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COMPARATIVE VERIFICATION OF GUIDANCE AND LOCAL AVIATION/PUBLIC WEATHER FORECASTS--NO. 4 (APRIL-SEPTEMBER 1977)

Edward A. Zurndorfer, Gary M. Carter, Paul J. Dallavalle,
David B. Gilhousen, Karl F. Hebenstreit, George W. Hollenbaugh,
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1. INTRODUCTION

This is the fourth in our series of combined verification of the Techniques Development Laboratory's (TDL's) operational guidance forecasts and National Weather Service (NWS) local forecasts made at Weather Service Forecast Offices (WSFO's). Verification statistics for objective guidance and subjective local forecasts of probability of precipitation, opaque sky cover, surface wind, ceiling height, visibility, and max/min temperature are presented here for the warm season months of April through September 1977. Note that verification of max/min temperature hadn't appeared in the previous three reports in this series, Carter et al. (1976), Crisci et al. (1977), and Bocchieri et al. (1977).

TDL's forecasts of these variables are based on the Model Output Statistics (MOS) (Glahn and Lowry, 1972) technique. Input to our MOS prediction equations comes from surface observations and forecast fields from the Limited-area Fine Mesh (LFM) (Howcroft and Desmarais, 1971), Trajectory (TJ) (Reap, 1972), and/or Primitive Equation (PE) (Shuman and Hovermale, 1968) models.

WSFO forecasts were provided to us by the Technical Procedures Branch (TPB) of the Office of Meteorology and Oceanography in conjunction with the NWS combined aviation/public weather verification system (National Weather Service, 1973). These forecasts were recorded daily for verification purposes under instructions that the value recorded be "...not inconsistent with..." the official weather forecasts. Surface observations as late as 2 hours before the first verification time may have been used in their preparation.

We obtained observed data to verify the guidance and local weather forecasts from the National Weather Records Center in Asheville, N.C.

2. PROBABILITY OF PRECIPITATION (PoP)

The objective PoP forecasts were generated by the warm season final guidance prediction equations described in National Weather Service (1977a). We generated forecasts for the 12-24 h first period, the 24-36 h second period, and the 36-48 h third period. The predictors for the first period equations were forecast fields from the LFM model and surface variables observed at the forecast site 2 hours after the model run time. Two different forecasts were produced for the second period. These were the early guidance forecasts based on forecast fields from the LFM and final guidance forecasts based on LFM, PE, and TJ model output. Third period equations used PE model predictors only.

We verified the forecasts by computing the Brier score (Brier, 1950). Please note that we use the standard NWS Brier score which is one-half the score defined by Brier. Brier scores will naturally vary from one section of the country to the next and from one year to the next because of changes in the relative frequency of precipitation. Therefore, we also verify in terms of percent improvement over climatology. This is the percent improvement of the Brier scores of the forecasts over the Brier scores produced by climatic forecasts. Climatic forecasts are defined as the relative frequencies of precipitation by month and for each station determined from a 15-year sample (Jorgensen, 1967).

This verification differed from the one done by TPB because the source of the surface observations was different. TPB collects the verifying observations from hourly data files on a day-to-day basis. We obtained surface data from our Asheville data collection. This resulted in nearly five percent increase in data over the TPB verification.

We verified PoP for the 87 stations shown in Table 2.1; these are the only stations where local PoP forecasts were available.

Table 2.2 shows the results for all 87 stations for combined 0000 and 1200 GMT forecasts made during the period April through September 1977. Tables 2.3 through 2.6 show scores for the NWS Eastern, Central, Southern, and Western Regions, respectively. Note that the second period verification is a three-way comparison between early guidance, final guidance, and subjective local forecasts.

The results of the verification can be summarized in three general statements. First, NWS forecasters improved upon the guidance by a small amount for most regions and projections. This improvement was greatest in the Western Region and was greatest during the first period except in the Eastern and Southern Regions. Previous verifications have also shown this to be true (Derouin and Cobb, 1972). Second, the subjective improvement does not decrease uniformly for longer range forecasts. In other words, Eastern and Central Region forecasters were able to improve more over the third period forecasts than for second period forecasts. This is a surprising result which is not consistent with previous studies (Bocchieri et al., 1977). A possible explanation for this is that forecasters could improve on our third period PE-based guidance by using the LFM 36- and 48-h forecasts since the LFM can resolve smaller scale features better than the PE. Perhaps less improvement is possible for second period forecasts because the guidance forecasts have LFM input. Thirdly, the early guidance forecasts performed better than the final guidance for second period forecasts in all regions. The improvements in Brier score were fairly substantial in the Eastern Region (3.4%) and Central Region (2.6%), but were marginal in the other two regions. This could lead us to the conclusion that we should produce only early guidance LFM-based forecasts for this period. However, all our MOS forecasts are currently run from the finer mesh LFM-II (Brown, 1977a) and 7-level PE (Brown, 1977b) models which may have different bias characteristics than their former counterparts. Therefore, this conclusion might not be justified.

Figure 2.1 shows the relative frequency of precipitation for each forecast value of PoP. This figure was constructed by combining all first period PoP forecasts for both the 0000 and 1200 GMT model runs. Both the local and guidance forecasts show good reliability for forecasts of 80% or less, but both tend to overforecast beyond this range.

3. OPAQUE SKY COVER

For the 1977 warm season, we implemented new prediction equations to generate forecasts of opaque sky cover, more commonly known as cloud amount, in both our early and final guidance packages. The new equations were regionalized equations instead of the single station equations used for the previous warm season (Crisci et al., 1977). We made this change to allow us to develop equations simultaneously for cloud amount and ceiling. Our objective was to provide greater consistency between forecasts of these two elements.

The regionalized equations produce probability forecasts of four categories of cloud amount as shown in Table 3.1; the predictors consist of forecast variables from the LFM and PE models and elements of surface observations. We generate forecasts in our early guidance package for 6-, 12-, 18-, and 24-h projections from both 0000 and 1200 GMT; these forecasts are made from LFM predictors and surface variables observed at the forecast site 2 hours after model run time. For our final guidance package, we provide forecasts for projections of 12 to 48 hours at 6-h intervals. Model predictors are from the LFM for the 12- and 18-h projections, from both the LFM and PE for 24- and 30-h projections, and from only the PE for the remaining projections. When surface predictors appear in the final guidance equations, they are extracted from observations taken 5 hours after model run time. For both guidance packages, we convert the probability estimates to a single "best category" forecast in a manner which improves the bias[1] characteristics of the product. For more details about our cloud amount forecast system, see National Weather Service (1977b).

For this verification, we compared the local forecasts at the 94 stations listed in Table 4.1 for 18-, 30-, and 42-h projections (0000 GMT cycle) to a matched sample of 18-h early guidance and 18-, 30-, and 42-h final guidance forecasts. We converted the local forecasts and the surface observations used for verification from opaque sky cover amount to the categories in Table 3.1. Four-category, forecast-observed contingency tables were prepared from the transformed local and best-category guidance predictions. Using these tables we computed the percent correct, Heidke skill score, and bias by category.

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[1] Bias is the number of forecasts of a category divided by the number of observations of that category. A categorical bias of 1 means unbiased forecasts of that category.

The results for all stations combined are shown in Table 3.2. For the 18-h projection, the percent correct and skill score for our early guidance was slightly better than that for our final guidance. Comparing the guidance with the local forecasts, we find that overall both the early and final guidance were superior to the locals in terms of percent correct and skill score.

The fact that there is a difference between the scores for our early and final guidance is quite interesting since both sets of prediction equations were derived from LFM data. The lag in observed surface predictors is different, of course. Also, part of the explanation probably rests in the transformation of the probability forecasts to the best category. This can be deduced from the slightly different bias values shown between the early and final guidance. The biases for both the early and final guidance were better than the local biases in all four categories. For the 30- and 42-h projections, the final guidance was definitely better than the locals for percent correct, skill score, and bias by category.

In Tables 3.3-3.6, we present the verification scores for stations in the NWS Eastern, Southern, Central, and Western Regions, respectively. Comparing the early and final guidance for the 18-h projection, we find that, with the exception of the Eastern Region, the percent correct and skill score were higher for the early guidance. Generally, the biases for the guidance were somewhat better than the local biases. For the 30- and 42-h projections, the percent correct and skill score for the guidance were substantially better than those for the locals. Also, for most cases the final guidance biases were better (i.e., closer to 1) than the locals.

The overall results of this comparative verification indicate that this warm season's cloud forecasts were somewhat better compared to the previous warm season cloud forecasts (see Crisci et al., 1977). For this verification, we are pleased that the change from the single station equations to regionalized prediction equations has not adversely affected our product.

4. SURFACE WIND

The objective wind forecasts were generated by early and final guidance prediction equations for the warm season (National Weather Service, 1978). Our early guidance equations are based on output from the LFM model, while PE model output is used as predictors for the final guidance equations. The sine and cosine of the day of the year also appear as predictors in both sets of equations. The definition of the objective surface wind forecast is the same as that of the observed wind: the one-minute average direction and speed for a specific time.

Since the local forecasts were recorded as calm if the wind speed was expected to be less than 8 knots, we verified the wind forecasts in two ways. First, for all those cases where both the local and guidance (early and final) wind speed forecasts were at least 8 knots, the mean absolute error (MAE) of speed was computed. Secondly, for all cases where both local and guidance forecasts were available, skill score, percent correct, and bias by category (i.e. the number of forecasts in a particular category divided by the number of observations in that category) were computed from contingency tables of wind speed. The seven categories were: less than 8, 8-12, 13-17, 18-22, 23-27, 28-32, and greater than 32 knots. Table 4.1 list the 94 stations used in the verification. Tables 4.2-4.12 show comparative verification scores (0000 GMT cycle only) for 18-, 30-, and 42-h projections for final guidance and 18- and 30-h projections for early guidance. It should also be noted that all the objective forecasts of wind speed were adjusted by an "inflation" equation (Klein et al., 1959), involving the multiple correlation coefficient and mean value of wind speed for a particular station and forecast valid time. The results for all 94 stations combined are shown in Tables 4.2 and 4.3. The direction MAE scores reveal an advantage for the guidance that is approximately 4° for all three forecast projections. Overall, the MAE's, skill scores, and percent correct were also better for the guidance. The speed MAE score for the 18-h early guidance was substantially lower than the corresponding final guidance and local scores. Both the biases by category in Table 4.2 and the contingency tables in 4.3 indicate that the early guidance and local forecasts tended to underestimate winds stronger than 22 knots (i.e. categories 5, 6, and 7); the final guidance was somewhat better in this regard.

Tables 4.4-4.7 show scores for the NWS Eastern, Southern, Central, and Western Regions, respectively. These regional values had the same general characteristics as those overall, except for the bias by category scores. For the Eastern Region in particular, winds between 18 and 27 knots (i.e., categories 4 and 5) were consistently overforecast by the final guidance.

Table 4.8 shows the distribution of wind direction absolute errors by categories--0-30°, 40-60°, 70-90°, 100-120°, 130-150°, and 160-180°--for all 94 stations combined. Here we see that the early guidance had about 6% fewer errors of 40° or more than did the local forecasters for both the 18- and 30-h projections. The final guidance was also superior to the locals in this respect with approximately 5% fewer errors for each of the three forecast projections.

Distributions of direction errors for the individual regions are given in Tables 4.9-4.12. In general, these results are much like those in Table 4.8, except that the magnitude of the advantage for the guidance over local forecasts differs from region to region. The 18-h early guidance forecasts for the Eastern and Southern Regions had about 8% fewer errors of 40° or more than did the locals. In contrast, both sets of guidance forecasts for the Western Region held only a 2% advantage over the locals.

A comparison of the overall MAE's and skill scores for the past four warm seasons is presented in Figures 4.1-4.3. In general, the verification data throughout this period were homogenous. The number of stations varied only slightly from season to season, and the same basic sets of verification stations were used. Early guidance scores were available for only the warm season of 1977.

The MAE's for direction are given in Figure 4.1. Except for a slight increase in some of the MAE's during 1975, both the final guidance and local forecasts for all three projections steadily improved over the span of these four seasons.

In contrast, the MAE's in Figure 4.2 indicate a decrease in accuracy for the final guidance speed forecasts. This was caused by the introduction of inflation in August of 1975. It was known inflation would have this effect; however, the bias values shown in Table 4.2 are somewhat closer to 1 compared to the bias values in previous warm season surface wind verifications (Crisci et al., 1977).

Figure 4.3 is a comparison of guidance and local skill scores computed on five (instead of seven) categories; the fifth category included all speeds greater than 22 knots. Here we see that the skill of the final guidance for all three projections remained relatively constant despite the use of inflation. Of particular note in Figure 4.3 is the large magnitude of the advantage in skill of the guidance over the locals for all three projections.

The 1977 18- and 30-h early guidance MAE and skill scores in Figures 4.1-4.3 clearly indicate the superiority of these forecasts over those from the other two systems. This is quite encouraging because the early (LFM-based) forecasts are rapidly becoming the primary source of detailed surface wind guidance available to NWS field forecasters prior to issuance of the public weather forecast.

5. CEILING AND VISIBILITY

In April 1977, we implemented the warm season equations as part of our new forecast system for ceiling and visibility. Our new system, which was first implemented for the 1976-77 cool season (National Weather Service, 1977b), differed from the previous warm season system in the following respects:

- Early guidance forecasts of ceiling and visibility became available for the first time.
- Forecasts were produced for six (instead of five) categories of the two elements. See Table 5.1 for the definitions.
- Threshold probabilities replaced the NWS scoring matrix for the transformation of the probability forecasts into categorical forecasts ("best category").

Details of this major system change can be found in National Weather Service (1977b).

In the early guidance equations, the predictors are from the LFM model and surface variables observed 2 hours after model run time; we generate forecasts for projections of 6, 12, 18, and 24 hours from the 0000 and and 1200 GMT cycles. For our final guidance package, we generate forecasts for projections of 12 to 48 hours at 6-h intervals from the two model run times. Model predictors are from the LFM for the 12- and 18-h projections; from both the LFM and PE models for 24- and 30-h; and from only the PE for the remaining projections. Surface predictors, when used, are from observations taken 5 hours after the two model run times.

For the period April through September 1977, we verified for both cycles: early guidance forecasts for 12-, 18-, and 24-h projections; final guidance forecasts for 12-, 18-, 24-, 36-, and 48-h projections; subjective local forecasts for 12-, 15-, and 21-h projections; and persistence forecasts which coincide with each of the preceding forecasts with respect to projection and cycle. In all cases, we used matched samples, and we assembled these data for the 94 terminals specified in Table 4.1.

Persistence forecasts were determined from the last hourly surface airways observation available to the local forecaster before the official (FT) filing deadline (1000 GMT for the 0000 GMT cycle and 2200 GMT for the 1200 cycle). The ceiling and visibility values which existed in that observation were used for each verification time that followed. We used the transformed ("best category") categorical forecast for verification of our guidance products. The best category is selected using the threshold probability technique (National Weather Service, 1977b).

For all the forecasts involved in this comparative verification, we constructed forecast-observed contingency tables which were then used to compute several different scores: bias by category, percent correct, Heidke skill score, and threat score for categories 1 and 2 combined. We have summarized the scores in Tables 5.2-5.5. Each table pertains to one element for one cycle time, for all types of forecasts, arranged by projection.

Direct comparison between the local and guidance forecasts is possible only for the 12-h projection. Here, the tables show that both persistence and the local forecasts were superior to both of our guidance products--for both elements at both cycles--in percent correct, skill score, and threat score. We're not surprised at these results; they occurred because of the advantage to the local forecast and persistence of using surface observations no less than 3 hours later than those used in the MOS equations.

At projections beyond 12 hours, both the local and guidance forecasts generally did better than persistence in terms of bias, percent correct, skill score, and threat score. The exception is for visibility at the 15-h projection where persistence performed slightly better than the locals in terms of percent correct and skill score.

The biases for the guidance forecasts are much improved over previous years. This is a result of the threshold probability technique used to determine the "best" category (National Weather Service, 1977b). Our goal was to increase the "acceptance" of the product by achieving biases in the range of 0.75 to 1.00 while not appreciably decreasing the other measures (threat score, Heidke skill score, and percent correct). The results are somewhat erratic, especially in the lower two categories. However, as we derive more stable threshold values with larger samples of dependent data, the results will tend not to be so erratic.

6. MAX/MIN TEMPERATURE

The early and final guidance forecasts for April through September of 1977 were generated from three different sets of seasonal regression equations. These equations had been developed by stratifying archived numerical model output into 3-month seasons as described by Hammons et al. (1976). Operationally, the early guidance forecasts are obtained by substituting LFM fields in PE-based multiple regression equations. Observed weather elements from surface reports are not used as predictors. In contrast, the final guidance is produced a few hours later each day using PE model forecasts in PE-derived equations. Surface observations 5 to 6 hours later than the model input data are also used as predictors for the first two projections. In addition, the sine and cosine of the day of the year are involved in producing both sets of forecasts.

The guidance forecasts are expressed as calendar day maximum (max) and minimum (min) temperatures. In contrast, the local forecasts in the FPUS4 teletype message are predicted for the following 12-h periods: max's between 1200 GMT and 0000 GMT, and min's between 0000 GMT and 1200 GMT. Using max/min observations from our Asheville data collection, we verified forecasts for projections of approximately 24 (max), 36 (min), 48 (max), and 60 (min) hours from 0000 GMT. Mean algebraic errors (mean forecast minus mean observed temperatures), mean absolute errors, and the number (or percent) of absolute errors of 10°F or more were computed for each case where all the guidance and local forecasts were available. Since the verifying observations did not correspond directly to the valid periods for the local forecasts, the magnitude of each of the verification scores should be viewed with some caution. However, general trends and relative differences between the guidance and local forecasts are still meaningful. Table 2.1 shows the 87 stations we used in this verification.

A comparison of the average scores for the 87 stations combined is given in Table 6.1. The mean algebraic errors indicate that the local forecasts are less biased (i.e., the errors are closer to zero) than both sets of guidance forecasts for the initial (24-h) projection. This may be a reflection of the advantage the local forecaster obtains from using observed data about 3 hours later than that contained in the final guidance. In contrast, the early guidance and locals tend to be equally biased for the other three (longer-range) projections. These scores also show that the final guidance has a tendency to underforecast both the max and min temperatures; the early guidance and local forecasts are somewhat better in this respect.

The mean absolute errors in Table 6.1 indicate that after the first projection there is very little difference in the overall quality of the three types of forecasts. In fact, the early guidance, which was handicapped by lack of observed input for the first two projections, has the best mean absolute error for the 48-h max. Conversely, the final guidance is clearly superior to both the early guidance and local forecasts in regard to having fewer absolute errors of 10°F or more (i.e., big busts) for all four projections. For the guidance, this is probably an indication of the increased stability associated with using PE forecasts in PE-derived equations.

Tables 6.2-6.6 show the scores for the NWS Eastern, Southern, Central, and Western Regions, respectively. The scores in Table 6.2 indicate that the early guidance is very competitive with the final guidance and local forecasts for all four projections in the Eastern Region. This is also the case for the 36-, 48-, and 60-h forecasts in the Southern and Central Regions (see Tables 6.3 and 6.4). However, as shown in Table 6.5, the early guidance strongly underforecasts max temperatures in the Western Region. These findings are similar to those of Dallavalle and Hammons (1976), and may be the result of LFM model initialization and boundary related problems in the West.

Also, of note in Tables 6.3 and 6.5 is the relatively large negative bias in the final guidance 24- and 48-h max forecasts for the Southern and Western Regions. Here, we suspect that unusually warm summer temperatures associated with droughts in the Southeast and West were major influences on these verification results.

7. CONCLUSIONS

This verification shows that TDL's aviation/public weather guidance forecasts generally compare very favorably with local forecasts produced at WSFO's. For PoP, the local forecasts are generally better than the guidance for all three forecast periods. The local's improvement over the guidance generally decreases from the first period to the second period; however, it increases from the first period to the second period in both the Eastern and Southern Regions. In both the Eastern and Central regions, the local's improvement over the guidance increases from the second to the third period. In the Western region, the local's improvement over the guidance decreases uniformly for the three projections.

For surface wind and opaque sky cover, the guidance forecasts are generally better than the local forecasts at the 18-, 30-, and 42-h projections.

Direct comparison between local, guidance, and persistence forecasts of ceiling and visibility was possible for only the 12-h projection; for that projection local forecasts are superior to the guidance for both elements, while persistence was frequently superior to both the locals and guidance. However, the bias of the guidance forecasts improved considerably for all projections as compared to previous verifications, with guidance better than persistence beyond the 12-h projection.

Finally, the max/min temperature guidance forecasts seem to compare favorably with the local forecasts except in the Western Region where the local forecasts are somewhat better. However, these results must be viewed with caution, since the locals are for a 12-h period and are verified over a 24-h period.

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Table 2.1. Eighty-seven stations used for comparative verification of guidance and local PoP and max/min temperature forecasts.

AVL	Asheville, North Carolina
RDU	Raleigh-Durham, North Carolina
ORF	Norfolk, Virginia
PHL	Philadelphia, Pennsylvania
RIC	Richmond, Virginia
DCA	Washington, D.C.
CRW	Charleston, West Virginia
CHS	Charleston, South Carolina
CLT	Charlotte, North Carolina
CAE	Columbia, South Carolina
LGA	New York (Laguardia), New York
BUF	Buffalo, New York
ALB	Albany, New York
BOS	Boston, Massachusetts
BDL	Hartford, Connecticut
BTV	Burlington, Vermont
PWM	Portland, Maine
PVD	Providence, Rhode Island
SYR	Syracuse, New York
CLE	Cleveland, Ohio
CMH	Columbus, Ohio
BAL	Baltimore, Maryland
ACY	Atlantic City, New Jersey
CVG	Cincinnatti, Ohio
DAY	Dayton, Ohio
PIT	Pittsburgh, Pennsylvania
ICT	Wichita, Kansas
MKC	Kansas City, Missouri
STL	St. Louis, Missouri
MDW	Chicago (Midway), Illinois
MKE	Milwaukee, Wisconsin
SSM	Sault Ste Marie, Michigan
DLH	Duluth, Minnesota
FAR	Fargo, North Dakota
MSP	Minneapolis, Minnesota
DSM	Des Moines, Iowa
OMA	Omaha, Nebraska
FSD	Sioux Falls, South Dakota
DEN	Denver, Colorado
BIS	Bismarck, North Dakota
CYS	Cheyenne, Wyoming
LBF	North Platte, Nebraska
BNA	Nashville, Tennessee
TOP	Topeka, Kansas
DFW	Ft. Worth, Texas
JAN	Jackson, Mississippi
MIA	Miami, Florida
ORL	Orlando, Florida
TPA	Tampa, Florida
MSY	New Orleans, Louisiana
BRO	Brownsville, Texas
SAT	San Antonio, Texas
IAH	Houston, Texas
ATL	Atlanta, Georgia
BHM	Birmingham, Alabama
JAX	Jacksonville, Florida
MEM	Memphis, Tennessee
SHV	Shreveport, Louisiana
AUS	Austin, Texas
LIT	Little Rock, Arkansas
OKC	Oklahoma City, Oklahoma
TUL	Tulsa, Oklahoma
MAF	Midland, Texas
ELP	El Paso, Texas
AMA	Amarillo, Texas
ABQ	Albuquerque, New Mexico
FLG	Flagstaff, Arizona
TUS	Tucson, Arizona
LAS	Las Vegas, Nevada
LAX	Los Angeles, California
RNO	Reno, Nevada
SAN	San Diego, California
SFO	San Francisco, California
BIL	Billings, Montana
SLC	Salt Lake City, Utah
BOI	Boise, Idaho
HLN	Helena, Montana
GEG	Spokane, Washington
PDX	Portland, Oregon
SEA	Seattle-Tacoma, Washington
CPR	Casper, Wyoming
RAP	Rapid City, South Dakota
IND	Indianapolis, Indiana
SDF	Louisville, Kentucky
DTW	Detroit, Michigan
PHX	Phoenix, Arizona
GTF	Great Falls, Montana

Table 2.2 Comparative verification of early and final guidance and local PoP forecasts for 87 stations, 0000 and 1200 GMT cycles.

Projection	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climatology (%)	Number of Cases
12-24 h (1st period)	Early/Final	.1131		24.0	27943
	Local	.1098	2.9	27.0	
24-36 h (2nd period)	Early	.1241		18.0	27879
	Final	.1267		16.5	
	Local	.1221	1.6[1] (3.6)	19.7	
36-48 h (3rd period)	Final	.1349		10.9	27959
	Local	.1316	2.4	13.2	

[1] This is the percent improvement of the locals over the early guidance; the figure in parentheses is the percent improvement of the locals over the final guidance.

Table 2.3 Same as Table 2.2 except for 26 stations in the Eastern Region.

Projection	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climatology (%)	Number of Cases
12-24 h (1st period)	Early/Final	.1111		31.9	7991
	Local	.1102	.8	32.4	
24-36 h (2nd period)	Early	.1271		24.2	7971
	Final	.1316		21.5	
	Local	.1252	1.5[1] (4.7)	25.3	
36-48 h (3rd period)	Final	.1404		17.3	7994
	Local	.1364	2.8	19.7	

[1] This is the percent improvement of the locals over the early guidance; the figure in parentheses is the percent improvement of the locals over the final guidance.

Table 2.4 Same as Table 2.2 except for 22 stations in the Central Region.

Projection	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climatology (%)	Number of Cases
12-24 h (1st period)	Early/Final	.1377		23.6	7277
	Local	.1327	3.6	26.4	
24-36 h (2nd period)	Early	.1470		18.8	7260
	Final	.1509		16.6	
	Local	.1488	-1.2[1] (1.4)	17.8	
36-48 h (3rd period)	Final	.1596		11.2	7282
	Local	.1587	.6	11.7	

[1] This is the percent improvement of the locals over the early guidance; the figure in parentheses is the percent improvement of the locals over the final guidance.

Table 2.5 Same as Table 2.2 except for 23 stations in the Southern Region.

Projection	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climatology (%)	Number of Cases
12-24 h (1st period)	Early/Final	.1176		15.9	7495
	Local	.1135	3.5	18.8	
24-36 h (2nd period)	Early	.1265		10.7	7484
	Final	.1274		10.0	
	Local	.1216	3.9[1] (4.6)	14.1	
36-48 h (3rd period)	Final	.1340		4.5	7503
	Local	.1290	3.7	7.9	

[1] This is the percent improvement of the locals over the early guidance; the figure in parentheses is the percent improvement of the locals over the final guidance.

Table 2.6 Same as Table 2.2 except for 16 stations in the Western Region.

Projection	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climatology (%)	Number of Cases
12-24 h (1st period)	Early/Final Local	.0795 .0717	9.9	24.1 31.6	5180
24-36 h (2nd period)	Early Final Local	.0840 .0842 .0804	4.3[1](4.5)	18.1 17.9 21.7	5164
36-48 h (3rd period)	Final Local	.0982 .0898	3.2	9.9 12.9	5180

[1] This is the percent improvement of the locals over the early guidance; the figure in parentheses is the percent improvement of the locals over the final guidance.

Table 3.1 Definitions of the categories used for guidance forecasts of cloud amount.

Category	Cloud Amount (Opaque Sky Cover in tenths)
1	0-1
2	2-5
3	6-9
4	10

Table 3.2. Comparative verification of early and final guidance and local forecasts of four categories of cloud amount (clear, scattered, broken, and overcast) for 94 stations, 0000 GMT cycle.

PROJECTION (HRS)	TYPE OF FORECAST	BIAS - NO. FCST/NO. OBS				PERCENT CORRECT	SKILL SCORE	NO. OF CASES
		CAT 1 (No. Obs.)	CAT 2 (No. Obs.)	CAT3 (No. Obs)	CAT4 (No. Obs.)			
18	EARLY	0.84	1.21	1.03	0.84	49.4	.313	13851
	FINAL	0.82	1.24	1.04	0.82	49.3	.311	
	LOCAL	0.65	1.48	1.06	0.61	47.0	.274	
		(3704)	(4209)	(3479)	(2459)			
30	FINAL	0.94	1.50	0.55	0.94	49.0	.269	15056
	LOCAL	0.67	1.88	1.59	0.53	41.7	.212	
		(6694)	(2985)	(2002)	(3375)			
42	FINAL	0.91	1.07	1.02	1.00	44.3	.250	15288
	LOCAL	0.54	1.70	1.08	0.46	39.9	.176	
		(4233)	(4552)	(3725)	(2776)			

Table 3.3. Same as Table 3.2 except for 24 stations in the Eastern Region.

PROJECTION (HRS)	TYPE OF FORECAST	BIAS - NO. FCST/NO. OBS				PERCENT CORRECT	SKILL SCORE	NO. OF CASES
		CAT 1 (No. Obs.)	CAT 2 (No. Obs.)	CAT3 (No. Obs)	CAT4 (No. Obs.)			
18	EARLY	0.59	1.16	1.18	0.90	49.6	.310	3531
	FINAL	0.59	1.16	1.16	0.91	50.6	.323	
	LOCAL	0.67 (630)	1.43 (1093)	1.07 (973)	0.60 (835)	47.1	.272	
30	FINAL	1.03	1.04	0.80	1.03	49.1	.282	3905
	LOCAL	0.79 (1453)	1.67 (732)	1.78 (515)	0.51 (1205)	41.8	.226	
42	FINAL	0.83	0.93	1.10	1.11	43.2	.235	3888
	LOCAL	0.57 (748)	1.55 (1171)	1.18 (1025)	0.46 (944)	39.0	.164	

Table 3.4. Same as Table 3.2 except for 24 stations in the Southern Region.

PROJECTION (HRS)	TYPE OF FORECAST	BIAS - NO. FCST/NO. OBS				PERCENT CORRECT	SKILL SCORE	NO. OF CASES
		CAT 1 (No. Obs.)	CAT 2 (No. Obs.)	CAT3 (No. Obs)	CAT4 (No. Obs.)			
18	EARLY	0.67	1.30	1.06	0.63	50.4	.293	3489
	FINAL	0.61	1.37	1.08	0.49	49.8	.280	
	LOCAL	0.53	1.56	0.94	0.41	48.6	.256	
		(868)	(1223)	(1010)	(388)			
30	FINAL	0.88	1.80	0.40	0.81	49.8	.252	3876
	LOCAL	0.67	2.05	1.36	0.39	42.2	.186	
		(1948)	(814)	(488)	(626)			
42	FINAL	0.71	1.15	1.15	0.83	44.6	.225	3860
	LOCAL	0.44	1.79	0.85	0.29	42.0	.159	
		(984)	(1311)	(1112)	(453)			

Table 3.5. Same as Table 3.2 except for 28 stations in the Central Region.

PROJECTION (HRS)	TYPE OF FORECAST	BIAS - NO. FCST/NO. OBS				PERCENT CORRECT	SKILL SCORE	NO. OF CASES
		CAT 1 (No. Obs.)	CAT 2 (No. Obs.)	CAT3 (No. Obs)	CAT4 (No. Obs.)			
18	EARLY	0.80	1.23	1.07	0.83	45.9	.268	4130
	FINAL	0.82	1.22	1.07	0.82	45.5	.263	
	LOCAL	0.56	1.52	1.15	0.60	41.8	.206	
		(1108)	(1251)	(972)	(799)			
30	FINAL	0.92	1.60	0.51	0.93	47.3	.253	4422
	LOCAL	0.54	1.99	1.75	0.59	38.0	.182	
		(1905)	(863)	(595)	(1059)			
42	FINAL	0.97	1.06	1.02	0.94	42.5	.227	4571
	LOCAL	0.40	1.77	1.18	0.49	36.6	.137	
		(1262)	(1347)	(1033)	(929)			

Table 3.6. Same as Table 3.2 except for 18 stations in the Western Region.

PROJECTION (HRS)	TYPE OF FORECAST	BIAS - NO. FCST/NO. OBS				PERCENT CORRECT	SKILL SCORE	NO. OF CASES
		CAT 1 (No. Obs.)	CAT 2 (No. Obs.)	CAT3 (No. Obs)	CAT4 (No. Obs.)			
18	EARLY	1.15	1.10	0.61	0.95	53.1	.330	2701
	FINAL	1.10	1.14	0.68	0.93	52.6	.327	
	LOCAL	0.81	1.36	1.11	0.81	52.7	.349	
		(1098)	(642)	(524)	(437)			
30	FINAL	0.96	1.49	0.47	0.96	50.6	.266	2853
	LOCAL	0.72	1.74	1.38	0.60	46.7	.253	
		(1388)	(576)	(404)	(485)			
42	FINAL	1.08	1.15	0.59	1.05	48.3	.259	2969
	LOCAL	0.74	1.62	1.14	0.55	43.4	.216	
		(1241)	(723)	(555)	(450)			

Table 4.1. Ninety-four stations used for comparative verification of guidance and local sky cover, surface wind, ceiling, and visibility forecasts.

PWM	Portland, Maine	GTF	Great Falls, Montana
BTV	Burlington, Vermont	TCC	Tucumcari, New Mexico
CON	Concord, New Hampshire	SSM	Sault Ste Marie, Michigan
BOS	Boston, Massachusetts	DTW	Detroit, Michigan
PVD	Providence, Rhode Island	SBN	South Bend, Indiana
BUF	Buffalo, New York	IND	Indianapolis, Indiana
SYR	Syracuse, New York	LEX	Lexington, Kentucky
ALB	Albany, New York	SDF	Louisville, Kentucky
JFK	New York (Kennedy), New York	MSN	Madison, Wisconsin
EWR	Newark, New Jersey	MKE	Milwaukee, Wisconsin
ERI	Erie, Pennsylvania	ORD	Chicago (O'Hare), Illinois
AVP	Scranton, Pennsylvania	SPI	Springfield, Illinois
PIT	Pittsburgh, Pennsylvania	STL	St. Louis, Missouri
PHL	Philadelphia, Pennsylvania	MCI	Kansas City, Missouri
CLE	Cleveland, Ohio	TOP	Topeka, Kansas
CMH	Columbus, Ohio	DDC	Dodge City, Kansas
HTS	Huntington, West Virginia	DEN	Denver, Colorado
CRW	Charleston, West Virginia	GJT	Grand Junction, Colorado
DCA	Washington, D.C.	SHR	Sheridan, Wyoming
ORF	Norfolk, Virginia	CYS	Cheyenne, Wyoming
RDU	Raleigh-Durham, North Carolina	BIS	Bismarck, North Dakota
CLT	Charlotte, North Carolina	FAR	Fargo, North Dakota
GSP	Greenville, South Carolina	RAP	Rapid City, South Dakota
CAE	Columbia, South Carolina	FSD	Sioux Falls, South Dakota
ATL	Atlanta, Georgia	BFF	Scottsbluff, Nebraska
SAV	Savannah, Georgia	OMA	Omaha, Nebraska
MIA	Miami, Florida	MSP	Minneapolis, Minnesota
JAX	Jacksonville, Florida	DSM	Des Moines, Iowa
BHM	Birmingham, Alabama	BRL	Burlington, Iowa
MOB	Mobile, Alabama	INL	International Falls, Minnesota
TYS	Knoxville, Tennessee	FLG	Flagstaff, Arizona
MEM	Memphis, Tennessee	PHX	Phoenix, Arizona
MEI	Meridian, Mississippi	CDC	Cedar City, Utah
JAN	Jackson, Mississippi	SLC	Salt Lake City, Utah
MSY	New Orleans, Louisiana	LAS	Las Vegas, Nevada
SHV	Shreveport, Louisiana	RNO	Reno, Nevada
IAH	Houston, Texas	SAN	San Diego, California
SAT	San Antonio, Texas	LAX	Los Angeles, California
DFW	Fort Worth, Texas	FAT	Fresno, California
ABI	Abilene, Texas	SFO	San Francisco, California
LBB	Lubbock, Texas	PDX	Portland, Oregon
ELP	El Paso, Texas	PDT	Pendleton, Oregon
LIT	Little Rock, Arkansas	SEA	Seattle (Tacoma), Washington
FSM	Fort Smith, Arkansas	GEG	Spokane, Washington
TUL	Tulsa, Oklahoma	BOI	Boise, Idaho
OKC	Oklahoma City, Oklahoma	PIH	Pocatello, Idaho
ABQ	Albuquerque, New Mexico	MSO	Missoula, Montana

Table 4.2. Comparative verification of early and final guidance and local surface wind forecasts for 94 stations, 0000 GMT.

FCST. PROJ. (HRS)	TYPE OF FCST.	DIRECTION: MEAN ABS. ERROR (DEG)	DIRECTION: NO. OF CASES	SPEED: MEAN ABS. ERROR (KTS)	SPEED: MEAN FCST (KTS)	SPEED: MEAN OBS. (KTS)	SPEED: NO. OF CASES	CONTINGENCY TABLE: SKILL SCORE	CONTINGENCY TABLE: PERCENT FCST. CORRECT	BIAS-NO. FCST./NO. OBS.: CAT1 (NO. OBS.)	CAT2 (NO. OBS.)	CAT3 (NO. OBS.)	CAT4 (NO. OBS.)	CAT5 (NO. OBS.)	CAT6 (NO. OBS.)	CAT7 (NO. OBS.)	NO. OF CASES
18	EARLY	28	6257	2.9	11.8	11.8	6280	0.30	56	1.22	0.93	0.74	0.58	0.69	0.43	0.17	15594
	FINAL	30		3.2	12.3			0.28	53	1.11	0.97	0.84	0.80	1.10	0.50	0.50	
	LOCAL	32		3.2	12.7			0.24	51	0.82	1.21	0.96	0.83	0.66	0.64	0.50	
										(6174)	(6303)	(2452)	(556)	(89)	(14)	(6)	
30	EARLY	30	2211	3.3	11.2	9.8	2251	0.32	70	1.02	0.99	0.87	0.40	0.21	*	0.0	14799
	FINAL	31		3.3	11.0			0.30	69	1.03	1.01	0.68	0.24	0.14	*	0.0	
	LOCAL	35		3.5	11.3			0.23	64	0.95	1.22	0.78	0.46	0.36	**	2.0	
										(10241)	(3581)	(828)	(134)	(14)	(0)	(1)	
42	FINAL	41	7280	3.4	11.5	10.9	7347	0.23	50	1.09	1.02	0.82	0.70	0.64	0.62	0.0	15383
	LOCAL	45		3.6	11.9			0.17	47	0.83	1.24	0.93	0.50	0.30	0.15	1.00	
										(6065)	(6264)	(2411)	(536)	(88)	(13)	(6)	

* This category was neither forecast nor observed.
** This category was forecast twice but was never observed.

Table 4.3. Contingency tables for early and final guidance and local surface wind speed forecasts for 94 stations, 0000 GMT cycle.

18-h Forecasts

EARLY

OBS	1	2	3	4	5	6	7	T
1	4595	1464	106	8	1	0	0	6174
2	2625	3092	537	45	4	0	0	6303
3	306	1154	855	126	11	0	0	2452
4	27	120	268	109	28	3	1	556
5	0	10	34	30	13	2	0	89
6	4	0	2	5	3	0	0	14
7	0	2	1	1	1	1	0	6
T	7557	5842	1803	324	61	6	1	15594

FINAL

OBS	1	2	3	4	5	6	7	T
1	4221	1758	179	13	3	0	0	6174
2	2364	3107	737	85	10	0	0	6303
3	253	1119	858	195	26	1	0	2452
4	27	121	241	118	44	3	2	556
5	1	13	26	32	14	2	1	89
6	2	1	7	3	1	0	0	14
7	0	1	4	0	0	1	0	6
T	6868	6120	2052	446	98	7	3	15594

LOCAL

OBS	1	2	3	4	5	6	7	T
1	3167	2685	296	21	2	2	1	6174
2	1642	3682	880	88	9	1	1	6303
3	213	1116	919	189	15	0	0	2452
4	32	152	220	128	21	2	1	556
5	1	15	31	31	9	2	0	89
6	1	2	4	3	3	1	0	14
7	0	1	3	1	0	1	0	6
T	5056	7653	2353	461	59	9	3	15594

30-h Forecasts

EARLY

OBS	1	2	3	4	5	6	7	T
1	8497	1558	179	7	0	0	0	10241
2	1742	1554	270	14	1	0	0	3581
3	209	369	227	22	1	0	0	828
4	25	60	39	10	0	0	0	134
5	4	6	3	0	1	0	0	14
6	0	0	0	0	0	0	0	0
7	1	0	0	0	0	0	0	1
T	10478	3547	718	53	3	0	0	14799

FINAL

OBS	1	2	3	4	5	6	7	T
1	8514	1615	106	5	1	0	0	10241
2	1835	1508	228	10	0	0	0	3581
3	203	424	187	13	1	0	0	828
4	36	58	36	4	0	0	0	134
5	8	3	3	0	0	0	0	14
6	0	0	0	0	0	0	0	0
7	1	0	0	0	0	0	0	1
T	10597	3608	560	32	2	0	0	14799

LOCAL

OBS	1	2	3	4	5	6	7	T
1	7691	2331	200	16	2	1	0	10241
2	1755	1545	258	20	1	1	1	3581
3	228	421	157	21	0	0	1	828
4	40	64	25	4	1	0	0	134
5	6	4	3	0	1	0	0	14
6	0	0	0	0	0	0	0	0
7	0	1	0	0	0	0	0	1
T	9720	4366	643	61	5	2	2	14799

42-h Forecasts

FINAL

OBS	1	2	3	4	5	6	7	T
1	3850	1914	266	34	1	0	0	6065
2	2362	3089	713	95	4	1	0	6264
3	345	1176	722	149	19	0	0	2411
4	36	157	236	78	25	4	0	536
5	2	21	38	19	6	2	0	88
6	1	5	6	0	0	1	0	13
7	0	3	0	2	1	0	0	6
T	6596	6365	1981	377	56	8	0	15383

LOCAL

OBS	1	2	3	4	5	6	7	T
1	2880	2768	387	24	3	0	3	6065
2	1775	3545	870	67	2	2	3	6264
3	345	1229	722	104	11	0	0	2411
4	56	200	216	57	7	0	0	536
5	6	27	41	11	3	0	0	88
6	1	3	8	1	0	0	0	13
7	0	4	0	2	0	0	0	6
T	5063	7776	2244	266	26	2	6	15383

Table 4.4. Same as Table 4.2 except for 24 stations in the Eastern Region

FCST. PROJ. (HRS)	TYPE OF FCST.	DIRECTION		SPEED													
								CONTINGENCY TABLE									
										BIAS-NO. FCST./NO. OBS.							
		MEAN ABS. ERROR (DEG)	NO. OF CASES	MEAN ABS. ERROR (KTS)	MEAN FCST (KTS)	MEAN OBS. (KTS)	NO. OF CASES	SKILL SCORE	PERCENT FCST. CORRECT	CAT1 (NO. OBS.)	CAT2 (NO. OBS.)	CAT3 (NO. OBS.)	CAT4 (NO. OBS.)	CAT5 (NO. OBS.)	CAT6 (NO. OBS.)	CAT7 (NO. OBS.)	NO. OF CASES
18	EARLY	28	1774	2.6	11.6	11.4	1779	0.32	57	1.22	0.95	0.73	0.80	0.63	0.33	0.0	3927
	FINAL	31		3.0	12.4			0.28	53	1.12	0.94	0.86	1.29	2.19	0.0	0.0	
	LOCAL	33		3.1	12.5			0.22	50	0.91	1.13	0.86	1.12	0.69	0.0	0.0	
										(1367)	(1752)	(695)	(93)	(16)	(3)	(1)	
30	EARLY	28	452	3.0	10.3	9.2	458	0.34	77	1.05	0.88	0.62	0.25	0.0	*	*	3756
	FINAL	29		3.5	11.1			0.31	75	1.01	0.98	0.91	1.00	2.00	*	*	
	LOCAL	32		3.9	11.7			0.26	69	0.92	1.25	1.41	1.25	2.00	*	**	
										(2876)	(750)	(117)	(12)	(1)	(0)	(0)	
42	FINAL	40	1924	3.2	11.7	10.8	1935	0.24	51	1.15	0.94	0.79	1.55	1.25	0.25	0.0	3885
	LOCAL	43		3.3	12.0			0.16	47	0.93	1.10	0.92	0.70	0.50	0.0	2.00	
										(1334)	(1777)	(670)	(83)	(16)	(4)	(1)	

* This category was neither forecast nor observed.
** This category was forecast once but was never observed.

Table 4.5. Same as Table 4.2 except for 24 stations in the Southern Region.

FCST. PROJ. (HRS)	TYPE OF FCST.	DIRECTION		SPEED													
										CONTINGENCY TABLE							
										BIAS-NO. FCST./NO. OBS.							
		MEAN ABS. ERROR (DEG)	NO. OF CASES	MEAN ABS. ERROR (KTS)	MEAN FCST (KTS)	MEAN OBS. (KTS)	NO. OF CASES	SKILL SCORE	PERCENT FCST. CORRECT	CAT1 (NO. OBS.)	CAT2 (NO. OBS.)	CAT3 (NO. OBS.)	CAT4 (NO. OBS.)	CAT5 (NO. OBS.)	CAT6 (NO. OBS.)	CAT7 (NO. OBS.)	NO. OF CASES
18	EARLY	26	1376	2.7	11.6	11.6	1379	0.32	58	1.29	0.82	0.67	0.67	1.10	0.0	0.0	3990
	FINAL	27		2.8	11.8			0.31	58	1.21	0.89	0.70	0.69	1.30	0.0	0.0	
	LOCAL	29		2.9	12.6			0.27	54	0.72	1.31	1.01	0.84	0.50	1.00	0.0	
										(1725)	(1609	(537)	(107)	(10)	(1)	(1)	
30	EARLY	25	477	3.1	11.5	10.4	483	0.39	75	1.02	0.97	0.93	0.50	0.0	*	*	3823
	FINAL	27		2.8	10.8			0.37	76	1.07	0.89	0.57	0.17	0.0	*	*	
	LOCAL	28		3.1	11.0			0.28	71	1.00	1.16	0.55	0.20	0.0	*	*	
										(2817)	(778)	(195)	(30)	(3)	(0)	(0)	
42	FINAL	38	1651	3.0	11.1	10.7	1666	0.25	53	1.18	0.93	0.76	0.56	0.50	**	0.0	3887
	LOCAL	43		3.4	11.8			0.18	48	0.75	1.31	0.96	0.56	0.25	*	1.00	
										(1656)	(1580)	(532)	(106)	(12)	(0)	(1)	

* This category was neither forecast nor observed.
** This category was forecast once but was never observed.

Table 4.6. Same as Table 4.2 except for 28 stations in the Central Region.

FCST. PROJ. (HRS)	TYPE OF FCST.	DIRECTION: MEAN ABS. ERROR (DEG)	DIRECTION: NO. OF CASES	SPEED: MEAN ABS. ERROR (KTS)	SPEED: MEAN FCST (KTS)	SPEED: MEAN OBS. (KTS)	SPEED: NO. OF CASES	CONTINGENCY TABLE: SKILL SCORE	CONTINGENCY TABLE: PERCENT FCST. CORRECT	BIAS-NO. FCST./NO. OBS.: CAT1 (NO. OBS.)	CAT2 (NO. OBS.)	CAT3 (NO. OBS.)	CAT4 (NO. OBS.)	CAT5 (NO. OBS.)	CAT6 (NO. OBS.)	CAT7 (NO. OBS.)	NO. OF CASES
18	EARLY	28	2291	3.0	12.0	12.3	2300	0.28	52	1.27	0.97	0.77	0.52	0.60	1.00	0.25	4650
	FINAL	29		3.2	12.6			0.24	49	1.08	1.02	0.89	0.76	0.87	1.20	0.50	
	LOCAL	34		3.4	13.0			0.21	47	0.65	1.28	1.05	0.75	0.64	1.60	0.25	
										(1501)	(1958)	(879)	(256)	(47)	(5)	(4)	
30	EARLY	32	827	3.6	11.7	9.8	842	0.27	64	0.99	1.03	1.06	0.50	0.75	*	0.0	4447
	FINAL	35		3.4	10.8			0.25	63	1.01	1.13	0.60	0.15	0.0	*	0.0	
	LOCAL	39		3.6	11.3			0.16	55	0.83	1.53	0.79	0.38	0.50	**	0.0	
										(2918)	(1145)	(327)	(52)	(4)	(0)	(1)	
42	FINAL	44	2735	3.5	11.5	11.2	2765	0.19	46	1.03	1.14	0.83	0.49	0.57	0.80	0.0	4624
	LOCAL	49-		3.8	12.0			0.13	43	0.64	1.39	0.98	0.38	0.24	0.0	0.75	
										(1509)	(1932)	(873)	(255)	(46)	(5)	(4)	

* This category was neither forecast nor observed.
** This category was forecast twice but was never observed.

Table 4.7. Same as Table 4.2 except for 18 stations in the Western Region.

FCST. PROJ. (HRS)	TYPE OF FCST.	DIRECTION MEAN ABS. ERROR (DEG)	DIRECTION NO. OF CASES	SPEED MEAN ABS. ERROR (KTS)	MEAN FCST (KTS)	MEAN OBS. (KTS)	NO. OF CASES	CONTINGENCY TABLE SKILL SCORE	PERCENT FCST. CORRECT	BIAS-NO. FCST./NO. OBS. CAT1 (NO. OBS.)	CAT2 (NO. OBS.)	CAT3 (NO. OBS.)	CAT4 (NO. OBS.)	CAT5 (NO. OBS.)	CAT6 (NO. OBS.)	CAT7 (NO. OBS.)	NO. OF CASES
18	EARLY FINAL LOCAL	31 31 33	816	3.5 3.7 3.9	11.9 12.3 12.5	11.7	822	0.25 0.24 0.22	56 55 53	1.11 1.02 1.01 (1581)	0.98 1.06 1.07 (984)	0.74 0.86 0.84 (341)	0.44 0.57 0.74 (100)	0.75 0.56 0.81 (16)	0.0 0.20 0.0 (5)	* ** *** (0)	3027
30	EARLY FINAL LOCAL	32 32 37	455	3.3 3.3 3.5	10.8 11.1 11.3	9.9	468	0.25 0.26 0.21	61 61 59	1.04 1.07 1.14 (1630)	1.05 0.97 0.85 (908)	0.63 0.78 0.60 (189)	0.22 0.17 0.50 (40)	0.0 0.0 0.17 (6)	* * * (0)	* * ** (0)	2773
42	FINAL LOCAL	42 46	970	4.1 4.1	11.8 11.7	10.4	981	0.20 0.16	52 50	1.00 1.03 (1566)	1.05 1.08 (975)	0.99 0.77 (336)	0.71 0.57 (92)	0.29 0.29 (14)	0.50 0.50 (4)	* * (0)	2987

* This category was neither forecast nor observed.
** This category was forecast once but was never observed.
*** This category was forecast twice but was never observed.

Table 4.8. Distribution of absolute errors associated with early and final guidance and local forecasts of surface wind direction for 94 stations, 0000 GMT cycle.

FCST. PROJ. (HRS.)	TYPE OF FCST.	PERCENTAGE FREQUENCY OF ABSOLUTE ERRORS BY CATEGORY					
		0-30°	40-60°	70-90°	100-120°	130-150°	160-180°
18	EARLY	74.4	16.8	4.3	1.8	1.5	1.2
	FINAL	71.9	17.6	5.5	2.2	1.5	1.3
	LOCAL	67.7	19.7	6.5	3.1	2.0	1.0
30	EARLY	74.0	14.0	4.7	3.3	2.5	1.5
	FINAL	72.8	13.4	6.2	3.1	2.2	2.3
	LOCAL	68.0	15.5	7.8	3.9	2.6	2.2
42	FINAL	59.5	20.4	8.2	5.2	3.8	2.9
	LOCAL	54.9	20.6	9.9	6.3	4.6	3.7

Table 4.9. Same as Table 4.8 except for 24 stations in the Eastern Region.

FCST. PROJ. (HRS.)	TYPE OF FCST.	PERCENTAGE FREQUENCY OF ABSOLUTE ERRORS BY CATEGORY					
		0-30°	40-60°	70-90°	100-120°	130-150°	160-180°
18	EARLY	73.6	17.5	4.8	2.0	1.4	0.7
	FINAL	67.2	21.8	6.4	2.0	1.7	0.9
	LOCAL	65.6	21.1	7.2	4.0	1.4	0.7
30	EARLY	72.4	18.1	5.5	2.2	1.1	0.7
	FINAL	71.5	16.6	8.2	2.2	1.1	0.4
	LOCAL	68.4	17.9	7.7	3.8	1.1	1.1
42	FINAL	58.8	23.0	8.6	5.2	2.8	1.6
	LOCAL	56.1	21.2	10.3	5.8	4.3	2.3

Table 4.10. Same as Table 4.8 except for 24 stations in the Southern Region.

FCST. PROJ. (HRS.)	TYPE OF FCST.	PERCENTAGE FREQUENCY OF ABSOLUTE ERRORS BY CATEGORY					
		0-30°	40-60°	70-90°	100-120°	130-150°	160-180°
18	EARLY	76.7	16.5	3.3	1.2	1.1	1.2
	FINAL	76.2	15.7	4.7	1.1	1.1	1.2
	LOCAL	72.5	18.2	4.2	2.4	1.8	0.9
30	EARLY	79.7	11.3	4.4	1.7	1.9	1.0
	FINAL	79.2	9.9	5.7	2.3	1.2	1.7
	LOCAL	76.1	12.4	6.1	2.1	2.1	1.2
42	FINAL	63.3	20.0	6.4	4.5	2.8	3.0
	LOCAL	58.1	19.9	8.9	5.0	4.6	3.5

4.11. Same as Table 4.8 except for 28 stations in the Central Region.

FCST. PROJ. (HRS.)	TYPE OF FCST.	PERCENTAGE FREQUENCY OF ABSOLUTE ERRORS BY CATEGORY					
		0-30°	40-60°	70-90°	100-120°	130-150°	160-180°
18	EARLY	74.6	16.5	4.5	1.6	1.6	1.2
	FINAL	73.1	16.6	5.0	2.6	1.5	1.2
	LOCAL	65.9	20.3	7.5	2.8	2.3	1.2
30	EARLY	72.3	13.9	4.5	4.3	3.2	1.8
	FINAL	69.3	14.3	6.2	3.4	3.6	3.2
	LOCAL	63.2	16.7	9.2	4.6	3.3	3.0
42	FINAL	56.4	20.7	9.4	5.4	4.5	3.6
	LOCAL	51.4	21.4	11.2	6.9	4.7	4.4

Table 4.12. Same as Table 4.8 except for 18 stations in the Western Region

FCST. PROJ. (HRS.)	TYPE OF FCST.	PERCENTAGE FREQUENCY OF ABSOLUTE ERRORS BY CATEGORY					
		0-30°	40-60°	70-90°	100-120°	130-150°	160-180°
18	EARLY	71.7	16.5	4.2	3.4	2.1	2.1
	FINAL	71.7	14.9	6.0	3.4	2.0	2.0
	LOCAL	69.4	17.0	5.9	3.0	3.2	1.5
30	EARLY	72.9	13.0	4.4	4.4	3.1	2.2
	FINAL	73.8	12.3	4.8	4.2	1.8	3.1
	LOCAL	67.7	14.1	7.3	4.6	3.3	3.1
42	FINAL	63.1	14.8	7.5	5.7	5.5	3.4
	LOCAL	57.2	18.0	6.8	7.7	5.1	5.2

Table 5.1 Definitions of the categories used for guidance forecasts of ceiling and visibility.

Category	Ceiling (ft)	Visibility (mi)
1	< 200	< 1/2
2	200-400	1/2 - 7/8
3	500-900	1 - 2 1/2
4	1000-2900	3-4
5	3000-7500	5-6
6	> 7500	> 6

Table 5.2. Comparative verification of early and final guidance, persistence, and local ceiling forecasts for 94 stations, 0000 GMT cycle. The threat score is for categories 1 and 2 combined.

Projection (h)	Type of Forecast	Bias by Category 1	2	3	4	5	6	Percent Correct	Heidke Skill Score	Threat Score
12	Early	0.42	0.54	0.86	0.93	1.19	1.02	73.8	.367	.071
	Final	0.45	0.52	0.73	0.95	1.11	1.03	75.0	.384	.105
	Persistence	0.92	0.64	0.71	0.90	1.01	1.04	79.9	.501	.218
	Local	0.49	0.84	0.74	1.21	1.04	1.00	78.0	.479	.181
	No. Obs.	136	403	670	1180	1457	11401			
15	Local	.57	.51	.43	.88	1.27	1.03	74.1	.387	.050
	Persistence	5.90	1.32	.71	.57	1.09	1.06	73.5	.354	.066
	No. Obs.	21	200	681	1874	1370	11433			
18	Early	0.33	0.66	0.80	0.80	1.05	1.03	71.3	.341	.076
	Final	0.00	0.57	0.79	0.78	1.06	1.03	71.7	.348	.048
	Persistence	20.83	3.27	1.69	0.67	0.63	1.08	69.2	.262	.031
	No. Obs.	6	80	285	1607	2327	11077			
21	Local	0.00	0.35	0.39	0.91	1.06	1.01	71.6	.281	.041
	Persistence	62.00	4.78	2.62	1.08	0.57	1.04	68.9	.208	.028
	No. Obs.	2	55	185	989	2619	11726			
24	Early	0.44	0.45	0.64	0.74	1.06	1.01	78.4	.304	.019
	Final	0.00	0.47	0.81	0.82	1.02	1.01	78.2	.299	.020
	Persistence	12.89	3.66	2.74	1.51	0.77	0.96	70.9	.166	.012
	No. Obs.	9	64	154	637	1740	11393			
36	Final	0.99	0.97	0.94	1.10	1.27	0.96	68.2	.276	.047
	Persistence	0.92	0.64	0.71	0.91	1.01	1.04	66.4	.160	.028
	No. Obs.	133	409	673	1164	1451	11465			
48	Final	0.50	0.70	1.85	0.93	1.11	0.98	73.6	.209	.008
	Persistence	12.30	3.71	2.56	1.53	0.78	0.96	67.5	.074	.007
	No. Obs.	10	70	186	694	1888	12445			

Table 5.3 Same as Table 5.2 except for visibility.

Projection (h)	Type of Forecast	Bias by Category 1	2	3	4	5	6	Percent Correct	Heidke Skill Score	Threat Score
12	Early	0.60	0.78	1.04	1.15	1.29	0.96	70.4	.315	.064
	Final	0.32	0.50	1.00	1.15	1.34	0.97	71.5	.334	.063
	Persistence	0.61	0.53	0.37	0.75	1.14	1.08	76.8	.377	.205
	Local	0.47	0.74	0.48	1.47	1.56	0.95	73.8	.398	.140
	No. Obs.	203	136	848	890	1094	9765			
15	Local	0.36	0.57	0.27	0.97	1.53	0.98	76.5	.290	.041
	Persistence	3.47	1.49	0.69	0.92	1.09	1.00	77.2	.292	.025
	No. Obs.	36	49	453	723	1156	10789			
18	Early	0.50	0.59	0.88	1.10	1.22	0.98	82.6	.287	.000
	Final	0.25	0.53	0.95	1.18	1.11	0.99	82.9	.290	.000
	Persistence	31.25	4.24	1.32	1.44	1.35	0.93	78.1	.218	.005
	No. Obs.	4	17	238	465	930	11418			
21	Local	1.33	0.83	0.15	0.63	1.57	0.99	84.5	.200	.036
	Persistence	42.00	6.08	1.65	1.75	1.68	0.91	78.7	.177	.000
	No. Obs.	3	12	189	380	747	11869			
24	Early	1.00	0.96	0.84	1.35	1.23	0.98	84.5	.265	.036
	Final	0.50	0.68	0.81	1.40	1.27	0.97	84.4	.267	.043
	Persistence	28.00	2.60	1.57	1.68	1.68	0.91	78.0	.162	.000
	No. Obs.	4	25	183	365	660	10643			
36	Final	0.71	1.07	1.34	1.37	1.29	0.91	67.2	.288	.047
	Persistence	0.62	0.52	0.36	0.74	1.14	1.08	69.1	.172	.043
	No. Obs.	201	136	861	898	1100	9799			
48	Final	1.00	0.29	1.18	1.53	1.35	0.96	82.8	.216	.000
	Persistence	41.67	3.00	1.52	1.69	1.80	0.91	76.5	.104	.000
	No. Obs.	3	24	205	392	697	11678			

Table 5.4. Same as Table 5.2 except for the 1200 GMT cycle.

Projection (h)	Type of Forecast	Bias by Category						Percent Correct	Heidke Skill Score	Threat Score
		1	2	3	4	5	6			
12.	Early	0.33	0.77	0.88	1.01	1.01	1.00	78.1	.324	.055
	Final	0.00	0.93	0.97	1.08	0.99	1.00	78.2	.332	.084
	Persistence	0.56	0.71	1.08	1.32	1.27	0.94	79.3	.424	.211
	Local	0.44	0.52	0.78	1.39	1.24	0.95	79.6	.426	.180
	No. Obs.	9	69	182	686	1882	12096			
15	Local	0.11	0.47	0.63	1.42	1.06	0.98	78.2	.356	.085
	Persistence	0.16	0.57	0.78	1.28	1.46	0.93	73.7	.286	.072
	No. Obs.	19	81	200	590	1403	9811			
18	Early	0.82	0.79	0.85	0.99	1.04	1.00	77.7	.331	.048
	Final	0.72	0.97	0.87	1.04	1.01	1.00	77.6	.331	.050
	Persistence	0.08	0.31	0.59	1.12	1.57	0.95	71.9	.232	.042
	No. Obs.	60	160	338	815	1530	12065			
21	Local	0.11	0.49	0.73	1.46	0.91	1.00	75.2	.336	.051
	Persistence	0.04	0.20	0.42	0.92	1.63	0.98	69.6	.210	.019
	No. Obs.	115	259	476	1014	1506	11975			
24	Early	0.86	0.78	0.83	0.97	1.21	1.00	70.9	.312	.057
	Final	0.70	0.75	0.78	1.11	1.19	0.99	70.8	.313	.069
	Persistence	0.04	0.11	0.30	0.79	1.69	1.02	65.6	.159	.010
	No. Obs.	116	369	579	1026	1289	10062			
36	Final	0.33	0.76	0.87	0.91	1.17	0.98	75.4	.257	.048
	Persistence	0.56	0.74	1.09	1.31	1.29	0.94	68.9	.130	.015
	No. Obs.	9	68	186	702	1885	12389			
48	Final	1.07	1.16	1.08	1.12	1.15	0.96	66.3	.239	.046
	Persistence	0.04	0.12	0.30	0.79	1.69	1.02	62.0	.068	.010
	No. Obs.	124	401	672	1167	1435	11356			

Table 5.5. Same as Table 5.3 except for the 1200 GMT cycle.

Projection (h)	Type of Forecast	Bias by Category 1	2	3	4	5	6	Percent Correct	Heidke Skill Score	Threa Score
12	Early	0.25	0.67	1.15	1.35	1.31	0.97	85.0	.306	.000
	Final	0.50	0.56	1.16	1.03	1.35	0.98	86.5	.356	.000
	Persistence	1.25	0.41	0.93	0.96	1.69	0.96	87.8	.446	.093
	Local	0.75	0.15	0.45	1.19	1.93	0.95	86.2	.400	.056
	No. Obs.	4	27	199	387	695	11416			
15	Local	0.12	0.70	0.65	1.42	2.01	0.93	82.6	.311	.029
	Persistence	0.29	1.00	1.19	1.00	1.65	0.95	84.8	.343	.024
	No. Obs.	17	10	140	320	612	9215			
18	Early	0.78	1.71	1.15	1.41	1.15	0.97	83.0	.288	.054
	Final	1.02	0.71	1.20	1.04	1.27	0.98	83.9	.305	.068
	Persistence	0.12	0.45	0.88	0.78	1.63	0.98	83.3	.281	.000
	No. Obs.	51	31	210	479	729	11286			
21	Local	0.29	0.64	1.00	1.65	1.70	0.92	76.2	.280	.087
	Persistence	0.05	0.23	0.55	0.59	1.41	1.02	79.8	.229	.000
	No. Obs.	133	64	335	632	861	11081			
24	Early	0.85	1.15	1.27	1.40	1.21	0.92	68.6	31.7	.055
	Final	0.67	0.91	1.16	1.31	1.26	0.94	69.1	31.2	.052
	Persistence	0.03	0.08	0.20	0.41	1.07	1.15	72.1	.174	.003
	No. Obs.	199	133	838	865	1068	9413			
36	Final	1.67	0.67	1.19	1.59	1.49	0.95	82.7	.242	.021
	Persistence	2.00	0.63	0.90	0.96	1.72	0.96	81.4	.145	.000
	No. Obs.	3	24	206	392	694	11722			
48	Final	1.04	1.21	1.49	1.51	1.18	0.89	66.5	.289	.054
	Persistence	0.03	0.12	0.22	0.41	1.10	1.14	69.8	.103	.000
	No. Obs.	204	129	862	907	1081	9852			

Table 6.1. Comparative verification of early and final guidance and local max/min temperature forecasts for 87 stations, 0000 GMT cycle.

FORECAST PROJECTION (HOURS)	TYPE OF FORECAST	MEAN ALGEBRAIC ERROR (^{o}F)	MEAN ABSOLUTE ERROR (^{o}F)	NUMBER (%) OF ABSOLUTE ERRORS $\geq 10^{o}$	NUMBER OF CASES
24 (MAX)	EARLY	-0.8	3.3	577 (4.0)	14467
	FINAL	-0.6	3.1	375 (2.6)	
	LOCAL	-0.0	2.9	461 (3.2)	
36 (MIN)	EARLY	0.2	3.0	345 (2.4)	14490
	FINAL	-0.2	2.9	301 (2.1)	
	LOCAL	0.3	3.1	419 (2.9)	
48 (MAX)	EARLY	-0.8	3.9	969 (6.7)	14459
	FINAL	-1.2	4.0	962 (6.7)	
	LOCAL	-0.9	4.1	1074 (7.4)	
60 (MIN)	EARLY	0.1	3.7	827 (5.7)	14491
	FINAL	-0.4	3.6	678 (4.7)	
	LOCAL	-0.0	3.6	743 (5.1)	

Table 6.2 Same as Table 6.1 except for 26 stations in the Eastern Region.

FORECAST PROJECTION (HOURS)	TYPE OF FORECAST	MEAN ALGEBRAIC ERROR (^{o}F)	MEAN ABSOLUTE ERROR (^{o}F)	NUMBER (%) OF ABSOLUTE ERRORS $\geq 10^{o}$	NUMBER OF CASES
24 (MAX)	EARLY	-0.5	3.1	122 (2.8)	4356
	FINAL	-0.6	3.1	115 (2.6)	
	LOCAL	-0.1	3.0	119 (2.7)	
36 (MIN)	EARLY	0.6	3.1	113 (2.6)	4347
	FINAL	0.4	3.0	93 (2.1)	
	LOCAL	0.7	3.2	137 (3.2)	
48 (MAX)	EARLY	-0.4	3.8	241 (5.5)	4355
	FINAL	-0.9	3.9	255 (5.9)	
	LOCAL	-0.9	4.1	293 (6.7)	
60 (MIN)	EARLY	0.6	3.9	250 (5.8)	4346
	FINAL	0.2	3.8	257 (5.9)	
	LOCAL	0.5	3.8	256 (5.9)	

Table 6.3 Same as Table 6.1 except for 23 stations in the Southern Region.

FORECAST PROJECTION (HOURS)	TYPE OF FORECAST	MEAN ALGEBRAIC ERROR (^{o}F)	MEAN ABSOLUTE ERROR (^{o}F)	NUMBER (%) OF ABSOLUTE ERRORS $\geq 10^{o}$	NUMBER OF CASES
24 (MAX)	EARLY	-0.7	2.8	61 (1.6)	3837
	FINAL	-0.9	2.6	46 (1.2)	
	LOCAL	-0.0	2.2	61 (1.6)	
36 (MIN)	EARLY	0.2	2.6	53 (1.4)	3833
	FINAL	-0.2	2.5	44 (1.1)	
	LOCAL	0.3	2.6	76 (2.0)	
48 (MAX)	EARLY	-0.5	3.0	119 (3.1)	3833
	FINAL	-1.5	3.4	135 (3.5)	
	LOCAL	-0.7	3.2	150 (3.9)	
60 (MIN)	EARLY	0.3	3.2	157 (4.1)	3831
	FINAL	-0.5	3.0	100 (2.6)	
	LOCAL	0.0	3.0	129 (3.4)	

Table 6.4 Same as Table 6.1 Except for 22 stations in the Central Region.

FORECAST PROJECTION (HOURS)	TYPE OF FORECAST	MEAN ALGEBRAIC ERROR (^{o}F)	MEAN ABSOLUTE ERROR (^{o}F)	NUMBER (%) OF ABSOLUTE ERRORS $\geq 10^{o}$	NUMBER OF CASES
24 (MAX)	EARLY FINAL LOCAL	-0.4 -0.5 0.3	3.6 3.5 3.3	170 (4.7) 149 (4.1) 158 (4.4)	3610
36 (MIN)	EARLY FINAL LOCAL	-0.1 -0.6 0.2	3.4 3.4 3.5	122 (3.3) 126 (3.5) 138 (3.8)	3652
48 (MAX)	EARLY FINAL LOCAL	-0.6 -1.0 -0.7	4.4 4.4 4.7	340 (9.4) 340 (9.4) 364 (10.1)	3607
60 (MIN)	EARLY FINAL LOCAL	-0.6 -0.9 -0.4	4.3 4.1 4.2	290 (7.9) 242 (6.6) 270 (7.4)	3654

Table 6.5 Same as Table 6.1 except for 16 stations in the Western Region.

FORECAST PROJECTION (HOURS)	TYPE OF FORECAST	MEAN ALGEBRAIC ERROR (^{o}F)	MEAN ABSOLUTE ERROR (^{o}F)	NUMBER (%) OF ABSOLUTE ERRORS $\geq 10^{o}$	NUMBER OF CASES
24 (MAX)	EARLY	-2.2	4.1	224 (8.4)	2664
	FINAL	-0.6	3.1	65 (2.4)	
	LOCAL	-0.2	3.2	123 (4.6)	
36 (MIN)	EARLY	0.1	2.9	57 (2.1)	2658
	FINAL	-0.5	2.8	38 (1.4)	
	LOCAL	-0.1	3.0	68 (2.6)	
48 (MAX)	EARLY	-2.0	4.6	269 (10.1)	2664
	FINAL	-1.5	4.4	232 (8.7)	
	LOCAL	-1.2	4.6	267 (10.2)	
60 (MIN)	EARLY	0.0	3.5	130 (4.9)	2660
	FINAL	-0.5	3.2	79 (3.0)	
	LOCAL	-0.4	3.3	88 (3.3)	

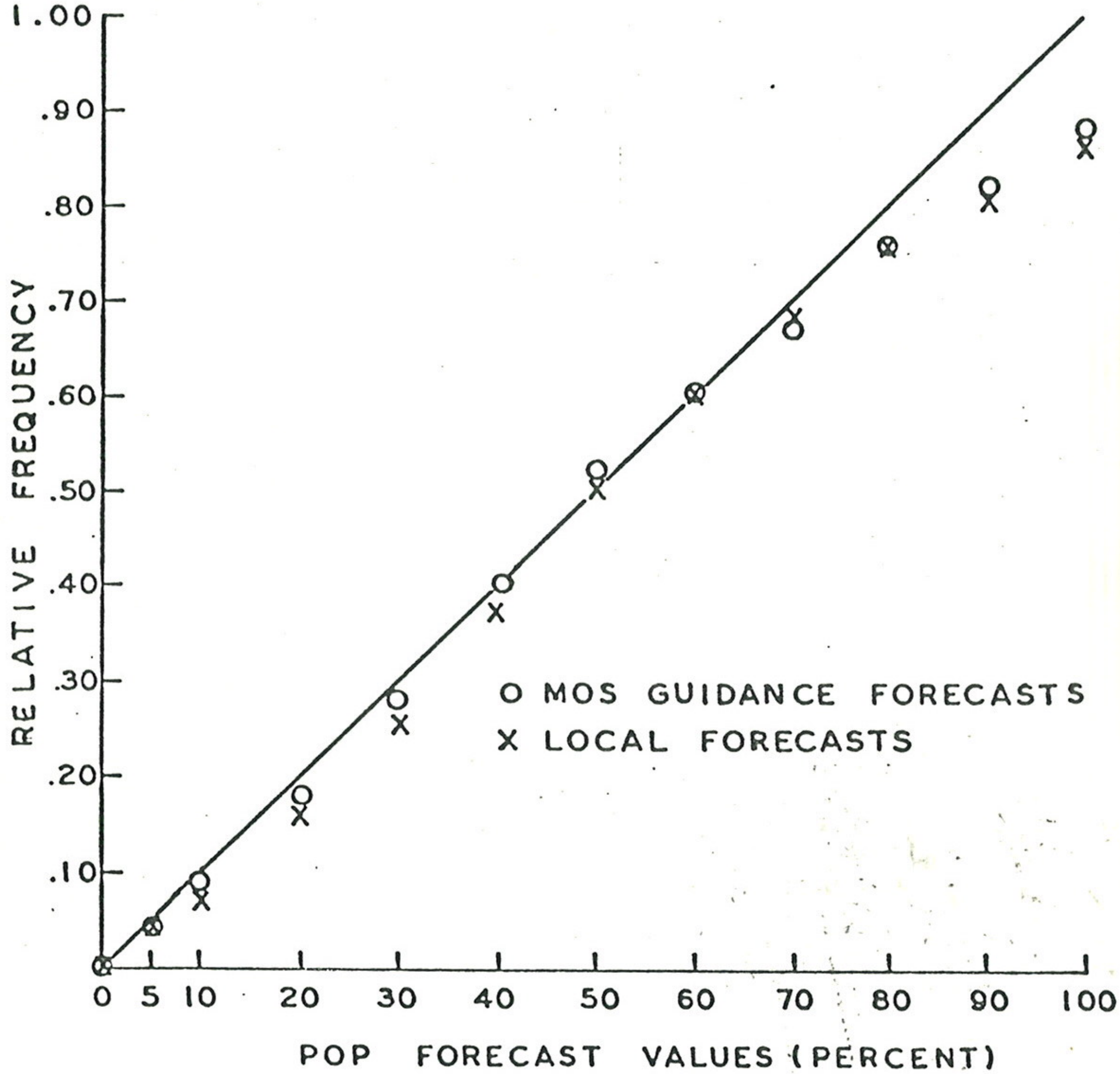

Figure 2.1 Reliability of guidance and local PoP forecasts for first forecast period.

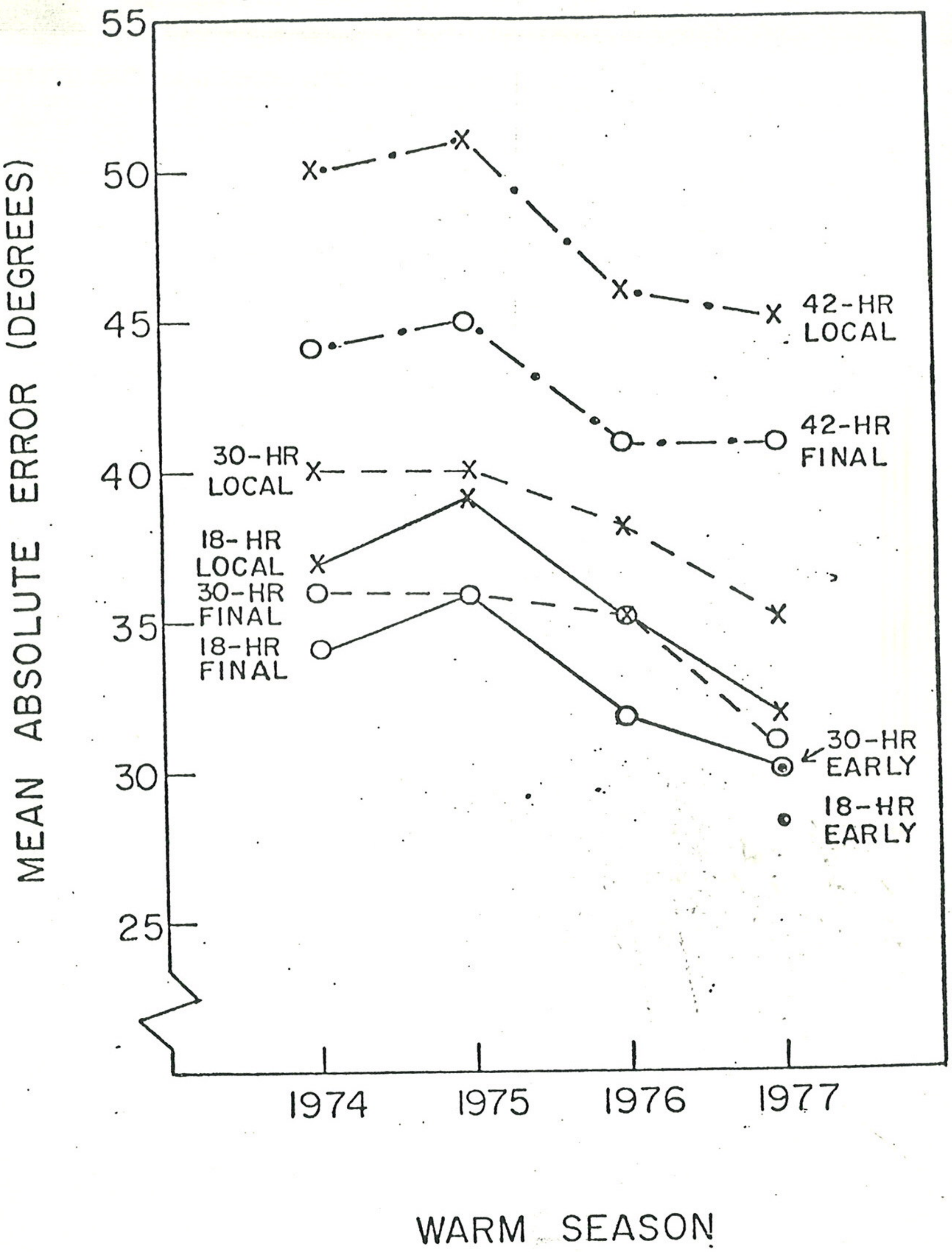

Figure 4.1. Mean absolute errors for subjective local and objective guidance (early and final) surface wind direction forecasts for approximately 90 stations.

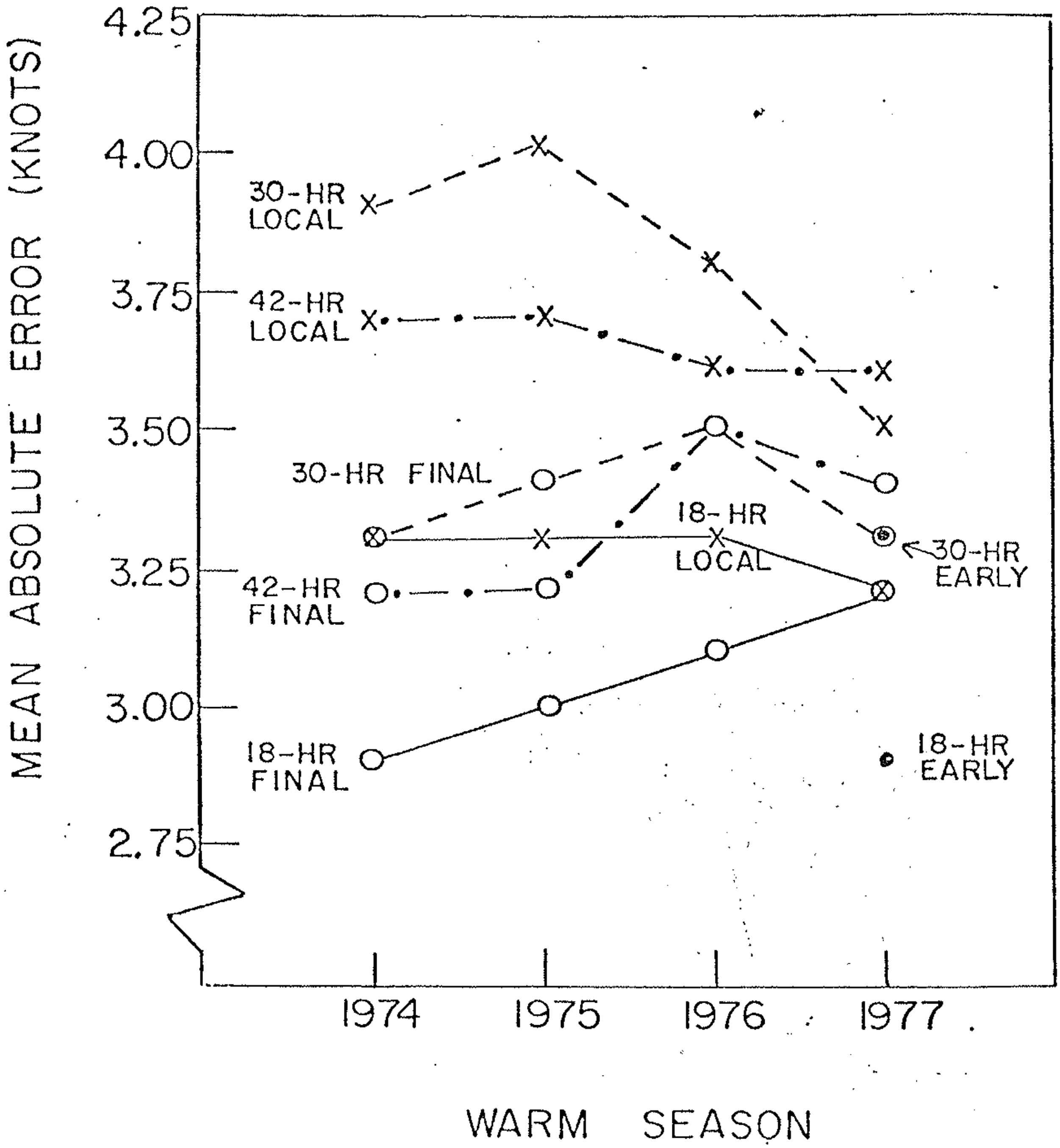

Figure 4.2. Same as Figure 4.1 except for wind speed forecasts.

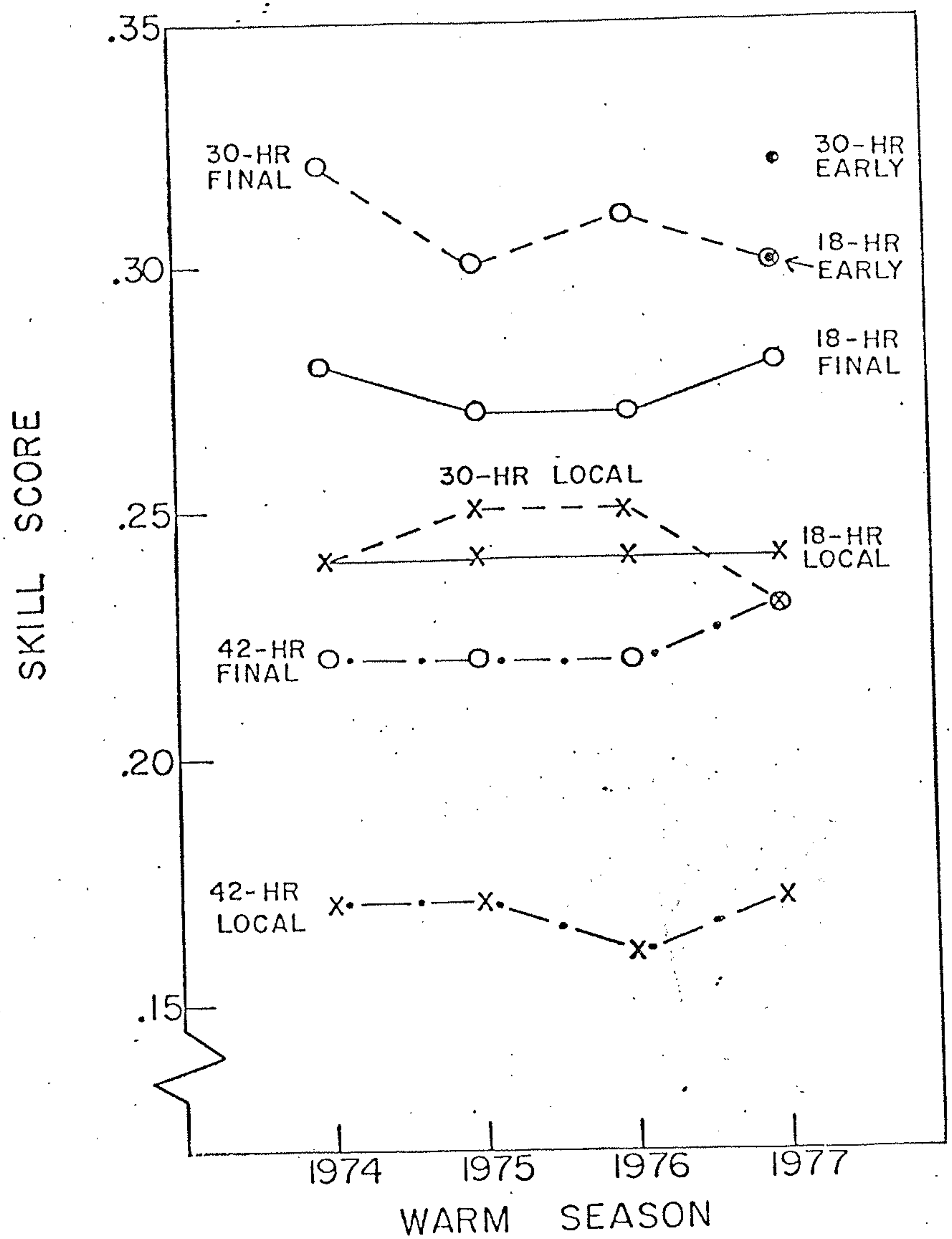

Figure 4.3. Skill scores for subjective local and objective guidance (early and final) surface wind speed forecasts for approximately 90 stations.