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

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Comparative Verification of Guidance and Local Aviation/Public Weather Forecasts--No. 3 (October 1976 - March 1977)

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1. INTRODUCTION

This is the third 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, precipitation type, surface wind, opaque sky cover, ceiling height, and visibility are presented here for the cool season months of October 1976 through March 1977. Note that verification of probability of precipitation hadn't appeared in the previous two reports in this series, Carter et al. (1976) and Crisci et al. (1977).

TDL's forecasts were based on a combination of the Model Output Statistics (MOS) (Glahn and Lowry, 1972) and classical statistics techniques. 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 cool season final guidance prediction equations described in National Weather Service (1976a). 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 2 hours after the model run time at the forecast site. Predictors for the second period equations were forecast fields from the LFM, PE, and TJ models. 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. Before computing this score, we combined all the data within each of the four NWS Regions for each of the three forecast periods. This verification differed from the one done by TPB (Derouin and Cobb, 1972) 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 a ten to twenty percent increase in data over the TPB verification. Unfortunately, we were unable to compute improvement over climatology statistics in time for this publication.

We verified PoP for the 86 stations shown in Table 2.1; these are the only stations where local PoP forecasts were available.

Table 2.2 shows the results for the 0000 GMT forecasts from October 1976 through March 1977. The Brier scores show that the local forecasts improved on the final guidance forecasts for all three forecast periods for both the central and Western Regions. However, the Western Region's improvement was almost twice as great as the Central Region's. In the Southern Region, the local forecasts were better than the guidance for the first period, but failed to improve upon guidance for the second and third periods. In the Eastern Region, our MOS forecasts held a slight advantage for all three forecast periods. Note that the local forecaster's improvement over the guidance generally decreased with increasing forecast projection. For short-range forecast periods, the forecasters use radar, satellite, and surface observation data to update the guidance. These updating techniques have limited usefulness beyond 24 hours.

These findings were similar to those of previous verifications (Derouin and Cobb, 1972) in that forecaster improvement was greatest for the first-period forecasts and for Western Region stations. However, this verification showed that the forecasters couldn't improve on the guidance for all forecast periods in the Eastern and Southern Regions.

Figure 2.1 is a plot of the relative frequency of precipitation for each forecast value when all PoP data are combined on a nationwide basis. This graph shows excellent reliability for both the local and final PoP forecasts.

3. PRECIPITATION TYPE

TDL's system for predicting the conditional probability of frozen precipitation (PoF) has been operational within the NWS since November 1972. The evolution of the PoF system is described in detail by Glahn and Bocchieri (1975), Bocchieri and Glahn (1976), and National Weather Service (1976b). The verification procedures used to compare the MOS PoF guidance forecasts with the local predictions are also described in Bocchieri and Glahn, (op. cit.). In our procedure, we divide the verification into two parts, A and B. For verification A, we include all cases, both the obvious and the difficult. In verification B, we include only those cases in which the guidance and local forecasts of precipitation type differ; therefore, some of the more difficult forecast situations are isolated. In all verifications, we include only cases where precipitation actually occurred.

Carter et al. (1976)showed comparative verification results for October 1975 through March 1976; the results indicated that the final PoF guidance forecasts were generally more accurate than the local forecasts. One of our concerns in the verification was that, because of the conditional nature of the forecasts, there were many cases when the forecasters may not have put much effort into making the forecast. In order to isolate those cases when the forecaster would have been more confident that precipitation was to occur, we intended to use only the cases when the local PoP was 30% or greater. The PoP values were valid for the 12-h periods centered on the 18-, 30-, and 42-h projections, which were used in the comparative verification. However, we erroneously used MOS PoPs as the stratifying variable rather than local PoPs. Therefore, our sample undoubtedly contained a number of cases when the local PoP was less than 30%. However, since the local and guidance PoP forecasts are similar most of the time, we feel that the results would not have significantly differed if the local PoP forecasts had actually been used. The error has been corrected so that, in the verification below, local PoP forecasts were used.

Table 3.1 lists the stations used in the verification. Tables 3.2 and 3.3 show the results for October 1976 through March 1977 for verifications A and B respectively. For this season, we also verified the early PoF guidance for the 18-h projection. Note that the early guidance is based on LFM model output, while the final guidance is based on PE model output. The sample includes only cases when the local PoP was 30% or greater. For verification A (Table 3.2), we computed scores for each NWS region and for all 61 stations combined. In verification B (Table 3.3), scores are not provided for each NWS region because of the small number of cases involved. Also, in verification B, only the percent correct was computed because the other scores would not have been very meaningful for this specialized sample.

The results for verification A can be summarized as follows:

a. For all stations combined, the final guidance forecasts were slightly better than the local forecasts for all projections and scores except that the locals had a better bias[1] at the 30-h projection. Both the guidance and locals slightly underforecasted (bias < 1.00) the snow event. For the 18-h projection, the early guidance

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[1] The bias is the number of forecasts for a category divided by the number of observed events for that category.

scored about the same as the final guidance.

b. In the Eastern Region, the final guidance and local forecasts were about the same for percent correct and skill score except that the guidance was slightly better at the 42-h projection. Both systems underforecasted the snow event to a similar extent. Also, the early and final guidance scored about the same at the 18-h projection. In the Southern Region, the final guidance and locals scored about the same for the percent correct and skill score except that the guidance was better at the 30-h projection. Both systems generally underforecasted the snow event, the guidance more so than the locals. Also, the final guidance was better than the early guidance at the 18-h projection. In the Central Region, the final guidance was better than the locals for percent correct and skill score except that they scored the same at the 18-h projection. The early guidance was slightly better than the final guidance and the locals at the 18-h projection. Also, both systems generally underforecasted the snow event, but the guidance was less biased than the locals. In the Western Region, the locals were better than the final guidance for the percent correct and skill score except that they scored the same at the 42-h projection. The locals were more biased for the 18- and 30-h projections, while the guidance was more biased at the 42-h projection. Also, the final guidance was better than the early guidance at the 18-h projection.

For verification B (when the local and guidance forecasts differed), the guidance was correct 56% to 63% of the time for all stations combined and for all projections.

It's not strictly valid to compare the above results with those obtained in Carter et al. (1976) since the number of stations differed significantly. However, it's interesting to note that the difference in scores between the guidance and local forecasts was smaller for the 1976-77 winter than for the previous season. One reason could be that, for the 1976-77 sample, local PoP forecasts were used, but, in the previous season, guidance PoP forecasts were mistakenly used to decide which cases would be verified. Another reason might be that local forecasters followed the guidance more closely. Also, the scores for all projections were better for the 1976-77 season than for the previous season.

4. SURFACE WIND

The objective wind forecasts were generated by early and final guidance prediction equations for the cool season (see National Weather Service, 1977a). Our early guidance equations are based on output from the LFM model. In contrast, PE forecasts are 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 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. Cases where the observed wind was calm were then eliminated from this sample and the MAE of direction 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 lists the 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 for the 18-h projection for early guidance. It should also be noted that all the objective forecasts of wind speed were adjusted by an "inflation" equation (National Weather Service, 1977a) involving the multiple correlation coefficient and mean value of wind speed for a particular station and forecast valid time.

The results for all 93 stations combined are shown in Tables 4.2 and 4.3. The direction MAE scores reveal an advantage for the guidance that increased from 4° (early versus local) at 18 hours to 6° (final versus local) at 42 hours. The MAE's, skill scores, and percents correct were somewhat better for the guidance forecasts for all three periods. The 18-h early guidance forecasts were definitely superior in this respect. Both the biases by category in Table 4.2 and the contingency tables in Table 4.3 indicate that the local forecasts had a tendency to underestimate winds stronger than 22 knots (i.e., categories 5, 6, and 7); the guidance was better in this respect.

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. The Eastern Region final guidance exhibited a strong tendency to overforecast winds stronger than 17 knots (i.e., categories 4, 5, 6, and 7).

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 93 stations combined. The guidance had approximately 6% fewer errors of 40° or more for all three 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. All three sets of forecasts--local, early and final guidance--for the Western Region stations had approximately the same number of errors from 0° to 30° for the 18-h projection.

A comparision of the overall MAE's and skill scores for the past four cool seasons is presented in Figures 4.1-4.3. In general, the verification data throughout this period were homogenous, with the exception that the cool season of 1973-74 did not include the month of October. The number of stations varied only slightly from season to season, and the same basic sets of verification stations were used. We computed skill scores using five (instead of seven) categories: the fifth category included all speeds greater than 22 knots. Early guidance scores were only available for the cool season of 1976-77.

The MAE's for direction are given in Figure 4.1. Both the final guidance and local forecasts for all three periods steadily improved over the span of these four seasons.

In contrast, the MAE's in Figure 4.2 show a dramatic decrease in accuracy for the final guidance speed forecasts. This was caused by the introduction of inflation in 1975. However, the use of the inflation adjustment improved the overall bias characteristics of the guidance forecasts (see Table 4.2).

Figure 4.3 is a comparison of guidance and local skill scores during these four seasons. Here we see that the skill of the final guidnace forecasts for both the 18- and 42-h projections continued to improve after the institution of inflation. However, the skill scores for the 30-h guidance forecasts did not reflect this trend towards greater accuracy. The local forecasts steadily increased in skill during this period.

The 1976-77 early guidance MAE and skill scores on Figures 4.1-4.3 clearly indicate the superiority of these predictions over those from the other two systems.

5. OPAQUE SKY COVER

For the cool season of 1976-77, we implemented new prediction equations to generate forecasts of opaque sky cover, more commonly known as cloud amount, in our early guidance package. The significant change was that the new equations are the regionalized type while those previously used were the single-station variety. We made this switch to allow us to develop equations simultaneously for both cloud amount and ceiling. Our objective was to provide greater consistency between forecasts of these two elements.

New regionalized prediction equations were developed for our final guidance package but were not implemented until 10 February 1977. The single-station equations developed for the previous cool season (National Weather Service, 1974) were used to provide final guidance from 1 October 1976 through 9 February 1977.

The regionalized equations produce probability forecasts of four categories of cloud amount as shown in Table 5.1; 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 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, and from only the PE for the rest. When surface predictors appear in the equations, they are extracted from observations taken 5 hours after model run time. For both guidance packages, we convert the probability estimates to single "best category" forecasts in a manner which improves the bias characteristics of the product. For more details about our cloud amount forecast system, see National Weather Service (1977b).

We divided our verification into two samples--1 October 1976 through 9 February 1977 and 10 February 1977 through 31 March 1977. In the first sample, we compared the local forecasts for 93 stations (see Table 4.1) for 18-, 30-, and 42-h projections (0000 GMT cycle) to a matched sample of 18-h early guidance (regionalized) and 18-, 30-, and 42-h final guidance (single-station). The second sample differed from the first in that regionalized equations were used in computing both the early and 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 5.1. 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.

Tables 5.2a and 5.2b show the results for all stations combined for the first and second data samples respectively. Note that the number of cases used in the second sample is relatively small compared to the first sample, therefore, conclusions based on the results should be judged accordingly. The early guidance was slightly better than the locals for all scores for the 18-h projection for both samples. In the second sample, the final guidance (regionalized equations) was better than the corresponding first sample final guidance (single-station equations) for both percent correct and skill score for the 18-h projections. This improvement is even more noteworthy since, in the first sample, the final guidance was worse than the early guidance and locals, while, in the second sample, the final guidance was slightly better than the early guidance and locals for the 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. In both samples, the bias values for the guidance were significantly better than the locals, especially for categories 2 and 3 which were overestimated by the locals. For the 30- and 42-h projections, the guidance was also markedly better than the locals for percent correct and skill score.

In Tables 5.3a-5.6a (for the period 1 October 1976 through 9 February 1977) and Tables 5.3b-5.6b (for the period 10 February 1977 through 31 March 1977), we present the verification scores for the stations in the NWS Eastern, Southern, Central, and Western Regions, respectively. These results display about the same pattern as for all 93 stations combined, with the exception of those for the Western Region where the 18-h local forecasts are clearly superior to either of our guidance forecasts.

The overall general results of this comparative verification are similar to those we obtained for the two previous cool seasons. (See Carter 1975 and Carter et al., 1976). For the latest verification, we're pleased that the change to regionalized prediction equations has not adversely affected our product.

6. CEILING AND VISIBILITY

On 9 February 1977, we implemented a new forecast system for ceiling and visibility which differed from the previous one 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 6.1 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 at 3 hours after model run time (2-h lag used for operations); we generate forecasts for projections of 6, 12, 18, and 24 hours from the 0000 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 6 hours after the two model run times (5-h lag used for operational forecasts).

The equations we first implemented in the new system were for the cool season. They were then replaced by warm season equations in early April 1977. Therefore, the sample of guidance forecasts we have available for comparative verification is relatively small and caution is advised with respect to conclusions about the results. Another handicap to this limited verification resulted from a lag in communication with a large number of field offices about new procedures for completing the official "mark sense" forecast cards for visibility categories 5 and 6. The effect was that we were unable, in many cases, to determine in which of the two categories the local forecast properly belonged. We dealt with this problem by assigning all forecasts of 5 miles or more to category 5 and did no verification for category 6. An additional problem arose because of a programming error in our guidance forecast archiving system. This resulted in a loss of all forecasts of visibility for the 24-h projection in the 1200 GMT cycle.

For the period 10 February to 31 March 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 forecast (FT) filing deadline. 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.

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 6.2-6.5. Each table pertains to one element for one cycle time, for all the 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 tremendous advantage to the local forecast and persistence of using surface observations no less than 5 hours later than those used in the MOS equations. On the other hand, even though quite variable, the biases were good for the guidance forecasts and were generally better than the locals. We also note that persistence consistently beat the locals.

For the 15- and 21-h projections, we find that the bias for persistence, in many cases, was better than that for the locals. Comparison of bias scores between our guidance forecasts and persistence, beyond the 12-h projection, shows that we did better than persistence in many instances, especially in the 18- and 24-h projections. A few examples of very low bias for guidance (and high bias for persistence) appeared for ceiling category 1--this may be partly due to the occurrence of only a few cases of that category in the overall data sample. Looking at the bias scores, guidance was much better than in the past (e.g. see Carter, et al., 1976). Also, our guidance forecasts were better than persistence in virtually all cases in terms of percent correct, skill scores, and threat score.

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, except in the Eastern Region where the guidance forecasts are better. The local's improvement over the guidance generally decreases with increasing forecast projection.

The PoF guidance forecasts continue to be generally better than the locals except in the Western Region. However, the scores for both systems are closer than in previous verifications.

For surface wind and opaque sky cover, the guidance forecasts are generally better than the locals except in the Western Region where the locals are better for opaque sky cover for the 18-h projection.

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

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Table 2.1 Eighty-six stations used for comparative verification of guidance and local PoP forecasts.

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

Table 2.2 Verification scores for subjective local and final guidance PoP forecasts for the period October 1976 through March 1977, 0000 GMT cycle.

Projection	Region	Type of Forecast	Brier Score	Improvement over final (%)	Number of cases
12-24 h (1st period)	Eastern	Final Local	.0940 .0942	-0.28	4495
	Central	Final Local	.0805 .0745	7.51	3785
	Southern	Final Local	.0768 .0699	9.09	4034
	Western	Final Local	.0731 .0615	15.95	2863
24-36 h (2nd period)	Eastern	Final Local	.1089 .1100	-1.03	4509
	Central	Final Local	.1062 .1038	2.63	3786
	Southern	Final Local	.0961 .0964	-0.31	4041
	Western	Final Local	.0768 .0702	8.57	2860
36-48 h (3rd period)	Eastern	Final Local	.1225 .1236	-0.86	4512
	Central	Final Local	.1058 .1021	3.49	3786
	Southern	Final Local	.0934 .0963	-3.08	4044
	Western	Final Local	.0848 .0800	5.65	2863

Table 3.1 Sixty-one stations used for comparative verification of guidance and local precipitation type forecasts.

PWM	Portland, Maine	ABQ	Albuquerque, New Mexico
BTV	Burlington, Vermont	GTF	Great Falls, Montana
BOS	Boston, Massachusetts	SSM	Sault Ste Marie, Michigan
PVD	Providence, Rhode Island	DTW	Detroit, Michigan
BUF	Buffalo, New York	IND	Indianapolis, Indiana
SYR	Syracuse, New York	SDF	Louisville, Kentucky
ALB	Albany, New York	MKE	Milwaukee, Wisconsin
PIT	Pittsburgh, Pennsylvania	STL	St. Louis, Missouri
PHL	Philadelphia, Pennsylvania	DEN	Denver, Colorado
CLE	Cleveland, Ohio	CYS	Cheyenne, Wyoming
CMH	Columbus, Ohio	BIS	Bismarck, North Dakota
CRW	Charleston, West Virginia	FAR	Fargo, North Dakota
DCA	Washington, D.C.	RAP	Rapid City, South Dakota
ORF	Norfolk, Virginia	FSD	Sioux Falls, South Dakota
RDU	Raleigh-Durham, North Carolina	OMA	Omaha, Nebraska
CLT	Charlotte, North Carolina	MSP	Minneapolis, Minnesota
CAE	Columbia, North Carolina	DSM	Des Moines, Iowa
ATL	Atlanta, Georgia	FLG	Flagstaff, Arizona
MIA	Miami, Florida	PHX	Phoenix, Arizona
JAX	Jacksonville, Florida	SLC	Salt Lake City, Utah
BHM	Birmingham, Alabama	LAS	Las Vegas, Nevada
MEM	Memphis, Tennessee	RNO	Reno, Nevada
JAN	Jackson, Mississippi	SAN	San Diego, California
MSY	New Orleans, Louisiana	LAX	Los Angeles, California
SHV	Shreveport, Louisiana	SFO	San Francisco, California
IAH	Houston, Texas	PDX	Portland, Oregon
SAT	San Antonio, Texas	SEA	Seattle (Tacoma), Washington
DFW	Fort Worth, Texas	GEG	Spokane, Washington
ELP	El Paso, Texas	BOI	Boise, Idaho
LIT	Little Rock, Arkansas	OKC	Oklahoma City, Oklahoma
TUL	Tulsa, Oklahoma		

Table 3.2 Comparative verification of early and final PoF guidance and local forecasts by NWS Region for October 1976 through March 1977 (verification A). Only cases when local PoP was ≥ 30% were included. Early PoF guidance was verified only for the 18-h projection.

Projection (h)	Region	Type of Fcst.	Bias Snow	Bias Rain	Percent Correct	Skill Score	Number of Cases
18	Eastern	Early	.96	1.05	94	.88	387
		Final	.96	1.05	94	.87	
		Local	.95	1.07	94	.87	
	Southern	Early	.54	1.04	96	.68	153
		Final	.69	1.03	97	.80	
		Local	.92	1.03	97	.80	
	Central	Early	1.01	.97	95	.87	222
		Final	.99	1.01	94	.86	
		Local	.97	1.07	94	.86	
	Western	Early	.94	1.04	92	.82	131
		Final	1.00	1.00	94	.87	
		Local	.90	1.00	95	.89	
	All Stations	Early	.96	1.04	94	.88	893
		Final	.97	1.03	94	.89	
		Local	.95	1.05	93	.87	
30	Eastern	Final	.92	1.10	93	.86	430
		Local	.97	1.03	93	.86	
	Southern	Final	.83	1.01	98	.80	165
		Local	1.08	.99	94	.61	
	Central	Final	.99	1.02	93	.82	220
		Local	1.03	.91	92	.79	
	Western	Final	1.13	.93	93	.86	88
		Local	1.16	.91	94	.88	
	All Stations	Final	.96	1.04	94	.88	903
		Local	1.01	.99	93	.86	
42	Eastern	Final	.94	1.09	91	.82	355
		Local	.92	1.12	89	.78	
	Southern	Final	.67	1.02	98	.79	112
		Local	.67	1.02	98	.79	
	Central	Final	.98	1.03	94	.86	190
		Local	.95	1.12	90	.78	
	Western	Final	1.06	.97	92	.82	97
		Local	1.00	1.00	92	.82	
	All Stations	Final	.96	1.04	93	.86	754
		Local	.93	1.07	91	.82	

Table 3.3 Comparative verification of early and final PoF guidance and local forecasts for October 1976 through March 1977 (verification B). Early PoF was verified only for the 18-h projection. Only cases when local PoF was ≥ 30% were included.

Projection (h)	Type of Forecast	Percent Correct	Number of Cases
18	Early	57	47
	Local	43	
	Final	60	48
	Local	40	
30	Final	56	52
	Local	44	
42	Final	63	57
	Local	37	

Table 4.1 Ninety-four stations used for comparative verification of guidance and local aviation/public weather 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	Forth 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

* Local forecasts of opaque sky cover and surface wind were not available for Kansas City, Missouri for this verification.

Table 4.2 (Revised). Verification scores for subjective local and objective guidance (early and/or final) surface wind forecasts for 93 stations across the United States during October 1976 through March 1977.

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	25	7249	3.2	13.4	13.0	7284	0.34	54	1.06	1.04	0.87	0.93	1.04	0.57	1.00	14585
	FINAL	26		3.6	14.0			0.30	51	0.99	1.00	0.94	1.13	1.33	0.99	0.85	
	LOCAL	29		3.7	14.2			0.30	50	0.78	1.15	1.15	1.11	0.93	0.60	1.00	
										(5475)	(4852)	(2979)	(970)	(224)	(72)	(13)	
30	FINAL	33	5097	4.0	12.3	10.2	5230	0.30	60	0.95	1.04	1.17	1.27	0.90	0.54	0.25	14665
	LOCAL	38		4.2	12.3			0.26	56	0.82	1.31	1.20	1.11	0.68	0.54	1.00	
										(8773)	(4046)	(1408)	(338)	(72)	(24)	(4)	
42	FINAL	37	8237	4.1	13.4	12.0	8329	0.24	46	0.95	1.05	0.98	1.08	1.25	0.70	1.00	14576
	LOCAL	43		4.1	13.0			0.22	45	0.77	1.33	1.02	0.72	0.56	0.26	0.62	
										(5462)	(4835)	(3000)	(973)	(223)	(70)	(13)	

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Table 4.3 (Revised). Contingency tables for subjective local and objective guidance (early and/or final) surface wind speed forecasts for 93 stations across the United States during October 1976 through March 1977.

18-Hr Forecasts

EARLY

OBS	1	2	3	4	5	6	7	T
1	3914	1367	179	13	2	0	0	5475
2	1577	2379	793	96	7	0	0	4852
3	267	1131	1176	358	46	1	0	2979
4	23	137	369	322	102	15	2	970
5	3	15	47	88	58	9	4	224
6	2	5	11	19	18	13	4	72
7	0	1	2	4	0	3	3	13
T	5786	5035	2577	900	233	41	13	14585

FINAL

OBS	1	2	3	4	5	6	7	T
1	3718	1443	261	47	6	0	0	5475
2	1445	2223	1002	159	23	0	0	4852
3	245	1031	1112	489	89	12	1	2979
4	28	144	367	301	99	28	3	970
5	5	21	42	83	54	17	2	224
6	1	4	11	18	24	12	2	72
7	0	1	2	3	2	2	3	13
T	5442	4867	2797	1100	297	71	11	14585

LOCAL

OBS	1	2	3	4	5	6	7	T
1	3111	1910	397	51	2	2	2	5475
2	952	2503	1169	214	11	1	2	4852
3	163	969	1361	423	52	10	1	2979
4	14	170	415	287	71	12	1	970
5	3	18	60	79	49	11	4	224
6	2	3	17	22	20	6	2	72
7	0	1	3	4	3	1	1	13
T	4245	5574	3422	1080	208	43	13	14585

30-Hr Forecasts

FINAL

OBS	1	2	3	4	5	6	7	T
1	6517	1906	315	33	2	0	0	8773
2	1555	1681	683	115	11	1	0	4046
3	192	524	484	185	21	2	0	1408
4	25	82	134	71	21	4	1	338
5	3	19	21	18	6	5	0	72
6	1	5	9	5	3	1	0	24
7	0	0	1	2	1	0	0	4
T	8293	4217	1647	429	65	13	1	14665

LOCAL

OBS	1	2	3	4	5	6	7	T
1	5737	2585	404	43	2	0	2	8773
2	1293	1943	662	124	17	5	2	4046
3	160	642	465	124	16	1	0	1408
4	24	119	127	56	9	3	0	338
5	3	20	20	22	3	4	0	72
6	4	2	10	6	2	0	0	24
7	0	1	3	0	0	0	0	4
T	7221	5312	1691	375	49	13	4	14665

42-Hr Forecasts

FINAL

OBS	1	2	3	4	5	6	7	T
1	3316	1652	431	55	7	1	0	5462
2	1444	2096	1037	216	36	4	2	4835
3	344	1089	1025	443	84	12	3	3000
4	47	210	355	250	94	14	3	973
5	9	30	65	65	42	9	3	223
6	1	12	16	17	14	8	2	70
7	1	2	3	4	2	1	0	13
T	5162	5091	2932	1050	279	49	13	14576

LOCAL

OBS	1	2	3	4	5	6	7	T
1	2809	2114	484	46	7	1	1	5462
2	1045	2579	1040	151	16	3	1	4835
3	298	1366	1016	274	39	3	4	3000
4	53	304	419	158	35	4	0	973
5	9	50	87	55	16	5	1	223
6	4	16	19	17	11	2	1	70
7	2	2	4	4	1	0	0	13
T	4220	6431	3069	705	125	18	8	14576

Table 4.4 (Revised). 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	24	2362	3.0	13.6	12.9	2371	0.32	51	0.97	1.03	0.94	1.13	1.23	0.71	0.0	3590
	FINAL	26		3.7	14.8			0.23	44	0.79	0.99	0.94	1.65	2.18	2.57	0.50	
	LOCAL	28		3.7	14.4			0.24	45	0.60	1.10	1.16	1.33	1.27	0.86	1.00	
										(960)	(1332)	(940)	(280)	(60)	(14)	(4)	
30	FINAL	33	1706	4.1	12.9	10.1	1748	0.29	54	0.78	1.14	1.38	2.33	1.57	2.33	*	3617
	LOCAL	36		4.2	12.8			0.24	51	0.68	1.35	1.40	1.79	1.30	2.00	**	
										(1993)	(1088)	(425)	(85)	(23)	(3)	(0)	
42	FINAL	35	2636	4.0	14.0	12.1	2658	0.18	40	0.69	1.07	1.02	1.48	2.00	1.57	0.75	3587
	LOCAL	38		4.0	13.5			0.16	41	0.57	1.25	1.08	1.10	0.93	0.43	0.50	
										(970)	(1311)	(956)	(273)	(59)	(14)	(4)	

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

Table 4.5 (Revised). 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	1831	3.2	12.6	12.4	1842	0.27	51	1.17	0.97	0.82	0.84	0.51	1.33	0.67	3819
	FINAL	27		3.5	13.1			0.24	48	1.05	0.98	0.97	0.97	0.94	1.17	0.0	
	LOCAL	30		3.6	13.7			0.24	48	0.71	1.19	1.13	1.11	0.75	0.83	1.00	
										(1322)	(1515)	(725)	(197)	(51)	(6)	(3)	
30	FINAL	34	1122	3.9	11.8	9.8	1160	0.28	62	0.99	0.97	1.19	1.00	0.42	0.20	*	3839
	LOCAL	39		4.1	11.8			0.25	58	0.85	1.34	1.02	1.00	0.25	0.0	***	
										(2400)	(1046)	(312)	(64)	(12)	(5)	(0)	
42	FINAL	37	2080	3.8	12.7	11.4	2101	0.17	43	1.06	0.94	1.03	1.08	0.77	0.71	0.0	3811
	LOCAL	44		3.8	12.4			0.16	44	0.79	1.25	1.01	0.63	0.19	0.29	0.0	
										(1306)	(1524)	(721)	(198)	(52)	(7)	(3)	

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

Table 4.6 (Revised). Same as Table 4.2 except for 27 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	23	2595	3.2	13.9	13.6	2605	0.31	50	1.01	1.11	0.87	0.92	1.23	0.44	1.50	4211
	FINAL	24		3.5	14.0			0.27	47	1.00	1.07	0.93	0.92	1.28	0.53	1.50	
	LOCAL	29		3.7	14.4			0.23	44	0.62	1.18	1.19	0.98	0.92	0.44	0.67	
										(1144)	(1450)	(1077)	(405)	(86)	(43)	(6)	
30	FINAL	31	1832	3.8	12.0	10.7	1865	0.27	55	0.95	1.10	1.05	0.85	0.70	0.40	0.33	4232
	LOCAL	38		4.1	12.2			0.21	49	0.74	1.39	1.17	0.80	0.47	0.40	0.33	
										(2167)	(1343)	(531)	(148)	(30)	(10)	(3)	
42	FINAL	37	2907	4.2	13.3	12.6	2934	0.18	40	0.92	1.16	0.92	0.88	1.08	0.46	1.50	4213
	LOCAL	44		4.3	13.0			0.14	39	0.60	1.48	1.03	0.55	0.47	0.10	1.00	
										(1144)	(1452)	(1070)	(413)	(87)	(41)	(6)	

Table 4.7 (Revised). 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)	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	33	461	4.1	13.2	13.0	466	0.28	67	1.05	1.05	0.67	0.49	1.00	0.44	***	2965
	FINAL	35		4.2	13.5			0.32	69	1.06	0.91	0.88	0.85	0.30	0.56	*	
	LOCAL	35		4.2	14.1			0.33	67	0.99	1.08	0.97	1.03	0.56	0.78	***	
										(2049)	(555)	(237)	(88)	(27)	(9)	(0)	
30	FINAL	38	437	4.4	12.0	10.1	457	0.27	71	1.04	0.87	0.94	1.00	0.43	0.17	0.0	2977
	LOCAL	45		4.7	12.5			0.26	70	1.00	1.00	1.11	0.98	0.29	0.50	0.0	
										(2213)	(569)	(140)	(41)	(7)	(6)	(1)	
42	FINAL	44	614	4.8	12.9	11.2	636	0.28	66	1.01	1.05	0.91	0.76	1.08	0.38	**	2965
	LOCAL	49		4.7	12.8			0.22	61	0.95	1.34	0.83	0.61	0.76	0.75	*	
										(2042)	(548)	(253)	(89)	(25)	(8)	(0)	

* 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 subjective local and objective guidance forecasts of surface wind direction for 93 stations in the United States during October 1976 through March 1977.

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	78.8	14.0	3.8	1.7	0.9	0.8
	FINAL	76.5	15.4	4.1	2.2	1.0	0.8
	LOCAL	72.3	17.4	5.6	2.2	1.5	0.9
30	FINAL	68.0	18.4	6.4	3.3	2.5	1.5
	LOCAL	61.6	20.8	8.7	4.3	2.8	1.9
42	FINAL	63.6	19.3	7.8	4.3	2.8	2.1
	LOCAL	57.0	21.3	9.6	5.7	3.6	2.7

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	78.9	14.7	3.8	1.4	0.6	0.5
	FINAL	75.7	16.8	4.2	2.2	0.6	0.5
	LOCAL	73.6	16.9	6.0	1.9	1.3	0.4
30	FINAL	66.9	20.3	7.0	2.7	1.6	1.4
	LOCAL	62.5	22.6	7.9	3.6	2.4	1.1
42	FINAL	64.0	20.7	7.4	4.2	2.1	1.6
	LOCAL	60.4	21.6	8.9	5.2	2.6	1.3

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	76.0	16.2	4.8	2.0	0.7	0.3
	FINAL	74.5	16.8	5.2	2.3	0.8	0.4
	LOCAL	71.0	18.7	5.7	2.5	1.4	0.8
30	FINAL	65.9	18.6	7.6	3.7	3.0	1.2
	LOCAL	59.6	21.6	9.7	4.5	2.6	2.0
42	FINAL	62.4	20.0	8.8	4.2	2.9	1.6
	LOCAL	55.0	21.3	11.3	6.2	3.8	2.3

Table 4.11 Same as Table 4.8 except for 27 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	82.5	11.3	3.0	1.3	0.9	1.0
	FINAL	80.0	13.4	3.1	1.5	1.2	0.9
	LOCAL	72.6	17.2	5.5	2.3	1.4	1.0
30	FINAL	70.6	17.7	4.9	3.4	2.1	1.3
	LOCAL	62.3	20.0	8.6	4.6	2.6	1.9
42	FINAL	64.7	18.3	7.4	4.1	3.2	2.3
	LOCAL	55.3	22.5	9.2	5.5	4.2	3.3

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	69.2	17.1	4.1	3.7	2.4	3.5
	FINAL	69.4	13.9	5.0	5.2	3.5	3.0
	LOCAL	69.2	16.5	4.1	2.6	3.7	3.9
30	FINAL	66.8	12.8	7.8	3.7	5.7	3.2
	LOCAL	60.2	14.9	8.9	5.0	6.2	4.8
42	FINAL	60.6	16.0	8.0	6.2	4.1	5.2
	LOCAL	57.7	14.8	8.3	7.5	4.1	7.7

Table 5.1 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 5.2a. Verification scores for subjective local and objective guidance forecasts of four categories of cloud amount (clear, scattered, broken and overcast) for 93 stations across the United States for the period 1 October 1976, to 9 February 1977 (early guidance, regionalized; final guidance, single station).

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	0.72	0.92	1.05	54.3	.360	10055
	FINAL	1.07	0.90	0.95	1.01	50.4	.311	
	LOCAL	0.74 (3656)	1.47 (1981)	1.31 (1590)	0.83 (2828)	52.0	.357	
30	FINAL	1.07	0.76	0.84	1.04	58.6	.355	10026
	LOCAL	0.70 (4790)	2.03 (1315)	2.08 (899)	0.72 (3022)	48.5	.290	
42	FINAL	1.06	0.96	0.94	0.98	46.2	.255	10082
	LOCAL	0.59 (3693)	1.86 (2030)	1.34 (1605)	0.71 (2754)	40.4	.214	

Table 5.2b. Same as Table 5.2a except for the period 10 February 1977, to 31 March 1977 (regionalized equations).

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	1.12	0.88	1.16	0.86	52.1	.350	3972
	FINAL	1.13	0.88	1.10	0.88	52.5	.355	
	LOCAL	0.72 (1264)	1.45 (836)	1.37 (709)	0.76 (1163)	50.9	.348	
30	FINAL	0.97	0.93	0.98	1.09	56.7	.359	4013
	LOCAL	0.67 (1775)	2.03 (546)	1.86 (433)	0.73 (1259)	46.9	.282	
42	FINAL	0.94	0.82	1.22	1.07	46.9	.280	4051
	LOCAL	0.56 (1311)	1.78 (862)	1.39 (721)	0.68 (1157)	39.4	.205	

Table 5.3a. Same as Table 5.2a 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	0.94	0.78	1.27	1.02	51.3	.334	2501
	FINAL	0.77	1.16	1.30	0.92	47.4	.289	
	LOCAL	0.57 (639)	1.58 (483)	1.39 (472)	0.79 (907)	48.5	.314	
30	FINAL	0.89	1.12	1.26	1.01	56.9	.364	2519
	LOCAL	0.68 (969)	1.86 (311)	2.50 (228)	0.71 (1011)	48.1	.295	
42	FINAL	0.77	1.29	1.30	0.84	42.5	.230	2507
	LOCAL	0.43 (654)	1.85 (521)	1.37 (466)	0.72 (866)	40.6	.216	

Table 5.3b. Same as Table 5.2b 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	1.01	0.88	1.24	0.93	54.3	.378	1016
	FINAL	0.94	0.97	1.21	0.95	54.4	.379	
	LOCAL	0.49 (273)	1.64 (193)	1.60 (186)	0.74 (364)	49.2	.329	
30	FINAL	1.01	0.54	1.20	1.07	57.8	.369	1038
	LOCAL	0.70 (379)	2.02 (123)	1.74 (118)	0.77 (418)	46.9	.275	
42	FINAL	0.59	0.82	1.78	1.04	47.1	.287	1035
	LOCAL	0.40 (290)	1.82 (201)	1.50 (183)	0.77 (361)	40.2	.212	

Table 5.4a. Same as Table 5.2a 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	1.21	0.72	0.61	1.04	61.1	.424	2592
	FINAL	0.99	1.04	0.91	1.03	56.8	.383	
	LOCAL	0.78 (1085)	1.66 (443)	1.44 (342)	0.72 (722)	56.2	.403	
30	FINAL	1.11	0.77	0.72	0.97	64.2	.409	2612
	LOCAL	0.77 (1362)	2.27 (297)	2.06 (207)	0.62 (746)	52.8	.324	
42	FINAL	1.07	1.13	0.84	0.88	50.5	.288	2605
	LOCAL	0.63 (1103)	2.33 (455)	1.45 (348)	0.50 (699)	41.5	.225	

Table 5.4b. Same as Table 5.2b 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	1.22	0.88	0.99	0.77	52.9	.338	1030
	FINAL	1.22	0.90	0.89	0.82	53.9	.351	
	LOCAL	0.87 (393)	1.50 (224)	1.25 (169)	0.59 (244)	52.8	.359	
30	FINAL	1.00	1.21	0.90	0.93	58.6	.345	1055
	LOCAL	0.81 (561)	2.02 (136)	1.85 (93)	0.57 (265)	51.3	.290	
42	FINAL	1.14	0.81	0.82	1.08	49.1	.284	1055
	LOCAL	0.74 (409)	1.96 (234)	1.09 (170)	0.44 (242)	39.0	.175	

Table 5.5a. Same as Table 5.2a except for 27 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	1.05	0.58	1.19	1.20	50.1	.311	2882
	FINAL	1.05	0.75	0.92	1.21	45.4	.243	
	LOCAL	0.62 (1078)	1.48 (650)	1.27 (462)	0.96 (692)	47.8	.303	
30	FINAL	1.05	0.72	0.78	1.12	55.7	.311	2804
	LOCAL	0.58 (1354)	2.32 (386)	1.94 (269)	0.76 (795)	43.2	.234	
42	FINAL	1.04	0.79	0.94	1.18	44.1	.227	2886
	LOCAL	0.43 (1076)	1.81 (647)	1.37 (470)	0.87 (693)	35.4	.152	

Table 5.5b. Same as Table 5.2b except for 27 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	1.10	0.88	1.16	0.91	53.5	.369	1163
	FINAL	1.14	0.85	1.06	0.95	52.1	.348	
	LOCAL	0.66 (325)	1.44 (248)	1.31 (201)	0.85 (389)	50.6	.341	
30	FINAL	0.91	0.87	1.17	1.12	57.2	.367	1143
	LOCAL	0.49 (474)	2.35 (157)	2.17 (103)	0.78 (409)	44.7	.267	
42	FINAL	0.87	0.85	1.26	1.07	44.7	.250	1187
	LOCAL	0.35 (337)	1.79 (254)	1.55 (211)	0.75 (385)	39.1	.201	

Table 5.6a. Same as Table 5.2a 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	1.36	0.86	0.36	0.90	55.2	.338	2080
	FINAL	1.40	0.67	0.52	0.88	52.8	.300	
	LOCAL	0.96 (854)	1.13 (405)	1.11 (314)	0.90 (507)	56.8	.397	
30	FINAL	1.20	0.46	0.56	1.08	57.7	.288	2091
	LOCAL	0.76 (1105)	1.61 (321)	1.79 (195)	0.80 (470)	50.9	.290	
42	FINAL	1.30	0.64	0.52	1.08	48.2	.238	2084
	LOCAL	0.88 (860)	1.43 (407)	1.13 (321)	0.77 (496)	45.9	.254	

Table 5.6b. Same as Table 5.2b 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	1.10	0.87	1.25	0.73	46.0	.260	763
	FINAL	1.18	0.81	1.26	0.66	48.8	.295	
	LOCAL	0.82 (273)	1.19 (171)	1.27 (153)	0.84 (166)	50.7	.337	
30	FINAL	0.95	1.09	0.64	1.29	51.7	.300	777
	LOCAL	0.65 (361)	1.64 (130)	1.73 (119)	0.74 (167)	44.4	.248	
42	FINAL	1.08	0.79	0.98	1.10	46.5	.268	774
	LOCAL	0.69 (275)	1.47 (173)	1.36 (157)	0.69 (169)	39.7	.196	

Table 6.1 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 6.2. Comparative verification of early and final MOS guidance, persistence, and local ceiling forecasts, 0000 GMT cycle, for the period 10 February through 31 March 1977, for 94 stations. 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	0.58	0.89	1.08	1.10	0.92	1.01	68.3	.40	.135
	Final	0.50	0.82	1.07	1.17	0.91	1.01	67.8	.39	.115
	Persistence	0.78	0.82	0.87	1.06	1.02	1.01	76.4	.55	.291
	Local	0.42	0.77	0.88	1.24	1.10	0.96	74.6	.53	.203
	No. Obs.	50	114	173	452	643	2767			
15	Local	0.23	0.42	0.64	1.16	1.32	0.96	69.7	.43	.070
	Persistence	1.29	0.92	0.77	0.87	1.18	1.01	67.5	.38	.135
	No. Obs.	31	103	197	553	561	2831			
18	Early	0.40	1.39	1.04	0.85	0.97	1.03	68.7	.39	.094
	Final	0.40	1.09	1.19	0.87	0.93	1.03	68.1	.37	.124
	Persistence	3.90	1.40	1.01	0.76	1.15	1.00	65.0	.33	.034
	No. Obs.	10	67	148	628	574	2800			
21	Local	0.25	0.15	0.46	1.01	1.24	0.98	68.9	.40	.014
	Persistence	4.75	1.83	1.16	0.89	0.95	1.00	62.6	.27	.038
	No. Obs.	8	52	130	544	694	2851			
24	Early	0.13	1.12	1.14	0.91	0.88	1.04	70.4	.37	.089
	Final	0.38	0.78	1.29	0.99	0.89	1.02	69.5	.36	.084
	Persistence	4.88	1.59	1.17	1.16	0.95	0.96	60.1	.21	.026
	No. Obs.	8	59	128	413	697	2919			
36	Final	0.33	1.13	1.10	1.39	1.07	0.92	60.7	.29	.102
	Persistence	0.76	0.82	0.87	1.04	1.02	1.01	53.4	.11	.042
	No. Obs.	51	115	172	460	643	2786			
48	Final	0.00	1.30	0.81	1.25	0.94	0.98	64.3	.28	.073
	Persistence	4.88	1.40	1.16	1.15	0.94	0.96	53.2	.07	.025
	No. Obs.	8	67	129	414	698	2908			

Table 6.3. Same as Table 6.2 except for visibility.

Projection (h)	Type of Forecast	Bias by Category* I	2	3	4	5	Percent Correct	Heidke Skill Score	Threat Score
12	Early	0.77	1.02	0.82	1.15	1.00	84.6	.27	.066
	Final	0.60	0.93	0.86	1.38	0.99	84.8	.31	.086
	Persistence	0.62	0.78	0.71	0.83	1.03	89.3	.44	.233
	Local	0.45	1.15	0.61	1.36	1.01	88.3	.44	.179
	No. Obs.	53	41	190	204	3712			
15	Local	0.21	0.54	0.35	1.28	1.04	85.3	.28	.070
	Persistence	0.70	0.62	0.56	0.84	1.05	85.1	.27	.072
	No. Obs.	47	52	250	208	3725			
18	Early	0.67	1.42	0.91	0.94	1.00	86.3	.24	.047
	Final	0.44	1.02	0.95	1.00	1.00	86.5	.25	.046
	Persistence	1.89	0.74	0.70	1.07	1.01	85.6	.17	.041
	No. Obs.	18	43	192	161	3812			
21	Local	0.36	0.38	0.35	1.28	1.02	89.8	.23	.029
	Persistence	2.36	0.89	0.88	1.29	0.99	86.3	.15	.026
	No. Obs.	14	37	161	135	3927			
24	Early	0.67	1.64	0.75	1.11	1.00	88.7	.27	.053
	Final	0.33	1.64	0.78	1.21	1.00	88.5	.27	.045
	Persistence	2.27	0.89	0.87	1.23	0.99	86.1	.13	.017
	No. Obs.	15	36	155	140	3879			
36	Final	0.40	0.54	1.16	1.40	0.99	82.1	.19	.015
	Persistence	0.59	0.86	0.71	0.89	1.03	82.4	.07	.013
	No. Obs.	58	37	191	194	3746			
48	Final	0.21	1.69	1.37	1.26	0.97	85.6	.20	.032
	Persistence	1.79	0.82	0.87	1.23	1.00	84.2	.03	.016
	No. Obs.	19	39	156	140	3871			

*for 5 categories only; see text for explanation.

Table 6.4. Same as Table 6.2 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	Threat Score
12	Early	1.25	0.97	1.26	0.95	0.84	1.03	71.5	.39	.069
	Final	1.25	0.87	1.01	1.08	0.87	1.02	72.5	.42	.107
	Persistence	1.50	0.87	0.95	1.27	1.01	0.96	77.5	.55	.193
	Local	0.75	0.66	0.76	1.38	1.03	0.96	77.4	.55	.182
	No. Obs.	8	62	128	406	684	2929			
15	Local	0.19	0.69	0.62	1.74	0.95	0.96	71.8	.44	.138
	Persistence	0.63	0.77	0.80	1.54	1.03	0.95	69.3	.39	.097
	No. Obs.	16	62	125	267	520	2242			
18	Early	0.62	1.07	1.24	0.92	1.01	1.00	69.3	.36	.111
	Final	1.12	1.04	1.10	1.03	0.99	0.99	69.7	.38	.117
	Persistence	0.46	0.68	0.84	1.23	1.15	0.96	65.9	.31	.094
	No. Obs.	26	81	147	425	611	2979			
21	Local	0.21	0.63	0.89	1.37	0.89	0.99	68.3	.39	.092
	Persistence	0.36	0.56	0.83	1.10	1.06	1.00	60.9	.24	.042
	No. Obs.	33	99	149	467	654	2814			
24	Early	0.43	0.92	1.26	1.02	1.07	0.98	64.3	.33	.106
	Final	0.47	1.00	1.10	1.03	1.15	0.97	64.2	.33	.102
	Persistence	0.23	0.47	0.70	1.14	1.09	1.01	57.9	.19	.030
	No. Obs.	53	118	175	459	641	2823			
36	Final	0.00	1.76	1.30	0.96	1.01	0.98	65.0	.30	.044
	Persistence	1.50	0.82	0.94	1.25	0.99	0.97	55.2	.10	.007
	No. Obs.	8	66	131	417	707	2937			
48	Final	0.51	1.09	1.58	1.09	1.04	0.94	58.2	.25	.064
	Persistence	0.24	0.45	0.69	1.09	1.06	1.03	50.6	.06	.008
	No. Obs.	51	123	179	478	659	2779			

Table 6.5. Same as Table 6.3 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			
12	Early	0.69	0.46	1.12	1.10	1.00	88.8	.29	.052
	Final	0.44	0.68	0.93	0.92	1.01	89.9	.31	.024
	Persistence	1.13	1.00	1.04	0.97	1.00	92.2	.50	.241
	Local	0.63	0.76	0.60	1.45	1.00	91.4	.44	.152
	No. Obs.	16	37	151	146	3887			
15	Local	0.45	0.86	0.88	1.48	0.99	90.4	.38	.097
	Persistence	1.36	1.14	1.25	1.00	0.99	90.0	.35	.147
	No. Obs.	11	28	95	114	2986			
18	Early	0.72	1.69	1.30	1.03	0.99	89.0	.29	.018
	Final	0.72	1.15	1.24	1.05	0.99	89.9	.33	.042
	Persistence	0.72	1.42	1.37	0.89	0.99	89.0	.27	.039
	No. Obs.	25	26	116	159	3952			
21	Local	0.23	0.93	1.26	1.46	0.98	87.6	.30	.052
	Persistence	0.51	1.17	1.28	0.83	1.00	87.2	.19	.044
	No. Obs.	35	30	122	171	3865			
24	Early	No Forecasts Available							
	Final								
	Persistence								
	No. Obs.								
36	Final	0.47	1.26	1.77	1.06	0.97	85.6	.21	.027
	Persistence	0.95	0.95	1.01	1.02	1.00	84.8	.03	.009
	No. Obs.	19	39	158	139	3922			
48	Final	0.55	1.49	1.45	1.13	0.97	79.9	.13	.011
	Persistence	0.32	1.00	0.81	0.70	1.04	81.8	.02	.000
	No. Obs.	56	37	196	202	3787			

*for 5 categories only; see text for explanation.

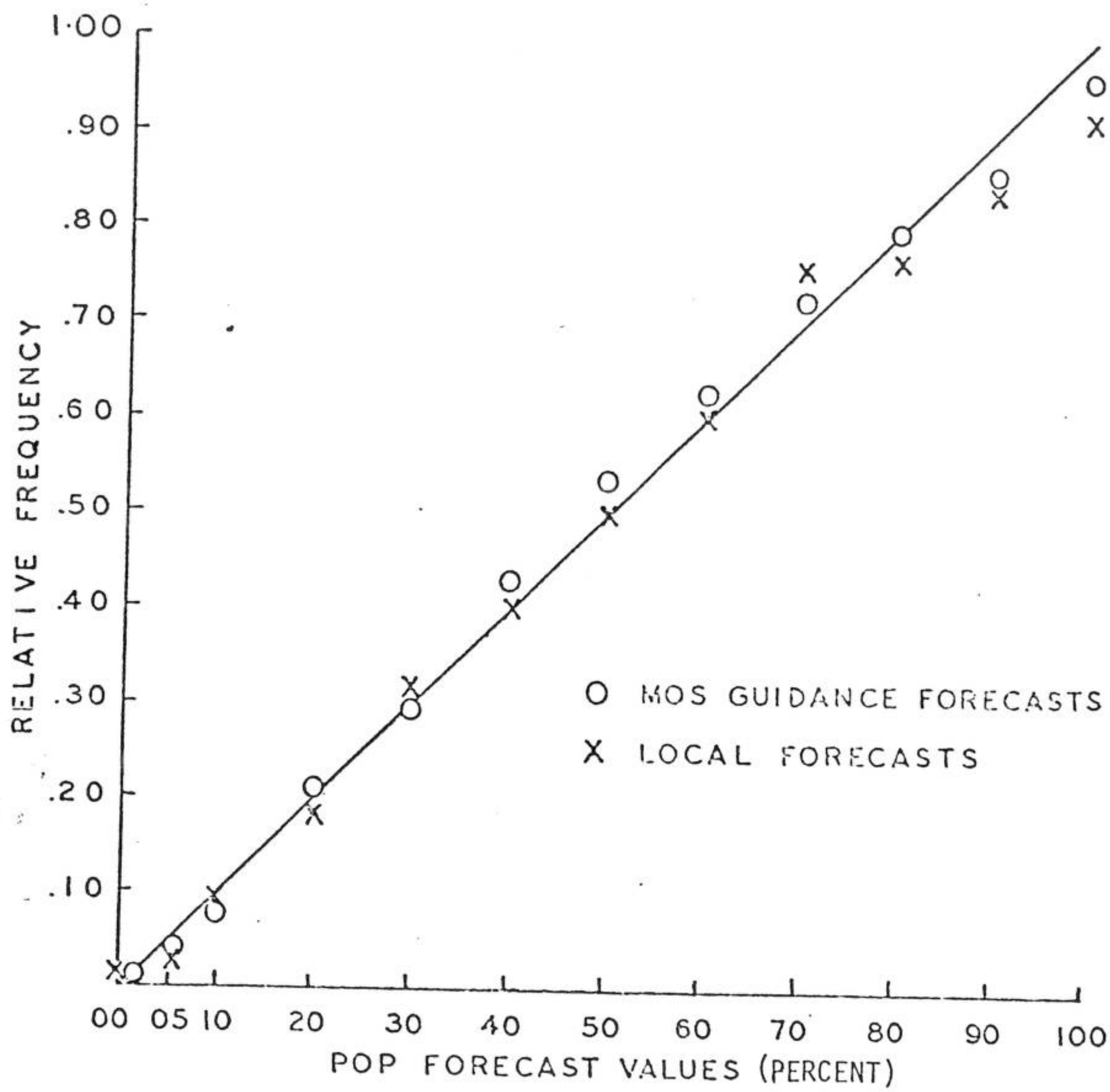

Figure 2.1 Reliability of final guidance and local PoP forecasts.

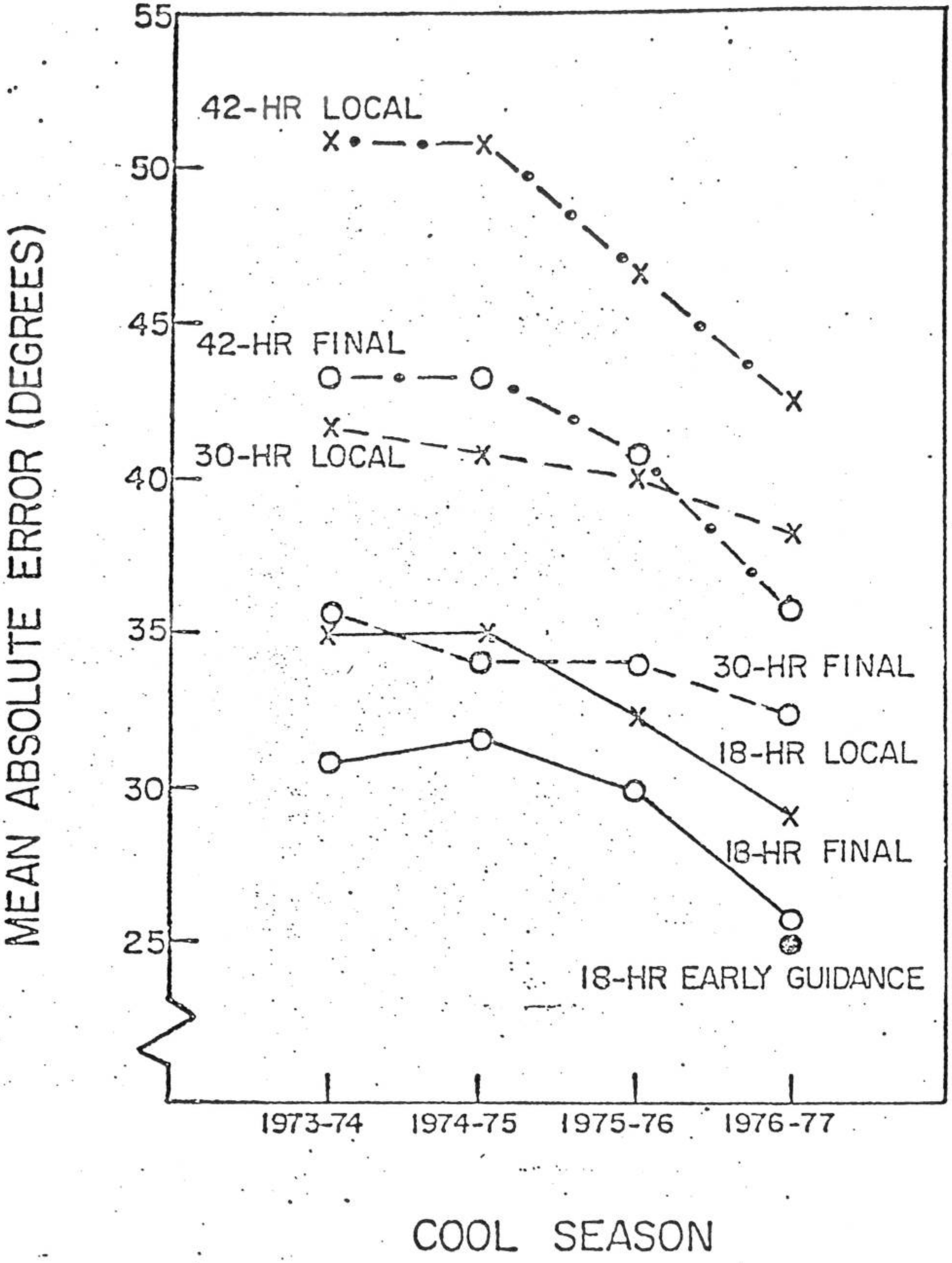

Figure 4.1 Mean absolute errors for subjective local and objective guidance (early and final) surface wind direction forecasts for approximately 90 U.S. stations.

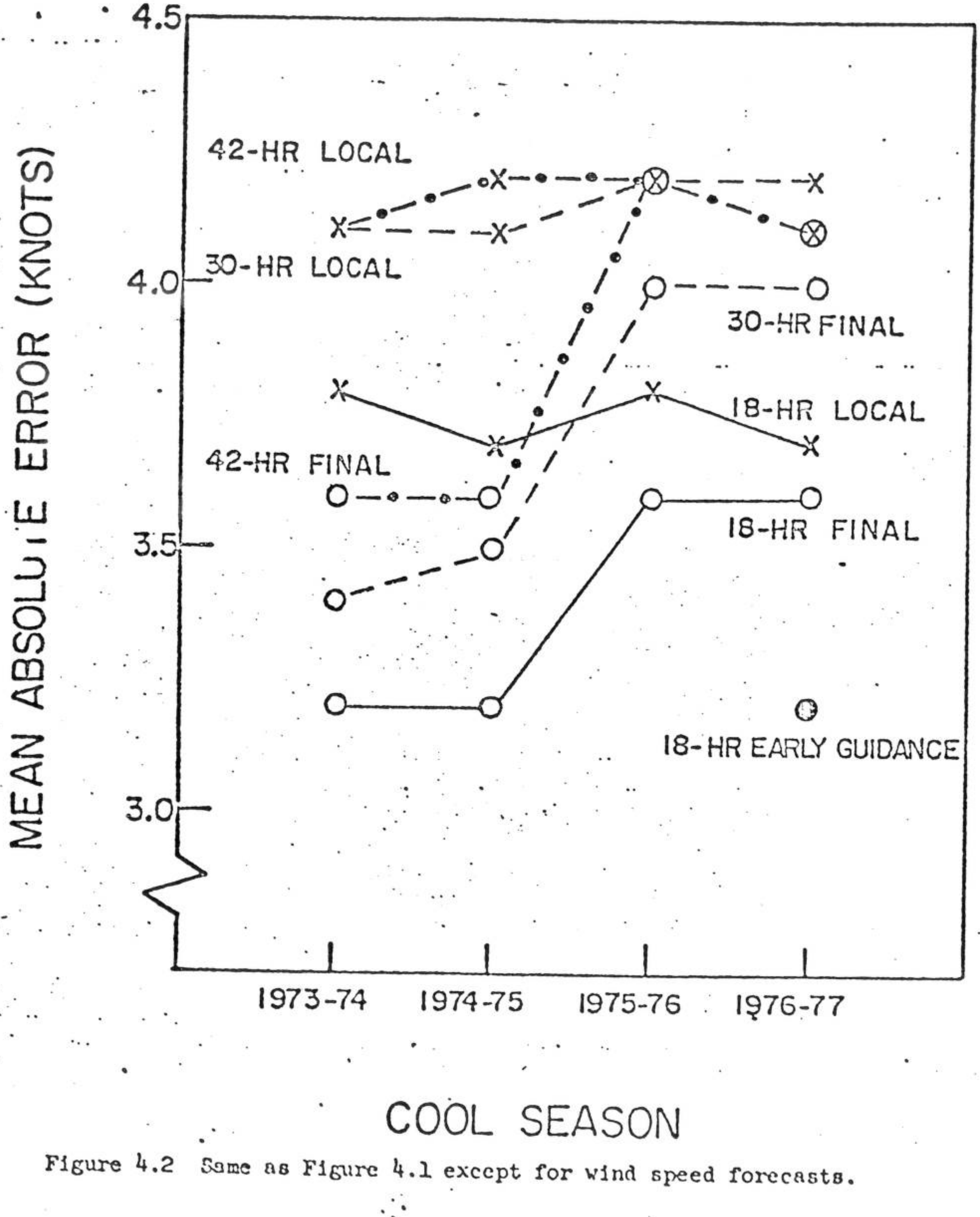

Figure 4.2 Same as Figure 4.1 except for wind speed forecasts.

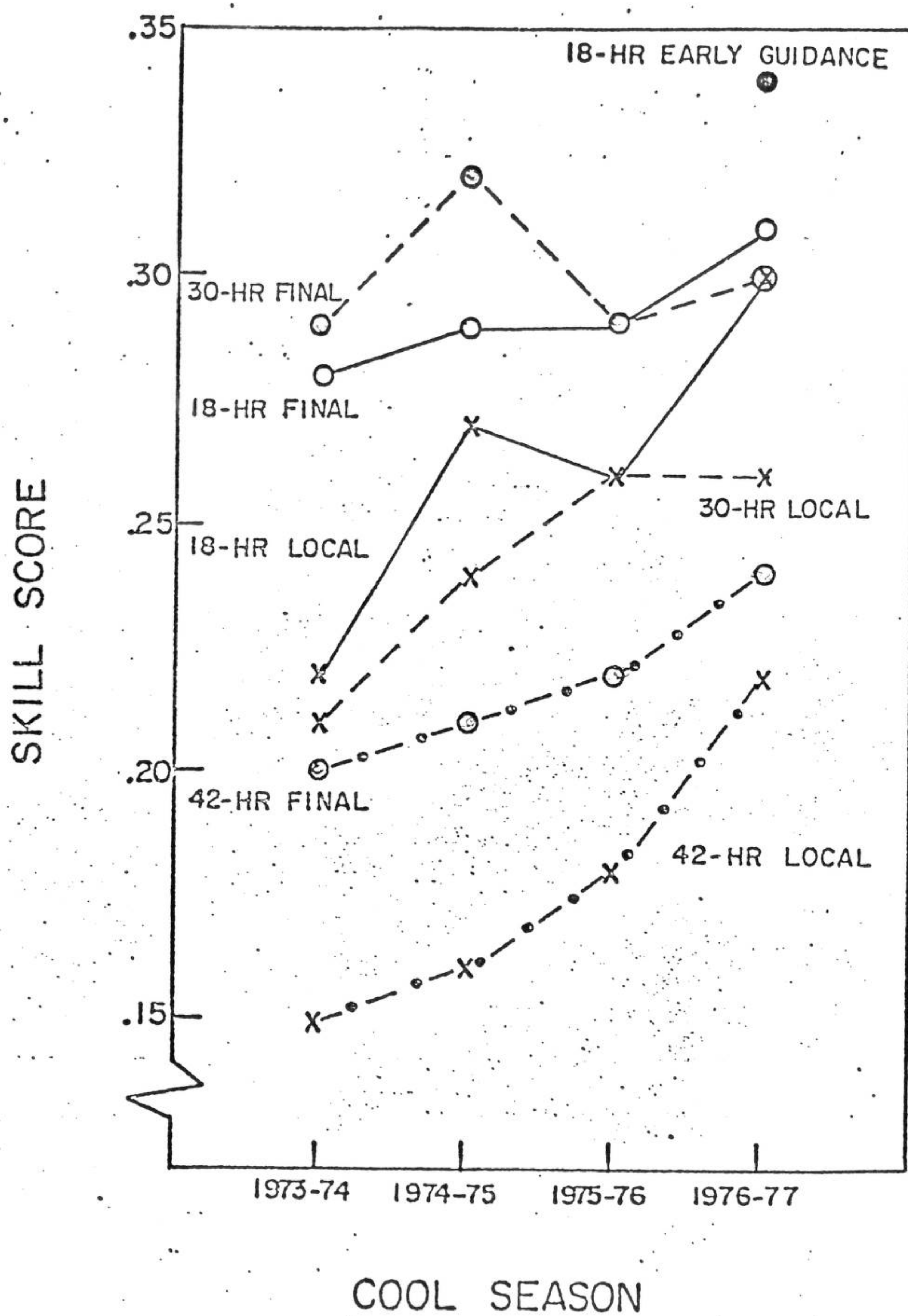

Figure 4.3 Skill scores for subjective local and objective guidance (early and final) surface wind speed forecasts for approximately 90