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COMPARATIVE VERIFICATION OF GUIDANCE AND LOCAL AVIATION/PUBLIC WEATHER FORECASTS--No. 15
(October 1982-March 1983)

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1. INTRODUCTION

This is the fifteenth in the series of Techniques Development Laboratory (TDL) office notes which compare the performance of TDL's automated guidance forecasts with National Weather Service (NWS) local forecasts made at Weather Service Forecast Offices (WSFO's). The local forecasts, which are produced subjectively, may or may not be based on the automated guidance. In this report, we present verification statistics for the cool season months of October 1982 through March 1983 for probability of precipitation (PoP), precipitation type (rain, freezing rain, or snow), surface wind, opaque sky cover (cloud amount), ceiling height, visibility, and maximum/minimum (max/min) temperature. The PoP, ceiling height, visibility, and max/min temperature verification results are provided for both forecast cycles, 0000 and 1200 GMT.

The objective guidance is based on equations developed through application of the Model Output Statistics (MOS) technique (Glahn and Lowry, 1972). Over the years we have derived many sets of prediction equations by using archived surface observations and forecast fields from the Limited-area Fine Mesh (LFM) model (Gerrity, 1977; Newell and Deaven, 1981; National Weather Service, 1981a), the Trajectory model (Reap, 1972), and/or the 6-layer coarse mesh Primitive Equation (PE) model (Shuman and Hovermale, 1968). Unless indicated otherwise, we usually refer to MOS forecasts based on the LFM model as "early" guidance; "final" guidance indicates the objective forecasts were based primarily on PE data. Also, the observation times of surface weather elements used as predictors in the early and final guidance generally differed. The final guidance is no longer disseminated operationally due to the superiority of the early guidance, but comparative results for previous years are included on the figures presented in this report.

The local public weather PoP forecasts used for this verification were official forecasts obtained from the Coded City Forecast (FPUS4) bulletin. In contrast, the local aviation forecasts from the WSFO's were collected by the Services Evaluation Branch of the Office of Meteorology for the purposes of the NWS combined aviation/public weather verification system (National Weather Service, 1973). These forecasts were recorded for verification according to the direction that they be "... not inconsistent with ..." the official weather prognosis. Surface observations as late as 2 hours before the first valid forecast time may have been used in the preparation of the local forecasts.

In the past, local max/min forecasts from the FPUS4 bulletin were compared with the MOS temperature guidance. However, the verification procedure was controversial because the local forecast was valid for a 12- or 18-h period, while the corresponding guidance applied to a particular calendar day. Hence, in conformance with a recommendation from the 1982 NWS Line Forecasters Technical Advisory Committee, this report contains temperature verification results for the guidance only. We will continue this policy in future reports until the new verification system outlined in the NWS National Verification Plan (National Weather Service, 1982a) is fully implemented.

We obtained all required observed verification data from the National Climatic Data Center in Asheville, North Carolina. These observations were carefully error-checked prior to computation of any of the verification scores.

2. PROBABILITY OF PRECIPITATION

Objective PoP forecasts were produced by the cool season prediction equations described in Technical Procedures Bulletin No. 289 (National Weather Service, 1980b). This guidance was available for the first, second, and third periods, which correspond to 12-24, 24-36, and 36-48 hours, respectively, after 0000 or 1200 GMT. The predictors for the equations were forecast fields from the LFM model and weather elements observed at the forecast site at 0300 or 1500 GMT. Only the early (LFM-based) guidance has been produced operationally since the 1980-81 cool season.

The forecasts were verified by computing Brier scores (Brier, 1950) for the 87 stations shown in Table 2.1. Please note that we used the standard NWS Brier score for PoP which is one-half the original score defined by Brier. Brier scores will vary from one station to the next and from one year to the next because of changes in the relative frequency of precipitation; in particular, the scores usually are better for periods of below normal precipitation. Therefore, we also computed the percent improvement over climate; that is, the percent improvement of Brier scores obtained from the local or guidance forecasts over analogous Brier scores produced by climatic forecasts. Climatic forecasts are defined as relative frequencies of precipitation by month and by station determined from a 15-yr sample (Jorgensen, 1967).

Tables 2.2 and 2.7 present the 1982-83 results for all 87 stations combined for the 0000 and 1200 GMT cycle forecasts, respectively. Tables 2.3-2.6 and Tables 2.8-2.11 show scores for the NWS Eastern, Southern, Central, and Western Regions, for the 0000 and 1200 GMT cycles, respectively. Comparison of the overall Brier scores and improvements over climate in Table 2.2 indicates the 0000 GMT cycle local forecasts were better than the guidance for all three periods. On the regional level for the 0000 GMT cycle (Tables 2.3-2.6), with the exception of the second period forecasts for the Eastern Region, the local forecasts for all regions were as good as, or slightly better than, the guidance for all three periods. Overall, as shown in Table 2.7, the 1200 GMT cycle local forecasts also were as good as, or better than, the guidance for all three periods. Regionally (Tables 2.8-2.11), the 1200 GMT cycle local forecasts for the Southern, Central, and Western Regions generally were better than the guidance for all three periods. In contrast, for the Eastern Region, the 1200 GMT cycle guidance forecasts were superior to the locals for all three periods.

Fig. 2.1 shows the trend since 1970-71 in skill (expressed in terms of percent improvement over climate) of the first- and third-period 0000 GMT cycle PoP forecasts. Due to the loss of local forecast data, we did not include the local verification results for the 1981-82 cool season. Fig. 2.1 indicates both local and guidance 0000 GMT first-period forecasts maintained about constant skill over the past 4 years, while there was a gradual decline in the skill of the third-period forecasts.

3. PRECIPITATION TYPE

The new objective conditional probability of precipitation type (PoPT) forecast system described in Technical Procedures Bulletin No. 319 (National Weather Service, 1982c) and Bocchieri and Maglaras (1983) provides categorical forecasts for three categories: frozen (snow or ice pellets), freezing (freezing rain or drizzle), and liquid (rain). Precipitation in the form of mixed snow and ice pellets is included in the frozen category; any mixed precipitation type (including freezing rain or drizzle) is included in the freezing category; all other mixed precipitation types are included in the liquid category. In this report, the frozen, freezing, and liquid categories will be referred to as snow, freezing rain, and rain, respectively.

For verification purposes, local categorical forecasts of precipitation type (made at about 1000 GMT) are recorded for three valid times: 1800 GMT (today), 0600 GMT (tonight), and 1800 GMT (tomorrow). Note, this is a conditional forecast; that is, it's a forecast of the type of precipitation if precipitation actually occurs. Therefore, a precipitation type forecast is always recorded. Similarly, the PoPT guidance forecasts are conditional and are available whether or not precipitation occurs.

Table 3.1 lists the 61 stations used for this verification study. Of course, the verification included only those cases in which precipitation actually occurred. Also, since we were concerned that some forecasters may not have put much effort into making the conditional forecasts when they considered precipitation to be unlikely, we used cases only when the local PoP was $\geq$30%. The PoP forecasts were valid for 12-h periods centered on the 18-, 30-, and 42-h projections from 0000 GMT.

We compared the PoPT guidance with local forecasts for the snow, freezing rain, and rain categories. Table 3.2 shows the verification results. The bias by category[1] values for freezing rain are not shown because there weren't enough cases to provide meaningful results. The percents correct and skill scores[2] for all stations combined indicate that the local and guidance forecasts were of comparable skill for the 18- and 30-h projections. For the

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[1]In the discussion of precipitation type, surface wind, opaque sky cover, ceiling height, and visibility, bias by category refers to the number of forecasts of a particular category (event) divided by the number of observations of that category. A value of 1.0 denotes unbiased forecasts for a particular category.

[2]The skill score used throughout this report is the Heidke skill score (Panofsky and Brier, 1965).

42-h projection, the guidance scores were slightly better than those for the locals. Also, as shown by the bias by category results, the guidance and local forecasts tended to overforecast the snow category. Overall, the local forecasts had slightly better bias characteristics than the guidance. In the regional breakdown, the results show that the guidance scores were generally better than the local forecasts in the Eastern and Western Regions, while the local forecast scores were better than the guidance in the Southern and Central Regions.

The percents correct shown in the verification tables are high because the sample included many "obvious" forecasts. For instance, on some days in the South, precipitation, if it occurred, would obviously be rain. Therefore, in order to isolate some of the more difficult forecasting situations, we verified cases in which the guidance and local forecasts of snow, freezing rain, or rain differed. Again, we used only those cases for which local PoP was $\geq$30%. The results, presented in Table 3.3, indicate the 18-, 30-, and 42-h guidance forecasts were correct 46.7%, 44.8%, and 49.2% of the time, respectively, while the corresponding local forecasts were correct 51.7%, 44.8%, and 44.6% of the time.

The skill scores for the guidance and local forecasts for the past 10 seasons are shown in Fig. 3.1; scores for only the 18- and 42-h forecasts are presented. Over the years, two changes in the verification procedure took place: (1) the number of stations changed from around 90 for the first 2 years to approximately 60 thereafter; and (2) starting with the 1975-76 season, we used cases only where the local PoP was $\geq$30% in order to isolate those situations where the forecaster was more confident precipitation would occur. Due to the loss of local forecast data, we did not include the results for the 1981-82 season. Fig. 3.1 shows that, for both projections, the skill of the guidance forecasts decreased considerably from the results for the 1980-81 season. This is also true for the local forecasts for the 42-h projection; however, for the 18-h projection, the skill score for the locals stayed about the same, and for the first time, was slightly better than the corresponding value for the guidance.

4. SURFACE WIND

The objective surface wind forecasts were generated by the cool season, LFM-based equations described in Technical Procedures Bulletin No. 316 (National Weather Service, 1982b). Only the early guidance has been available since the 1978-79 cool season. In addition to LFM model forecasts, predictors in the equations include the sine and cosine of the day of the year and twice the day of the year. Prior to the 1980-81 cool season, a significant change occurred in the operational early guidance wind prediction system. New equations were developed without screening as predictors any surface pressure or boundary layer fields from the LFM model. The impact of removal of the surface pressure and boundary layer fields as predictors in objective surface wind forecasting is described by Janowiak (1981).

We verified the 18-, 30-, and 42-h forecasts from 0000 GMT. The objective surface wind forecast is defined in the same way as the observed wind, namely, the 1-minute average wind 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, the wind forecasts were verified in two ways. First, for all those cases in which both the local and objective 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. Second, for all cases where both local and automated forecasts were available, skill score, percent correct, and bias by category were computed from contingency tables of wind speed. The seven categories in the tables were: <8, 8-12, 13-17, 18-22, 23-27, 28-32, and >32 knots. Table 4.1 lists the 90 stations used in the verification. All the objective forecasts of wind speed were adjusted by an "inflation" technique (Klein et al., 1959) involving the multiple correlation coefficient and the mean value of wind speed for each particular station and forecast valid time.

The results for all 90 stations combined are shown in Tables 4.2 and 4.3. In Table 4.2, the forecast direction MAE's reveal an advantage for the guidance that is 2° for the 18-h projection and 4° for both the 30- and 42-h projections. The speed MAE's, skill scores, and percents correct also are generally better for the guidance. The bias by category values in Table 4.2 and the contingency tables in Table 4.3, indicate the guidance overestimated winds stronger than 22 knots (i.e., categories 5, 6, and 7) for all three forecast projections, whereas the local forecasts underestimated speeds in these categories. We have noticed this characteristic of the guidance since the 1981-82 cool season. We think it is partly due to the implementation of new equations. Some of the overforecasting may also be related to LFM model errors in forecasting the movement and intensity of synoptic scale weather systems. Although the guidance was not developed to overforecast strong winds, this characteristic may actually be desirable.

Tables 4.4-4.7 show scores for the NWS Eastern, Southern, Central, and Western Regions, respectively. The regional comparisons generally have the same characteristics as for the entire group of stations, except the advantage of the guidance over the local forecasts varies from region to region. However, for all areas except the Eastern Region, the local speed MAE's were generally as good as, or better than, those for the 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 90 stations combined. The guidance had about 4%, 7%, and 5% fewer errors of 40° or more than did the local forecasts for the 18-, 30-, and 42-h projections, respectively.

The distribution of direction errors for each of the four regions are given in Tables 4.9-4.12. In general, these results are much like those in Table 4.8 except, once again, the advantage of the guidance over the local forecast differs in magnitude from region to region.

A comparison of overall MAE's and skill scores during the past 10 cool seasons for the 18- and 42-h guidance and local forecasts is presented in Figs. 4.1-4.4. The verification data throughout this period were relatively homogeneous; the number of stations varied only slightly from season to season, while the basic set of verification stations remained the same. The MAE's and skill scores in these figures reveal the consistent superiority of the early over the final guidance during the period when both were available.

The MAE's for direction are given in Fig. 4.1. For the most part, the guidance and local forecasts for both projections generally improved over the 8 years prior to the 1981-82 cool season. The scores deteriorated (especially for the 42-h projection) during the 1981-82 cool season, but they recovered somewhat during the 1982-83 cool season.

The MAE's for speed in Fig. 4.2 reveal that the accuracy of the final guidance forecast deteriorated after the introduction of inflation in July of 1975. We realized inflation would have this effect; however, previous wind speed verifications indicated the bias by category values of inflated forecasts were somewhat closer to 1.0 compared to the values of uninflated forecasts (Carter and Hollenbaugh, 1976). Despite the use of the inflation technique, the MAE's for the 18-h early guidance are generally as good as the 1973-74 and 1974-75 (pre-inflation) final guidance values. Of note is the consistent superiority of the early guidance forecasts over the local forecasts for the 18-h projection, as well as the increase in the MAE's during 1981-82 and their recovery during 1982-83.

Fig. 4.3 is a comparison of guidance and local skill scores computed on five (instead of seven) categories of wind speed; the fifth category included all speeds >22 knots. Of particular interest in Fig. 4.3 is the magnitude of the advantage in skill of the guidance over the locals for both projections. With the exception of the 18-h final guidance for 1978-79, the guidance outperformed the local forecasts throughout the entire period.

Fig. 4.4 shows a comparison of guidance and local skill scores computed on two categories; the first category contained all wind speeds ≤22 knots, while the second category included speeds >22 knots. In this manner, we attempted to assess more directly the skill of the guidance and local forecasts in predicting strong winds. Here again, the skill scores for the early guidance have been consistently superior to those for the local forecasts. However, the skill scores for the guidance deteriorated from 1981-82 to 1982-83, while those for the locals improved.

5. OPAQUE SKY COVER

During the 1982-83 cool season, the opaque sky cover forecasts were produced by the prediction equations described in Technical Procedures Bulletin No. 303 (National Weather Service, 1981b). These regional, generalized-operator equations used LFM model output and 0300 (1500) GMT surface observations to produce probability forecasts of the four categories of opaque sky cover, more commonly known as cloud amount, shown in Table 5.1. We converted the probability estimates to "best category" forecasts in a manner which produced good bias characteristics, that is, a bias value of approximately 1.0 for each category. The threshold technique described in Technical Procedures Bulletin No. 303 was used to obtain the best category forecast.

We compared the local forecasts with a matched sample of early guidance forecasts for the 90 stations listed in Table 4.1 for the 18-, 30-, and 42-h forecast projections from 0000 GMT. The local forecasts and the surface observations used for verification were converted from opaque sky cover amounts to the categories given in Table 5.1. Four-category (clear, scattered, broken, and overcast), forecast-observed contingency tables were prepared from the local and objective categorical predictions. Using these tables, we computed the percent correct, skill score, and bias by category.

The results for all stations combined are shown in Table 5.2. For all three projections, the guidance forecasts were superior to the local forecasts in terms of percent correct and skill score. Examination of the bias by category scores shows the guidance forecasts were better (i.e., closer to 1.0) than the locals for each projection and category. The local forecasts exhibited a tendency to underforecast the clear and overcast categories, and overforecast the scattered and broken categories.

The verification scores for stations in the NWS Eastern, Southern, Central, and Western Regions are given in Tables 5.3-5.6, respectively. In the regional breakdown, except for the 18-h forecasts for the Western Region, the percents correct, skill scores, and bias by category values for the guidance forecasts were generally better than those for the local forecasts.

Percents correct and skill scores for the past nine cool seasons are shown in Figs. 5.1 and 5.2, respectively, for the 18- and 42-h projections. The figures show that for 1982-83 both guidance and local forecasts improved over those for the previous year.

Figs. 5.3-5.6 show bias values for categories 1 through 4, respectively, for the 18-h forecasts.[3] The local forecast biases for all four categories, with some minor fluctuations, have remained relatively constant over the years. The graphs also show that the locals tend to underforecast the clear and overcast categories, and overforecast the scattered and broken categories. Over the years, the biases for the guidance have been superior to those for the local forecasts.

6. CEILING AND VISIBILITY

During the 1982-83 cool season, the ceiling and visibility guidance was produced by the prediction equations described in Technical Procedures Bulletin No. 303 (National Weather Service, 1981b). Operationally, the guidance was based primarily on LFM model output and 0300 (1500) GMT surface observations.

Verification scores were computed for both local and guidance forecasts for the 90 stations listed in Table 4.1. Persistence based on an observation taken at 0900 GMT for the 0000 GMT forecast cycle and at 2100 (or 2200) GMT for the 1200 GMT forecast cycle was used as a standard of comparison. The objective forecasts were verified for both cycles for the 12-, 18-, 24-, 36-, and 48-h projections. The local forecasts were verified for the 12-, 15-, and 21-h projections from 0000 and 1200 GMT. On a daily basis, the guidance

[3]In many of our past verification reports (e.g., Schwartz et al., 1981), the bias by category graphs were plotted on a linear scale. Here, the bias graphs are plotted on a semi-log scale. The reason for the change is because we think that biases of X and 1/X are equally bad. For example, forecasting an event four times as often as it occurred should appear as bad as forecasting that event only one-fourth as many times as it occurred.

and persistence observations usually were available in time for preparation of the local forecasts.

We constructed forecast-observed contingency tables for the six categories given in Table 6.1 for all the forecasts involved in the comparative verification. These categories were used for computing several different scores: bias by category, percent correct, and skill score. We then collapsed the tables to two categories (categories 1 and 2 combined versus categories 3 through 6 combined) and calculated the bias and the threat score[4] for categories 1 and 2 combined. Skill score and percent correct also were calculated for the two-category contingency tables. We have summarized the results in Tables 6.2-6.9. Skill scores and bias values for categories 1 and 2 combined for the past eight cool seasons are also shown in Figs. 6.1-6.8 for selected projections from 0000 GMT.

The scores in Tables 6.2-6.5 for the 12-h projections from 0000 and 1200 GMT indicate the skill of the local ceiling and visibility forecasts did not exceed the skill of persistence, but did exceed the skill of the guidance. With the exception of the visibility forecasts for the 15-h projection, the local forecasts of ceiling and visibility had higher skill scores than persistence for the 15- and 21-h projections for both forecast cycles. For the 18-, 24-, 36-, and 48-h projections, the guidance usually outperformed persistence by a wide margin in terms of skill score. Also, for the 12-h projection (actually a 3-h projection for both the local and persistence forecasts, and a 9-h projection for the guidance), the bias values for persistence generally were better than those for both the locals and the guidance.

Tables 6.6-6.9 show comparative verification results for the two-category ceiling and visibility forecasts. The relative frequency of ceiling less than 500 feet and visibility less than 1 mile ranged from 0.013 to 0.069. This fact, plus lower skill scores for the two-category tables as compared to the six-category tables, indicate these events are quite difficult to forecast. For the 12-h projection, the skill of the persistence ceiling and visibility forecasts exceeded the value for the local forecasts and was much better than the skill of the guidance. The persistence ceiling and visibility skill scores were superior to those for the 15-h local forecasts; however, for the 21-h projection, the local skill scores were generally better than those for persistence. For the 24-, 36-, and 48-h projections, the guidance ceiling and visibility skill scores were superior to those for persistence in all cases; however, for the 18-h projection, the persistence skill scores were better than those for the guidance, except for the 1200 GMT cycle visibility forecasts.

Figs. 6.1-6.8 are trend graphs for skill score and bias by category for selected projections of the 0000 GMT cycle, two-category ceiling and visibility forecasts (see footnote 3 for details about the format). Figs. 6.1-6.4 indicate that the early guidance skill scores for the 12-h projection have

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[4]Threat score = H/(F+0-H) where H is the number of correct forecasts of a category, and F and 0 are the number of forecasts and observations of that category, respectively.

remained about the same over the years, while skill scores for the 18-h forecasts have been variable. In particular, the 1982-83 ceiling and visibility guidance for the 18-h projection decreased in skill. Figs. 6.5-6.8 indicate the ceiling and visibility guidance overforecast categories 1 and 2. This appears to be the result of the new prediction equations and threshold values which were implemented during the 1981-82 cool season.

7. MAXIMUM/MINUMUM TEMPERATURE

The objective max/min temperature guidance for October 1982 through March 1983 was generated by the LFM-based regression equations described in Technical Procedures Bulletin No. 285 (National Weather Service, 1980a). The predictand data for these equations consisted of local calendar day max or min temperatures valid approximately 24, 36, 48, and 60 hours after the model initial data times of 0000 and 1200 GMT. The guidance was based on equations developed by stratifying archived LFM model forecasts, station observations, and the first two harmonics of the day of the year into seasons of 3-mo duration (Dallavalle et al., 1980). We defined fall as September-November, winter as December-February, and spring as March-May. Station observations taken 3 hours after initial model time were also included as predictors in many of the equations for the first two periods.

Since the automated max/min forecasts are valid for the local calendar day, the first period objective forecast of the max based on 0000 GMT model data is for the calendar day starting at the subsequent midnight. The max/min guidance for the other periods corresponds to specific calendar days in an analogous manner.

In prior verification reports (e.g., Schwartz et al., 1981), we compared the skill of the local max/min temperature forecasts with that of the objective guidance. However, the valid period of the local forecasts corresponds to a daytime max and a nighttime min, rather than a particular calendar day. This procedure of using a calendar day verifying observation generated a considerable amount of controversy. Because appropriate daytime max and nighttime min observations are not available for verification, the 1982 NWS Line Forecasters Technical Advisory Committee recommended that comparisons between local and objective max/min forecasts no longer be published. In this report, we have complied with this request; only the automated forecasts were verified and discussed. Eventually, with implementation of the new AFOS verification system, the required observations will be available and comparisons between the guidance and locals will be possible.

For the 1982-83 cool season, we verified both the 0000 and 1200 GMT cycle objective forecasts. Because a matched sample between the local forecasts and automated guidance was not required, the number of cases increased by approximately 55% from the previous cool season. Since the max/min verification statistics generally are based on stable samples, this relatively large change in the number of cases should not alter significantly the overall measures of accuracy. For the 1982-83 cool season, the mean algebraic error (forecast minus observed temperature), mean absolute error, and the number of absolute errors $\geq 10^{\circ}$F were computed for 87 stations (Table 2.1). For the 0000 GMT cycle, forecast projections of approximately 24 (max), 36 (min), 48 (max), and 60 (min) hours were verified; for the 1200 GMT cycle, forecasts of approximately 24 (min), 36 (max), 48 (min), and 60 (max) hours were verified.

For all stations combined, the results for 0000 and 1200 GMT are shown in Tables 7.1 and 7.6, respectively. Similarly, Tables 7.2-7.5 give the 0000 GMT verification scores for the Eastern, Southern, Central, and Western Regions, respectively. Tables 7.7-7.10 show analogous scores by NWS region for the 1200 GMT cycle.

In all regions and for all projections, the min temperature guidance exhibited a pronounced cold bias (negative algebraic error). Note in Tables 7.1 and 7.6 that for all stations combined this bias ranged from -1.1°F for the 24-h min to -2.2°F for the 60-h min. Although the cold bias in the min forecast was persistent from region to region, the negative algebraic errors were greatest in the Central Region. In fact, the bias in the Central Region (Tables 7.4 and 7.9) ranged from -1.4°F for the 24-h min to -3.1°F for the 60-h min. These large algebraic errors in the min forecasts were associated with large mean absolute errors.

The biases for the max guidance tended to be much smaller than for the min forecasts. However, in the Eastern Region, the max forecasts also had a cold bias except for the 24-h projection. In contrast, the max guidance in the Western Region had a warm bias at all projections. The verifications for all stations combined indicate that for the same projection the min temperature was much more difficult to predict than the max. As an example, the mean absolute error for the 24-h projection of the min was 3.8°F; for the max, the error was 3.2°F. For the four projections combined, the MAE's of the min guidance averaged 0.5°F more than the corresponding errors for the max. This trend in the relative difficulty of forecasting the max or min temperature was evident in the scores for nearly all four regions and all projections, but it was most pronounced in the results for the Eastern and Central Regions. Overall, the greatest number of temperature forecasts with errors $\geq$10°F occurred for the 48-h min and the 60-h max/min.

In the past (e.g., Schwartz et al., 1981), we've found that the min is usually more difficult to forecast than the max during the cool season. This difference in predictability is likely due to the effects of mesoscale phenomena on nighttime cooling. Factors such as drainage winds, soil moisture, low-level stratus, and snow cover influence the minimum temperature, yet the LFM model lacks the vertical and horizontal resolution to predict these features. The winter of 1982-83 was somewhat out of the ordinary, however, because of the unusually large errors in the min guidance. The cold bias in the MOS guidance may be a result of the exceptionally warm winter of 1982-83 which ranked as the fifth warmest over the entire United States since 1931. It appears that the MOS forecast equations, which were developed from a series of relatively cold winters in the mid and late 1970's, were unable to account for last winter's warmer than normal conditions.

Max temperature forecast MAE's for the 0000 GMT cycle during the last 12 cool seasons are shown in Fig. 7.1. The final guidance, based on output from the coarse-mesh primitive equation model (Shuman and Hovermale, 1968) or the Spectral model (Sela, 1980), was ended in December 1980 because of poor performance relative to the LFM-based early guidance. Local forecast errors were not plotted for the 1981-82 and 1982-83 cool seasons. It is evident that the max temperature forecasts have improved considerably over the period of record. From the 1971-72 to the 1982-83 cool season, the guidance improved by 1.5°F and 1.3°F at the 24- and 48-h projections, respectively. In fact, the smallest errors yet recorded were seen in the 1982-83 cool season. Note that a large improvement occurred in the guidance during the 1973-74 cool season when MOS equations were first used (Klein and Hammons, 1975). Improvements in the early guidance coincided with the introduction of LFM-based equations prior to the 1978-79 cool season (Carter et al., 1979) and with the use of 3-mo LFM equations during the 1980-81 cool season (Dallavalle et al., 1980).

An analogous time series is shown in Fig. 7.2 for the min forecasts from 0000 GMT. Again, no results are available for the local forecasts for the 1981-82 and 1982-83 cool seasons. Also, verifications for the 60-h projection are shown only for the last six cool seasons. Natural variability and the difficulty of predicting the min during the cool season result in highly irregular error curves. Nevertheless, there has been an overall improvement in the min forecasts during the period of record. The greatest improvement in the 36-h guidance coincided with the introduction of 3-mo PE-based equations prior to the 1975-76 cool season (Hammons et al., 1976). Analogously, the 60-h guidance improved with the use of 3-mo LFM-based equations during the 1980-81 cool season (Dallavalle et al., 1980). Ironically, while the max temperature forecasts were very accurate during the 1982-83 cool season, some of the largest errors in the min guidance over the last four seasons occurred during 1982-83. We've already mentioned that the winter was abnormally warm. Also, numerous changes have been made to the LFM model over the past few years (e.g., National Weather Service, 1981a). These changes may have modified some of the systematic biases in the model. Furthermore, if the changes had a strong effect on the moisture fields, then the MOS minimum temperature equations, which frequently use the mean relative humidity or precipitable water as predictors, would especially be affected.

8. SUMMARY

Highlights of the 1982-83 cool season verification results, summarized by general type of weather element are:

- Probability of Precipitation - The comparative verification involved 87 stations and forecast projections of 12-24, 24-36, and 36-48 hours from both 0000 and 1200 GMT. The NWS Brier scores for all stations combined for 0000 GMT indicate the local forecasts for all three periods were better than the corresponding LFM-based guidance. For 1200 GMT, the local forecasts were as good as, or better than, the guidance for all three periods. Improvements of locals over guidance ranged from 5.6% for the first period 0000 GMT cycle to 0.1% for the third period 1200 GMT cycle. Although we do not have scores for the local forecasts for 1981-82 due to loss of data, it appears both local and guidance 0000 GMT first-period forecasts maintained about constant skill over the past 4 years, while there was a gradual decline in the skill of the third-period forecasts over that period.

o Precipitation Type - Local and guidance forecasts for 61 stations and projections of 18, 30, and 42 hours from 0000 GMT comprised the comparative verification; only those cases where the local PoP was $\geq$30% were verified. The guidance for the 1982-83 cool season was produced by a new set of prediction equations. In terms of percent correct and Heidke skill score, the results for all stations combined indicate the local forecasts were better than the guidance for the 18-h projection, while guidance forecasts were better than the local forecasts for the 42-h projection; there was very little difference at 30 hours. Except for the 18-h local forecasts, the skill scores for both the guidance and locals have decreased since the cool season of 1980-81.

o Surface Wind - The wind verification study was conducted for 90 stations and forecast projections of 18, 30, and 42 hours from 0000 GMT. While the overall results indicated the surface wind direction and speed guidance was more accurate than the locals, we noticed a tendency for the guidance to overforecast the occurrence of strong winds. Most of the scores for both the guidance and local forecasts improved over those for the previous cool season.

o Opaque Sky Cover - Verfication results for all 90 stations combined indicate the 0000 GMT cycle guidance was better than the local forecasts in terms of percent correct, skill score, and bias by category (clear, scattered, broken, and overcast) for all three projections of 18, 30, and 42 hours. In comparison to the previous cool season, the scores for the local and guidance forecasts generally improved. Consistent with past records, the verification also shows that local forecasters had a tendency to overforecast the scattered and broken categories while underforecasting the clear and overcast categories.

o Ceiling and Visibility - The verification involved comparison of local forecasts, LFM-based guidance, and persistence forecasts for 90 stations, and for projections ranging from 12 to 48 hours from both 0000 and 1200 GMT. However, direct comparison of local, MOS, and persistence forecasts was possible only for the 12-h projection. This projection is actually a 3-h forecast from the latest available surface observation for the local and persistence forecasts, and in this sense it is a 9-h projection for the guidance. The 12-h projection verification scores for both ceiling and visibility indicate the persistence and local forecasts were superior to the guidance. In contrast, for the longer range projections, the local and guidance forecasts generally were much better than persistence. The 0000 GMT cycle trend graphs of skill score indicate the two-category ceiling and visibility early guidance for the 12-h projection has remained at about the same level of skill over the years.

o Maximum/Minimum Temperature - The objective max/min forecasts were verified for 87 stations in the conterminous United States for both the 0000 and 1200 GMT cycles. At 0000 (1200) GMT, the maximum temperature guidance was valid for calendar day periods approximately 24 (36) and 48 (60) hours in advance, while the minimum temperature forecasts were valid for calendar day periods approximately 36 (24) and 60 (48) hours after the initial model time. We found that the min temperature guidance had a pronounced cold bias (negative algebraic error) in all NWS regions and for all projections. The biases for the max guidance tended to be smaller than for the min. Moreover, the mean absolute errors for all stations combined indicated the min temperature was more difficult to predict than the max for the same projection. The max guidance during the 1982-83 cool season was the most accurate yet, while the min forecasts were the least accurate since the 1979-80 cool season. This latest cool season was extraordinary because the 1982-83 winter ranked as the fifth warmest over the entire United States since 1931. It appears that the MOS forecast equations, which were developed from a series of relatively cold winters in the mid and late 1970's, were unable to account for last winter's warmer than normal conditions.

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

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

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

Projection (h)	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climate (%)	Number of Cases
12-24	Early	.0942		47.1	
(1st period)	Local	.0890	5.6	50.0	11020
24-36	Early	.1128		34.7	
(2nd period)	Local	.1117	1.1	35.4	11024
36-48	Early	.1243		29.6	
(3rd period)	Local	.1210	2.6	31.5	10936

Table 2.3. Same as Table 2.2 except for 25 stations in the Eastern Region.

Projection (h)	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climate (%)	Number of Cases
12-24	Early	.0992		50.6	
(1st period)	Local	.0963	2.9	52.0	2814
24-36	Early	.1127		43.4	
(2nd period)	Local	.1157	-2.6	41.9	2815
36-48	Early	.1314		34.1	
(3rd period)	Local	.1303	0.8	34.6	2790

Table 2.4. Same as Table 2.2 except for 24 stations in the Southern Region.

Projection (h)	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climate (%)	Number of Cases
12-24	Early	.0842		53.5	
(1st period)	Local	.0783	7.0	56.8	3112
24-36	Early	.1014		33.2	
(2nd period)	Local	.0997	1.7	34.3	3116
36-48	Early	.1105		36.7	
(3rd period)	Local	.1066	3.5	38.9	3089

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

Projection (h)	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climate (%)	Number of Cases
12-24	Early	.0875		43.7	
(1st period)	Local	.0842	3.7	45.8	3077
24-36	Early	.1165		32.0	
(2nd period)	Local	.1160	0.5	32.3	3075
36-48	Early	.1202		23.8	
(3rd period)	Local	.1182	1.6	25.1	3055

Table 2.6. Same as Table 2.2 except for 15 stations in the Western Region.

Projection (h)	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climate (%)	Number of Cases
12-24	Early	.1129		35.7	
(1st period)	Local	.1024	9.3	41.7	2017
24-36	Early	.1252		26.7	
(2nd period)	Local	.1180	5.7	30.9	2018
36-48	Early	.1419		19.8	
(3rd period)	Local	.1346	5.1	23.9	2002

Table 2.7. Comparative verification of early guidance and local PoP forecasts for 87 stations, 1200 GMT cycle.

Projection (h)	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climate (%)	Number of Cases
12-24	Early	.0996		42.6	
(1st period)	Local	.0952	4.4	45.1	10094
24-36	Early	.1099		38.0	
(2nd period)	Local	.1096	0.2	38.1	10089
36-48	Early	.1260		27.1	
(3rd period)	Local	.1259	0.1	27.2	10099

Table 2.8. Same as Table 2.7 except for 25 stations in the Eastern Region.

Projection (h)	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climate (%)	Number of Cases
12-24	Early	.0946		52.2	
(1st period)	Local	.0958	-1.3	51.6	2348
24-36	Early	.1140		43.5	
(2nd period)	Local	.1180	-3.4	41.5	2347
36-48	Early	.1233		37.9	
(3rd period)	Local	.1275	-3.4	35.8	2348

Table 2.9. Same as Table 2.7 except for 24 stations in the Southern Region.

Projection (h)	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climate (%)	Number of Cases
12-24	Early	.0969		37.0	
(1st period)	Local	.0926	4.4	39.8	2913
24-36	Early	.1005		43.7	
(2nd period)	Local	.0978	2.6	45.1	2907
36-48	Early	.1130		26.6	
(3rd period)	Local	.1122	0.7	27.2	2914

Table 2.10. Same as Table 2.7 except for 23 stations in the Central Region.

Projection (h)	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climate (%)	Number of Cases
12-24	Early	.1007		41.7	
(1st period)	Local	.0954	5.3	44.8	2900
24-36	Early	.1051		32.9	
(2nd period)	Local	.1059	-0.8	31.5	2903
36-48	Early	.1323		21.9	
(3rd period)	Local	.1318	0.4	22.2	2904

Table 2.11. Same as Table 2.7 except for 15 stations in the Western Region.

Projection (h)	Type of Forecast	Brier Score	Improvement Over Guidance (%)	Improvement Over Climate (%)	Number of Cases
12-24	Early	.1081		38.0	
(1st period)	Local	.0984	9.0	43.6	1933
24-36	Early	.1263		29.6	
(2nd period)	Local	.1229	2.7	31.4	1932
36-48	Early	.1392		20.5	
(3rd period)	Local	.1356	2.6	22.5	1933

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

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

Table 3.2. Comparative verification of early PoPT guidance and local forecasts for 61 stations, 0000 GMT cycle. Only cases where the local PoP was ≥30% are included.

Projection (h)	Region (No. Stns)	Type of Forecast	Bias Snow	Bias Rain	Percent Correct	Skill Score	Number of Cases
18	Eastern (18)	Early	1.20	0.89	89.3	.769	
		Local	1.07	0.96	90.4	.785	261
	Southern (15)	Early	0.90	1.01	96.1	.743	
		Local	1.30	0.99	96.1	.760	155
	Central (17)	Early	1.06	0.95	89.5	.798	
		Local	1.02	0.99	89.5	.797	191
	Western (11)	Early	0.88	1.03	96.4	.867	
		Local	0.79	1.04	96.4	.863	138
	All Stations	Early	1.09	0.96	92.1	.813	
		Local	1.03	0.99	92.5	.817	745
30	Eastern (18)	Early	1.20	0.92	90.8	.801	
		Local	1.18	0.92	89.3	.767	261
	Southern (15)	Early	0.75	0.96	94.9	.648	
		Local	1.50	0.97	97.1	.785	137
	Central (17)	Early	0.99	0.90	80.2	.635	
		Local	1.05	0.89	80.7	.639	187
	Western (11)	Early	1.07	0.99	95.6	.795	
		Local	1.13	0.99	95.6	.794	135
	All Stations	Early	1.07	0.94	89.7	.758	
		Local	1.13	0.94	89.7	.755	720
42	Eastern (18)	Early	1.30	0.84	86.2	.712	
		Local	1.19	0.91	84.4	.658	269
	Southern (15)	Early	0.78	1.03	92.2	.538	
		Local	1.22	1.01	93.0	.619	115
	Central (17)	Early	1.15	0.81	82.8	.666	
		Local	1.05	0.97	84.0	.687	163
	Western (11)	Early	1.00	1.00	95.3	.806	
		Local	0.94	1.01	94.5	.768	128
	All Stations	Early	1.18	0.92	88.1	.737	
		Local	1.11	0.96	87.7	.717	675

Table 3.3. Comparative verification of early PoPT guidance and local forecasts for 61 stations, 0000 GMT cycle. Only those cases in which the locals and guidance differed, and the local PoP was $\geq$30%, are included.

Projection (h)	Type of Forecast	Percent Correct	Number of Cases
18	Early	46.7	60
	Local	51.7	
30	Early	44.8	67
	Local	44.8	
42	Early	49.2	65
	Local	44.6	

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

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

Table 4.2. Comparative verification of early guidance and local surface wind forecasts for 90 stations, 0000 GMT cycle.

		Direction		Speed													
								Contingency Table									
										Bias by Category							
Fcst. Proj. (h)	Type of Fcst.	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	1 (No. Obs)	2 (No. Obs)	3 (No. Obs)	4 (No. Obs)	5 (No. Obs)	6 (No. Obs)	7 (No. Obs)	No. of Cases
18	Early	27	7464	3.3	12.9	12.0	7523	.327	54.0	1.03	0.97	0.97	1.02	1.37	1.30	1.80	13681
	Local	29		3.4	13.2			.283	50.6	0.76 (5196)	1.16 (5067)	1.18 (2505)	1.05 (730)	0.68 (136)	0.68 (37)	0.70 (10)	
30	Early	31	4499	3.8	12.2	10.6	4576	.324	61.8	1.01	0.99	1.00	1.01	1.10	0.82	1.60	13550
	Local	35		4.0	12.4			.278	57.7	0.89 (7949)	1.20 (3815)	1.11 (1353)	0.95 (351)	0.67 (60)	0.59 (17)	0.20 (5)	
42	Early	36	7215	4.0	13.1	11.6	7287	.232	47.3	0.99	0.98	1.00	1.09	1.51	1.62	2.78	13567
	Local	40		3.9	12.8			.199	45.6	0.82 (5149)	1.20 (5041)	1.04 (2475)	0.82 (722)	0.64 (134)	0.46 (37)	0.44 (9)	

Table 4.3. Contingency tables for early guidance and local surface wind speed forecasts for 90 stations, 0000 GMT cycle.

18-h Forecasts

		Guidance							
		1	2	3	4	5	6	7	T
	1	3567	1385	210	33	1	0	0	5196
	2	1594	2505	823	123	18	3	1	5067
	3	177	912	1050	298	56	10	2	2505
OBS	4	10	106	298	231	69	13	3	730
	5	3	5	30	50	28	15	5	136
	6	0	2	6	10	12	4	3	37
	7	0	0	1	0	2	3	4	10
	T	5351	4915	2418	745	186	48	18	13681
		Local							
		1	2	3	4	5	6	7	T
	1	2774	2079	303	38	2	0	0	5196
	2	1049	2759	1113	140	5	1	0	5067
	3	128	909	1148	293	21	6	0	2505
OBS	4	12	109	346	224	36	3	0	730
	5	0	11	41	56	16	9	3	136
	6	1	1	6	12	11	5	1	37
	7	0	0	0	4	2	1	3	10
	T	3964	5868	2957	767	93	25	7	13681

30-h Forecasts

		Guidance							
		1	2	3	4	5	6	7	T
	1	6228	1450	239	27	2	2	1	7949
	2	1572	1618	513	98	11	2	1	3815
	3	168	603	432	123	26	1	0	1353
OBS	4	23	80	149	80	14	3	2	351
	5	3	8	17	19	8	3	2	60
	6	0	0	3	6	4	3	1	17
	7	0	0	2	1	1	0	1	5
	T	7994	3759	1355	354	66	14	8	13550
		Local							
		1	2	3	4	5	6	7	T
	1	5517	2077	307	44	4	0	0	7949
	2	1379	1773	565	87	9	2	0	3815
	3	188	587	454	111	12	1	0	1353
OBS	4	16	107	153	66	7	2	0	351
	5	4	16	17	16	5	2	0	60
	6	1	0	5	7	2	2	0	17
	7	0	1	0	1	1	1	1	5
	T	7105	4561	1501	332	40	10	1	13550

42-h Forecasts

		Guidance							
		1	2	3	4	5	6	7	T
	1	3179	1571	334	56	8	1	0	5149
	2	1612	2221	963	194	41	8	2	5041
	3	263	963	833	317	78	17	4	2475
OBS	4	33	158	289	165	49	24	4	722
	5	5	15	38	42	18	7	9	134
	6	1	5	7	12	7	3	2	37
	7	0	2	1	1	1	0	4	9
	T	5093	4935	2465	787	202	60	25	13567
		Local							
		1	2	3	4	5	6	7	T
	1	2582	2101	416	44	5	1	0	5149
	2	1310	2625	933	160	11	2	0	5041
	3	285	1099	842	216	29	4	0	2475
OBS	4	44	218	306	124	25	5	0	722
	5	4	22	57	33	14	2	2	134
	6	0	6	13	14	1	2	1	37
	7	0	1	2	3	1	1	1	9
	T	4225	6072	2569	594	86	17	4	13567

Table 4.4. Same as Table 4.2 except for 23 stations in the Eastern Region.

Fcst. Proj. (h)	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 by Category: 1 (No. Obs)	2 (No. Obs)	3 (No. Obs)	4 (No. Obs)	5 (No. Obs)	6 (No. Obs)	7 (No. Obs)	No. of Cases
18	Early	26	2228	2.9	12.5	11.9	2245	.338	54.8	1.07	0.97	0.94	0.99	1.24	0.60	0.00	3823
	Local	28		3.3	13.3			.262	49.2	0.70 (1313)	1.14 (1511)	1.21 (763)	1.14 (200)	0.79 (29)	1.00 (5)	0.50 (2)	
30	Early	28	1286	3.6	11.9	11.0	1308	.351	63.8	1.05	0.98	0.81	0.87	1.27	0.50	1.00	3816
	Local	33		3.9	12.9			.312	58.4	0.84 (2229)	1.28 (1026)	1.14 (441)	1.03 (104)	1.64 (11)	1.00 (4)	0.00 (1)	
42	Early	32	2204	3.4	12.6	11.7	2223	.264	49.7	1.01	0.99	0.95	1.05	1.68	1.00	0.50	3795
	Local	37		3.6	12.8			.205	46.1	0.75 (1300)	1.21 (1503)	1.05 (758)	0.85 (199)	0.79 (28)	0.80 (5)	0.00 (2)	

Table 4.5. Same as Table 4.2 except for 22 stations in the Southern Region.

		Direction		Speed													
								Contingency Table									
										Bias by Category							
Fcst. Proj. (h)	Type of Fcst.	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	1 (No. Obs)	2 (No. Obs)	3 (No. Obs)	4 (No. Obs)	5 (No. Obs)	6 (No. Obs)	7 (No. Obs)	No. of Cases
18	Early	27	1956	3.3	12.8	11.9	1969	.311	52.6	1.09	0.95	0.85	1.17	2.00	3.33	***	3360
	Local	30		3.3	12.9			.248	49.1	0.65 (1122)	1.25 (1356)	1.10 (668)	0.98 (186)	0.36 (25)	0.33 (3)	* (0)	
30	Early	33	1003	3.9	12.1	10.0	1030	.325	63.2	0.98	0.97	1.09	1.47	2.40	**	*	3227
	Local	36		3.9	12.0			.257	57.8	0.85 (1981)	1.31 (900)	1.04 (288)	1.00 (53)	0.80 (5)	* (0)	* (0)	
42	Early	39	1875	4.1	13.1	11.5	1893	.169	42.7	1.05	0.94	0.94	1.15	1.92	6.33	****	3331
	Local	41		3.6	12.4			.140	42.6	0.76 (1110)	1.26 (1351)	0.98 (657)	0.68 (185)	0.20 (25)	0.33 (3)	* (0)	

*This category was neither forecast nor observed.
**This category was forecast once but was not observed.
***This category was forecast five times but was not observed.
****This category was forecast seven times but was not observed.

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

Fcst. Proj. (h)	Type of Fcst.	Direction		Speed													
								Contingency Table									
										Bias by Category							
		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	1 (No. Obs)	2 (No. Obs)	3 (No. Obs)	4 (No. Obs)	5 (No. Obs)	6 (No. Obs)	7 (No. Obs)	No. of Cases
18	Early	24	2482	3.2	13.3	12.5	2496	.322	52.4	1.12	0.91	0.96	0.94	1.34	1.28	1.86	4191
	Local	26		3.4	13.5			.274	49.2	0.82 (1333)	1.05 (1636)	1.20 (878)	1.01 (251)	0.82 (61)	0.72 (25)	0.86 (7)	
30	Early	28	1617	3.8	12.6	11.1	1634	.315	58.2	1.05	0.92	0.95	1.07	1.18	1.11	2.33	4196
	Local	31		3.8	12.4			.259	54.3	0.96 (2159)	1.07 (1366)	1.03 (486)	0.96 (140)	0.36 (33)	0.67 (9)	0.33 (3)	
42	Early	35	2487	4.0	13.6	12.0	2501	.222	45.2	1.05	0.93	0.96	1.09	1.64	1.42	2.83	4156
	Local	39		4.0	13.1			.171	42.7	0.83 (1321)	1.14 (1629)	1.03 (870)	0.94 (247)	0.85 (59)	0.46 (24)	0.67 (6)	

Table 4.7. Same as Table 4.2 except for 17 stations in the Western Region.

		Direction		Speed													
								Contingency Table									
										Bias by Category							
Fcst. Proj. (h)	Type of Fcst.	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	1 (No. Obs)	2 (No. Obs)	3 (No. Obs)	4 (No. Obs)	5 (No. Obs)	6 (No. Obs)	7 (No. Obs)	No. of Cases
18	Early	41	798	4.5	12.8	10.8	813	.278	57.5	0.85	1.21	1.48	0.99	0.86	0.75	0.00	2307
	Local	42		4.1	12.8			.281	58.0	0.86 (1428)	1.29 (564)	1.24 (196)	1.10 (93)	0.52 (21)	0.25 (4)	0.00 (1)	
30	Early	42	593	4.5	11.9	9.7	604	.273	63.0	0.91	1.19	1.61	0.67	0.09	0.25	0.00	2311
	Local	47		4.7	12.2			.255	62.7	0.93 (1580)	1.14 (523)	1.42 (138)	0.70 (54)	0.55 (11)	0.00 (4)	0.00 (1)	
42	Early	48	649	5.1	13.0	10.6	670	.214	54.2	0.87	1.17	1.53	1.04	0.45	0.40	0.00	2285
	Local	55		5.0	12.6			.195	54.5	0.92 (1418)	1.22 (558)	1.21 (190)	0.73 (91)	0.41 (22)	0.20 (5)	0.00 (1)	

Table 4.8. Distribution of absolute errors associated with early guidance and local forecasts of surface wind direction for 90 stations, 0000 GMT cycle.

Forecast Projection (h)	Type of Forecast	Percentage Frequency of Absolute Errors by Category					
		0-30°	40-60°	70-90°	100-120°	130-150°	160-180°
18	Early	76.0	15.3	4.5	2.0	1.3	1.0
	Local	72.1	17.6	5.1	2.4	1.7	1.1
30	Early	71.4	16.2	6.0	3.0	1.9	1.4
	Local	64.7	19.8	7.5	3.8	2.6	1.6
42	Early	64.3	19.6	7.5	4.0	2.7	1.9
	Local	59.6	21.3	8.3	4.9	3.5	2.4

Table 4.9. Same as Table 4.8 except for 23 stations in the Eastern Region.

Forecast Projection (h)	Type of Forecast	Percentage Frequency of Absolute Errors by Category					
		0-30°	40-60°	70-90°	100-120°	130-150°	160-180°
18	Early	76.2	17.3	4.0	1.5	0.6	0.4
	Local	72.0	19.8	4.4	2.1	0.9	0.7
30	Early	74.7	15.6	5.1	3.0	1.2	0.4
	Local	64.9	21.2	7.9	3.7	1.6	0.8
42	Early	67.6	20.2	6.6	3.2	1.5	1.0
	Local	61.8	22.9	7.7	3.6	2.4	1.6

Table 4.10. Same as Table 4.8 except for 22 stations in the Southern Region.

Forecast Projection (h)	Type of Forecast	Percentage Frequency of Absolute Errors by Category					
		0-30°	40-60°	70-90°	100-120°	130-150°	160-180°
18	Early	74.4	17.1	4.7	2.0	0.9	0.9
	Local	70.9	18.7	6.1	1.8	1.7	0.8
30	Early	68.4	17.2	7.3	3.2	2.2	1.7
	Local	62.7	20.7	7.1	4.7	3.8	1.0
42	Early	61.1	21.1	8.7	4.3	2.9	1.9
	Local	57.7	21.8	9.7	5.1	3.5	2.3

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

Forecast Projection (h)	Type of Forecast	Percentage Frequency of Absolute Errors By Category					
		0-30°	40-60°	70-90°	100-120°	130-150°	160-180°
18	Early	81.7	11.3	3.5	1.7	1.2	0.6
	Local	77.0	14.5	4.2	2.1	1.4	0.8
30	Early	75.1	15.6	4.2	2.2	1.4	1.5
	Local	69.8	17.7	6.4	2.9	1.7	1.5
42	Early	66.6	18.1	6.3	4.0	3.3	1.7
	Local	61.9	20.3	7.2	4.8	3.7	2.1

Table 4.12. Same as Table 4.8 except for 17 stations in the Western Region.

Forecast Projection (h)	Type of Forecast	Percentage Frequency of Absolute Errors By Category					
		0-30°	40-60°	70-90°	100-120°	130-150°	160-180°
18	Early	61.4	17.5	8.1	4.5	4.4	4.0
	Local	60.0	18.5	7.3	5.4	4.6	4.1
30	Early	59.2	17.5	10.3	5.4	4.4	3.2
	Local	53.5	20.7	10.5	5.2	5.4	4.7
42	Early	53.5	19.3	11.6	6.0	4.5	5.2
	Local	49.0	18.2	10.5	8.6	6.9	6.8

Table 5.1. Definitions of the cloud amount categories used for the local forecasts of opaque sky cover. The same definitions were used for the guidance forecasts except category 1 included only 0 tenths of opaque sky cover, while category 2 included 1-5 tenths.

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

Table 5.2. Comparative verification of early guidance and local forecasts of four categories of opaque sky cover (clear, scattered, broken, and overcast) for 90 stations, 0000 GMT cycle.

Projection (h)	Type of Forecast	Bias by Category				Percent Correct	Skill Score	Number of Cases
		1	2	3	4			
18	Early	1.12	0.76	1.09	1.00	54.0	.372	13664
	Local	0.64	1.41	1.37	0.82	51.6	.354	
	No. Obs.	3469	2724	2632	4839			
30	Early	1.18	0.74	0.95	0.94	57.0	.369	13349
	Local	0.64	2.04	1.83	0.72	46.9	.289	
	No. Obs.	4718	1824	1582	5225			
42	Early	1.30	0.72	0.93	0.99	48.7	.296	13586
	Local	0.54	1.81	1.44	0.64	40.6	.219	
	No. Obs.	3420	2696	2625	4845			

Table 5.3. Same as Table 5.2 except for 23 stations in the Eastern Region.

Projection (h)	Type of Forecast	Bias by Category 1	2	3	4	Percent Correct	Skill Score	Number of Cases
18	Early	1.09	0.75	1.12	1.01	54.2	.362	3822
	Local	0.56	1.47	1.55	0.79	50.8	.338	
	No. Obs.	895	734	684	1509			
30	Early	1.16	0.74	0.83	1.00	59.0	.380	3822
	Local	0.69	1.93	1.83	0.76	49.3	.302	
	No. Obs.	1237	465	426	1694			
42	Early	1.24	0.63	0.93	1.07	50.1	.300	3799
	Local	0.50	1.79	1.46	0.71	42.8	.237	
	No. Obs.	881	720	690	1508			

Table 5.4. Same as Table 5.2 except for 22 stations in the Southern Region.

Projection (h)	Type of Forecast	Bias by Category 1	2	3	4	Percent Correct	Skill Score	Number of Cases
18	Early	1.09	0.74	1.07	1.05	57.0	.415	3347
	Local	0.74	1.52	1.31	0.71	52.2	.367	
	No. Obs.	998	684	644	1021			
30	Early	1.07	0.74	0.94	1.03	59.7	.394	3208
	Local	0.66	2.41	1.65	0.67	48.2	.303	
	No. Obs.	1401	413	362	1032			
42	Early	1.19	0.75	1.09	0.93	50.0	.321	3326
	Local	0.64	1.97	1.33	0.49	40.5	.223	
	No. Obs.	982	679	636	1029			

Table 5.5. Same as Table 5.2 except for 28 stations in the Central Region.

Projection (h)	Type of Forecast	Bias by Category				Percent Correct	Skill Score	Number of Cases
		1	2	3	4			
18	Early	1.24	0.77	1.10	0.93	53.2	.360	4183
	Local	0.52	1.39	1.38	0.89	51.9	.349	
	No. Obs.	950	875	784	1574			
30	Early	1.38	0.73	0.90	0.83	56.0	.354	4009
	Local	0.56	2.17	2.03	0.68	44.7	.263	
	No. Obs.	1274	557	453	1725			
42	Early	1.56	0.75	0.75	0.93	47.5	.279	4163
	Local	0.37	1.81	1.59	0.64	38.8	.190	
	No. Obs.	941	859	781	1582			

Table 5.6. Same as Table 5.2 except for 17 stations in the Western Region.

Projection (h)	Type of Forecast	Bias by Category				Percent Correct	Skill Score	Number of Cases
		1	2	3	4			
18	Early	1.05	0.79	1.07	1.04	51.0	.335	2312
	Local	0.80	1.18	1.20	0.92	51.7	.353	
	No. Obs.	626	431	520	735			
30	Early	1.11	0.74	1.17	0.94	51.8	.324	2310
	Local	0.65	1.57	1.75	0.75	45.0	.271	
	No. Obs.	806	389	341	774			
42	Early	1.16	0.74	0.99	1.03	46.4	.273	2298
	Local	0.70	1.59	1.31	0.67	40.5	.215	
	No. Obs.	616	438	518	726			

Table 6.1. Definitions of the categories used for guidance forecasts of ceiling height and visibility.

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

Table 6.2. Comparative verification of early guidance, persistence, and local ceiling height forecasts for 90 stations, 0000 GMT cycle.

Projection (h)	Type of Forecast	Bias by Category 1	2	3	4	5	6	Percent Correct	Skill Score
12	Early	1.19	1.21	0.86	0.94	1.04	1.00	60.4	.378
	Local	0.59	1.05	0.90	1.12	1.08	0.97	72.0	.563
	Persistence	0.85	0.89	0.94	0.95	1.01	1.03	74.9	.599
	No. Obs.	308	621	928	2099	2043	7557		
15	Local	0.39	0.67	0.74	1.21	1.21	0.97	65.5	.456
	Persistence	1.23	0.85	0.85	0.91	1.09	1.03	65.3	.444
	No. Obs.	212	648	1024	2184	1894	7602		
18	Early	0.88	1.18	0.84	0.97	1.09	1.00	62.7	.385
	Persistence	3.78	1.28	0.99	0.81	1.12	0.99	60.7	.357
	No. Obs.	69	429	880	2463	1853	7880		
21	Local	0.25	0.35	0.70	1.22	1.18	0.95	64.9	.400
	Persistence	5.00	1.66	1.25	0.92	1.00	0.95	57.8	.294
	No. Obs.	52	331	694	2151	2069	8262		
24	Early	1.24	1.32	0.87	0.92	0.93	1.03	64.9	.367
	Persistence	3.84	1.63	1.36	1.05	0.95	0.93	55.4	.247
	No. Obs.	68	337	641	1888	2191	8456		
36	Early	1.81	1.68	0.75	0.90	0.78	1.03	55.3	.295
	Persistence	0.84	0.88	0.93	0.95	1.02	1.04	46.3	.143
	No. Obs.	309	624	940	2103	2038	7562		
48	Early	1.41	1.34	0.94	0.94	0.85	1.04	60.1	.284
	Persistence	3.84	1.61	1.35	1.05	0.94	0.93	45.7	.086
	No. Obs.	68	341	644	1885	2204	8357		

Table 6.3. Same as Table 6.2 except for visibility, 0000 GMT cycle.

Projection (h)	Type of Forecast	Bias by Category 1	2	3	4	5	6	Percent Correct	Skill Score
12	Early	1.24	1.90	1.14	1.06	1.03	0.95	69.3	.305
	Local	0.63	1.30	0.84	1.45	1.57	0.92	73.6	.424
	Persistence	0.71	0.96	0.85	0.88	1.19	1.01	79.0	.487
	No. Obs.	371	200	784	955	1018	10161		
15	Local	0.44	0.66	0.47	1.14	1.33	1.02	68.7	.287
	Persistence	0.95	0.84	0.66	0.89	1.00	1.05	70.6	.311
	No. Obs.	278	230	1011	950	1210	9814		
18	Early	1.12	1.33	1.08	1.08	0.97	0.99	73.9	.276
	Persistence	2.83	1.18	0.89	1.16	1.21	0.96	71.1	.233
	No. Obs.	93	165	749	734	1002	10791		
21	Local	0.48	0.36	0.41	1.13	1.57	0.99	77.0	.240
	Persistence	5.02	1.42	1.07	1.44	1.40	0.92	71.3	.187
	No. Obs.	52	137	624	589	861	11231		
24	Early	1.06	1.34	1.07	1.03	1.02	0.99	79.0	.289
	Persistence	3.65	1.96	1.14	1.42	1.48	0.91	70.9	.163
	No. Obs.	72	99	590	598	821	11361		
36	Early	2.20	2.71	1.20	1.06	0.97	0.90	63.7	.227
	Persistence	0.71	0.94	0.84	0.90	1.21	1.01	64.4	.130
	No. Obs.	371	207	800	943	1009	10206		
48	Early	1.43	1.43	1.00	1.12	1.27	0.97	75.1	.215
	Persistence	3.65	1.87	1.14	1.38	1.50	0.91	66.5	.057
	No. Obs.	72	104	587	615	809	11066		

Table 6.4. Same as Table 6.2 except for ceiling height, 1200 GMT cycle.

Projection (h)	Type of Forecast	Bias by Category						Percent Correct	Skill Score
		1	2	3	4	5	6		
12	Early	1.44	1.38	0.95	0.95	0.98	1.00	67.2	.416
	Local	0.47	0.80	0.86	1.30	0.98	0.96	76.1	.582
	Persistence	0.81	0.94	1.03	1.13	0.94	0.99	77.0	.593
	No. Obs.	64	334	636	1844	2162	8441		
15	Local	0.34	0.84	0.84	1.38	0.86	0.98	70.4	.483
	Persistence	0.47	0.86	0.92	1.15	0.97	0.99	68.5	.445
	No. Obs.	110	368	714	1837	2145	8472		
18	Early	1.22	1.60	0.70	0.94	0.93	1.02	63.4	.376
	Persistence	0.31	0.68	0.82	1.15	0.97	1.03	63.2	.368
	No. Obs.	170	460	793	1818	2091	7996		
21	Local	0.28	0.95	0.95	1.39	0.83	0.98	62.0	.382
	Persistence	0.21	0.57	0.74	1.09	1.00	1.06	58.4	.298
	No. Obs.	252	550	871	1927	2050	7814		
24	Early	1.31	1.64	0.77	0.87	0.91	1.02	58.6	.343
	Persistence	0.18	0.51	0.71	1.02	1.02	1.10	54.8	.251
	No. Obs.	295	612	915	2055	1996	7481		
36	Early	1.24	1.44	0.93	0.91	0.88	1.04	62.4	.319
	Persistence	0.78	0.93	1.02	1.12	0.95	0.99	52.5	.160
	No. Obs.	67	342	641	1867	2150	8436		
48	Early	1.42	1.64	0.76	0.97	0.77	1.03	54.0	.272
	Persistence	0.17	0.51	0.69	1.02	1.01	1.11	44.6	.086
	No. Obs.	305	621	931	2057	2004	7435		

Table 6.5. Same as Table 6.2 except for visibility, 1200 GMT cycle.

Projection (h)	Type of Forecast	Bias by Category 1	2	3	4	5	6	Percent Correct	Skill Score
12	Early	1.23	1.38	0.97	1.03	0.98	1.00	80.6	.325
	Local	0.45	1.01	0.71	1.50	1.73	0.94	81.6	.432
	Persistence	0.83	1.24	1.09	1.02	1.47	0.96	84.0	.483
	No. Obs.	69	105	573	583	796	11295		
15	Local	0.43	1.23	0.98	1.76	1.72	0.91	78.0	.342
	Persistence	0.60	1.20	1.31	0.99	1.47	0.96	79.9	.343
	No. Obs.	93	108	483	599	805	11491		
18	Early	1.54	1.63	1.02	1.06	1.05	0.98	76.4	.287
	Persistence	0.36	0.87	1.19	0.87	1.37	0.98	76.7	.287
	No. Obs.	158	142	522	684	854	10927		
21	Local	0.39	1.46	1.19	1.95	1.53	0.88	68.4	.263
	Persistence	0.21	0.69	0.96	0.76	1.31	1.02	73.0	.225
	No. Obs.	261	178	649	782	899	10620		
24	Early	1.74	1.96	1.09	1.02	1.00	0.95	67.1	.261
	Persistence	0.16	0.61	0.79	0.64	1.19	1.07	68.5	.168
	No. Obs.	357	203	785	930	984	10054		
36	Early	1.75	1.42	1.06	1.12	1.06	0.98	76.6	.236
	Persistence	0.78	1.24	1.07	0.98	1.48	0.96	72.4	.126
	No. Obs.	73	105	578	606	791	11101		
48	Early	1.72	2.23	1.11	1.03	0.95	0.94	64.2	.203
	Persistence	0.16	0.59	0.78	0.64	1.18	1.07	64.6	.068
	No. Obs.	363	210	797	922	993	10027		

Table 6.6. Comparative verification for early guidance, persistence, and local ceiling height forecasts for 90 stations, 0000 GMT cycle. Scores are computed from two-category (categories 1 and 2 combined versus categories 3-6 combined) contingency tables.

Projection (h)	Type of Forecast	Rel. Freq. Cats. 1&2 combined	Bias Cats. 1&2 combined	Percent Correct	Skill Score	Threat Score
	Early		1.21	90.7	.339	.241
12	Local	0.069	0.89	94.7	.563	.419
	Persistence		0.87	95.2	.605	.460
	Local	0.063	0.60	93.7	.343	.230
15	Persistence		0.94	93.5	.442	.313
	Early	0.037	1.14	94.2	.225	.147
18	Persistence		1.63	93.4	.281	.186
	Local	0.028	0.34	96.9	.164	.096
21	Persistence		2.11	93.3	.203	.132
	Early	0.030	1.31	94.8	.220	.140
24	Persistence		2.00	93.1	.197	.129
	Early	0.069	1.72	86.6	.219	.167
36	Persistence		0.87	89.8	.156	.117
	Early	0.030	1.35	94.0	.124	.083
48	Persistence		1.98	91.8	.052	.047

Table 6.7. Same as Table 6.6 except for visibility, 0000 GMT cycle.

Projection (h)	Type of Forecast	Rel. Freq. Cats. 1&2 combined	Bias Cats. 1&2 combined	Percent Correct	Skill Score	Threat Score
	Early		1.47	92.8	.278	.187
12	Local	0.042	0.86	96.7	.562	.408
	Persistence		0.80	97.0	.586	.430
	Local	0.038	0.54	96.1	.317	.201
15	Persistence		0.90	95.7	.372	.245
	Early	0.019	1.26	96.5	.161	.098
18	Persistence		1.77	95.8	.190	.117
	Local	0.014	0.40	98.3	.129	.073
21	Persistence		2.40	95.9	.119	.073
	Early	0.013	1.22	97.6	.141	.083
24	Persistence		2.67	95.9	.108	.066
	Early	0.043	2.38	88.8	.173	.126
36	Persistence		0.79	93.7	.142	.095
	Early	0.013	1.43	96.9	.032	.024
48	Persistence		2.60	95.5	.029	.024

Table 6.8. Same as Table 6.6 except for ceiling height, 1200 GMT cycle.

Projection (h)	Type of Forecast	Rel. Freq. Cats. 1&2 combined	Bias Cats. 1&2 combined	Percent Correct	Skill Score	Threat Score
12	Early	0.030	1.39	95.1	.282	.181
	Local		0.74	97.5	.494	.340
	Persistence		0.92	97.6	.565	.406
15	Local	0.035	0.73	96.3	.362	.235
	Persistence		0.77	96.3	.392	.259
18	Early	0.047	1.50	92.1	.295	.201
	Persistence		0.58	95.0	.301	.194
21	Local	0.057	0.77	92.9	.282	.189
	Persistence		0.47	93.5	.221	.143
24	Early	0.068	1.53	88.6	.280	.205
	Persistence		0.40	92.2	.144	.097
36	Early	0.030	1.41	94.1	.159	.104
	Persistence		0.90	94.9	.097	.066
48	Early	0.069	1.57	87.0	.204	.157
	Persistence		0.40	91.1	.038	.039

Table 6.9. Same as Table 6.6 except for visibility, 1200 GMT cycle.

Projection (h)	Type of Forecast	Rel. Freq. Cats. 1&2 combined	Bias Cats. 1&2 combined	Percent Correct	Skill Score	Threat Score
12	Early	0.013	1.32	97.6	.191	.113
	Local		0.79	98.7	.411	.264
	Persistence		1.07	98.5	.447	.294
15	Local	0.015	0.86	97.9	.214	.127
	Persistence		0.93	97.9	.242	.145
18	Early	0.023	1.58	95.5	.197	.123
	Persistence		0.60	97.0	.165	.098
21	Local	0.033	0.82	95.7	.258	.163
	Persistence		0.41	95.9	.096	.060
24	Early	0.042	1.82	91.3	.224	.154
	Persistence		0.32	95.0	.076	.050
36	Early	0.013	1.56	96.9	.082	.051
	Persistence		1.05	97.4	.058	.037
48	Early	0.043	1.90	89.8	.136	.102
	Persistence		0.31	94.6	.025	.023

Table 7.1. Verification of the guidance max/min temperature forecasts for 87 stations, 0000 GMT cycle.

Forecast Projection (h)	Type of Forecast	Mean Algebraic Error (°F)	Mean Absolute Error (°F)	Number (%) of Absolute Errors ≥10°F	Number of Cases
24 (Max)	Early	0.7	3.2	515 (3.3)	15628
36 (Min)	Early	-1.3	4.2	1206 (7.7)	15623
48 (Max)	Early	-0.2	4.3	1402 (9.0)	15541
60 (Min)	Early	-2.2	5.4	2450 (15.8)	15536

Table 7.2. Same as Table 7.1 except for 25 stations in the Eastern Region.

Forecast Projection (h)	Type of Forecast	Mean Algebraic Error (°F)	Mean Absolute Error (°F)	Number (%) of Absolute Errors ≥10°F	Number of Cases
24 (Max)	Early	0.3	3.1	108 (2.4)	4500
36 (Min)	Early	-1.5	4.3	332 (7.4)	4500
48 (Max)	Early	-1.3	4.2	410 (9.2)	4475
60 (Min)	Early	-2.3	5.5	705 (15.8)	4475

Table 7.3. Same as Table 7.1 except for 24 stations in the Southern Region.

Forecast Projection (h)	Type of Forecast	Mean Algebraic Error (°F)	Mean Absolute Error (°F)	Number (%) of Absolute Errors ≥10°F	Number of Cases
24 (Max)	Early	0.9	3.3	174 (4.1)	4288
36 (Min)	Early	-1.1	4.0	290 (6.8)	4289
48 (Max)	Early	0.4	4.3	373 (8.7)	4264
60 (Min)	Early	-2.0	5.0	563 (13.2)	4265

Table 7.4. Same as Table 7.1 except for 23 stations in the Central Region.

Forecast Projection (h)	Type of Forecast	Mean Algebraic Error (°F)	Mean Absolute Error (°F)	Number (%) of Absolute Errors ≥10°F	Number of Cases
24 (Max)	Early	1.0	3.4	149 (3.6)	4140
36 (Min)	Early	-1.8	4.8	441 (10.7)	4135
48 (Max)	Early	-0.2	4.5	418 (10.2)	4117
60 (Min)	Early	-3.1	6.3	922 (22.4)	4112

Table 7.5. Same as Table 7.1 except for 15 stations in the Western Region.

Forecast Projection (h)	Type of Forecast	Mean Algebraic Error (°F)	Mean Absolute Error (°F)	Number (%) of Absolute Errors ≥10°F	Number of Cases
24 (Max)	Early	0.8	3.0	84 (3.1)	2700
36 (Min)	Early	-0.7	3.6	143 (5.3)	2699
48 (Max)	Early	0.7	4.0	201 (7.5)	2685
60 (Min)	Early	-1.2	4.4	260 (9.7)	2684

Table 7.6. Verification of the guidance max/min temperature forecasts for 87 stations, 1200 GMT cycle.

Forecast Projection (h)	Type of Forecast	Mean Algebraic Error (°F)	Mean Absolute Error (°F)	Number (%) of Absolute Errors $\geq 10°F$	Number of Cases
24 (Min)	Early	-1.1	3.8	849 (5.5)	15449
36 (Max)	Early	0.2	3.9	1058 (6.8)	15454
48 (Min)	Early	-1.9	4.9	1919 (12.4)	15449
60 (Max)	Early	-0.3	4.9	2024 (13.1)	15454

Table 7.7. Same as Table 7.6 except for 25 stations in the Eastern Region.

Forecast Projection (h)	Type of Forecast	Mean Algebraic Error (°F)	Mean Absolute Error (°F)	Number (%) of Absolute Errors ≥10°F	Number of Cases
24 (Min)	Early	-1.1	3.9	212 (4.8)	4450
36 (Max)	Early	-0.7	3.8	272 (6.1)	4450
48 (Min)	Early	-2.0	4.9	535 (12.0)	4450
60 (Max)	Early	-1.6	4.7	490 (11.0)	4450

Table 7.8. Same as Table 7.6 except for 24 stations in the Southern Region.

Forecast Projection (h)	Type of Forecast	Mean Algebraic Error (°F)	Mean Absolute Error (°F)	Number (%) of Absolute Errors ≥10°F	Number of Cases
24 (Min)	Early	-1.1	3.7	218 (5.1)	4241
36 (Max)	Early	0.2	4.1	315 (7.4)	4240
48 (Min)	Early	-1.9	4.7	476 (11.2)	4241
60 (Max)	Early	0.1	4.9	557 (13.1)	4240

Table 7.9. Same as Table 7.6 except for 23 stations in the Central Region.

Forecast Projection (h)	Type of Forecast	Mean Algebraic Error (°F)	Mean Absolute Error (°F)	Number (%) of Absolute Errors ≥10°F	Number of Cases
24 (Min)	Early	-1.4	4.2	308 (7.5)	4089
36 (Max)	Early	0.7	4.2	317 (7.7)	4094
48 (Min)	Early	-2.8	5.6	692 (16.9)	4089
60 (Max)	Early	-0.6	5.4	680 (16.6)	4094

Table 7.10. Same as Table 7.6 except for 15 stations in the Western Region.

Forecast Projection (h)	Type of Forecast	Mean Algebraic Error (°F)	Mean Absolute Error (°F)	Number (%) of Absolute Errors ≥10°F	Number of Cases
24 (Min)	Early	-0.7	3.4	111 (4.2)	2669
36 (Max)	Early	1.0	3.7	154 (5.8)	2670
48 (Min)	Early	-0.6	4.1	216 (8.1)	2669
60 (Max)	Early	1.4	4.6	297 (11.1)	2670

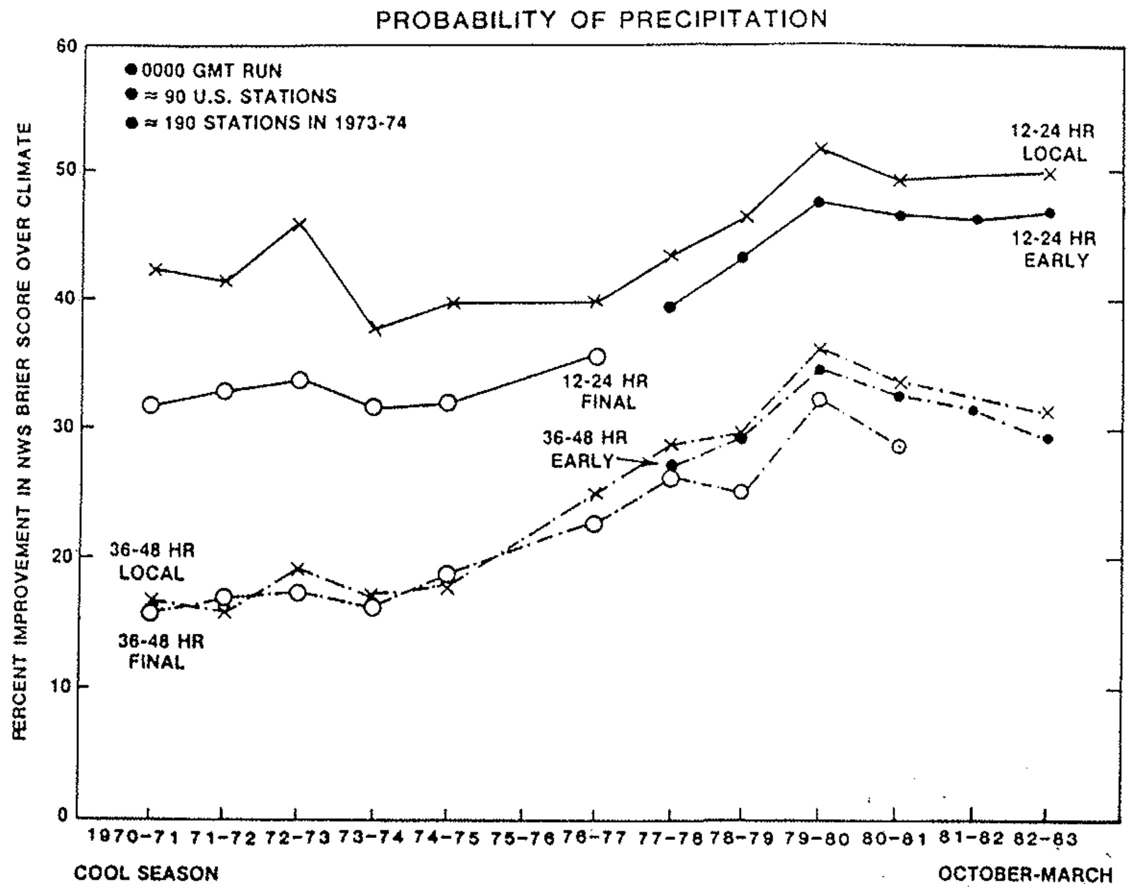

Figure 2.1. Percent improvement over climate in the Brier score of the local and the early and final guidance PoP forecasts. Results for 1975-76 (final and local) and 1981-82 (local) are unavailable because of missing data.

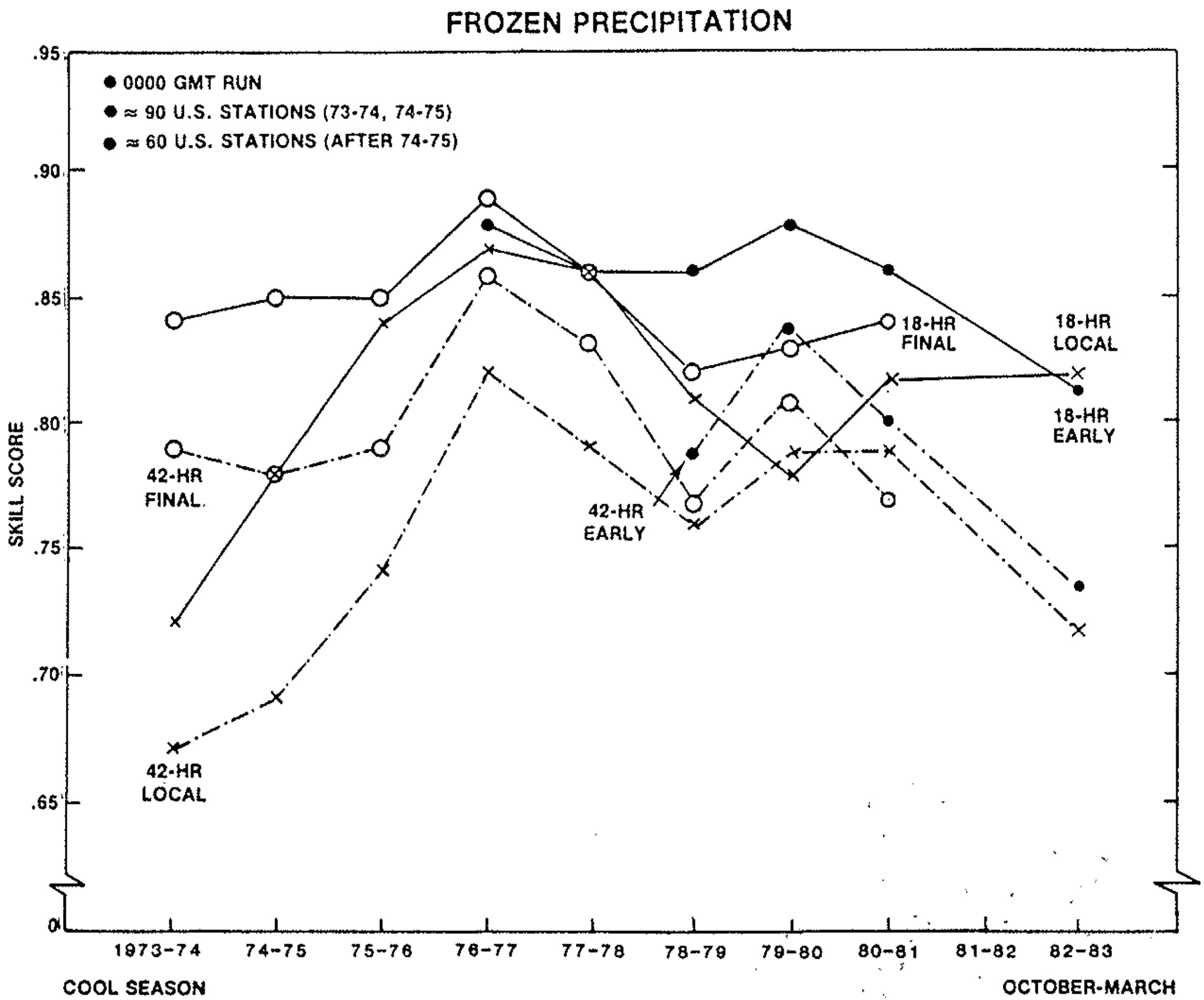

Figure 3.1. Skill score for the local and the early and final guidance frozen precipitation forecasts. Results for 1981-82 (early and local) are unavailable because of missing data.

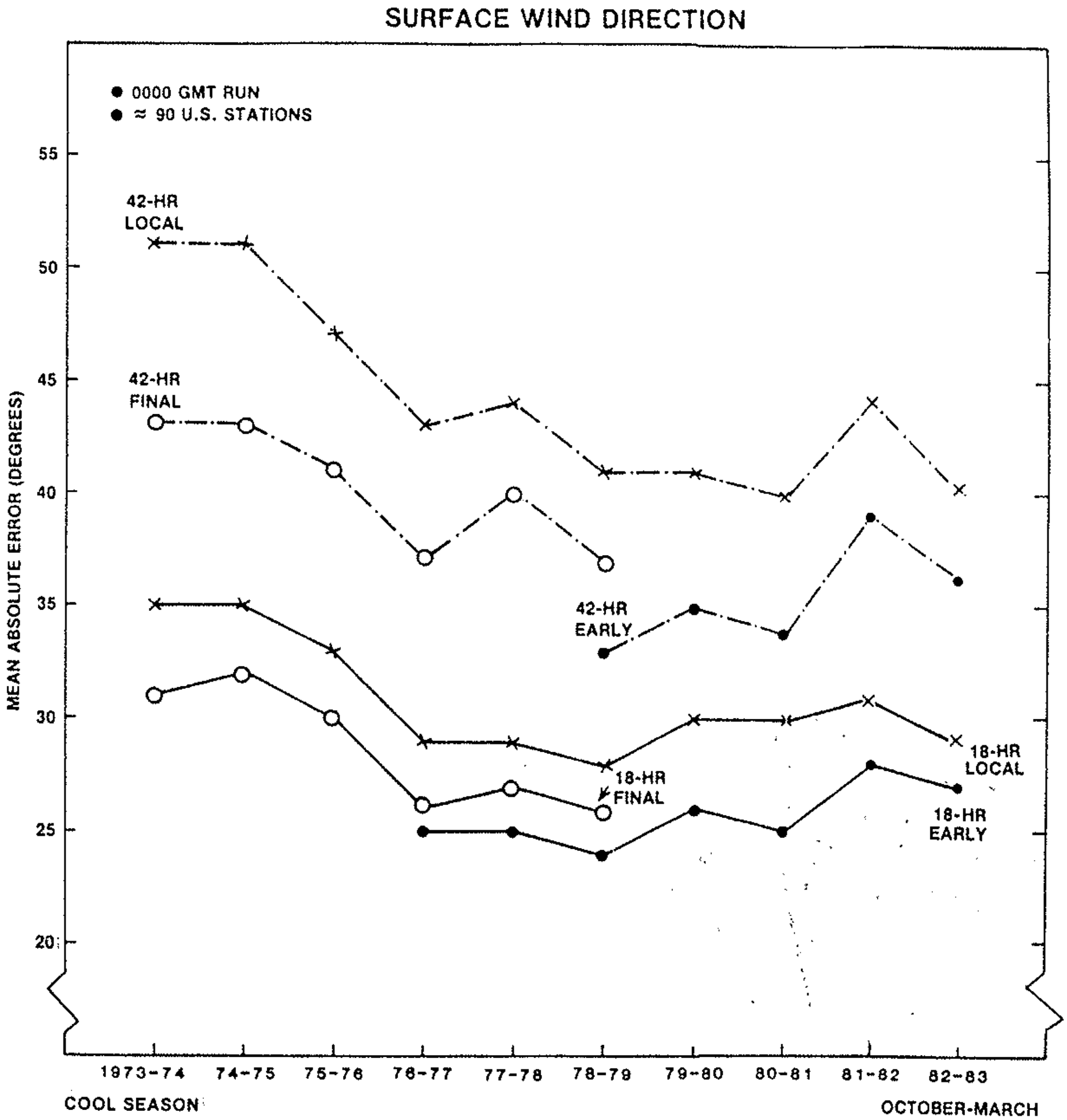

Figure 4.1. Mean absolute error for the local and the early and final guidance surface wind direction forecasts.

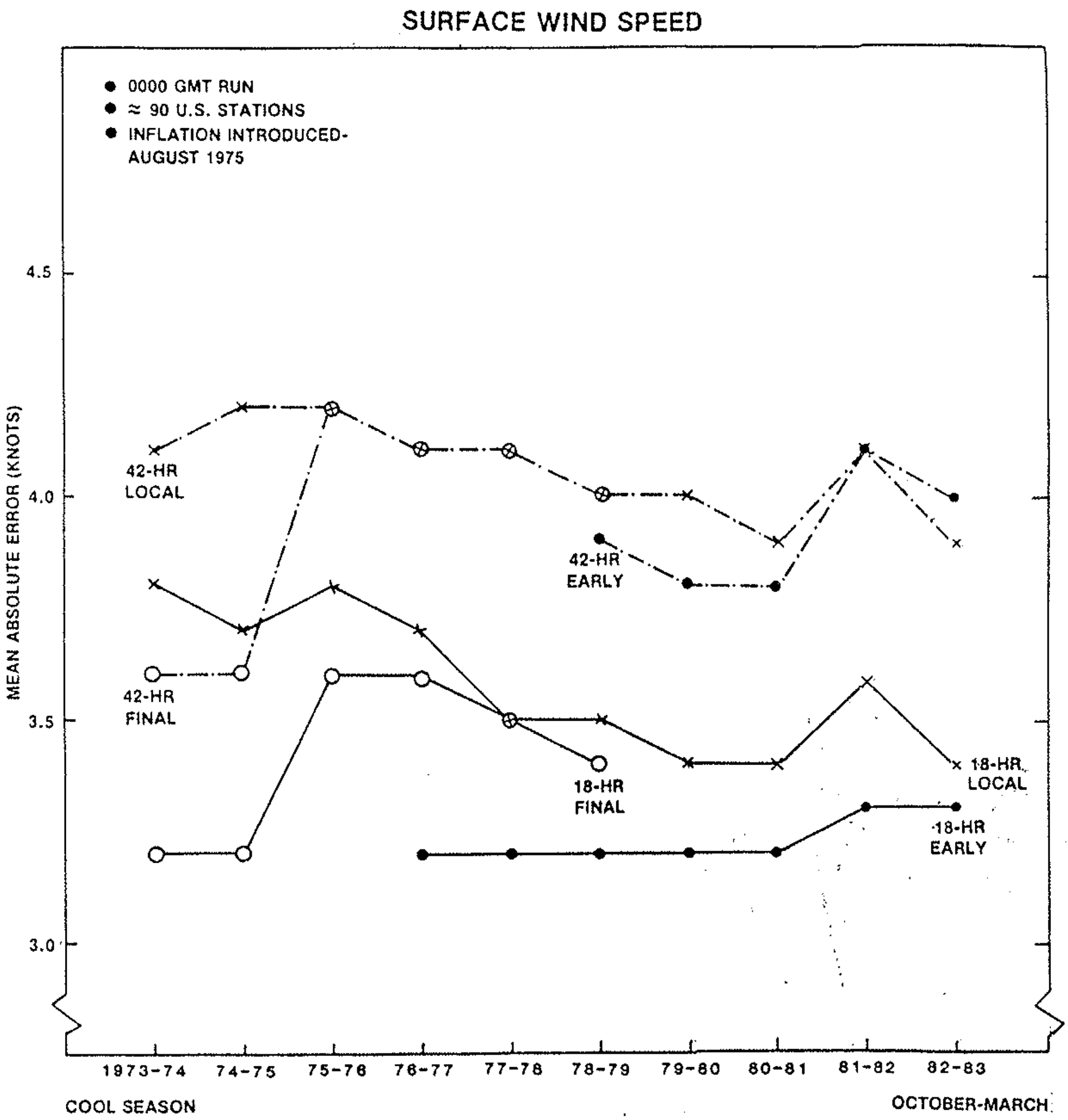

Figure 4.2. Same as Fig. 4.1 except for surface wind speed.

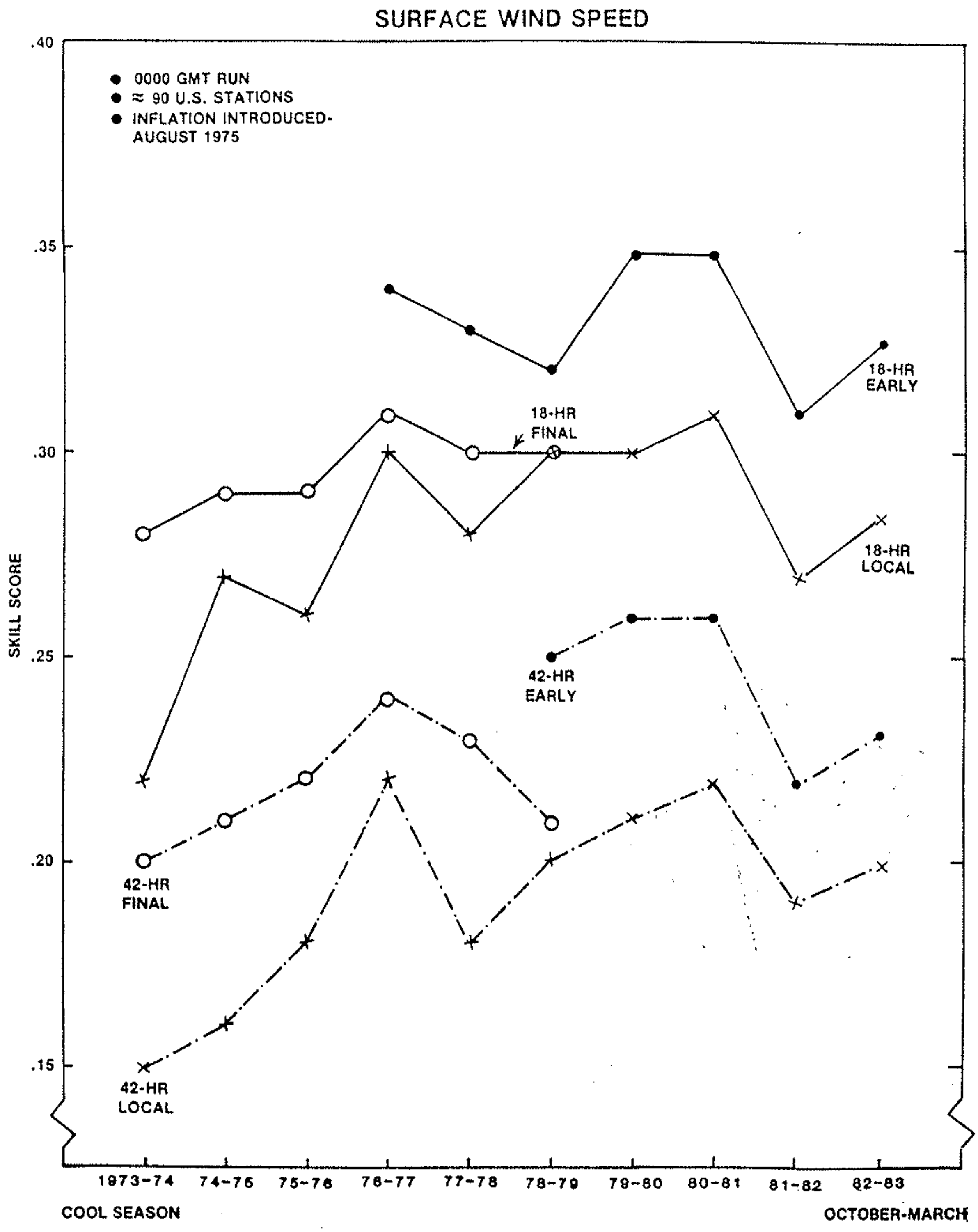

Figure 4.3. Skill score computed from five-category contingency tables for the local and the early and final guidance surface wind speed forecasts.

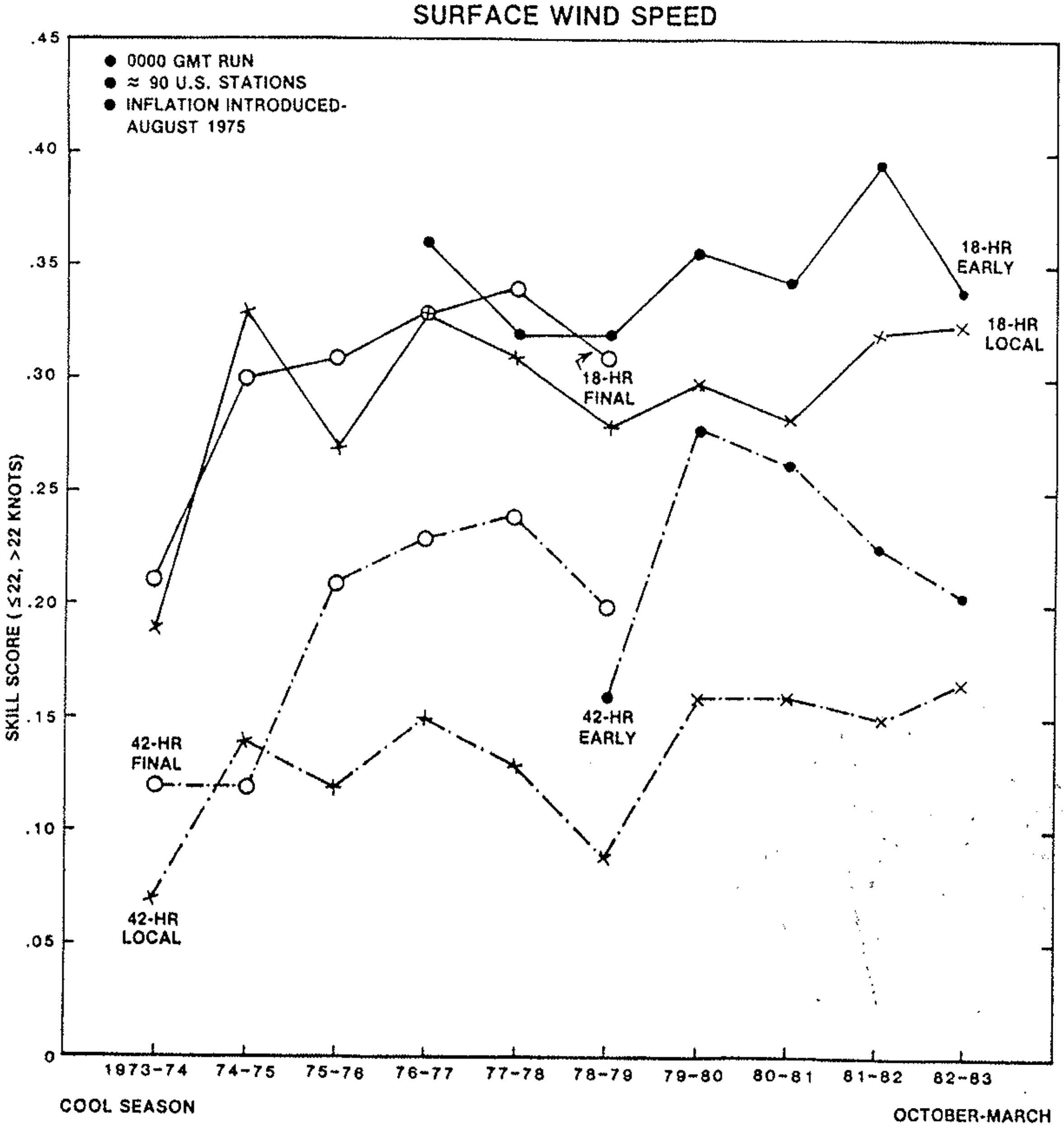

Figure 4.4. Same as Fig. 4.3 except for two-category contingency tables.

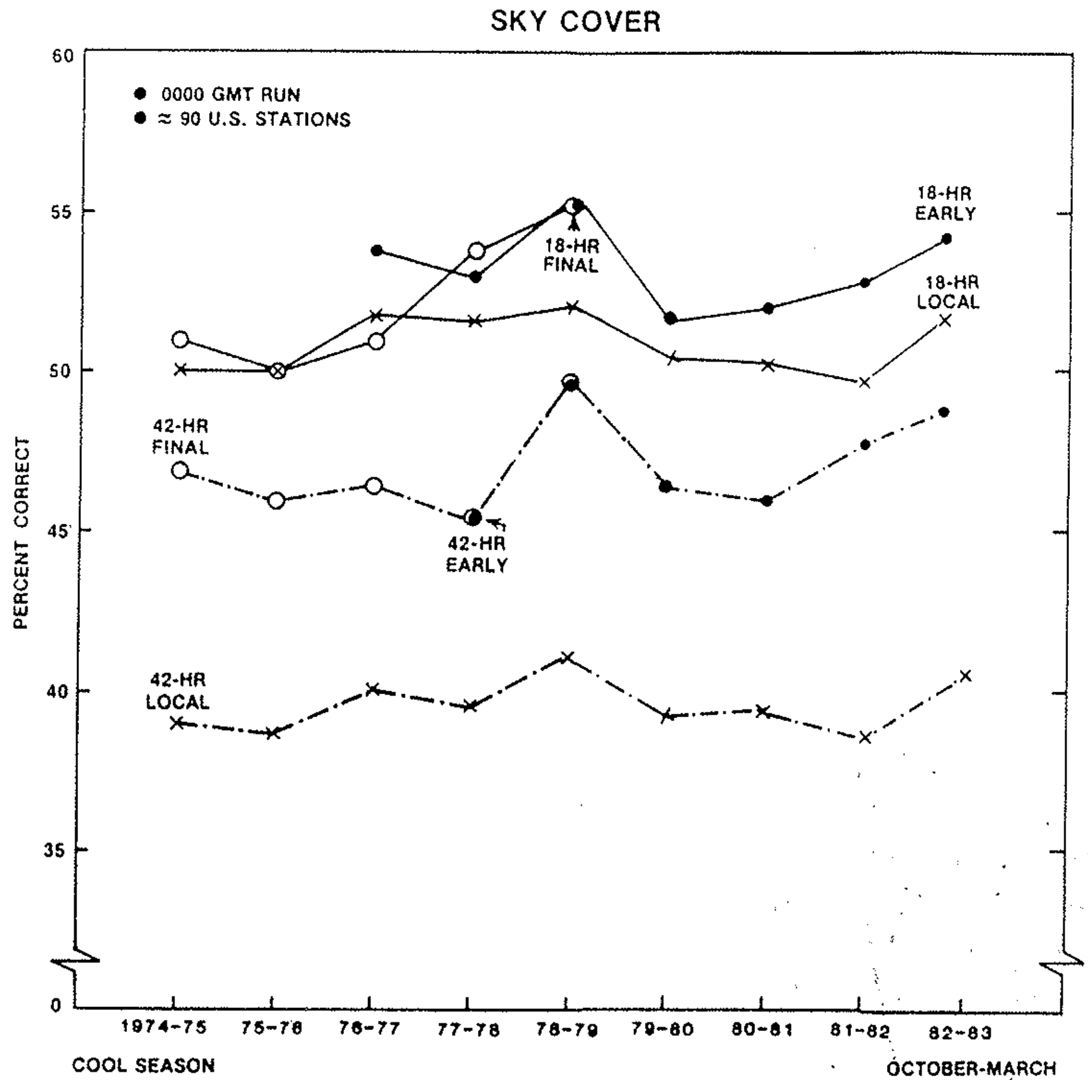

Figure 5.1. Percent correct for the local and the early and final guidance opaque sky cover forecasts.

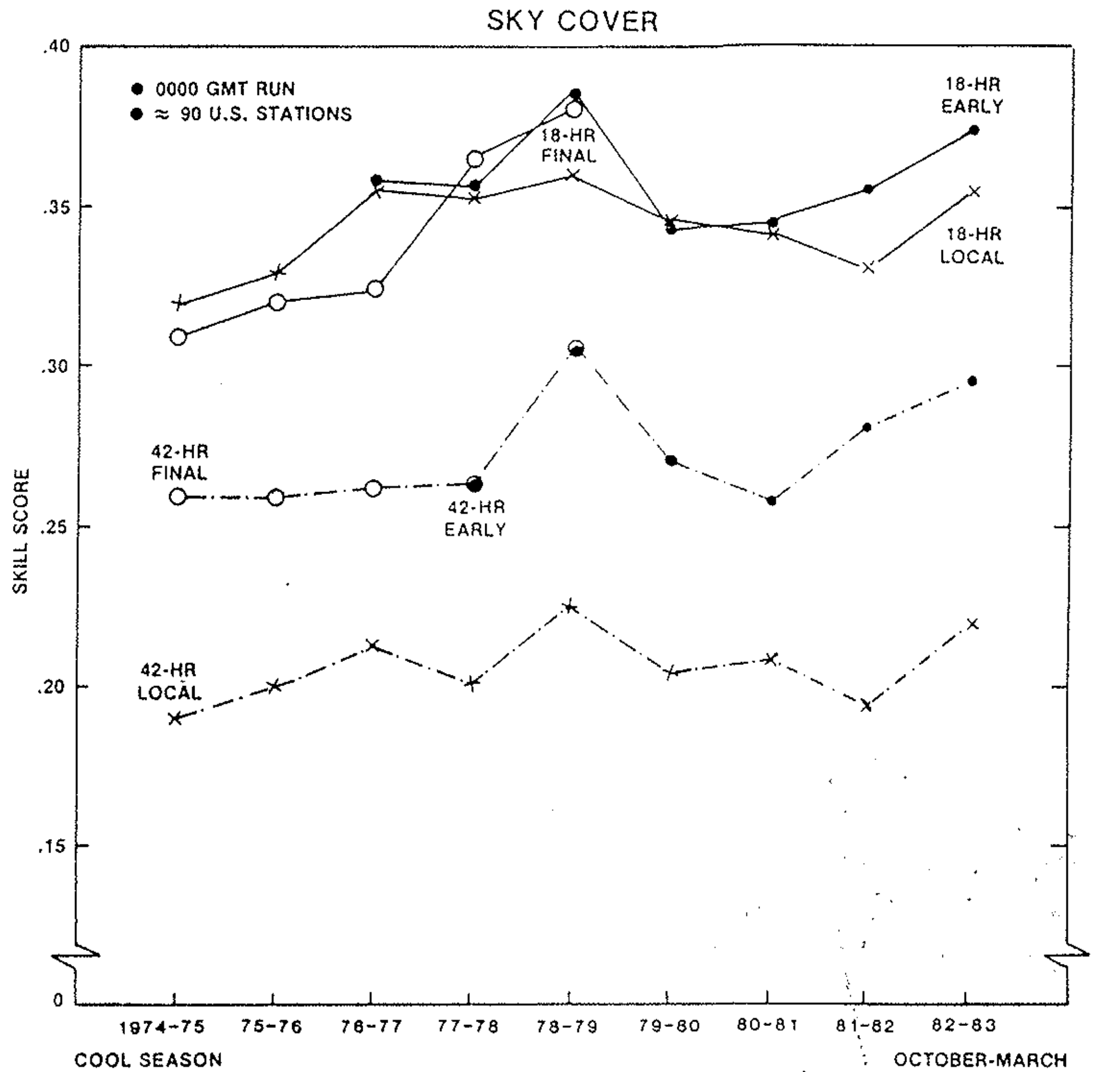

Figure 5.2. Skill score for the local and the early and final guidance opaque sky cover forecasts.

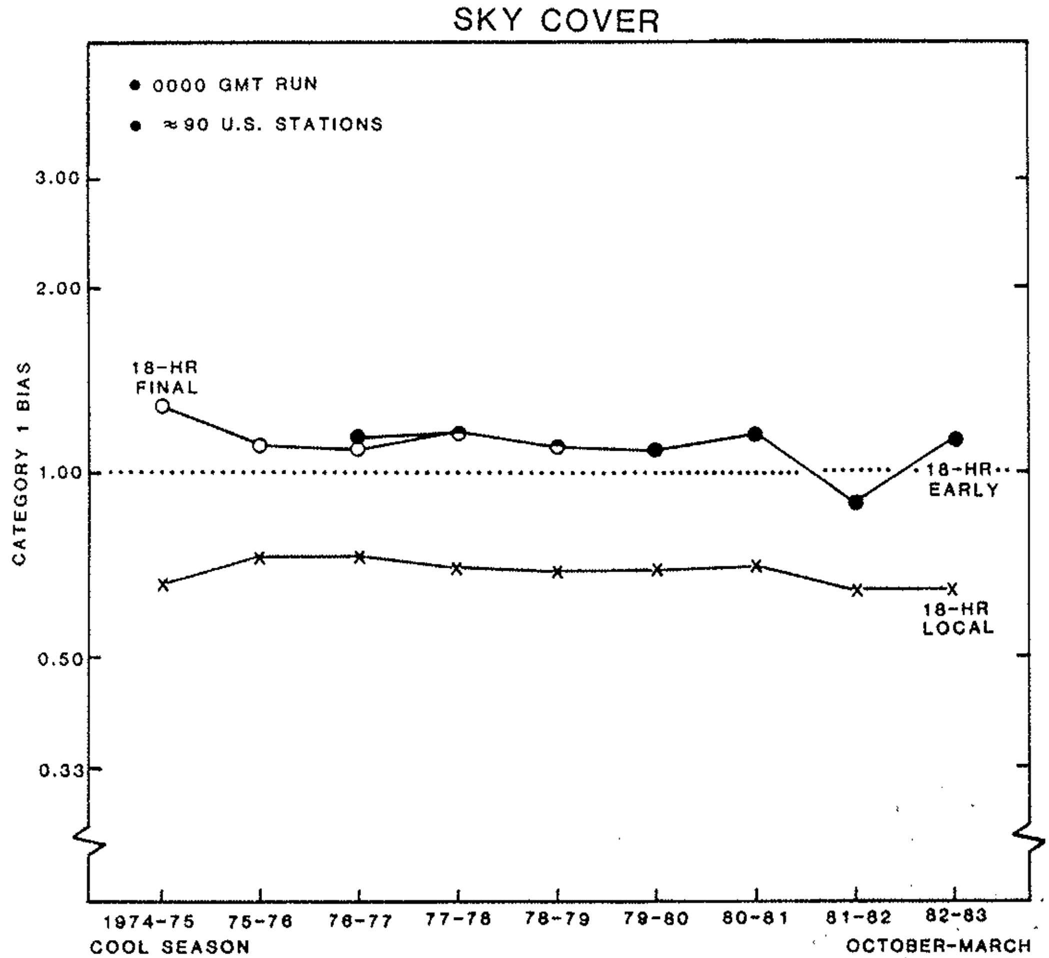

Figure 5.3. Category 1 bias for the local and the early and final guidance opaque sky cover forecasts.

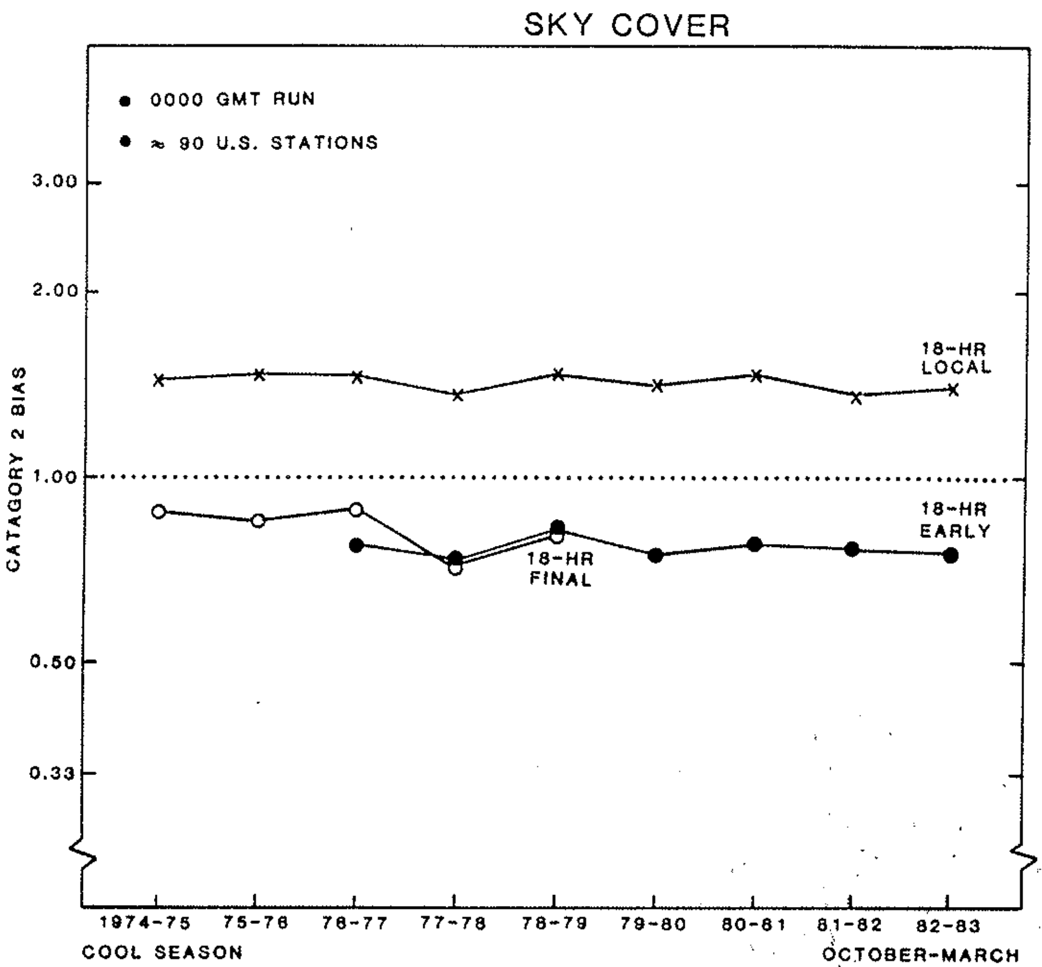

Figure 5.4. Same as Fig. 5.3 except for category 2 bias.

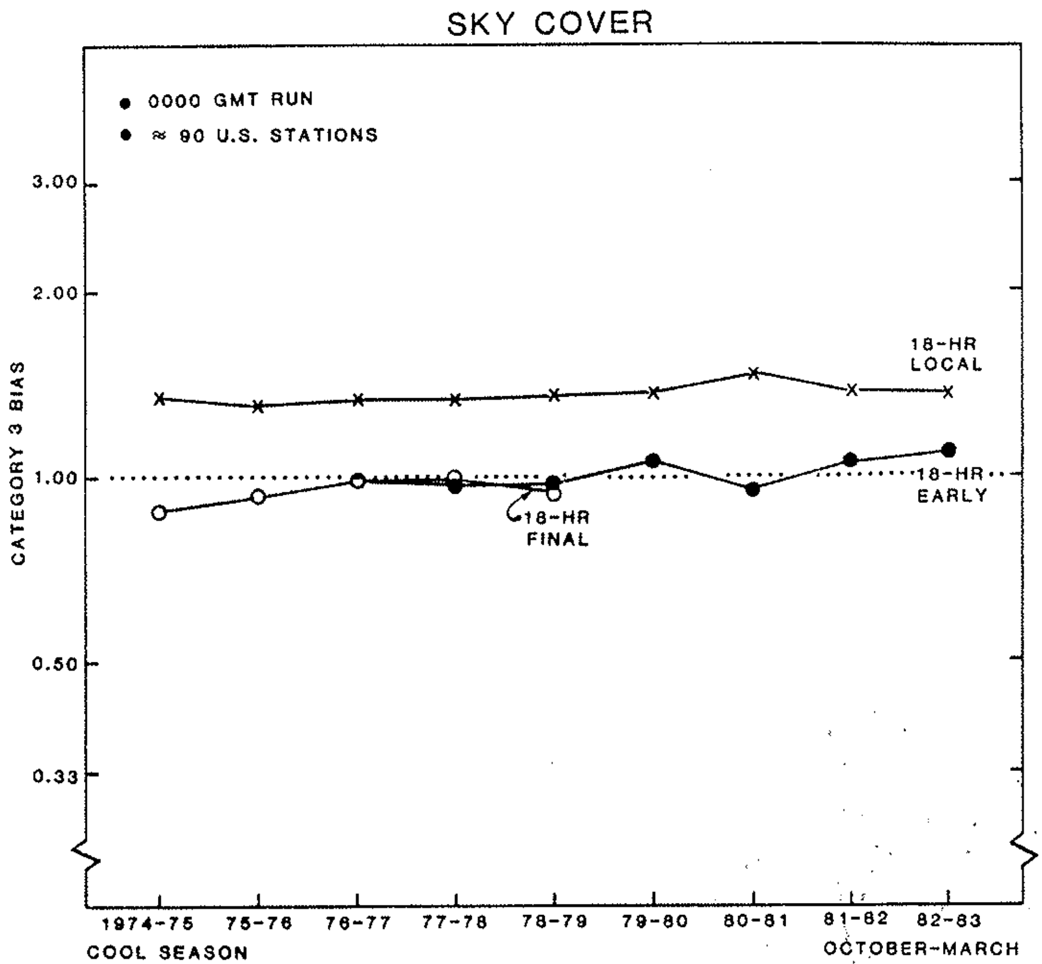

Figure 5.5. Same as Fig. 5.3 except for category 3 bias.

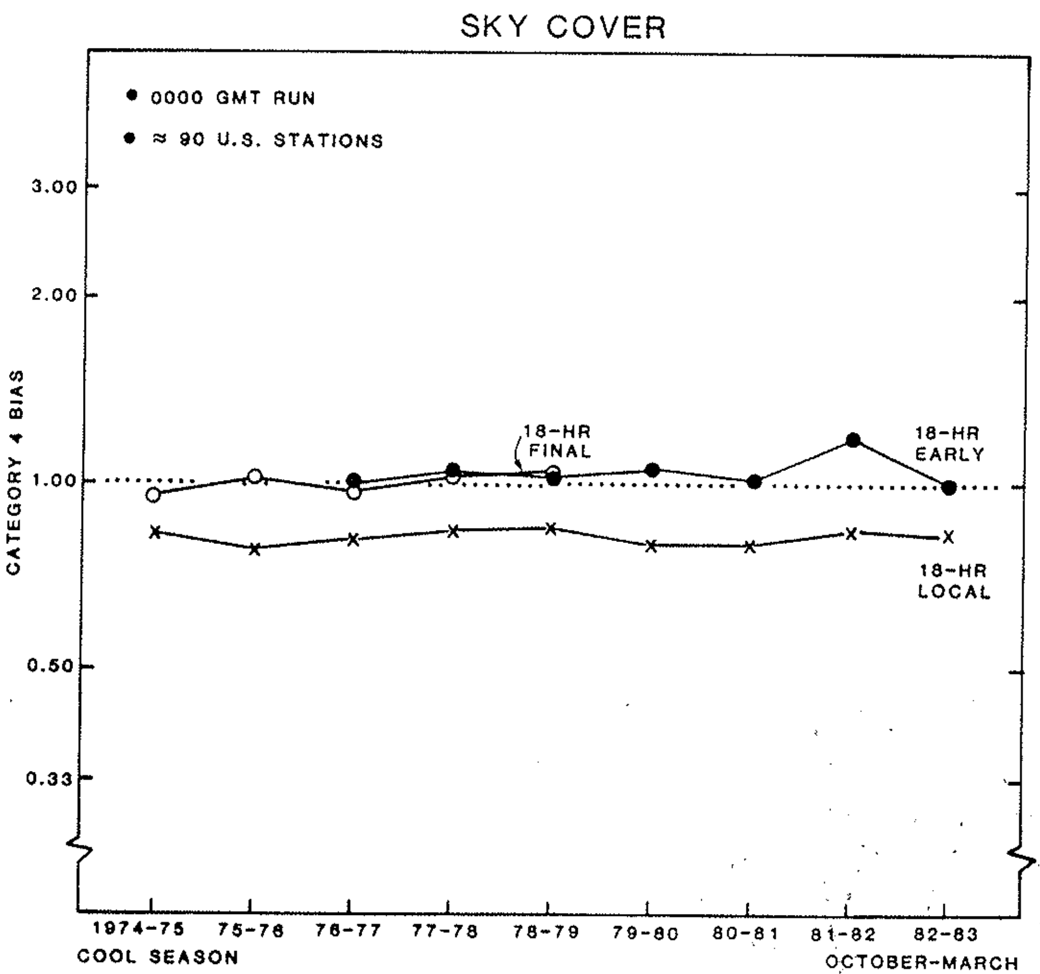

Figure 5.6. Same as Fig. 5.3 except for category 4 bias.

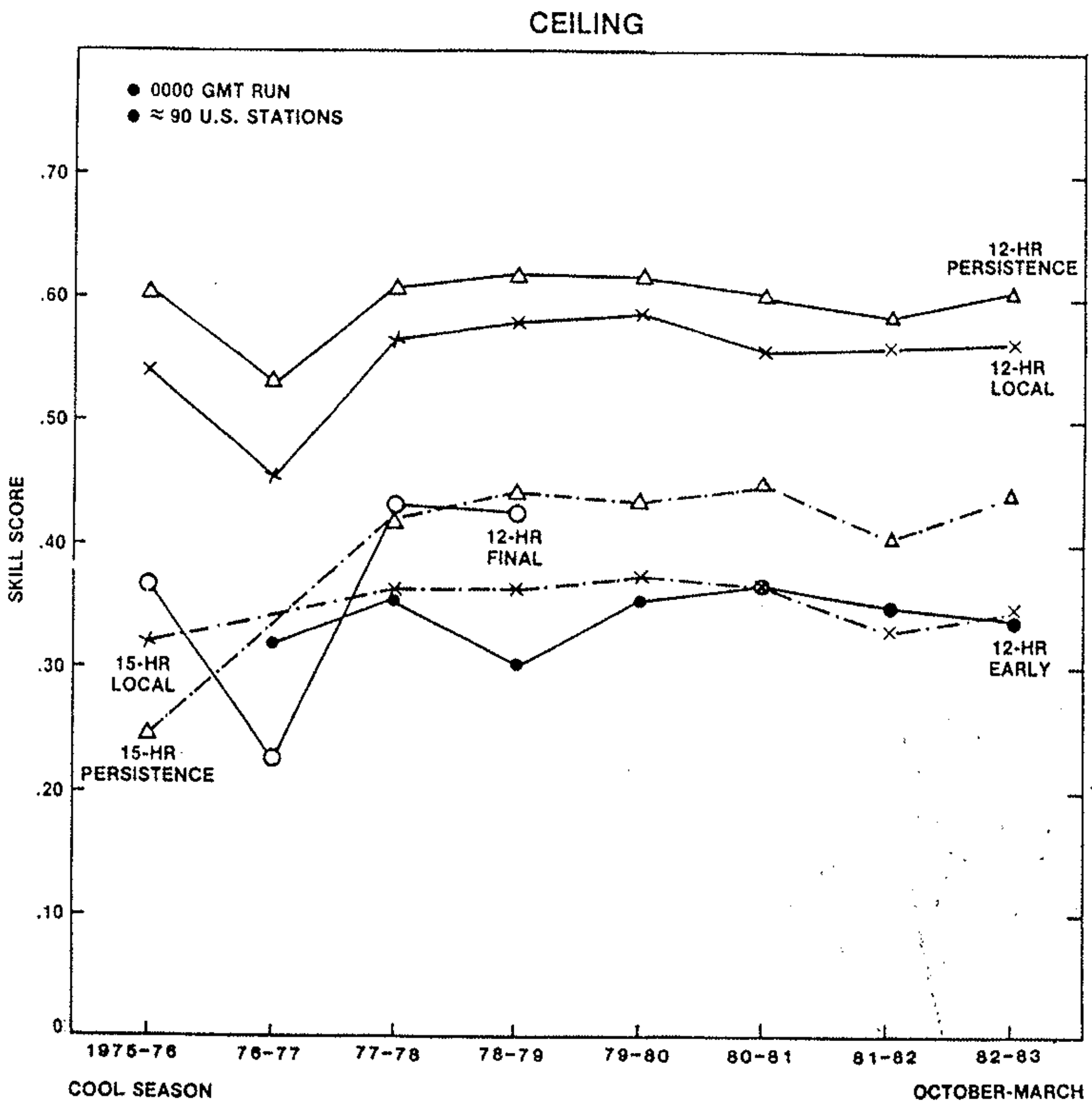

Figure 6.1. Skill score computed from two-category contingency tables for persistence, local, and guidance (early and final) ceiling height forecasts.

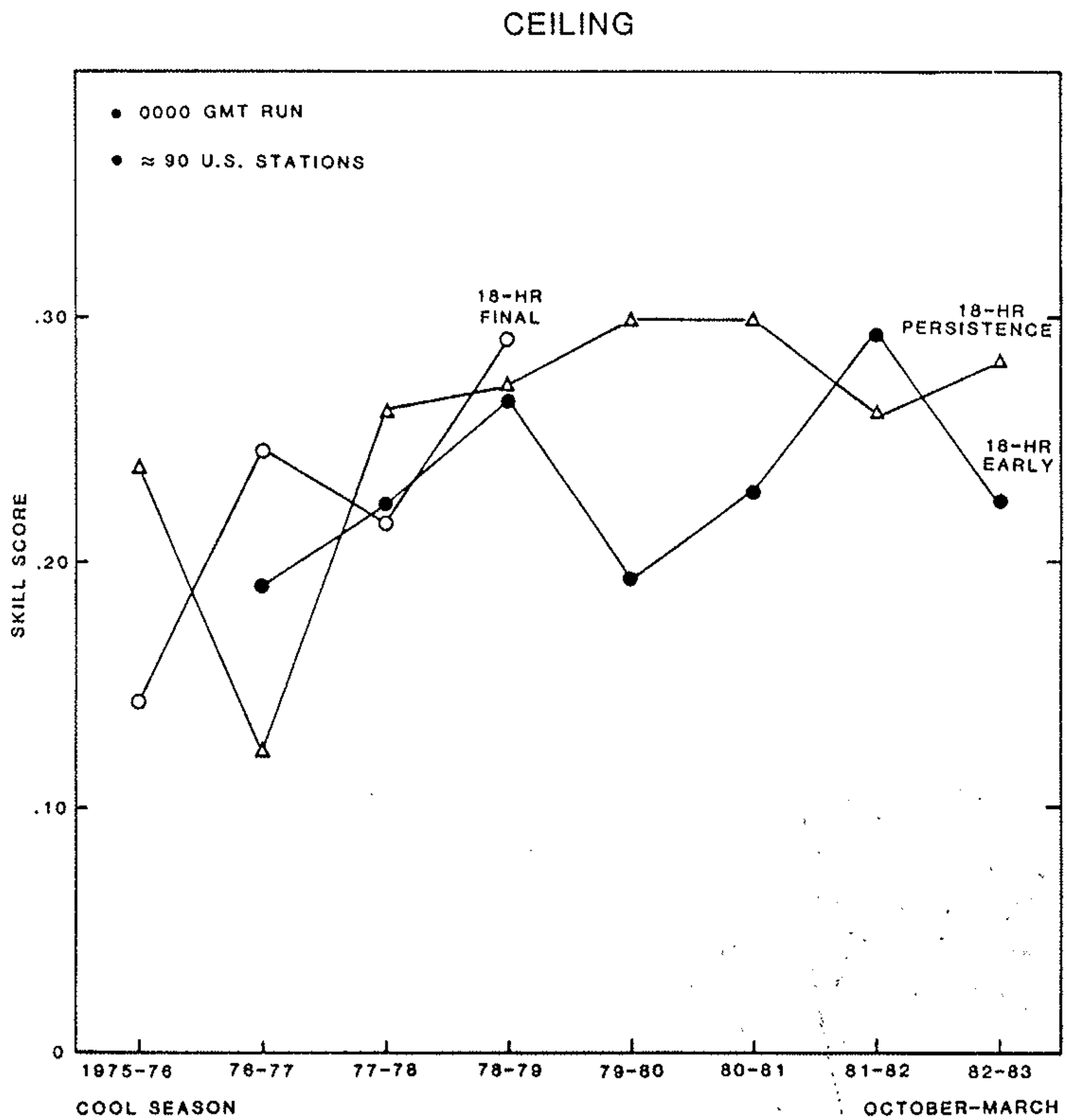

Figure 6.2. Same as Fig. 6.1 except for forecast projection.

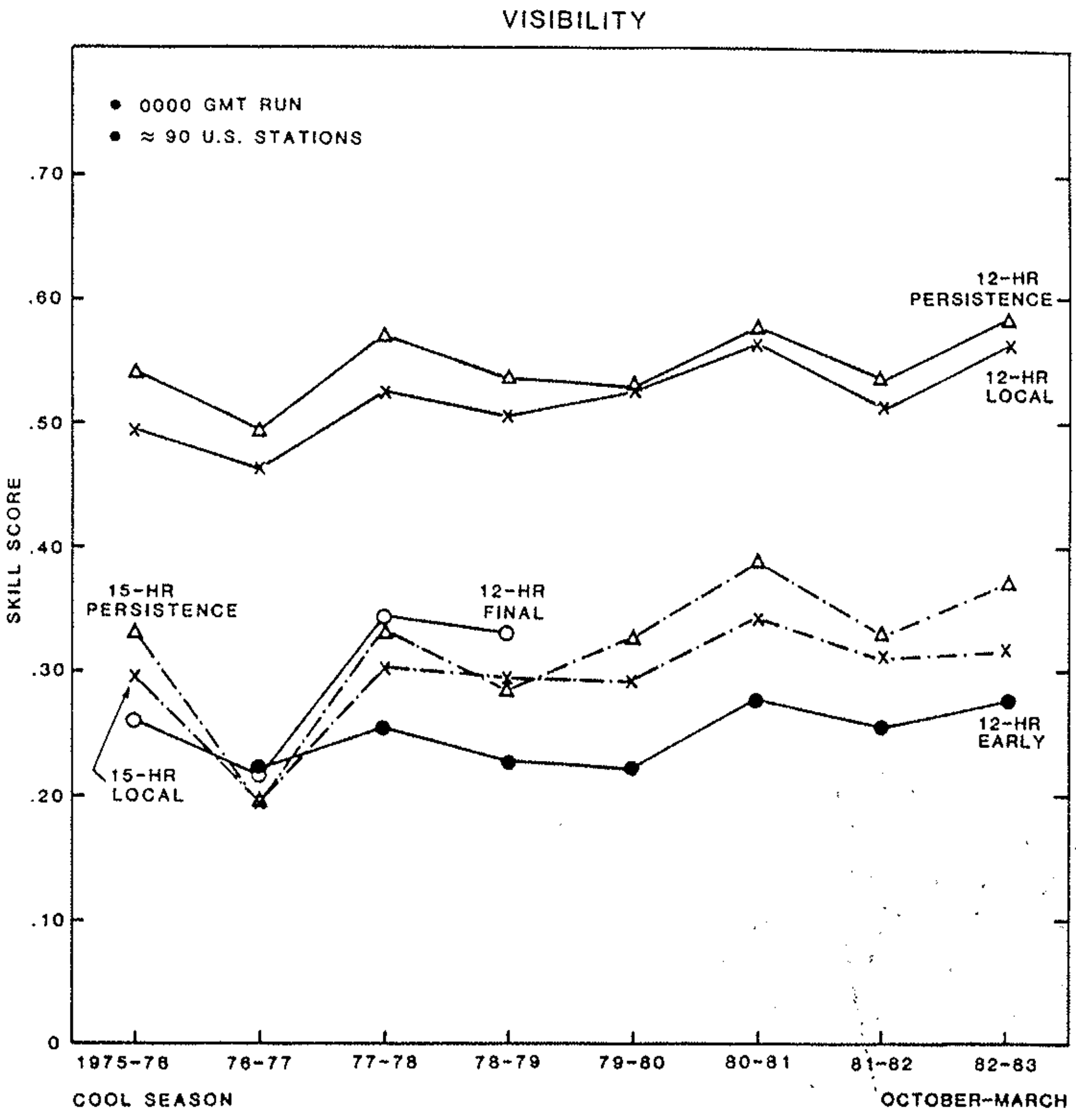

Figure 6.3. Same as Fig. 6.1 except for visibility.

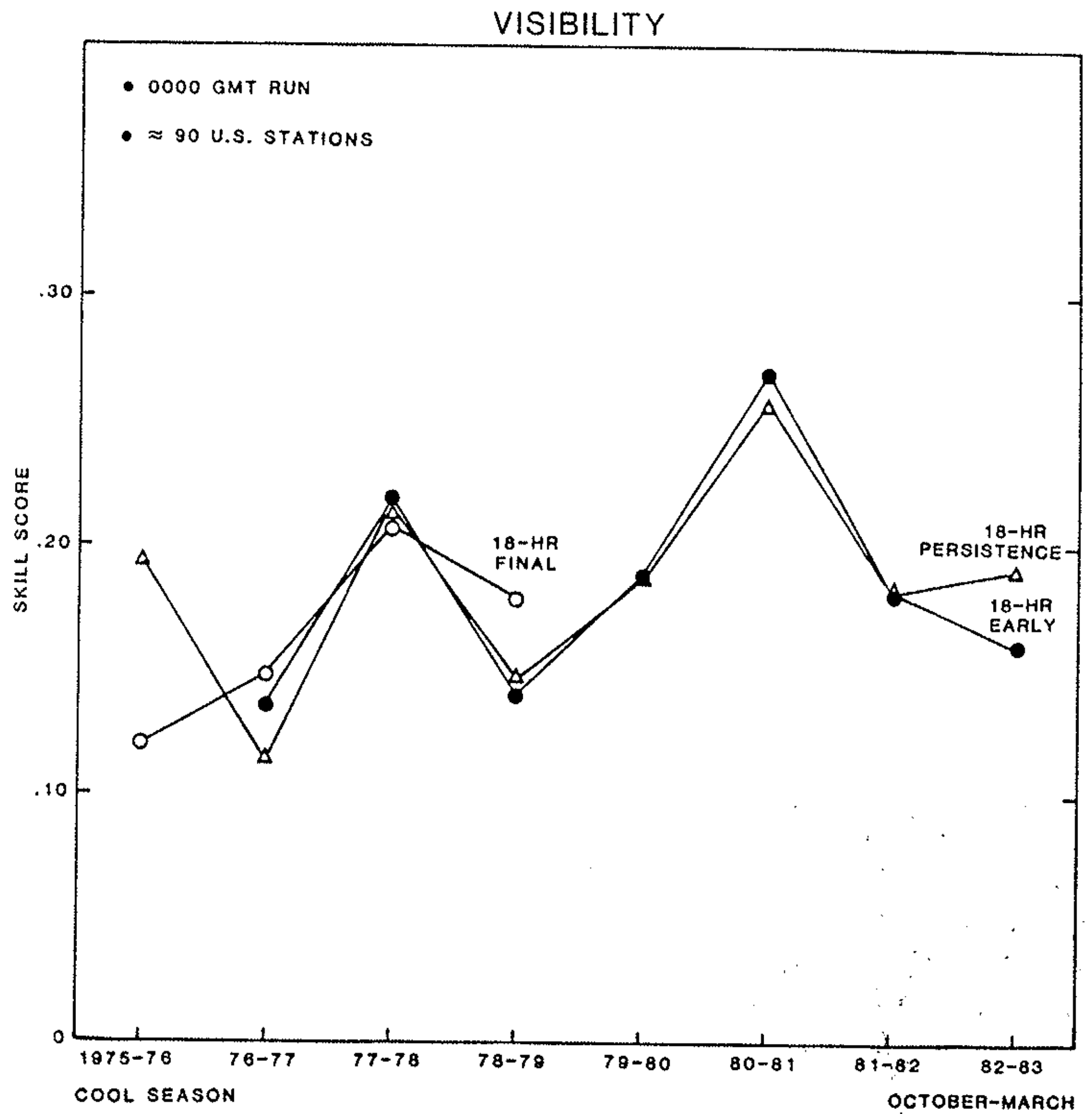

Figure 6.4. Same as Fig. 6.1 except for visibility and forecast projection.

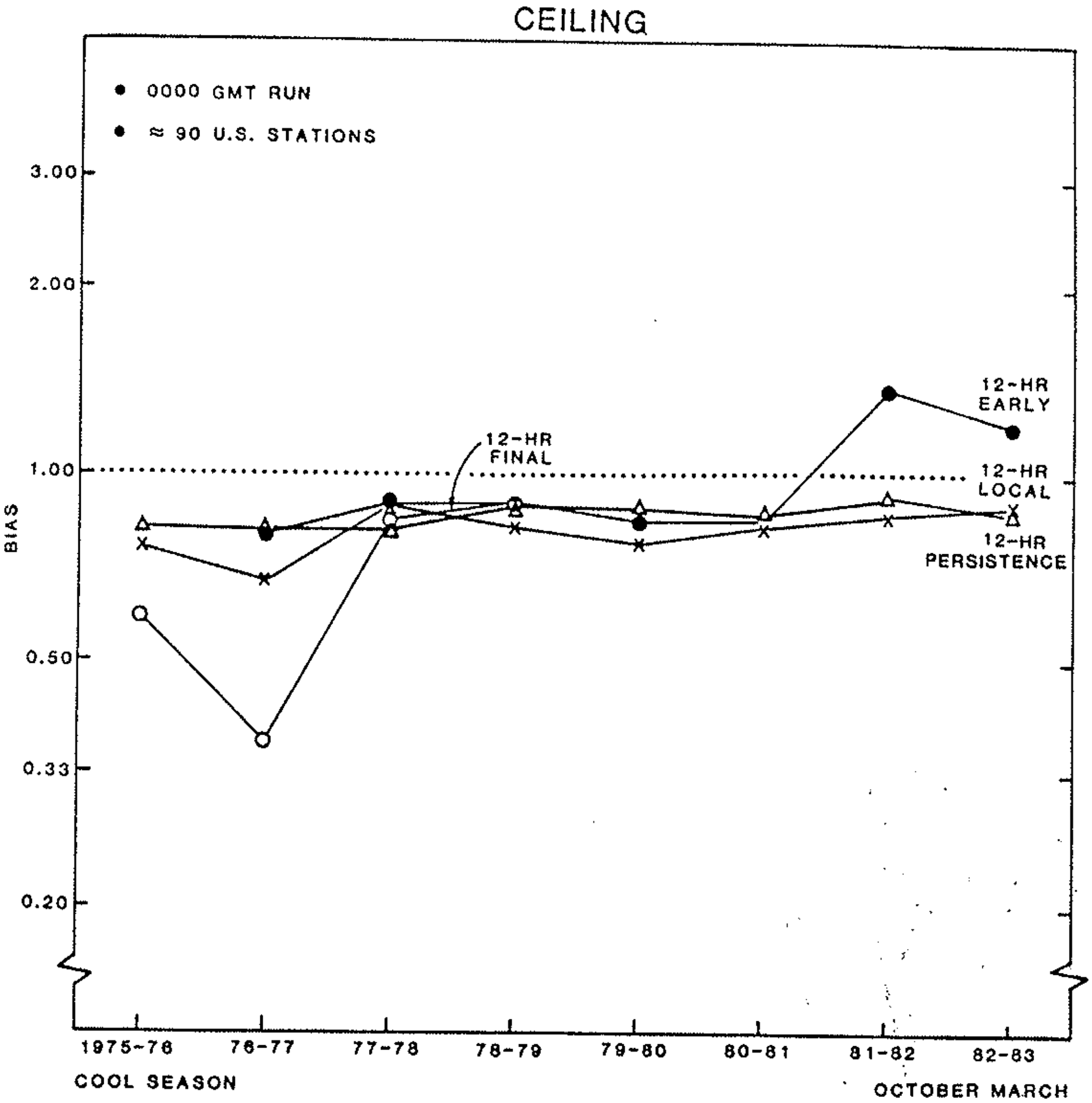

Figure 6.5. Bias for categories 1 and 2 combined for persistence, local, and guidance (early and final) ceiling height forecasts.

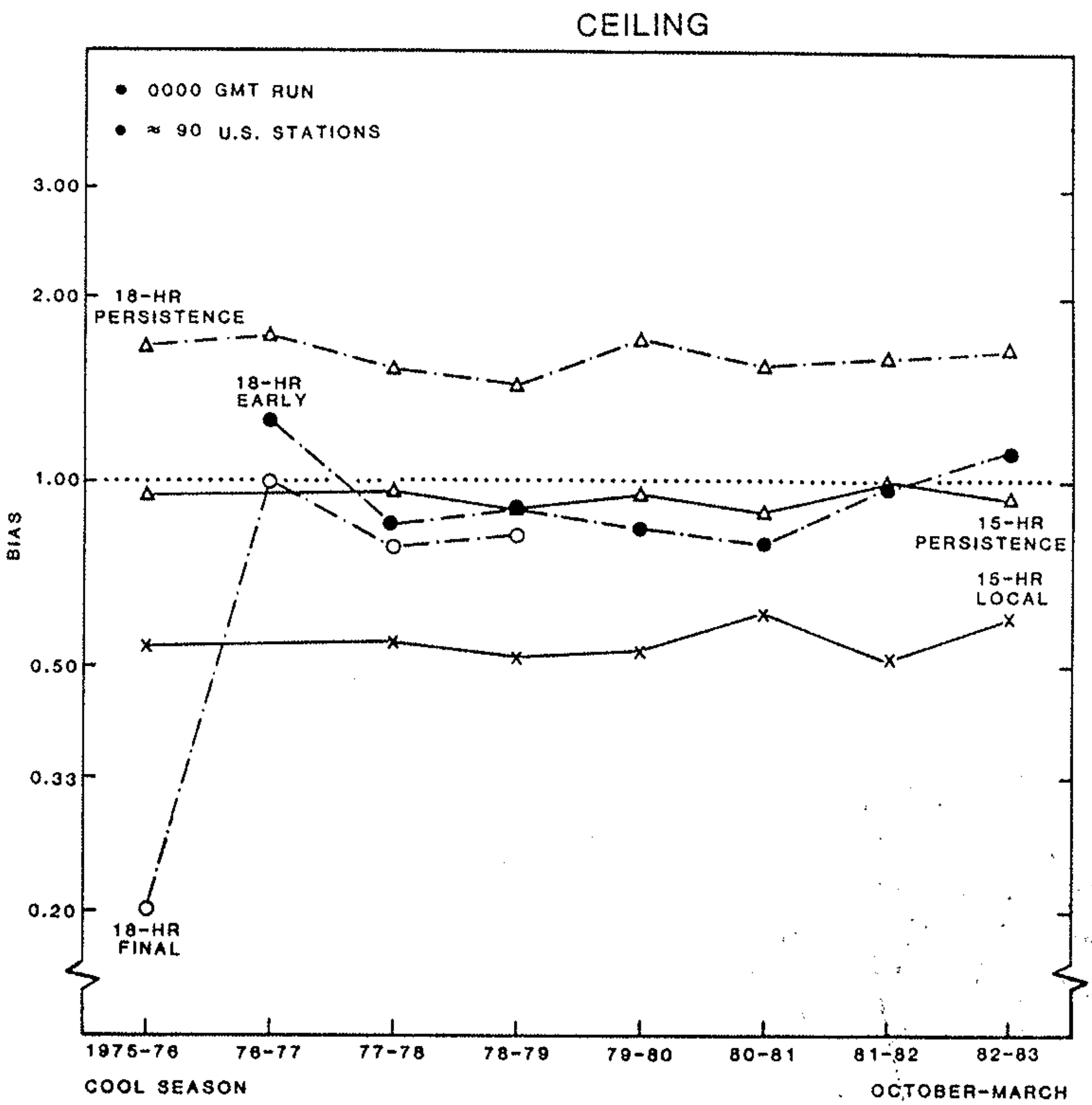

Figure 6.6. Same as Fig. 6.5 except for forecast projection.

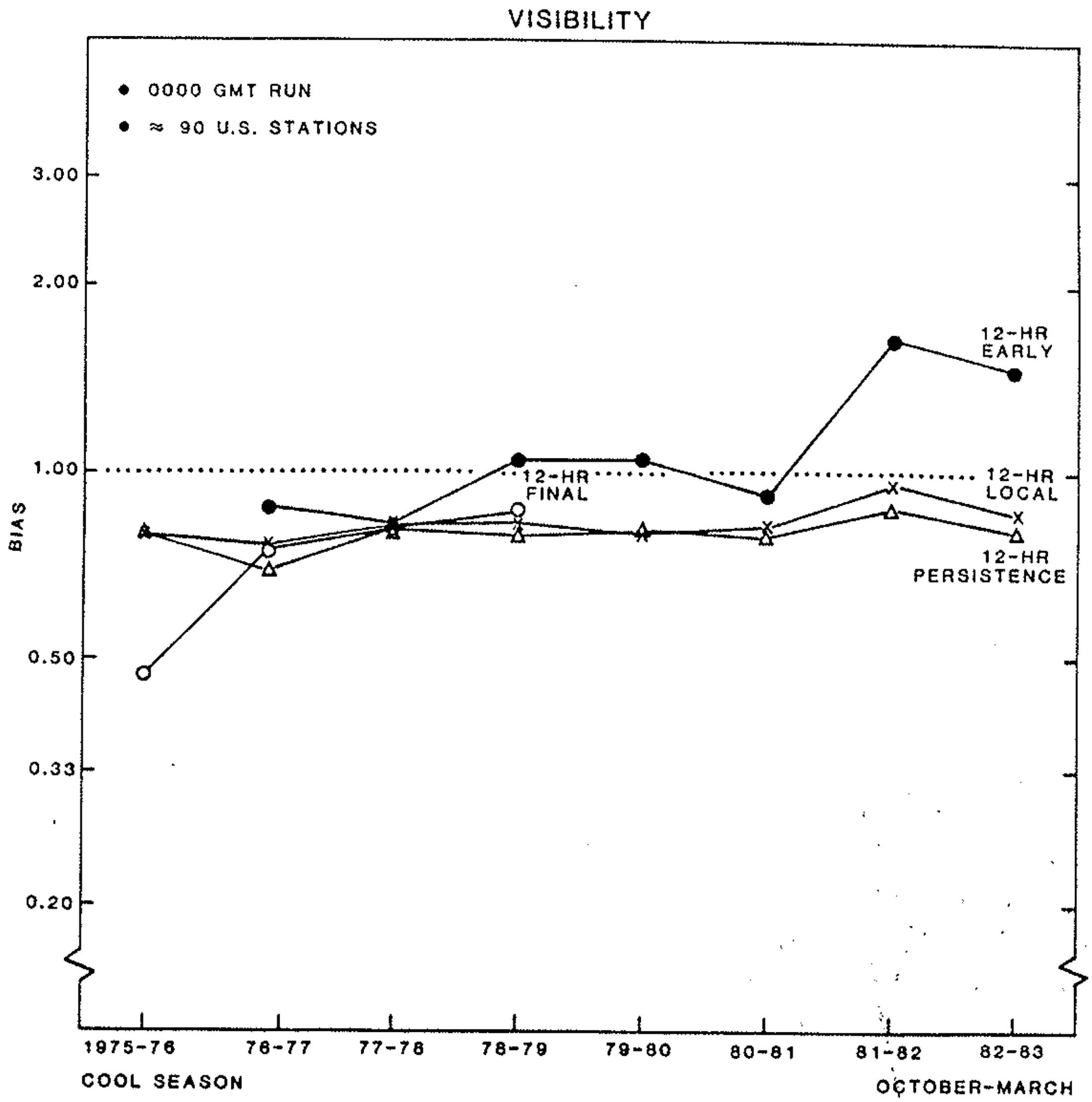

Figure 6.7. Same as Fig. 6.5 except for visibility.

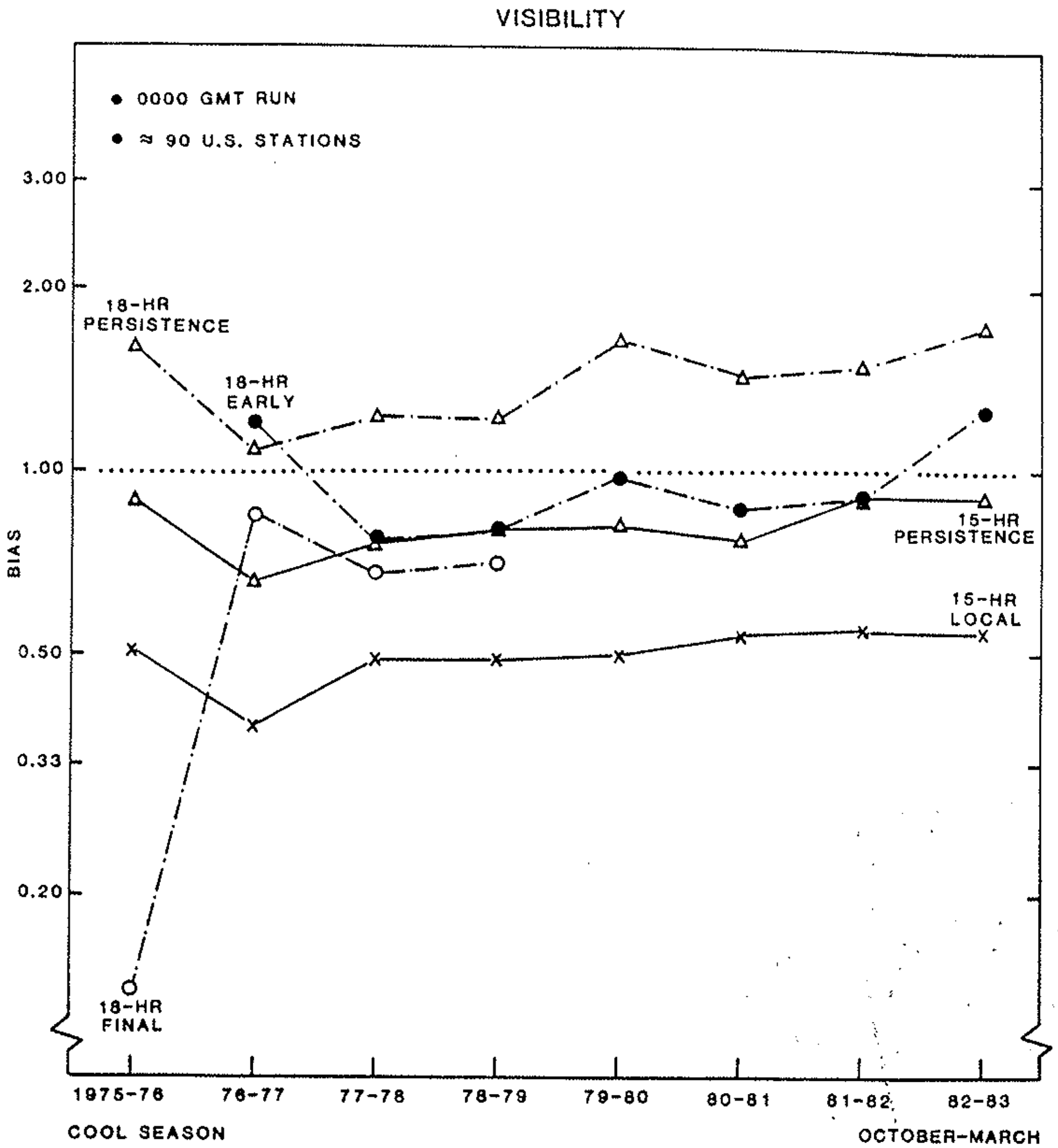

Figure 6.8. Same as Fig. 6.5 except for visibility and forecast projection.

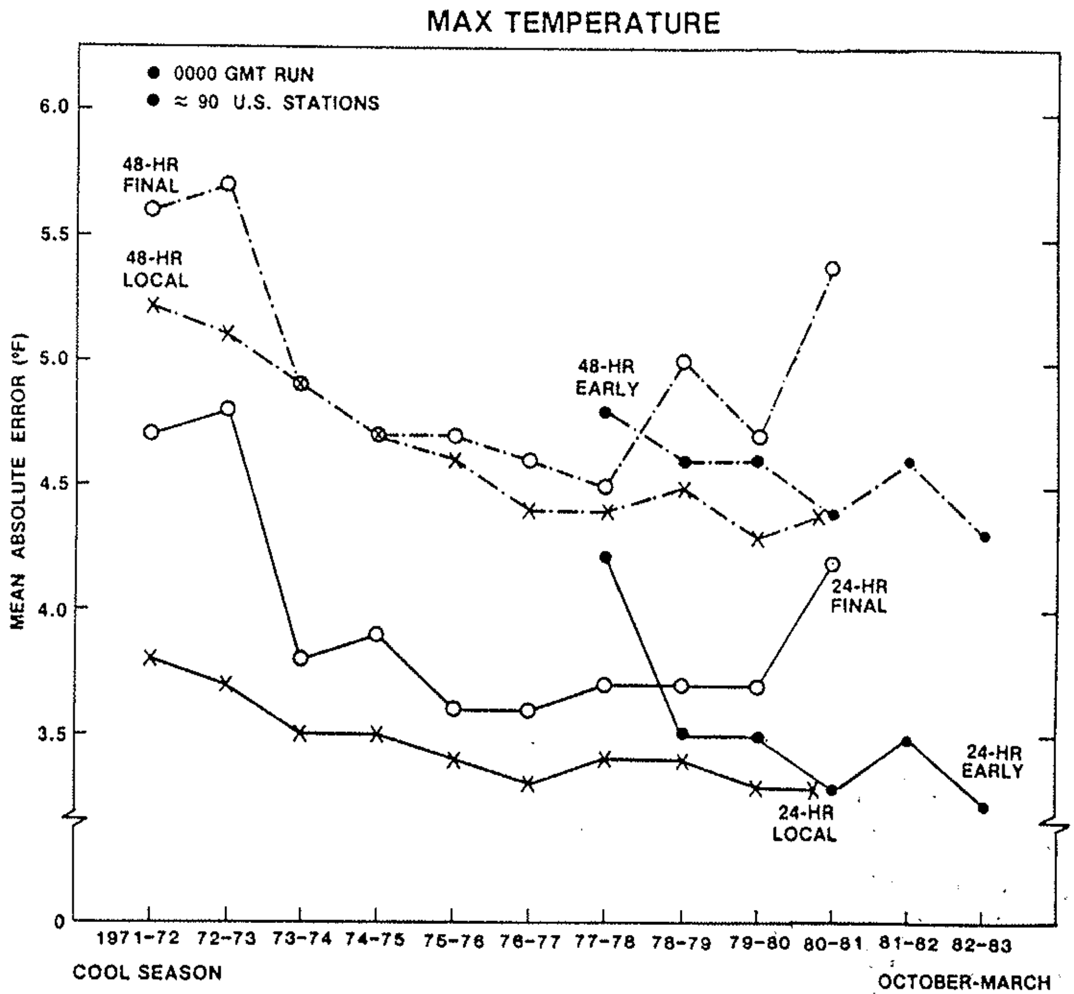

Figure 7.1. Mean absolute error for the local and the early and final guidance max temperature forecasts.

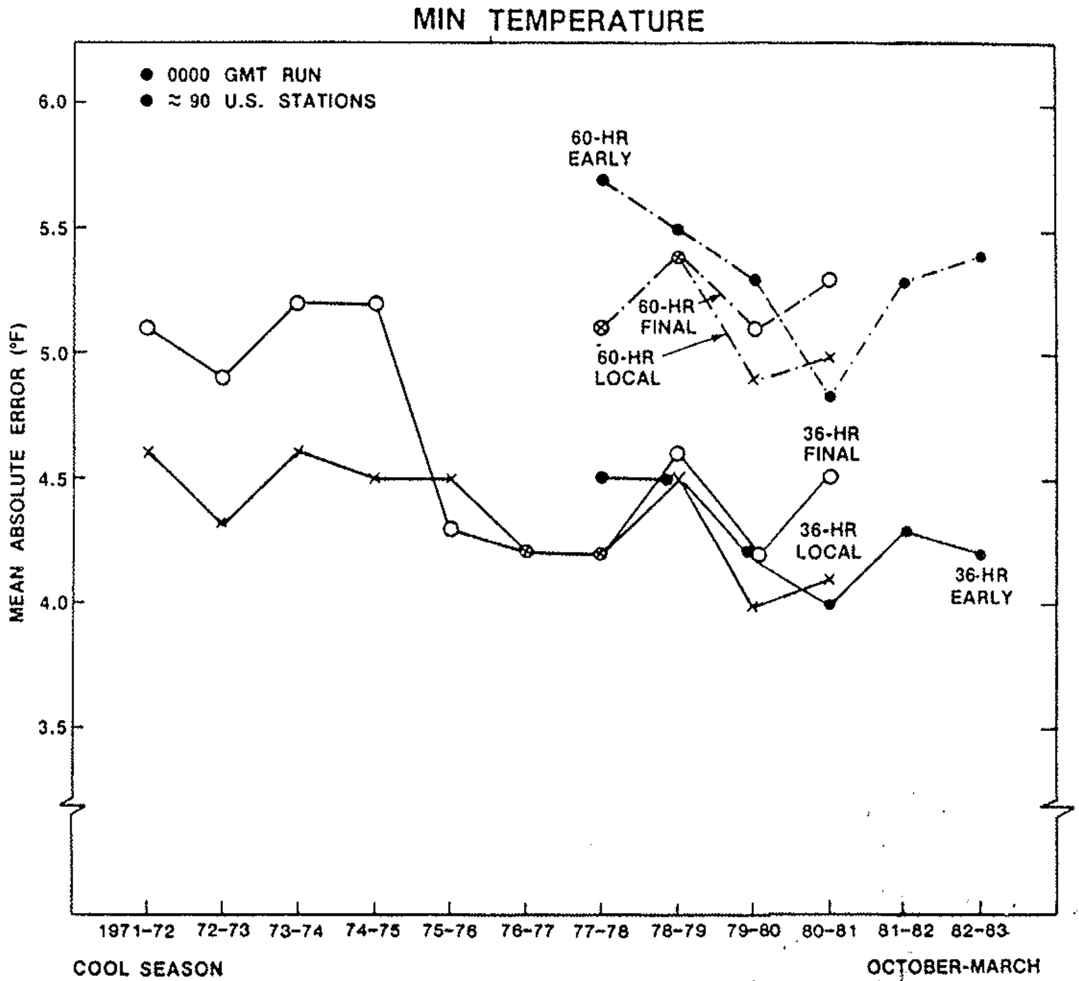

Figure 7.2. Same as Fig. 7.1 except for the min temperature.