTS ON VARIOUS PREDICTOR LISTS USED IN DEVELOPMENT OF MAXIMUM/MINIMUM FORECAST EQUATIONS

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1. INTRODUCTION

When we used the Model Output Statistics (MOS) technique (Glahn and Lowry, 1972) to derive and implement maximum/minimum temperature forecast equations for 3-month (spring: March-May; summer: June-August; fall: September-November; and winter: December-February) rather than 6-month (cool: April-September; and warm: October-March) seasons, we found a significant improvement in the accuracy of the forecasts (Hammons, Dallavalle, and Klein, 1976). We were not, however, able to determine how much of the improvement was due exclusively to the shorter seasons because we had also added a number of new predictors and dropped a few of the old ones in the screening for the 3-month season equations. Thus, we decided to do some experimenting to find out which change was more important. At the same time, we tried various combinations of other predictors. This note describes our experiments on a series of predictor lists.

2. EXPERIMENTAL PROCEDURE

All experiments were done with winter (December-February) season data; our previous work indicates that we obtain maximum differences among various predictor lists in this season. At the time we began these tests, we had five winters (December 1969-February 1975) of model output fields. The first four seasons (310 days) comprised the developmental sample. We reserved the fifth winter season (December 1974-February 1975) for an independent test.

By using the stepwise screening regression technique, we derived single station, linear multiple regression equations for 49 stations (Figure 1) in the United States for the 0000 GMT cycle. The predictand was the station's calendar day maximum or minimum, depending on the particular projection. Thus, forecasts of the calendar day maximum were valid approximately 24 (Day 1) and 48 (Day 2) hr after 0000 GMT. The forecast of the calendar day minimum was valid approximately 36 (Day 2) and 60 (Day 3) hr after 0000 GMT. As predictors, we screened model output from the Primitive Equation (PE) model, (Shuman and Hovermale, 1968), the Trajectory (TJ) model, (Reap, 1972), and the first and second harmonics of the day of the year. We composed ten predictor lists for deriving complete equation sets (4 projections, 49 stations). Although station observations are used operationally as possible predictors in the first two projections, we chose to ignore observations in our derivations except for two minor tests. This was done primarily to simplify the experiments, but also because we had previously estimated the effect of using observations in the equations.

3. DEVELOPMENT OF THE EXPERIMENTAL MAXIMUM/MINIMUM EQUATIONS

Table 1 lists the predictors (OP) for each projection that we used in the derivation of the operational equations (Hammons, et al., 1976). For purposes of this test, we rederived equations using this predictor list from 4 years of data (a 5-year data sample was used in the operational derivation). Table 2 (set KS) expands the operational set of predictors (OP). For instance, we added as potential predictors the PE boundary layer vertical velocity forecasts, the nongeostrophic temperature advection at 850 mb, the 500-mb geostrophic vorticity advection, the relative humidity in three atmospheric layers, the boundary layer moisture divergence, the precipitation amount (both continuous and as a binary predictor with limits of .00025, .000127, .000254, and .00635 m), the terrain vertical velocity, and the G index (a stability parameter). As the table indicates, various projections and smoothings of each of these fields were used. From the TJ model, we added the total totals index, the convective index, and the surface 12- and 24-hr net vertical displacements. When observations were used in KS, we also screened the visibility observed at 06Z for both the 24- and 36-hr projections and the latest observed snowcover (binary: 0, 1, 2, and 5 inches as limits) for the 24-hr projection. Since this last field was available only from October 1972, there were just 148 days of developmental data available for deriving the 24-hr forecast equations from KS (with obs).

Table 3 is the predictor list (6M) used in the older 6-month equations (Klein and Hammons, 1975). This list is practically a subset of OP. The other predictor lists (Table 4) were modifications of OP. Set 4 tested limited smoothings of most of the predictor fields. Set 5 omitted all trajectory predictors. Sets 6 and 7 tested changes in the projections of the predictors. In set 8 we forced a minimum of 1% for the reduction of variance contributed by any one predictor. In other words, each predictor used in the equation explained at least 1% of the variance in the extreme temperatures. This normally resulted in equations with less than ten terms. Set 9 tested specific space smoothings of all the predictors. We five-point smoothed all the fields in the first three projections and nine-point smoothed all the fields in the last projection. For the last test, we changed only the predictors used in the fourth projection. All 24- and 36-hr predictors were dropped, several PE fields were added, and the minimum in the reduction of variance was set equal to 0.5%.

Table 5 lists the average standard errors of estimate and reduction of variance for all tests on the dependent data. We did derive two sets of equations from predictor lists that included observations (KS and OP). Since KS with observations had only 148 cases of data for the first projection, it is difficult to make exact comparisons with the analagous equation set that did not use observations.

However, adding observations to the operational predictor list (OP) decreased the standard error by 0.6°F for the 24-hr forecasts and by 0.2°F for the 36-hr forecasts. Neither result is unusual--we saw a similar pattern in the original 3-month derivations (Hammons, et al., 1976).

When observations were not used, KS produced the lowest standard errors of estimate over all four projections. However, the improvement over the operational predictor list (OP) was only in the last two projections and then only 0.1°F. The improvement of OP compared to the 6-month predictor list (6M) was also small, never exceeding 0.2°F at any one projection. Set 6, which was comprised of predictors at limited projections, had the largest standard errors during the first three projections. It is noteworthy that when we forced a 1% limit in the reduction of variance (set 8), we obtained standard errors that were nearly as large as in set 6. In the last projection for set 10 when we dropped some predictors, added others, and limited the reduction of variance to 0.5%, we saw one of the largest standard errors (7.0°F). We will return to this point later. For tests 4, 5, 7, and 9 the standard errors were close to those of 6M.

4. TESTING ON INDEPENDENT DATA

Mean absolute errors, mean algebraic errors, and root mean square errors at the 49 stations for the various predictor lists are given in Table 6 for the independent test on December 1974 - February 1975 data. Two points are clear. First, the root mean square errors for the independent sample were larger in all projections than the corresponding standard errors in the developmental sample. This is not unexpected, though such a large deterioration is not a desirable characteristic. Secondly, the mean absolute errors for all predictor lists without obs were quite close to each other in value. For the first three projections, the range between the highest and lowest values in the mean absolute errors was 0.2°F or less. In fact, the best predictor list for these three projections seemed to be the current operational list. Forecasts using KS, which contained many more predictors than OP, actually yielded larger mean absolute and root mean square errors in the first two periods. The only substantial differences among predictor lists appeared in the 60-hr projection when using a cutoff in the reduction of variance of 1% (set 8) or dropping all trajectory predictors (set 5) improved the mean absolute error by 0.1°F over the operational predictor list. An opposite result was evident in the developmental sample (Table 5). The root mean square error also decreased by 0.1°F with sets 8 and 10 and 0.2°F with set 5. Neither set 5 nor 8 was, however, as good as the operational list in the first three projections. Finally, the new predictors in the operational list (OP) seemed to help the 6-month predictor list (6M) by only 0.1° to 0.2°F mean absolute error in the 36- and 60-hr projections.

The worst predictor list in the last projection was set 4 where few model fields were smoothed. This result was not surprising since in the 60-hr projection only 48-hr forecast fields were screened as potential predictors. It is reasonable to suppose that less spurious information was introduced at 60 hr by the 48-hr predictors when they were smoothed by an areal filter.

Generally, the mean algebraic errors for all the predictor lists were quite similar. Again, the operational predictor list was as good as or better than most of the other lists. There was, however, some indication that the cutoff in the reduction of variance (set 8: 36 hr; set 10; 60 hr) decreased the mean algebraic error.

When observations were used in the first two projections (KS, OP), the improvement in the mean absolute error was 0.7 to 0.8°F at 24 hr and 0.2 to 0.3°F at 36 hr. Screening the additional observations of ceiling and snow cover in KS did not improve over OP in an absolute sense, but the improvement over the corresponding set without observations was 0.1°F greater for KS than for OP.

5. DISCUSSION AND CONCLUSIONS

Apparently, simple modifications of the predictor list are not going to improve the max/min forecasts by significant amounts. When we added a number of new predictors (KS), the standard error of estimate on dependent data decreased by only 0.1°F at the last two projections and none at the first two. This improvement not only evaporated in tests on independent data, but some forecast deterioration also occurred. We speculate that using too many potential predictors increases the chance that spurious relationships are found in the dependent data. Thus, any significant improvement in the short-range maximum/minimum forecast guidance will come from new approaches or improved numerical models and not from screening additional model predictors.

The standard errors of estimate for the dependent data are only guidelines to the relative merits of various predictor lists. While the standard errors had indicated that substantial differences among the numerous lists would appear in the independent data tests, we found actual differences in the root mean square errors and mean absolute errors to be very small. No list emerged as clearly the best set of predictors. This implies that there is a certain minimum error and limited amount of information to be obtained from the model output; our skill in forecasting on independent data will not exceed this.

Though the developmental statistics did not indicate it, our independent tests imply that the use of trajectory model fields causes some forecast deterioration at 60 hr. We suspect that the trajectory predictors explained spurious relationships at this projection that were not present in the independent data. This is likely due to the large time lag between predictor and predictand. Similarly, when we limited the cutoff in the reduction of variance (set 8 or 10), we improved the 60-hr forecasts. Apparently, selecting 10 terms in the earlier projections (24, 36, 48 hr) provided a small amount of additional information, but doing so in the last projection may have established chance relationships.

If we were to rederive max/min temperature equations, we would not screen trajectory fields as potential predictors at 60 hr. At later projections when we do not have model fields that verify at those times (for example, in deriving 96-hr forecasts from 84-hr fields), we probably should also impose a minimum in the reduction of variance contributed by any one predictor. Equations with less than 10 terms would likely result.

When we switched from 6-month to 3-month seasons, and simultaneously added new predictors, most of the forecast improvement seemed to come from the shorter seasonal stratification. Some of the new predictors may have helped in the 36- and 60-hr min forecasts, but not in the amounts that we found in our earlier comparisons (Hammons, et al., 1976).

Finally, in our limited tests with observations, there were no differences in mean absolute errors between KS and OP. If snow cover presents a problem to the MOS temperature forecasts, we have not found a solution by screening snow cover as a binary predictor. At this time, it does not appear that using additional station observations will improve the forecasts. However, inclusion of observations definitely improves the forecasts over those made without observations.

6. REFERENCES

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Table 1. Potential predictors of maximum and minimum surface temperature for MOS screening regression tests. Numbers indicate valid time of predictors in hours after 0000 GMT. Stars indicate the predictor was smoothed by 5 points (*), 9 points (**) or 25 points (***). These are called set "OP" in the text.

Predictor	Today's Max	Tonight's Min	Tomorrow's Max	Tomorrow Night's Min
		a) PE Model		
850-mb height	12,24	24,36	36,48	48,48*
500-mb height	12,24	24,36	36,48	36*,48,48*
1000-500 mb thickness	12,24	24,36	36,48	48,48*
1000-850 mb thickness	12,24	24,36	36,48	48,48*
850-500 mb thickness	12,24	24,36	36,48	48,48*
1000-mb temperature	12,24,24*,36*	24*,36,36*,48*	36*,48,48*,48**	48*,48**,48***
850-mb temperature	12,24,24*,36*	24*,36,36*,48*	36*,48,48*,48**	48*,48**,48***
700-mb temperature	24	24*	24**	–
Boundary layer potential temp	12,24,24*,36*	24*,36*,48*	36*,48*,48**	48*,48**,48***
Boundary layer U wind	12,24*	24*,36*	36*,48*	48*,48**,48***
Boundary layer V wind	12,24*	24*,36*	36*,48*	48*,48**,48***
Boundary layer wind speed	24	36	48	48*,48**
850-mb U wind	24	24*	24**	24***
850-mb V wind	24	24*	24**	24***
700-mb U wind	24	24*	24**	24***
700-mb V wind	24	24*	24**	24***
1000-mb relative vorticity	24*	36*	48**	48***
850-mb relative vorticity	24*	36*	48*	48**
500-mb relative vorticity	24*	36*	48*	48**,48***
850-mb vertical velocity	24	24*	24**	–
650-mb vertical velocity	24	24*	24**	–
Stability (1000-700 mb temp)	24	24*	24**	–
Stability (850-500 mb temp)	24	24*	24**	–
400-1000 mb mean rel hum	12*,24*,36*	24*,36*,48*	36**,48**	48**,48***
Precipitable water	18*,30*	30*,42*	42*,42**	42**,42***
Boundary layer wind divergence	24*	36*	48*	48**,48***

Table 1. (Continued).

Predictor	Today's Max	Tonight's Min	Tomorrow's Max	Tomorrow Night's Min
		b) Trajectory Model		
Surface temperature	24,24*	24*,24**	24*,24**	24**,24***
850-mb temperature	24,24*	24*,24**	24*,24**	24**,24***
700-mb temperature	24	24*	24**	24**,24***
Surface dew point	24,24*	24*,24**	24*,24**	24***
850-mb dew point	24*	24*	24**	24***
700-mb dew point	24	24*	24**	24***
700-mb surface mean rel hum	24	24*	24**	24***
850-mb 12-hr net vert displ	24	24*	24**	24***
850-mb 24-hr net vert displ	24	24*	24**	24***
700-mb 12-hr net vert displ	24	24*	24**	24***
700-mb 24-hr net vert displ	24	24*	24**	24***
Surface 12-hr horiz conv	24,24*	24*,24*	24*,24**	24***
850-mb 12-hr horiz conv	24	24*	24**	24***
George's K index	24	24*	24**	24***
		c) Other Variables		
Sine day of year	00	00	00	00
Cosine day of year	00	00	00	00
Sine of twice day	00	00	00	00
Cosine of twice day	00	00	00	00
Latest surface temperature	06#	06#	-	-
Latest surface dew point	06#	06#	-	-
Latest cloud cover	06#	06#	-	-
Latest surface U wind	06#	06#	-	-
Latest surface V wind	06#	06#	-	-
Latest surface wind speed	06#	06#	-	-
Latest ceiling	06#	06#	-	-
Previous maximum	06#	-	-	-
Previous minimum	-	06#	-	-

when observations are used as potential predictors

Table 2. Same as Table 1 except set KS.

Predictor	Today's Max	Tonight's Min	Tomorrow's Max	Tomorrow Night's Min
		a) PE Model		
850-mb height	12,24	24,36	36,48	48,48*
500-mb height	12,24	24,36	36,48	36*,48,48*
1000-500 mb thickness	12,24	24,36	36,48	48,48*
1000-850 mb thickness	12,24	24,36	36,48	48,48*
850-500 mb thickness	12,24	24,36	36,48	48,48*
1000-mb temperature	12,24,24*,36*	24*,36,36*,48*	36*,48,48*,48**	48*,48**,48***
850-mb temperature	12,24,24*,36*	24*,36,36*,48*	36*,48,48*,48**	48*,48**,48***
700-mb temperature	24	24*	24**	–
Boundary layer potential temp	12,24,24*,36*	24*,36*,48*	36*,48*,48**	48*,48**,48***
Boundary layer U wind	12,24*	24*,36*	36*,48*	48*,48**,48***
Boundary layer V wind	12,24*	24*,36*	36*,48*	48*,48**,48***
Boundary layer wind speed	24	36	48	48*,48**
850-mb U wind	24	24*	24**	24***
850-mb V wind	24	24*	24**	24***
700-mb U wind	24	24*	24**	24***
700-mb V wind	24	24*	24**	24***
1000-mb relative vorticity	24*	36*	48**	48***
850-mb relative vorticity	24*	36*	48*	48**
500-mb relative vorticity	24*	36*	48*	48**,48***
850-mb vertical velocity	24	24*	24**	–
650-mb vertical velocity	24	24*	24**	–
Stability (1000-700 mb temp)	24	24*	24**	–
Stability (850-500 mb temp)	24	24*	24**	–
400-1000 mb mean rel hum	12*,24*,36*	24*,36*,48*	36**,48**	48**,48***
Precipitable water	18*,30*	30*,42*	42*,42**	42**,42***
Boundary layer wind divergence	24*	36*	48*	48**,48***
Boundary layer vertical velocity	24*	36*	48*	48**,48***
850-mb temperature advection	24*	36*	48*	48**,48***
500-mb vorticity advection	24*	36*	48*	48**,48***
Boundary layer rel hum	12*,24*,36*	24*,36*,48*	36**,48*,48**	48*,48**,48***
Layer 1 rel hum (1000 mb-720 mb)	12*,24*,36*	24*,36*,48*	36**,48*,48**	48*,48**,48***
Layer 2 rel hum (720 mb-490 mb)	12*,24*,36*	24*,36*,48*	36**,48*,48**	48*,48**,48***

Table 2. (Continued).

Predictor	Today's Max	Tonight's Min	Tomorrow's Max	Tomorrow Night's Min
Boundary layer moisture divergence	24*	36*	48*	48**,48***
Precipitation amount (continuous)	24*	36*	48*	48**
Precipitation amount (binary: .00025, .00127, .00254, .00635 m)	24*	36*	48*	48**
Terrain vertical velocity	24*	36*	48*	48**,48***
G index	24	36	48	48*
		b) Trajectory Model		
Surface temperature	24,24*	24*,24**	24*,24**	24**,24***
850-mb temperature	24,24*	24*,24**	24*,24**	24**,24***
700-mb temperature	24	24*	24**	24**,24***
Surface dew point	24,24*	24*,24**	24*,24**	24***
850-mb dew point	24*	24*	24**	24***
700-mb dew point	24	24*	24**	24***
700-mb surface mean rel hum	24	24*	24**	24***
850-mb 12-hr net vert displ	24	24*	24**	24***
850-mb 24-hr net vert displ	24	24*	24**	24***
700-mb 12-hr net vert displ	24	24*	24**	24***
700-mb 24-hr net vert displ	24	24*	24**	24***
Surface 12-hr horiz conv	24,24*	24*,24**	24*,24**	24***
850-mb 12-hr horiz conv	24	24*	24**	24***
George's K index	24	24*	24**	24***
Total Totals index	24	24*	24**	24***
Convective index	24	24*	24**	24***
Surface 12-hr net vert displ	24	24*	24**	24***
Surface 24-hr net vert displ	24	24*	24**	-24***

Table 2. (Continued).

Predictor	Today's Max	Tonight's Min	Tomorrow's Max	Tomorrow Night's Min
c) Other Variables				
Sine day of year	0	0	0	0
Cosine day of year	0	0	0	0
Sine of twice day	0	0	0	0
Cosine of twice day	0	0	0	0
Latest surface temperature	6#	6#	-	-
Latest surface dew point	6#	6#	-	-
Latest cloud cover	6#	6#	-	-
Latest surface U wind	6#	6#	-	-
Latest surface V wind	6#	6#	-	-
Latest surface wind speed	6#	6#	-	-
Latest ceiling	6#	6#	-	-
Previous maximum	6#	-	-	-
Previous minimum	-	6#	-	-
Latest visibility	6#	6#	-	-
Latest snow cover (binary: 0,1,2,5 inches)	-12#	-	-	-

when observations are used as potential predictors

Table 3. Same as Table 1 except Set 6M.

Predictor	Today's Max	Tonight's Min	Tomorrow's Max	Tomorrow Night's Min
		a) PE Model		
1000-mb height	24	36	48	48*
850-mb height	24	36	48	48*
500-mb height	12,24	24,36	36,48	48,48*
1000-500 mb thickness	12,24	24,36	36,48	48,48*
1000-850 mb thickness	12,24	24,36	36,48	48,48*
850-500 mb thickness	–	–	–	–
1000-mb temperature	12,24,24*	24*,36,36*	36*,48,48*	48,48*,48**
850-mb temperature	12,24,24*	24*,36,36*	36*,48,48*	48,48*,48**
700-mb temperature	24	24	24*	24*
Boundary layer potential temp	12,24,24*	24*,36,36*	36*,48,48*	48,48*,48**
Boundary layer U wind	12,24*	24*,36*	36*,48*	48*,48**
Boundary layer V wind	12,24*	24*,36*	36*,48*	48*,48**
Boundary layer wind speed	–	–	–	–
850-mb U wind	24*	24*	24**	24**
850-mb V wind	24*	24*	24**	24**
700-mb U wind	24	24	24*	24*
700-mb V wind	24	24	24*	24*
1000-mb relative vorticity	–	–	–	–
850-mb relative vorticity	–	–	–	–
500-mb relative vorticity	–	–	–	–
850-mb vertical velocity	24*	24*	24**	24**
650-mb vertical velocity	24*	24*	24**	24**
Stability (1000-700 mb temp)	–	–	–	–
Stability (850-500 mb temp)	–	–	–	–
400-1000 mb mean rel hum	12*,24*	24*,36*	36**,48**	48*,48**
Precipitable water	18*	30*	42**	42**
Boundary layer wind divergence	–	–	–	–

Table 3. (Continued).

Predictor	Today's Max	Tonight's Min	Tomorrow's Max	Tomorrow Night's Min
		b) Trajectory Model		
Surface temperature	24,24*	24,24*	24,24*	24*,24**
850-mb temperature	24,24*	24,24*	24,24*	24*,24**
700-mb temperature	24,24*	24,24*	24,24*	24*,24**
Surface dew point	24*	24*	24*	24**
850-mb dew point	–	–	–	–
700-mb dew point	–	–	–	–
700-mb-surface mean rel hum	24*	24*	24**	24**
850-mb 12-hr net vert displ	24*	24*	24**	24**
850-mb 24-hr net vert displ	24*	24*	24**	24**
700-mb 12-hr net vert displ	24*	24*	24**	24**
700-mb 24-hr net vert displ	24*	24*	24**	24**
Surface 12-hr horiz conv	24*	24*	24**	24**
850-mb 12-hr horiz conv	–	–	–	–
George's K index	–	–	–	–
850-mb rel hum	24*	24*	24**	24**
700-mb rel hum	24*	24*	24**	24**
		c) Other Variables		
Sine day of year	0	0	0	0
Cosine day of year	0	0	0	0
Sine of twice day	–	–	–	–
Cosine of twice day	–	–	–	–
Latest surface temperature	–	–	–	–
Latest surface dew point	–	–	–	–
Latest cloud cover	–	–	–	–
Latest surface U wind	–	–	–	–
Latest surface V wind	–	–	–	–
Latest surface wind speed	–	–	–	–
Latest ceiling	–	–	–	–
Previous maximum	–	–	–	–
Previous minimum	–	–	–	–

Table 4. Changes made to predictor set OP to construct new sets of predictors.

Predictor Set	Basic Characteristics	Changes
4	limited smoothings	Use unsmoothed fields in all projections for the mean rel humidities, the precipitable water, the boundary layer wind divergence, the surface and 850-mb convergence and the model dew points. These latter fields are smoothed by a 5-point filter at all projections. Drop 36* 500-mb height in the 60-hr projection.
5	no trajectory fields	Drop all trajectory fields in the four projections.
6	limited predictor projections	Drop all 12- and 36-hr predictors from the first projection. Drop all 24- and 48-hr predictors from the second projection. Drop all 24- and 36-hr predictors from the third and fourth projections. Smoothing of the fields stays the same.
7	varied predictor projections	In the first projection, add 36-hr predictor fields for heights, thickness, boundary layer winds and wind speed, vorticity, and boundary layer divergence. Fields are smoothed or unsmoothed according to the 24-hr predictor. For the second projection, add the 48-hr fields to the same types of predictors. Add the 24-hr vorticity, the boundary layer wind speed, and divergence. All added fields are smoothed according to the corresponding 36-hr field. For the third projection, drop all 24-hr predictor fields. Add smoothed 36-hr boundary layer wind speed, boundary layer divergence, and vorticity. Add the 30-hr precipitable water. The last projection is the same as test 6, i.e., all 24- and 36-hr fields are dropped.
8	cut-off in reduction of variance	The operational predictor list is used for all projections, but screening continues only until no predictor contributes more than 1% reduction to the explained variance.

Table 4 (Continued)

Predictor Set	Basic Characteristics	Changes
9	specific smoothings	All fields from the operational predictor list are smoothed by a five-point filter only in the first three projections. No unsmoothed fields are used. In the last projection, all fields are screened as nine-point smoothed quantities only.
10	change in 4th projection only	For the last projection drop all 24- and 36-hr fields. Set a limit in the reduction of variance of .5%. From the PE model, add the 9- and 25-point smoothed fields for the 500-mb vorticity advection, the boundary layer vertical velocity and relative humidity, and the layer 1 and layer 2 relative humidities.

Table 5. Standard errors of estimate and the reduction of variance on dependent data for equations derived by screening various predictor lists. The values are averages for the 49 stations used in the tests. There were 310 developmental cases for all predictor lists and projections except for the 24-hr projection of KS (with obs) when only 148 days were available.

Predictor Set	Standard Error of Estimate (°F)				Reduction of Variance (%)			
	24 hr	36 hr	48 hr	60 hr	24 hr	36 hr	48 hr	60 hr
OP - no obs	4.7	5.6	5.6	6.7	83	75	77	65
OP - with obs	4.1	5.4	--	--	87	77	--	--
KS - no obs	4.7	5.6	5.5	6.6	84	75	78	66
KS - with obs	3.6	5.4	--	--	90	77	--	--
6M	4.8	5.8	5.6	6.9	83	74	77	63
4	4.8	5.8	5.7	7.0	83	74	76	61
5	4.8	5.9	5.8	6.9	82	73	75	63
6	5.2	6.2	6.3	6.9	80	70	71	62
7	4.7	5.6	5.9	6.9	83	75	75	62
8	5.1	6.0	5.9	7.0	80	72	75	62
9	4.7	5.7	5.6	6.8	83	75	77	64
10	4.7	5.6	5.6	7.0	83	75	77	62

Table 6. Mean absolute error, mean algebraic error, and the root mean square error in °F averaged at 49 stations for the test on independent data (December 1974-February 1975). The station list identifiers are explained in the text and in Tables 1-4.

Predictor Set	Mean Abs. Error				Mean Alg. Error				Root Mean Sq. Error			
	24 hr	36 hr	48 hr	60 hr	24 hr	36 hr	48 hr	60 hr	24 hr	36 hr	48 hr	60 hr
OP - no obs	4.3	5.1	4.7	6.0	-0.2	-1.2	-0.7	-1.5	5.7	6.6	6.1	7.7
OP - with obs	3.6	4.9	--	--	0.1	-1.0	--	--	4.8	6.3	--	--
KS - no obs	4.4	5.2	4.7	6.0	-0.3	-1.5	-0.7	-1.6	5.8	6.7	6.1	7.8
KS - with obs	3.6	4.9	--	--	0.1	-1.1	--	--	4.8	6.4	--	--
6M	4.3	5.2	4.7	6.2	-0.2	-1.2	-0.6	-1.7	5.7	6.7	6.1	7.8
4	4.3	5.2	4.8	6.3	-0.2	-1.2	-0.7	-1.7	5.7	6.7	6.3	8.0
5	4.4	5.3	4.8	5.9	-0.2	-1.6	-0.6	-1.5	5.8	6.8	6.2	7.5
6	4.4	5.1	4.9	5.9	-0.2	-1.4	-0.7	-1.5	5.8	6.6	6.4	7.6
7	4.3	5.1	4.8	5.9	-0.2	-1.1	-0.6	-1.5	5.7	6.6	6.2	7.6
8	4.4	5.1	4.8	5.9	-0.2	-1.0	-0.6	-1.5	5.8	6.6	6.2	7.6
9	4.3	5.1	4.8	6.1	-0.2	-1.2	-0.8	-1.7	5.6	6.6	6.2	7.8
10	4.3	5.1	4.7	5.9	-0.2	-1.2	-0.7	-1.4	5.7	6.6	6.1	7.6

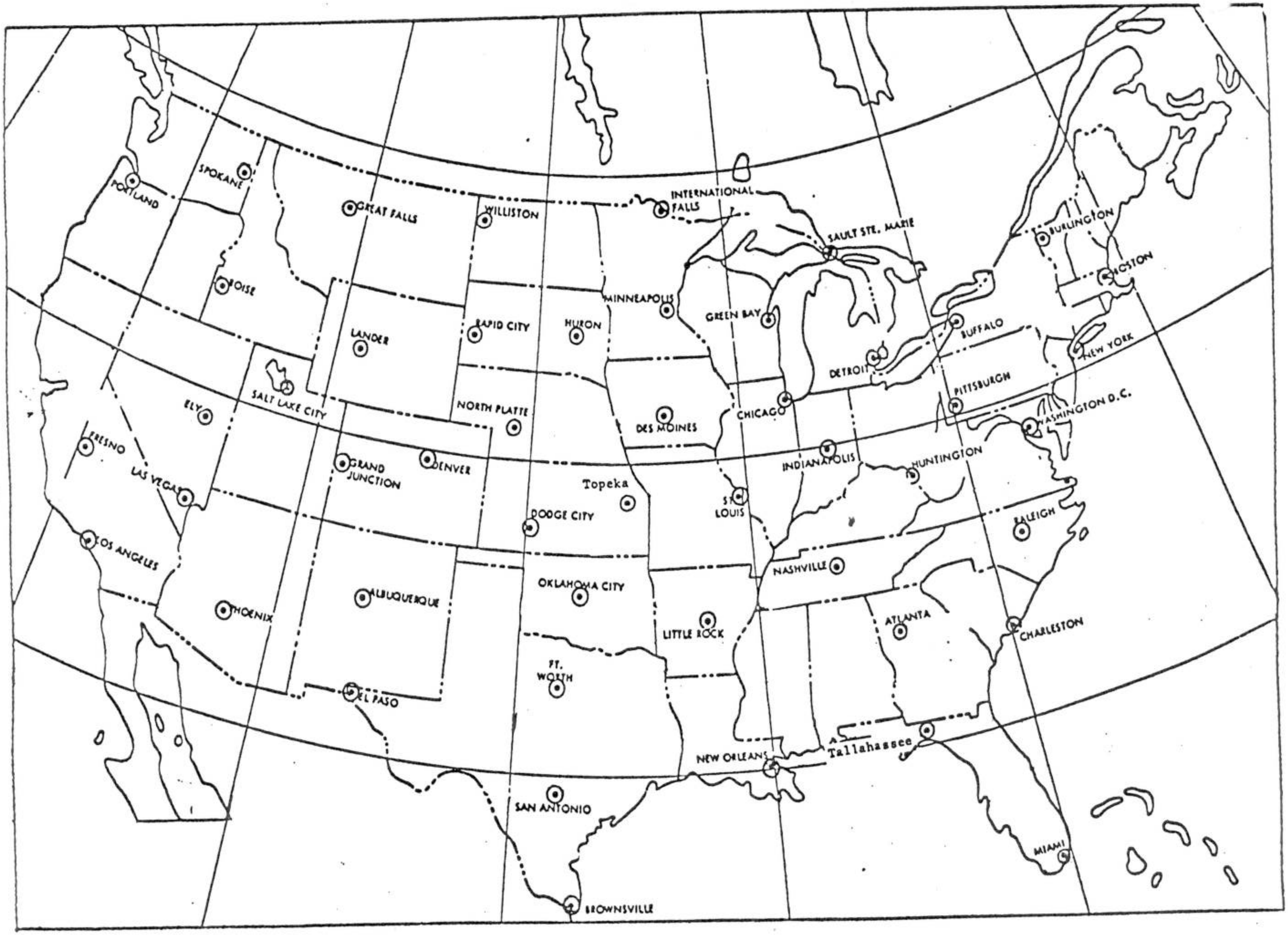

Figure 1. Names and locations of the 49 test stations used in evaluating MOS predictor lists.