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# COMPARATIVE VERIFICATION OF GUIDANCE AND LOCAL AVIATION/PUBLIC WEATHER FORECASTS--NO. 10
(April 1980 - September 1980)

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## 1. INTRODUCTION

This is the tenth 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 warm season months of April through September 1980 for probability of precipitation (PoP), surface wind, opaque sky cover, ceiling height, visibility, and maximum/minimum (max/min) temperature.

The objective guidance is based on equations developed through application of the Model Output Statistics (MOS) technique (Glahn and Lowry, 1972). We derived these prediction equations by using archived surface observations and forecast fields from the Limited-area Fine Mesh (LFM) model (National Weather Service, 1971), the Trajectory (TJ) model (Reap, 1972), and/or the 6-layer coarse mesh Primitive Equation (6LPE) model (Shuman and Hovermale, 1968). In operations, forecast fields from the LFM-II (National Weather Service, 1977a) and the 7-layer PE (7LPE) model (National Weather Service, 1977b) are employed in the MOS guidance equations when LFM or PE data, respectively, are required; however, on August 13, 1980 the 7LPE was replaced in operations by a spectral version of the PE model (National Weather Service, 1980). Unless indicated otherwise, we usually refer to MOS forecasts based on the LFM-II as "early" guidance; "final" guidance indicates the objective forecasts were produced from PE data. Also, the observation times of surface weather elements used as predictors in the early and final guidance generally differ.

The local forecasts from the WSFO`s were collected by the Technical Procedures Branch of the Office of Meteorology and Oceanography for the purposes of the NWS combined aviation/public weather verification system (National Weather Service, 1973). The aviation forecasts were recorded for verification according to the direction that they be "...not inconsistent with..." the official weather prognosis. The public weather max/min and PoP forecasts used for verification were official forecasts taken from the Coded City Forecast (FPUS4) bulletin. Surface observations as late as 2 hours before the first valid forecast time may have been used in the preparation of the local forecasts. We obtained the observed verification data from the National Climatic Center in Asheville, North Carolina.

## 2. PROBABILITY OF PRECIPITATION (PoP)

Objective PoP forecasts were produced by the warm season prediction equations described in Technical Procedures Bulletin No. 233 (National Weather Service, 1978a). Guidance was available for the first, second, and third periods, which correspond to 12-24 hours, 24-36 hours, and 36-48 hours, respectively, after 0000 GMT or 1200 GMT. The predictors for the first period equations were forecast fields from the LFM-II model and surface variables observed at the forecast site at 0300 GMT or 1500 GMT.

While both early and final objective guidance PoP forecasts were produced for the second and third periods, only early guidance was available for the first period. All of the early guidance forecasts were based on the LFM-II model output. The final guidance for the second period was based on a combination of fields from the LFM-II, PE (7LPE and spectral), and TJ models. Third period final guidance equations used PE predictors only.

The PoP forecasts were verified by computing the Brier score (Brier, 1950) for the 87 stations shown in Table 2.1. Please note that we used the standard NWS Brier score which is one-half the original score defined by Brier. Brier scores will naturally 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 climatology; that is, the percent improvement of the 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-year sample (Jorgensen, 1967).

Table 2.2 shows the results for all 87 stations for 0000 GMT cycle forecasts made during the period April through September 1980; Tables 2.3-2.6 show scores for the NWS Eastern, Southern, Central, and Western Regions, respectively. The second and third period verifications are a three-way comparison between the early guidance, the final guidance, and the subjective local forecasts.

In comparison to the 1979 warm season (Vercelli et al., 1980), the early and final guidance and local forecasts generally showed improved Brier scores for all three periods. Only in the Western Region did the Brier scores deteriorate slightly. Most likely, this is related to the exceptionally dry summer in the Eastern, Southern, and Central Regions. Overall, the early guidance was better than the local forecasts for the second period, and the final guidance was better than the locals in the third period except in the Southern Region. In addition, the early guidance continued to be more accurate than the final guidance for the second period. In contrast, for the third period, the final guidance was substantially better than the early guidance in the Eastern and Western Regions.

Fig. 2.1 shows the trend since 1971 in the skill (expressed in terms of percent improvement over climatology) of the first and third period 0000 GMT cycle PoP forecasts for all 87 stations. During the 1980 warm season, both the early guidance and the local forecasts decreased in skill considerably for the first period. For the third period, the skill of the early and final guidance and the local forecasts also deteriorated, but to a lesser degree. Starting with the warm season of 1977, the final and early guidance have had the same skill for the first period. Although the current warm season reversed the trend of the previous 3 warm seasons in which improvement was made for all types of forecasts, the 1980 guidance and local scores were much better than those for any warm season between 1971 and 1975; the first period local forecasts were the only exception. Results for the 1974 and 1976 seasons are unavailable because of missing data.

## 3. SURFACE WIND

The objective surface wind forecasts were generated by the LFM-based equations valid for the warm season described in Technical Procedures Bulletin No. 271 (National Weather Service, 1979). In addition to LFM model forecasts, predictors in the equations included the sine and cosine of the day of the year and twice the day of the year; surface weather observations are not used beyond the 12-h projection. Wind guidance produced by PE-based equations was terminated in May 1979, so the final guidance was unavailable for the 1980 warm season. We verified the 18-, 30-, and 42-h forecast projections from 0000 GMT. Note that 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, 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. Secondly, for all cases where both local and automated forecasts were available, Heidke skill score, percent correct, and bias by category[1] were computed from contingency tables of wind speed. The seven categories in the tables were: less than 8, 8-12, 13-17, 18-22, 23-27, 28-32, and greater than 32 knots. Table 3.1 lists the 90 stations used in the verification. Tables 3.2-3.12 show comparative verification scores (0000 GMT cycle only) for the 18-, 30-, and 42-h projections. Note that all the objective forecasts of wind speed were adjusted in daily operations 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 3.2 and 3.3. The MAE`s for the direction reveal an advantage for the guidance that is approximately 4° for all three forecast projections. Overall, the speed MAE`s, skill scores, and percent correct also were better for the guidance. The biases by category in Table 3.2 and the contingency tables in Table 3.3 indicate that both the guidance and the local forecasts generally underestimated winds stronger than 22 knots (i.e, categories 5,6, and 7). For most of the seven categories, the guidance exhibited better bias characteristics than the local forecasts, especially for the 42-h projection. In fact, the biases of the guidance wind speed forecasts for the 1980 warm season, particularly for the first four categories, were the best of any of the previous 6 warm seasons (see, for example, Vercelli et al., 1980).

Tables 3.4-3.7 show scores for the NWS Eastern, Southern, Central, and Western Regions, respectively. The regional comparisons generally had the same characteristics as for the entire group of stations, except the advantage of the guidance over the local forecasts varied in magnitude from region to region. However, for the Southern, Central, and Western Regions, the MAE for local 42-h wind speed forecasts was better than the corresponding score for the guidance.

Table 3.8 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. Note that the guidance had about 5% fewer errors of 40° or more than did the local forecasts for the 18- and 42-h projections, and about 7% fewer errors for the 30-h projection.

Distributions of direction errors for the individual regions are given in Tables 3.9-3.12. In general, these results are much like those in Table 3.8

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

except, once again, the advantage of the guidance over local forecasts differed in magnitude from region to region.

A comparison of the overall MAE`s and skill scores during the past 7 warm seasons for the 18- and 42-h guidance and local forecasts is presented in Figs. 3.1-3.3. 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. Since the final (PE-based) guidance was terminated during the 1979 warm season, Figs. 3.1-3.3 do not show any verification results for the final guidance forecasts after 1978.

The MAE`s for direction are given in Fig. 3.1. Although the guidance and local forecasts have generally improved over the span of 7 seasons, notice that the 1980 warm season showed the first increase in the MAE`s for both projections since the 1975 warm season.

The MAE`s for speed in Fig. 3.2 denote a general decrease in accuracy for the final guidance forecasts after the introduction of inflation in July of 1975. We realized that inflation would have this effect; however, previous wind speed verifications indicated that the bias values of inflated forecasts were somewhat closer to 1.0 compared to the bias values of uninflated forecasts (Carter and Hollenbaugh, 1976). Despite use of the inflation technique, the MAE`s for the 18-h guidance were generally as good as, or better than, the pre-inflation values. Note the consistent superiority of the early guidance forecasts over the local forecasts at the 18-h projection.

Fig. 3.3 is a comparison of guidance and local skill score computed on five (instead of seven) categories of wind speed; the fifth category included all speeds greater than 22 knots. The skill of the guidance for both projections, which remained relatively constant up to 1979, increased slightly during the 1980 warm season. Of note in Fig. 3.3 is the superiority of the guidance over the local forecasts for both projections.

The 18- and 42-h early guidance MAE and skill scores in Figs. 3.1-3.3 show the consistent superiority of the early guidance over the final guidance. Because of this, we stopped producing final surface wind guidance in 1979.

## 4. OPAQUE SKY COVER

The early guidance equations used in forecasting opaque sky cover during the 1980 warm season are described in Technical Procedures Bulletin No. 234 (National Weather Service, 1978b). These equations used LFM-II model output and 0300 (1500) GMT surface observations to produce forecasts for eight projections at 6-h intervals from 6 to 48 hours after 0000 (1200) GMT. Opaque sky cover final guidance was terminated after the 1979 warm season and, hence, was not verified. Regionalized equations produced probability forecasts of the four categories of opaque sky cover, more commonly known as cloud amount, shown in Table 4.1. We converted the probability estimates to a single "best category" forecast in a manner which produced good bias characteristics, that is, a bias value of approximately 1.0 for each category.

We compared the local forecasts with a matched sample of early guidance forecasts at the 90 stations listed in Table 3.1 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 in Table 4.1. Four-category, forecast-observed contingency tables were prepared from the transformed local and the best-category objective predictions. Using these tables, we computed the percent correct, Heidke skill score, and bias by category.

The results for all stations combined are shown in Table 4.2. For the 30- and 42-h projections, the guidance forecasts were clearly superior to the local forecasts in terms of percent correct and skill score. Although the guidance was also better at 18 hours, the differences were not as great. Examination of the bias-by-category scores shows that, except for two cases, the guidance forecasts were better (i.e, closer to 1.0) than the local forecasts for each projection and category. The two exceptions were the 18- and 42-h broken categories. The local forecasts exhibited a tendency to underforecast the clear and the overcast categories, while overforecasting the scattered and (to a lesser extent) the broken categories.

The verification scores for stations in the NWS Eastern, Southern, Central, and Western Regions are given in Tables 4.3-4.6, respectively. The percent correct and skill scores for the guidance forecasts were, for the most part, superior to those of the local forecasts. For the 18-h projection, the percent correct for the Southern Region local forecasts was equal to that of the guidance and, in the Western Region, the local skill score was better than that for the guidance. In the regional breakdown, the bias scores for the guidance forecasts generally were better than those for the local forecasts.

The percent correct and skill scores over the past 6 warm seasons are shown in Figs. 4.1 and 4.2, respectively, for the 18- and 42-h projections. These figures show that both the 1980 guidance and the local forecasts deteriorated noticeably compared to the previous warm season. Although the rate of deterioration of the percent correct and skill scores was greater for the guidance, the guidance scores themselves remained superior to the locals, as they have since the early guidance was introduced.

Figures 4.3-4.6 show the biases for categories 1 through 4, respectively, for the 18- and 42-h projections. The local forecast biases for all four categories have, with some minor fluctuations, remained relatively constant over the years. The figures show that the locals had a strong tendency to underforecast the clear and overcast categories, and overforecast the scattered category.

The biases for the guidance forecasts have, for all but the broken category, been consistently superior to the local forecasts. For the broken category, both the guidance and the local forecasts had relatively good bias characteristics until the 1980 warm season. In 1980, the guidance forecast bias for the broken category deteriorated and the locals, for the first time, had better category 3 bias characteristics for both the 18- and 42-h projections.

## 5. CEILING AND VISIBILITY

During the 1980 warm season, we continued to use the ceiling and visibility prediction equations first implemented during the 1977 warm season. Only early guidance was available since final guidance was discontinued after the 1979 warm season. Operationally, the early guidance was based on LFM-II output and used 0300 (1500) GMT surface observations. Guidance consisted of forecasts at 6-h intervals from 6 to 48 hours after 0000 (1200) GMT. For details concerning the automated ceiling and visibility forecast system see Technical Procedures Bulletin No. 234 (National Weather Service, 1978b).

Verification scores were computed for both the subjective local forecasts and the objective guidance forecasts for the 90 stations listed in Table 3.1. In each case, persistence based on an observation taken at 0900 GMT for the 0000 GMT cycle and at 2100 (or 2200) GMT for the 1200 GMT cycle provided a standard of comparison. Guidance forecasts were verified for both cycles at the 12-, 18-, 24-, 36-, and 48-h projections and local forecasts at the 12-, 15-, and 21-h projections. The guidance forecast and the persistence observation usually were available to the local forecaster.

We constructed six-category forecast-observed contingency tables (Table 5.1) for all the forecasts involved in the comparative verification. These categories were used for computing several different scores: bias-by-category, percent correct, and Heidke skill score. We then collapsed the tables to two categories (categories 1 and 2 combined versus categories 3 through 6 combined) and calculated bias and threat score for categories 1 and 2 combined and skill score and percent correct for the reduced tables. We have summarized these results in Tables 5.2-5.9. The skill score and bias for categories 1 and 2 combined are also given in Figs. 5.1-5.8 for selected projections from 0000 GMT for the past 5 warm seasons.

Tables 5.2-5.5 present verification results for the six-category ceiling and visibility forecasts. For the 12-h projection from 0000 GMT, the skill of the local visibility forecasts exceeded the skill of persistence. For the 12-h projection from 1200 GMT, the skill of the local ceiling forecasts also exceeded that of persistence. For both forecast cycles, the guidance forecasts had significantly lower skill than the locals and persistence for the 12-h projection. With the exception of visibility forecasts for the 15-h projection from 1200 GMT, the local forecasts had higher skill scores than persistence for the 15- and 21-h projections for both ceiling and visibility. At the longer-range projections, the guidance outperformed persistence by a wide margin in skill.

For projections beyond 12 hours, guidance forecast bias-by-category characteristics were generally better (i.e., closer to 1.0) than those for either the local or persistence forecasts. At the 12-h projection (actually a 3-h projection for both the local and persistence forecasts), the bias of the guidance (actually a 9-h forecast from the latest surface observation) was only slightly worse than that of the locals and persistence. The persistence of weather conditions, especially during the warm season, should be reflected in the bias characteristics of persistence forecasts at 24-h intervals. Tables 5.2-5.5 show this to be true, since the persistence forecast bias values for the 12- and 36-h projections, and for the 24- and 48-h projections, are nearly the same. The rarity of the category 1 ceiling and visibility events during afternoon and evening hours (generally less than 15 cases in a sample of over 10,000) results in an extremely low bias for category 1 for both ceiling and visibility.

Tables 5.6-5.9 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 0.002 to 0.030, indicating that these events are rare, and, hence, are difficult to forecast, as is indicated by the low skill scores. For the 12-h projection, the persistence forecasts of ceiling and visibility had the highest skill scores although values for the local forecasts were only slightly lower; in contrast, the guidance skill score was much lower than both the persistence and local skill scores. For the 15-h projection, the persistence skill score was higher than that of the local forecasts for 0000 GMT cycle ceiling and for 1200 GMT cycle visibility. For the 21-h projection, the skill score for the local forecasts was much higher than that of persistence except for 0000 GMT cycle ceiling. Guidance forecasts for the 18-, 24-, 36-, and 48-h projections were generally more skillful than persistence, the exceptions being the 24-h ceiling and the 36-h visibility forecasts from 0000 GMT.

Figs. 5.1-5.8 are trend graphs for skill score and bias for selected projections for 0000 GMT cycle two-category ceiling and visibility forecasts. These data indicate the guidance bias characteristics in the difficult-to-forecast low categories improved substantially after the threshold technique for category selection was introduced in 1977. This improvement has been maintained despite changes which the LFM-II model has undergone over the period. The graphs also reveal a consistent low bias for the local forecasts for the 15- and 21-h projections (i.e., a tendency to underforecast the significant weather conditions which these categories represent). Also, while the guidance skill for the 12-h projection has remained level, the skill of the 18-h projection has been more variable. In particular, the skill for guidance ceiling forecasts for the 18-h projection has decreased over the past 3 years, while guidance forecast skill for visibility has varied considerably.

## 6. MAX/MIN TEMPERATURE

The objective max/min guidance for April through September of 1980 was generated by several different sets of regression equations. The predictand for both the early and final guidance was the local calendar day max or min valid approximately 24, 36, 48, and 60 hours after the model input data time (0000 GMT or 1200 GMT).

The final guidance was based on equations developed by stratifying archived 6LPE and TJ model output, station observations, and the first two harmonics of the day of the year into seasons of 3-month duration (Hammons et al., 1976). We used spring (March-May), summer (June-August), and fall (September-November) equations to produce the final guidance during the appropriate months of the warm season. Station observations taken 6 hours after the initial model time also were used in the final guidance equations for the first two projections.

In contrast, the early guidance system depended on new prediction equations (Dallavalle et al., 1980) derived from LFM and LFM-II model output, and the first two harmonics of the day of the year. Surface observations 3 hours after the initial model time also were used as input to much of the early guidance for the first two periods. For all projections, forecast equations were available for the same 3-month seasons of spring, summer, and fall as the final guidance. The new early guidance equations were implemented on April 16, 1980. For the first two weeks of April, an older set of LFM-derived equations (Carter et al., 1979), based on a different seasonal stratification, were used.

As discussed before, the automated max/min forecasts are valid for the local calendar day; for example, the first period objective forecast of the max based on 0000 GMT model data is valid for the calendar day that starts at the following midnight. In contrast, the valid period of the local max/min forecast does not correspond to a calendar day. Rather, the local forecaster predicts a max for the 1200 to 0000 GMT interval and a min valid generally from 0000 to 1200 GMT. This latter time, however, is extended to 1800 GMT for forecasters in the Western Region and for others in the western parts of the Central and Southern Regions. Hence, caution is necessary in comparing verification scores for the local forecasts and the objective guidance.

We verified both the local and objective forecasts, using calendar day max and min temperatures obtained from the National Climatic Center as the verifying observations. Mean algebraic error (forecast minus observed temperature), mean absolute error, and the number of absolute errors greater than or equal to 10°F were computed for 87 stations (Table 2.1) in the conterminous United States. Four forecast projections of approximately 24 (max), 36 (min), 48 (max), and 60 (min) hours after 0000 GMT were verified.

Verification results are shown in Table 6.1 for all stations combined. For all four projections, the early guidance was considerably more accurate than the final guidance in terms of mean absolute error and number of large errors ($\geq$10°F). In fact, averaged over the four projections, the mean absolute error of the early guidance was 0.4° less than the final guidance. This was a dramatic reversal of the 1979 warm season (Vercelli et al., 1980) when the early and final guidance MAE`s were about the same for all four projections. We attribute the superiority of the early guidance to two factors. The first is the development and implementation of new prediction equations; we found before (Hammons et al., 1976) that 3-month seasonal stratification improves the temperature guidance. The second contributing factor was the implementation of the spectral version of the PE model in August 1980. In preliminary tests (Stackpole, 1980), the spectral model forecasts caused a deterioration in the max/min forecasts for Alaska produced by PE-derived equations. Because of differences between the spectral and 7LPE models with regard to the timing of synoptic features and the depth of the boundary layer, we believe that spectral model output deteriorated the final guidance over the conterminous United States.

As Table 6.1 shows, there was little difference between the local forecasts and the early guidance in terms of mean algebraic error, mean absolute error, and number of large errors. Also, of interest is the fact that the 48-h max guidance had larger mean absolute errors than did the guidance for the 60-h min. We have noted before (Hammons et al., 1976) that the max is more difficult to predict than the min during the warm season. Finally, despite the excessively hot and dry summer (Wagner, 1981), neither the local forecasts nor the early guidance had pronounced biases.

Tables 6.2-6.5 show the verification scores for the Eastern, Southern, Central, and Western Regions, respectively. As discussed before, the early guidance was more accurate than the final in all regions of the country and for all projections. The local forecasters in the Southern Region improved upon the MOS early guidance at all four projections; the greatest difference occurred for 24-h and 48-h max forecasts. In contrast, differences between the local forecasts and the early guidance were small for the Eastern, Central, and Western Regions.

Max temperature forecast mean absolute errors (0000 GMT cycle only) for the last 10 warm seasons are given in Fig. 6.1. The curves are irregular because of natural variability in the max and the difficulty of predicting this element during the warm season. Nevertheless, there has been an overall improvement in the quality of the local forecasts with the smallest errors of the 10 year period being recorded in 1980. Likewise, the accuracy of the objective guidance has improved during the same period. The final guidance improved in 1974 when MOS equations were introduced (Klein and Hammons, 1975) and again in 1976 when the 3-month season MOS equations were first used (Hammons et al., 1976). The 24-h early guidance was enhanced in 1978 with the introduction of LFM-based equations (Carter et al., 1979). In 1980, the 48-h early guidance improved with application of the new, 3-month LFM equations; however, the 1980 final guidance was no more accurate than the guidance produced in 1974.

An analogous time series is shown in Fig. 6.2 for the min forecasts. Verifications for the 60-h projection are available for only the last 5 seasons. For the 36-h projection, there has been an overall improvement in both the objective and local forecasts since 1971. Similar to the max temperature guidance, the greatest improvements in accuracy for the 36-h min were in 1974 and 1976. Of note is the large deterioration in the accuracy of the final guidance in 1980.

## 7. CONCLUSIONS

This verification showed that, overall, both the guidance and local forecasts were less accurate than during the previous year. Some exceptions to this trend are: the ceiling and visibility forecasts which did about as well, the surface wind speed guidance which improved, and the early guidance and local max/min forecasts which remained as accurate or improved.

The local PoP forecasts for the 1980 warm season were superior to the guidance in terms of Brier score and percent improvement over climate for the first period. For the second period, the local forecasts were superior to the final guidance, but the early guidance was better than the locals. For the third period, the local forecasts were more accurate than the early guidance, but final guidance was better than the locals. The trend for percent improvement in Brier score over climatology decreased for both the local and guidance forecasts.

The guidance wind speed and direction forecasts generally were more accurate than the local forecasts for both the national and regional verifications. The bias characteristics of the guidance wind speed forecasts improved during the 1980 warm season and, in fact, were the best of any of the previous 6 warm seasons. However, both the guidance and local forecasts continued to underestimate wind speeds stronger than 22 knots at the 18- and 30-h projections.

The various performance measures indicate the guidance forecasts of opaque sky cover for all regions combined were, for the most part, more accurate than the local forecasts; the only exceptions were the 18- and 42-h broken category biases. Examination of the long-term trends for percent correct and skill scores revealed noticeable decreases in accuracy for both the local and guidance forecasts during 1980. The trend in the bias characteristics showed that the guidance continued to be superior to the local forecasts except as noted before for the broken category.

A direct comparison between local, MOS, and persistence forecasts of ceiling and visibility was possible only for the 12-h projection. For that projection, local forecasts were superior to the guidance for both elements, but persistence generally outperformed the locals. At most projections, bias characteristics for the guidance forecasts were generally better than those for either persistence or the locals.

For max/min temperature, the early guidance was more accurate than the final guidance for all four projections and all four NWS regions. Though comparisons between the objective guidance and the local max/min forecasts are difficult to make because of the different forecast periods involved, we found that, when verified against calendar day observations, there was little difference between the scores for the local forecasts and the early guidance.

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

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

Table 2.2 Comparative verification of early and final 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 (1st period) | Early/Final | .0993 | | 26.5 | 11489 |
| | Local | .0966 | 3.1 | 28.9 | |
| 24-36 (2nd period) | Early | .1023 | | 21.8 | 11493 |
| | Final | .1075 | | 17.9 | |
| | Local | .1041 | -2.1*(2.9) | 20.2 | |
| 36-48 (3rd period) | Early | .1144 | | 14.7 | 11416 |
| | Final | .1127 | | 15.9 | |
| | Local | .1135 | 0.7*(-0.8) | 15.3 | |

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

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

| Projection (h) | Type of Forecast | Brier Score | Improvement Over Guidance (%) | Improvement Over Climate (%) | Number of Cases |
|---|---|---|---|---|---|
| 12-24 | Early/Final | .1129 | | 32.2 | |
| (1st period) | Local | .1112 | 1.5 | 33.2 | 3409 |
| 24-36 | Early | .1140 | | 28.2 | |
| (2nd period) | Final | .1213 | | 23.6 | 3407 |
| | Local | .1148 | -0.7*(5.4) | 27.8 | |
| 36-48 | Early | .1341 | | 18.2 | |
| (3rd period) | Final | .1288 | | 21.5 | 3383 |
| | Local | .1302 | 2.9*(-1.1) | 20.6 | |

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/Final | .0964 | | 24.0 | |
| (1st period) | Local | .0938 | 2.7 | 26.0 | 3370 |
| 24-36 | Early | .0863 | | 18.2 | |
| (2nd period) | Final | .0904 | | 14.2 | 3376 |
| | Local | .0872 | -1.1*(3.5) | 17.3 | |
| 36-48 | Early | .1107 | | 14.2 | |
| (3rd period) | Final | .1114 | | 13.7 | 3357 |
| | Local | .1097 | 0.9*(1.5) | 15.0 | |

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

Table 2.5. Same as Table 2.2 except for 22 stations in the Central Region.

| Projection (h) | Type of Forecast | Brier Score | Improvement Over Guidance (%) | Improvement Over Climate (%) | Number of Cases |
|---|---|---|---|---|---|
| 12-24 | Early/Final | .1019 | | 28.1 | |
| (1st period) | Local | .1020 | -0.2 | 28.0 | 2667 |
| 24-36 | Early | .1299 | | 20.4 | |
| (2nd period) | Final | .1357 | | 16.9 | 2667 |
| | Local | .1323 | -1.8*(2.5) | 18.9 | |
| 36-48 | Early | .1197 | | 14.5 | |
| (3rd period) | Final | .1204 | | 14.0 | 2644 |
| | Local | .1229 | -2.7*(-2.1) | 12.2 | |

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/Final | .0783 | | 19.0 | |
| (1st period) | Local | .0700 | 10.6 | 27.6 | 2043 |
| 24-36 | Early | .0730 | | 19.0 | |
| (2nd period) | Final | .0760 | | 15.7 | 2043 |
| | Local | .0776 | -6.3*(-2.1) | 13.9 | |
| 36-48 | Early | .0808 | | 9.9 | |
| (3rd period) | Final | .0781 | | 13.0 | 2032 |
| | Local | .0799 | 1.2*(-2.2) | 11.0 | |

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

Table 3.1. Ninety stations used for comparative verification of guidance and local sky cover, surface wind, ceiling, and visibility forecasts.

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

Table 3.2. Comparative verification of early guidance and local surface wind forecasts for 90 stations, 0000 GMT cycle only.

| 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 | 30 | 6978 | 2.9 | 11.8 | 11.3 | 7004 | .31 | 55 | 1.08 | 0.97 | 0.94 | 0.83 | 0.47 | 0.38 | 2.00 | 14361 |
| | Local | 34 | | 3.1 | 12.2 | | | .24 | 51 | 0.87 (5686) | 1.16 (5903) | 0.98 (2191) | 0.84 (487) | 0.39 (85) | 0.63 (8) | 0.00 (1) | |
| 30 | Early | 34 | 3281 | 3.4 | 10.9 | 9.3 | 3282 | .31 | 68 | 1.00 | 1.02 | 1.04 | 0.34 | 0.19 | 0.33 | 0.00 | 14375 |
| | Local | 38 | | 3.6 | 11.1 | | | .26 | 64 | 0.93 (9780) | 1.22 (3606) | 0.93 (829) | 0.48 (140) | 0.38 (16) | 0.67 (3) | 0.00 (1) | |
| 42 | Early | 40 | 6987 | 3.5 | 12.0 | 10.8 | 7035 | .23 | 50 | 1.00 | 0.98 | 1.03 | 1.08 | 0.87 | 0.88 | 2.00 | 14240 |
| | Local | 44 | | 3.5 | 11.9 | | | .18 | 48 | 0.87 (5602) | 1.21 (5859) | 0.89 (2209) | 0.59 (474) | 0.28 (87) | 0.38 (8) | 0.00 (1) | |

Table 3.3. 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 | 3894 | 1618 | 159 | 14 | 1 | 0 | 0 | 5686 |
| | 2 | 2065 | 3030 | 760 | 46 | 2 | 0 | 0 | 5903 |
| | 3 | 173 | 949 | 882 | 182 | 5 | 0 | 0 | 2191 |
| OBS | 4 | 14 | 95 | 233 | 122 | 21 | 2 | 0 | 487 |
| | 5 | 0 | 8 | 27 | 39 | 9 | 1 | 1 | 85 |
| | 6 | 0 | 0 | 6 | 0 | 2 | 0 | 0 | 8 |
| | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | T | 6146 | 5700 | 2067 | 403 | 40 | 3 | 2 | 14361 |

Local

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | T |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 3061 | 2372 | 229 | 22 | 2 | 0 | 0 | 5686 |
| | 2 | 1645 | 3335 | 847 | 68 | 5 | 3 | 0 | 5903 |
| | 3 | 199 | 1007 | 808 | 169 | 8 | 0 | 0 | 2191 |
| OBS | 4 | 13 | 129 | 224 | 111 | 10 | 0 | 0 | 487 |
| | 5 | 3 | 7 | 30 | 37 | 7 | 1 | 0 | 85 |
| | 6 | 0 | 0 | 6 | 1 | 1 | 0 | 0 | 8 |
| | 7 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| | T | 4921 | 6850 | 2144 | 408 | 33 | 5 | 0 | 14361 |

### 30-h Forecasts

Guidance

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | T |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 7913 | 1663 | 200 | 4 | 0 | 0 | 0 | 9780 |
| | 2 | 1648 | 1589 | 359 | 9 | 1 | 0 | 0 | 3606 |
| | 3 | 190 | 375 | 238 | 25 | 1 | 0 | 0 | 829 |
| OBS | 4 | 18 | 54 | 59 | 8 | 1 | 0 | 0 | 140 |
| | 5 | 5 | 5 | 4 | 1 | 0 | 1 | 0 | 16 |
| | 6 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 3 |
| | 7 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| | T | 9774 | 3689 | 861 | 47 | 3 | 1 | 0 | 14375 |

Local

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | T |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 7305 | 2221 | 231 | 20 | 2 | 1 | 0 | 9780 |
| | 2 | 1597 | 1688 | 299 | 21 | 1 | 0 | 0 | 3606 |
| | 3 | 209 | 409 | 188 | 20 | 2 | 1 | 0 | 829 |
| OBS | 4 | 31 | 58 | 45 | 6 | 0 | 0 | 0 | 140 |
| | 5 | 1 | 9 | 5 | 0 | 1 | 0 | 0 | 16 |
| | 6 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 3 |
| | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | T | 9144 | 4386 | 770 | 67 | 6 | 2 | 0 | 14375 |

### 42-h Forecasts

Guidance

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | T |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 3336 | 1857 | 341 | 59 | 9 | 0 | 0 | 5602 |
| | 2 | 1976 | 2823 | 914 | 130 | 14 | 1 | 1 | 5859 |
| | 3 | 276 | 903 | 807 | 195 | 26 | 2 | 0 | 2209 |
| OBS | 4 | 41 | 123 | 182 | 102 | 22 | 3 | 1 | 474 |
| | 5 | 1 | 25 | 29 | 27 | 4 | 1 | 0 | 87 |
| | 6 | 0 | 1 | 7 | 0 | 0 | 0 | 0 | 8 |
| | 7 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| | T | 5630 | 5732 | 2280 | 513 | 76 | 7 | 2 | 14240 |

Local

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | T |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2779 | 2500 | 293 | 26 | 3 | 1 | 0 | 5602 |
| | 2 | 1713 | 3265 | 799 | 76 | 5 | 1 | 0 | 5859 |
| | 3 | 338 | 1093 | 666 | 105 | 7 | 0 | 0 | 2209 |
| OBS | 4 | 52 | 180 | 180 | 54 | 8 | 0 | 0 | 474 |
| | 5 | 8 | 30 | 28 | 19 | 1 | 1 | 0 | 87 |
| | 6 | 0 | 3 | 5 | 0 | 0 | 0 | 0 | 8 |
| | 7 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| | T | 4890 | 7071 | 1972 | 280 | 24 | 3 | 0 | 14240 |

Table 3.4. Same as Table 3.2 except for 22 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) | Bias by Category: 2 (No. Obs) | Bias by Category: 3 (No. Obs) | Bias by Category: 4 (No. Obs) | Bias by Category: 5 (No. Obs) | Bias by Category: 6 (No. Obs | Bias by Category: 7 (No. Obs) | No. of Cases |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | Early | 31 | 1850 | 2.6 | 11.5 | 11.2 | 1854 | .30 | 56 | 1.17 | 0.96 | 0.83 | 0.74 | 0.20 | * | * | 3515 |
| | Local | 34 | | 3.0 | 12.2 | | | .20 | 49 | 0.98 (1151) | 1.05 (1633) | 0.91 (624) | 1.04 (97) | 0.60 (10) | ** (0) | * (0) | |
| 30 | Early | 35 | 694 | 3.2 | 10.3 | 8.6 | 710 | .30 | 72 | 1.03 | 0.94 | 0.87 | 0.41 | 0.00 | * | * | 3491 |
| | Local | 42 | | 4.2 | 11.8 | | | .25 | 65 | 0.89 (2532) | 1.25 (800) | 1.53 (141) | 1.53 (17) | 3.00 (1) | ** (0) | * (0) | |
| 42 | Early | 39 | 1900 | 3.0 | 11.7 | 10.8 | 1907 | .23 | 50 | 1.03 | 1.00 | 0.93 | 1.07 | 1.09 | * | * | 3450 |
| | Local | 43 | | 3.3 | 12.1 | | | .15 | 46 | 0.93 (1131) | 1.09 (1593) | 0.88 (627) | 1.08 (88) | 1.09 (11) | * (0) | * (0) | |

* This catagory was neither forecast nor observed.
** This category was forecast once, but not observed.

Table 3.5. Same as Table 3.2 except for 24 stations in the Southern 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 | 27 | 1909 | 2.6 | 11.6 | 10.8 | 1913 | .33 | 58 | 1.13 | 0.86 | 1.04 | 1.17 | 0.83 | * | * | 4025 |
| | Local | 31 | | 2.9 | 11.9 | | | .22 | 52 | 0.73 (1663) | 1.25 (1755) | 1.05 (505) | 0.96 (90) | 0.33 (12) | * (0) | * (0) | |
| 30 | Early | 29 | 773 | 3.3 | 11.3 | 9.5 | 784 | .38 | 74 | 1.00 | 0.97 | 1.18 | 0.76 | 0.00 | 0.50 | * | 3973 |
| | Local | 33 | | 3.2 | 10.8 | | | .33 | 71 | 0.96 (2881) | 1.20 (862) | 0.77 (200) | 0.40 (25) | 0.33 (3) | 0.00 (2) | * (0) | |
| 42 | Early | 38 | 1878 | 3.4 | 11.9 | 10.3 | 1887 | .21 | 50 | 1.04 | 0.88 | 1.15 | 1.74 | 1.85 | ** | * | 3959 |
| | Local | 42 | | 3.3 | 11.6 | | | .16 | 48 | 0.76 (1616) | 1.26 (1740) | 0.96 (504) | 0.63 (86) | 0.15 (13) | * (0) | * (0) | |

* This category was neither forecast nor observed.
** This category was forecast once, but was not observed.

Table 3.6. Same as Table 3.2 except for 27 stations in the Central 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 | 30 | 2339 | 3.0 | 12.2 | 11.8 | 2349 | .26 | 50 | 1.14 | 0.94 | 1.00 | 0.77 | 0.50 | 0.43 | 2.00 | 4025 |
| | Local | 33 | | 3.3 | 12.6 | | | .23 | 49 | 0.83 (1266) | 1.14 (1738) | 1.07 (753) | 0.72 (220) | 0.50 (40) | 0.29 (7) | 0.00 (1) | |
| 30 | Early | 35 | 1101 | 3.4 | 10.8 | 9.6 | 1124 | .30 | 65 | 1.01 | 1.02 | 0.96 | 0.24 | 0.25 | 0.00 | 0.00 | 4130 |
| | Local | 39 | | 3.6 | 11.2 | | | .24 | 59 | 0.88 (2625) | 1.36 (1126) | 0.89 (314) | 0.36 (55) | 0.13 (8) | 1.00 (1) | 0.00 (1) | |
| 42 | Early | 40 | 2355 | 3.7 | 12.4 | 11.3 | 2368 | .19 | 45 | 1.11 | 0.93 | 1.03 | 0.87 | 0.72 | 0.50 | 2.00 | 4067 |
| | Local | 44 | | 3.6 | 12.1 | | | .14 | 44 | 0.84 (1263) | 1.24 (1756) | 0.93 (782) | 0.42 (220) | 0.18 (39) | 0.33 (6) | 0.00 (1) | |

Table 3.7. Same as Table 3.2 except for 17 stations in the Western 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 | 37 | 880 | 3.4 | 11.7 | 11.1 | 888 | .29 | 58 | 0.92 | 1.27 | 0.88 | 0.70 | 0.35 | 0.00 | * | 2796 |
| | Local | 41 | | 3.5 | 11.9 | | | .24 | 56 | 0.96 (1606) | 1.23 (777) | 0.78 (309) | 0.79 (80) | 0.13 (23) | 0.00 (1) | * (0) | |
| 30 | Early | 34 | 646 | 3.6 | 11.0 | 9.2 | 663 | .24 | 60 | 0.94 | 1.15 | 1.15 | 0.19 | 0.25 | * | * | 2781 |
| | Local | 39 | | 3.6 | 10.8 | | | .20 | 60 | 1.05 (1742) | 1.00 (818) | 0.68 (174) | 0.26 (43) | 0.25 (4) | * (0) | * (0) | |
| 42 | Early | 45 | 854 | 4.1 | 12.1 | 10.3 | 873 | .26 | 55 | 0.87 | 1.27 | 1.04 | 0.96 | 0.50 | 1.00 | * | 2764 |
| | Local | 51 | | 3.9 | 11.4 | | | .21 | 55 | 0.97 (1592) | 1.27 (770) | 0.70 (296) | 0.47 (80) | 0.13 (24) | 0.50 (2) | * (0) | |

* This category was neither forecast nor observed.

Table 3.8. 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 | 71.3 | 17.6 | 5.5 | 2.7 | 1.9 | 1.0 |
| | Local | 65.7 | 20.4 | 7.1 | 3.1 | 2.3 | 1.3 |
| 30 | Early | 69.9 | 14.6 | 6.7 | 3.9 | 2.7 | 2.2 |
| | Local | 62.6 | 18.5 | 8.0 | 4.8 | 3.3 | 2.8 |
| 42 | Early | 60.3 | 20.2 | 9.0 | 4.7 | 3.1 | 2.7 |
| | Local | 55.4 | 22.0 | 9.7 | 5.7 | 4.3 | 3.0 |

Table 3.9. Same as Table 3.8 except for 22 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 | 70.3 | 18.0 | 6.4 | 2.8 | 1.5 | 0.9 |
| | Local | 63.2 | 22.9 | 8.1 | 2.6 | 2.2 | 0.9 |
| 30 | Early | 66.4 | 17.6 | 7.6 | 4.2 | 2.2 | 2.0 |
| | Local | 56.1 | 22.5 | 11.1 | 4.3 | 3.3 | 2.7 |
| 42 | Early | 60.5 | 20.3 | 9.9 | 4.1 | 3.1 | 2.2 |
| | Local | 55.2 | 22.7 | 10.5 | 5.6 | 3.8 | 2.1 |

Table 3.10. Same as Table 3.8 except for 24 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 | 74.7 | 16.6 | 4.8 | 1.6 | 1.4 | 0.9 |
| | Local | 69.3 | 20.4 | 5.4 | 2.3 | 1.4 | 1.6 |
| 30 | Early | 75.9 | 9.6 | 6.5 | 3.8 | 2.1 | 1.9 |
| | Local | 69.6 | 14.6 | 6.1 | 5.2 | 2.6 | 1.9 |
| 42 | Early | 63.0 | 19.3 | 8.4 | 4.3 | 2.8 | 2.1 |
| | Local | 58.2 | 21.7 | 8.6 | 5.1 | 3.3 | 3.0 |

Table 3.11. Same as Table 3.8 except for 27 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 | 71.2 | 19.0 | 5.0 | 2.3 | 1.8 | 0.8 |
| | Local | 66.4 | 19.4 | 7.4 | 3.7 | 2.0 | 1.1 |
| 30 | Early | 67.2 | 16.9 | 6.7 | 4.3 | 2.5 | 2.5 |
| | Local | 60.8 | 20.8 | 7.4 | 5.0 | 2.9 | 3.1 |
| 42 | Early | 58.4 | 22.3 | 9.0 | 4.9 | 2.6 | 2.8 |
| | Local | 54.6 | 22.3 | 10.4 | 5.6 | 4.4 | 3.0 |

Table 3.12. Same as Table 3.8 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 | 66.0 | 15.6 | 6.5 | 5.7 | 4.1 | 2.2 |
| | Local | 61.5 | 17.7 | 7.7 | 4.7 | 5.5 | 2.8 |
| 30 | Early | 71.2 | 13.5 | 5.4 | 2.9 | 4.6 | 2.3 |
| | Local | 64.4 | 15.0 | 7.7 | 4.6 | 5.0 | 3.3 |
| 42 | Early | 59.0 | 15.7 | 8.8 | 6.6 | 5.3 | 4.7 |
| | Local | 51.4 | 20.1 | 8.4 | 7.5 | 7.4 | 5.2 |

Table 4.1. 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 4.2. Comparative verification of early guidance and local forecasts of four categories of cloud amount (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 | 0.84 | 1.34 | 0.86 | 0.87 | 49.2 | .304 | 14220 |
| | Local | 0.66 | 1.49 | 1.11 | 0.64 | 48.1 | .291 | |
| | No. Obs. | 4552 | 4238 | 3022 | 2408 | | | |
| 30 | Early | 0.99 | 1.45 | 0.57 | 0.88 | 50.9 | .265 | 13738 |
| | Local | 0.66 | 2.02 | 1.51 | 0.58 | 44.0 | .229 | |
| | No. Obs. | 6737 | 2557 | 1681 | 2763 | | | |
| 42 | Early | 0.94 | 1.33 | 0.63 | 1.01 | 44.1 | .234 | 14041 |
| | Local | 0.58 | 1.73 | 1.03 | 0.49 | 40.9 | .188 | |
| | No. Obs. | 4451 | 4164 | 3030 | 2396 | | | |

Table 4.3. Same as Table 4.2 except for 22 stations in the Eastern Region.

| Projection (h) | Type of Forecast | Bias by Category | | | | Percent Correct | Skill Score | Number of Cases |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | | | |
| 18 | Early | 0.54 | 1.21 | 1.23 | 0.91 | 46.2 | .268 | 3395 |
| | Local | 0.57 | 1.39 | 1.29 | 0.56 | 45.0 | .245 | |
| | No. Obs. | 751 | 1108 | 787 | 749 | | | |
| 30 | Early | 1.16 | 0.96 | 0.75 | 0.95 | 47.9 | .261 | 3346 |
| | Local | 0.69 | 1.91 | 1.52 | 0.58 | 41.5 | .227 | |
| | No. Obs. | 1267 | 610 | 489 | 980 | | | |
| 42 | Early | 0.80 | 1.12 | 0.79 | 1.24 | 42.1 | .215 | 3359 |
| | Local | 0.47 | 1.45 | 1.26 | 0.58 | 40.6 | .180 | |
| | No. Obs. | 737 | 1104 | 788 | 730 | | | |

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

| Projection (h) | Type of Forecast | Bias by Category | | | | Percent Correct | Skill Score | Number of Cases |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | | | |
| 18 | Early | 0.71 | 1.54 | 0.58 | 1.09 | 50.4 | .304 | 3999 |
| | Local | 0.65 | 1.58 | 0.87 | 0.57 | 50.4 | .297 | |
| | No. Obs. | 1256 | 1332 | 931 | 480 | | | |
| 30 | Early | 1.01 | 1.52 | 0.31 | 0.84 | 55.7 | .279 | 3907 |
| | Local | 0.71 | 2.08 | 1.21 | 0.51 | 48.6 | .244 | |
| | No. Obs. | 2169 | 736 | 448 | 554 | | | |
| 42 | Early | 0.83 | 1.53 | 0.51 | 0.95 | 43.8 | .210 | 3944 |
| | Local | 0.58 | 1.79 | 0.79 | 0.36 | 43.3 | .191 | |
| | No. Obs. | 1220 | 1302 | 930 | 492 | | | |

Table 4.5. Same as Table 4.2 except for 27 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 | 0.88 | 1.35 | 0.94 | 0.74 | 47.3 | .279 | 4082 |
| | Local | 0.60 | 1.62 | 1.09 | 0.67 | 45.6 | .262 | |
| | No. Obs. | 1345 | 1156 | 833 | 748 | | | |
| 30 | Early | 0.95 | 1.53 | 0.62 | 0.84 | 50.0 | .249 | 3884 |
| | Local | 0.56 | 2.18 | 1.76 | 0.60 | 41.1 | .202 | |
| | No. Obs. | 1950 | 729 | 427 | 778 | | | |
| 42 | Early | 1.03 | 1.31 | 0.66 | 0.87 | 42.3 | .209 | 4046 |
| | Local | 0.53 | 1.91 | 1.00 | 0.43 | 37.7 | .152 | |
| | No. Obs. | 1304 | 1143 | 846 | 753 | | | |

Table 4.6. Same as Table 4.2 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 | 1.13 | 1.12 | 0.67 | 0.81 | 53.9 | .325 | 2744 |
| | Local | 0.79 | 1.27 | 1.32 | 0.81 | 52.5 | .339 | |
| | No. Obs. | 1200 | 642 | 471 | 431 | | | |
| 30 | Early | 0.84 | 1.88 | 0.57 | 0.83 | 48.7 | .240 | 2601 |
| | Local | 0.69 | 1.83 | 1.61 | 0.63 | 44.8 | .222 | |
| | No. Obs. | 1351 | 482 | 317 | 451 | | | |
| 42 | Early | 1.04 | 1.31 | 0.57 | 0.92 | 49.8 | .272 | 2692 |
| | Local | 0.69 | 1.75 | 1.19 | 0.57 | 42.2 | .203 | |
| | No. Obs. | 1190 | 615 | 466 | 421 | | | |

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

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

Table 5.2. Comparative verification of early guidance, persistence, and local ceiling 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 | 0.52 | 0.77 | 0.71 | 0.83 | 0.96 | 1.05 | 75.5 | .365 |
| | Local | 0.58 | 0.78 | 0.76 | 1.19 | 1.05 | 1.00 | 79.6 | .506 |
| | Persistence | 0.85 | 0.76 | 0.80 | 0.91 | 0.99 | 1.03 | 81.4 | .532 |
| | No. Obs. | 110 | 316 | 540 | 1037 | 1467 | 10686 | | |
| 15 | Local | 0.70 | 0.44 | 0.49 | 0.92 | 1.28 | 1.01 | 76.0 | .408 |
| | Persistence | 4.90 | 1.21 | 0.82 | 0.64 | 1.14 | 1.03 | 75.0 | .381 |
| | No. Obs. | 20 | 200 | 544 | 1512 | 1335 | 10960 | | |
| 18 | Early | 0.00 | 0.65 | 0.59 | 0.62 | 0.91 | 1.08 | 75.0 | .339 |
| | Persistence | 12.25 | 3.14 | 1.47 | 0.71 | 0.77 | 1.04 | 71.4 | .287 |
| | No. Obs. | 8 | 79 | 303 | 1363 | 1916 | 10760 | | |
| 21 | Local | 1.25 | 0.21 | 0.39 | 0.87 | 1.09 | 1.01 | 73.5 | .303 |
| | Persistence | 24.25 | 3.07 | 2.50 | 1.05 | 0.68 | 1.01 | 70.3 | .230 |
| | No. Obs. | 4 | 80 | 180 | 922 | 2227 | 11167 | | |
| 24 | Early | 0.50 | 0.81 | 0.57 | 0.71 | 1.02 | 1.02 | 79.0 | .323 |
| | Persistence | 12.25 | 3.22 | 2.13 | 1.55 | 0.82 | 0.96 | 71.5 | .196 |
| | No. Obs. | 8 | 77 | 209 | 622 | 1814 | 11700 | | |
| 36 | Early | 0.76 | 0.64 | 0.86 | 1.01 | 0.97 | 1.02 | 71.4 | .285 |
| | Persistence | 0.88 | 0.78 | 0.79 | 0.92 | 0.99 | 1.03 | 67.3 | .179 |
| | No. Obs. | 111 | 319 | 561 | 1052 | 1503 | 10882 | | |
| 48 | Early | 1.13 | 1.38 | 1.96 | 0.93 | 0.85 | 1.01 | 76.0 | .255 |
| | Persistence | 12.25 | 3.44 | 2.15 | 1.57 | 0.81 | 0.96 | 67.4 | .082 |
| | No. Obs. | 8 | 72 | 207 | 615 | 1829 | 11699 | | |

Table 5.3. Same as Table 5.2 except for visibility.

| Projection (h) | Type of Forecast | Bias by Category 1 | 2 | 3 | 4 | 5 | 6 | Percent Correct | Skill Score |
|---|---|---|---|---|---|---|---|---|---|
| 12 | Early | 0.63 | 1.00 | 0.97 | 1.00 | 1.17 | 0.99 | 68.5 | .295 |
| | Local | 0.52 | 0.78 | 0.49 | 1.35 | 1.19 | 0.99 | 74.3 | .421 |
| | Persistence | 0.75 | 0.76 | 0.46 | 0.65 | 0.76 | 1.12 | 76.7 | .389 |
| | No. Obs. | 204 | 126 | 872 | 1075 | 1479 | 10337 | | |
| 15 | Local | 0.71 | 0.57 | 0.23 | 0.89 | 1.09 | 1.03 | 78.6 | .316 |
| | Persistence | 6.67 | 2.47 | 0.87 | 0.96 | 0.78 | 1.02 | 77.7 | .308 |
| | No. Obs. | 24 | 40 | 477 | 763 | 1494 | 11791 | | |
| 18 | Early | 0.14 | 1.18 | 0.77 | 0.98 | 1.18 | 0.99 | 81.9 | .267 |
| | Persistence | 22.43 | 5.82 | 1.63 | 1.57 | 0.98 | 0.95 | 78.8 | .234 |
| | No. Obs. | 7 | 17 | 251 | 460 | 1183 | 12510 | | |
| 21 | Local | 1.67 | 0.26 | 0.17 | 0.62 | 1.03 | 1.02 | 85.5 | .216 |
| | Persistence | 52.67 | 5.11 | 1.86 | 1.99 | 1.17 | 0.93 | 79.0 | .193 |
| | No. Obs. | 3 | 19 | 223 | 370 | 995 | 12944 | | |
| 24 | Early | 0.08 | 0.94 | 0.53 | 1.02 | 1.08 | 1.00 | 84.9 | .257 |
| | Persistence | 13.08 | 5.50 | 1.67 | 1.88 | 1.20 | 0.93 | 78.7 | .183 |
| | No. Obs. | 12 | 18 | 244 | 385 | 960 | 12809 | | |
| 36 | Early | 0.45 | 0.50 | 0.78 | 0.95 | 1.07 | 1.03 | 67.1 | .233 |
| | Persistence | 0.73 | 0.77 | 0.45 | 0.65 | 0.75 | 1.13 | 68.6 | .183 |
| | No. Obs. | 216 | 128 | 898 | 1112 | 1542 | 10531 | | |
| 48 | Early | 1.08 | 1.88 | 1.32 | 1.63 | 1.27 | 0.95 | 80.3 | .188 |
| | Persistence | 12.08 | 6.19 | 1.70 | 1.87 | 1.19 | 0.93 | 76.9 | .115 |
| | No. Obs. | 13 | 16 | 240 | 386 | 971 | 12802 | | |

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

| Projection (h) | Type of Forecast | Bias by Category 1 | 2 | 3 | 4 | 5 | 6 | Percent Correct | Skill Score |
|---|---|---|---|---|---|---|---|---|---|
| 12 | Early | 0.71 | 0.60 | 0.81 | 0.92 | 0.93 | 1.02 | 79.3 | .343 |
| | Local | 0.71 | 0.87 | 0.60 | 1.37 | 1.19 | 0.96 | 81.0 | .461 |
| | Persistence | 0.57 | 1.00 | 0.88 | 1.33 | 1.19 | 0.95 | 80.7 | .455 |
| | No. Obs. | 7 | 70 | 194 | 603 | 1801 | 11266 | | |
| 15 | Local | 0.47 | 0.54 | 0.72 | 1.46 | 1.04 | 0.98 | 79.7 | .385 |
| | Persistence | 0.37 | 0.59 | 0.83 | 1.35 | 1.31 | 0.95 | 76.1 | .318 |
| | No. Obs. | 19 | 123 | 215 | 625 | 1714 | 11947 | | |
| 18 | Early | 0.58 | 0.72 | 0.72 | 0.98 | 0.91 | 1.03 | 78.7 | .337 |
| | Persistence | 0.08 | 0.44 | 0.56 | 1.15 | 1.42 | 0.96 | 73.2 | .255 |
| | No. Obs. | 53 | 160 | 309 | 705 | 1506 | 11287 | | |
| 21 | Local | 0.20 | 0.44 | 0.65 | 1.44 | 0.91 | 1.01 | 75.7 | .356 |
| | Persistence | 0.07 | 0.31 | 0.41 | 0.89 | 1.46 | 0.99 | 70.1 | .217 |
| | No. Obs. | 105 | 235 | 431 | 938 | 1502 | 11096 | | |
| 24 | Early | 0.58 | 0.61 | 0.81 | 0.95 | 1.09 | 1.02 | 73.5 | .340 |
| | Persistence | 0.04 | 0.23 | 0.32 | 0.79 | 1.47 | 1.02 | 67.9 | .192 |
| | No. Obs. | 114 | 314 | 538 | 1029 | 1473 | 10662 | | |
| 36 | Early | 1.14 | 1.18 | 0.58 | 1.09 | 0.93 | 1.01 | 77.7 | .292 |
| | Persistence | 0.57 | 1.01 | 0.90 | 1.39 | 1.20 | 0.95 | 69.5 | .132 |
| | No. Obs. | 7 | 71 | 194 | 590 | 1815 | 11588 | | |
| 48 | Early | 0.62 | 0.65 | 1.02 | 1.10 | 1.04 | 1.00 | 70.0 | .270 |
| | Persistence | 0.04 | 0.23 | 0.32 | 0.80 | 1.48 | 1.02 | 63.5 | .079 |
| | No. Obs. | 110 | 309 | 547 | 1020 | 1462 | 10682 | | |

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

| Projection (h) | Type of Forecast | Bias by Category | | | | | | Percent Correct | Skill Score |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 12 | Early | 0.45 | 0.94 | 0.74 | 1.18 | 1.15 | 0.99 | 85.7 | .319 |
| | Local | 0.09 | 0.94 | 0.42 | 1.22 | 1.37 | 0.98 | 88.1 | .451 |
| | Persistence | 0.09 | 1.19 | 0.94 | 0.89 | 1.11 | 1.00 | 90.5 | .532 |
| | No. Obs. | 11 | 16 | 222 | 371 | 903 | 12408 | | |
| 15 | Local | 0.36 | 1.30 | 0.67 | 1.42 | 1.58 | 0.95 | 85.1 | .359 |
| | Persistence | 0.14 | 1.10 | 1.16 | 0.80 | 1.19 | 0.99 | 87.6 | .383 |
| | No. Obs. | 22 | 20 | 187 | 430 | 883 | 13028 | | |
| 18 | Early | 0.73 | 0.85 | 0.75 | 0.98 | 1.05 | 1.00 | 83.8 | .275 |
| | Persistence | 0.02 | 0.31 | 0.85 | 0.69 | 1.17 | 1.01 | 84.7 | .300 |
| | No. Obs. | 66 | 65 | 253 | 481 | 880 | 12291 | | |
| 21 | Local | 0.25 | 0.86 | 0.87 | 2.04 | 1.43 | 0.92 | 74.8 | .275 |
| | Persistence | 0.02 | 0.29 | 0.60 | 0.50 | 0.97 | 1.06 | 80.7 | .237 |
| | No. Obs. | 154 | 80 | 362 | 690 | 1085 | 12032 | | |
| 24 | Early | 0.79 | 1.18 | 1.00 | 1.34 | 1.11 | 0.95 | 67.3 | .293 |
| | Persistence | 0.00 | 0.17 | 0.25 | 0.31 | 0.70 | 1.21 | 71.8 | .165 |
| | No. Obs. | 206 | 121 | 864 | 1085 | 1475 | 10396 | | |
| 36 | Early | 0.42 | 2.00 | 0.82 | 1.25 | 1.42 | 0.96 | 81.8 | .207 |
| | Persistence | 0.08 | 1.18 | 0.90 | 0.90 | 1.11 | 1.00 | 83.2 | .180 |
| | No. Obs. | 12 | 17 | 238 | 374 | 930 | 12706 | | |
| 48 | Early | 1.01 | 0.90 | 1.38 | 1.30 | 0.95 | 0.95 | 64.8 | .251 |
| | Persistence | 0.00 | 0.16 | 0.25 | 0.31 | 0.69 | 1.21 | 69.5 | .105 |
| | No. Obs. | 211 | 124 | 858 | 1096 | 1509 | 10348 | | |

Table 5.6. Comparative verification for early guidance, persistence, and local ceiling forecasts for 90 stations, 0000 GMT cycle. Scores are computed from two-category contingency tables.

| 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 | 0.70 | 96.1 | .212 | .131 |
| | Local | | 0.73 | 97.2 | .449 | .301 |
| | Persistence | | 0.78 | 97.4 | .503 | .348 |
| 15 | Local | 0.015 | 0.47 | 98.2 | .190 | .110 |
| | Persistence | | 1.55 | 97.1 | .228 | .138 |
| 18 | Early | 0.006 | 0.59 | 99.2 | .127 | .070 |
| | Persistence | | 3.98 | 97.3 | .093 | .054 |
| 21 | Local | 0.006 | 0.26 | 99.3 | .017 | .010 |
| | Persistence | | 4.08 | 97.3 | .076 | .044 |
| 24 | Early | 0.006 | 0.78 | 99.0 | .075 | .041 |
| | Persistence | | 4.07 | 97.3 | .079 | .046 |
| 36 | Early | 0.030 | 0.67 | 95.7 | .107 | .069 |
| | Persistence | | 0.80 | 95.3 | .097 | .064 |
| 48 | Early | 0.006 | 1.35 | 98.9 | .122 | .068 |
| | Persistence | | 3.08 | 97.1 | .024 | .017 |

Table 5.7. Same as Table 5.6 except for visibility.

| Projection (h) | Type of Forecast | Rel. Freq. Cats. 1&2 combined | Bias Cats. 1&2 combined | Percent Correct | Skill Score | Threat Score |
|---|---|---|---|---|---|---|
| 12 | Early | 0.023 | 0.77 | 96.7 | .192 | .117 |
| | Local | | 0.62 | 98.0 | .462 | .309 |
| | Persistence | | 0.75 | 97.9 | .491 | .334 |
| 15 | Local | 0.004 | 0.63 | 99.4 | .093 | .051 |
| | Persistence | | 4.05 | 98.0 | .080 | .045 |
| 18 | Early | 0.002 | 0.88 | 99.7 | .088 | .047 |
| | Persistence | | 10.67 | 98.1 | .033 | .018 |
| 21 | Local | 0.002 | 0.45 | 99.8 | .062 | .032 |
| | Persistence | | 11.59 | 98.1 | .004 | .004 |
| 24 | Early | 0.002 | .60 | 99.7 | .040 | .021 |
| | Persistence | | 8.53 | 98.1 | .017 | .011 |
| 36 | Early | 0.024 | 0.47 | 96.9 | .113 | .068 |
| | Persistence | | 0.74 | 96.4 | .115 | .071 |
| 48 | Early | 0.002 | 1.52 | 99.5 | .080 | .043 |
| | Persistence | | 8.83 | 98.1 | .025 | .014 |

Table 5.8. Same as Table 5.6 except for 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 | 0.006 | 0.61 | 99.3 | .174 | .097 |
| | Local | | 0.86 | 99.3 | .346 | .212 |
| | Persistence | | 0.96 | 99.4 | .447 | .291 |
| 15 | Local | 0.010 | 0.46 | 98.9 | .289 | .172 |
| | Persistence | | 0.56 | 99.0 | .311 | .187 |
| 18 | Early | 0.015 | 0.69 | 97.9 | .167 | .098 |
| | Persistence | | 0.35 | 98.3 | .146 | .083 |
| 21 | Local | 0.024 | 0.37 | 97.4 | .179 | .105 |
| | Persistence | | 0.23 | 97.4 | .116 | .066 |
| 24 | Early | 0.030 | 0.60 | 96.0 | .159 | .098 |
| | Persistence | | 0.18 | 96.7 | .075 | .043 |
| 36 | Early | 0.005 | 1.18 | 99.0 | .183 | .104 |
| | Persistence | | 0.97 | 99.0 | .047 | .027 |
| 48 | Early | 0.030 | 0.64 | 95.7 | .095 | .062 |
| | Persistence | | 0.18 | 96.7 | .048 | .029 |

Table 5.9. Same as Table 5.7 except for 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 | .002 | 0.74 | 99.7 | .126 | .068 |
| | Local | | 0.59 | 99.7 | .185 | .103 |
| | Persistence | | 0.74 | 99.8 | .297 | .175 |
| 15 | Local | .003 | 0.81 | 99.6 | .156 | .086 |
| | Persistence | | 0.60 | 99.6 | .058 | .031 |
| 18 | Early | .009 | 0.79 | 98.6 | .164 | .093 |
| | Persistence | | 0.16 | 98.9 | .024 | .013 |
| 21 | Local | .016 | 0.46 | 98.1 | .191 | .110 |
| | Persistence | | 0.11 | 98.3 | .028 | .016 |
| 24 | Early | .023 | 0.94 | 96.4 | .184 | .112 |
| | Persistence | | 0.06 | 97.6 | .003 | .003 |
| 36 | Early | .002 | 1.34 | 99.6 | .057 | .030 |
| | Persistence | | 0.72 | 99.6 | -.002 | .000 |
| 48 | Early | .024 | 0.97 | 95.9 | .104 | .066 |
| | Persistence | | 0.06 | 97.5 | .008 | .006 |

Table 6.1. Comparative verification of early and final guidance and local 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° | Number of Cases |
|---|---|---|---|---|---|
| 24 (Max) | Early | 0.3 | 2.9 | 303 (2.6) | 11843 |
| | Final | -0.8 | 3.3 | 389 (3.3) | |
| | Local | 0.2 | 2.8 | 293 (2.5) | |
| 36 (Min) | Early | 0.0 | 2.9 | 233 (2.0) | 11839 |
| | Final | 0.2 | 3.2 | 290 (2.4) | |
| | Local | 0.6 | 3.0 | 308 (2.6) | |
| 48 (Max) | Early | -0.2 | 3.7 | 668 (5.6) | 11844 |
| | Final | -1.1 | 4.1 | 868 (7.3) | |
| | Local | -0.0 | 3.6 | 670 (5.7) | |
| 60 (Min) | Early | -0.3 | 3.4 | 475 (4.0) | 11839 |
| | Final | 0.2 | 3.8 | 669 (5.7) | |
| | Local | 0.3 | 3.5 | 530 (4.5) | |

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

| Forecast Projection (h) | Type of Forecast | Mean Algebraic Error (°F) | Mean Absolute Error (°F) | Number (%) of Absolute Errors ≥ 10° | Number of Cases |
|---|---|---|---|---|---|
| 24 (Max) | Early | 0.4 | 2.9 | 72 (2.0) | 3683 |
| | Final | -0.5 | 3.1 | 107 (2.9) | |
| | Local | 0.2 | 2.9 | 80 (2.2) | |
| 36 (Min) | Early | 0.0 | 2.9 | 70 (1.9) | 3682 |
| | Final | 0.6 | 3.3 | 91 (2.5) | |
| | Local | 0.8 | 3.1 | 102 (2.8) | |
| 48 (Max) | Early | -0.0 | 3.5 | 175 (4.8) | 3684 |
| | Final | -0.5 | 3.9 | 227 (6.2) | |
| | Local | 0.1 | 3.5 | 193 (5.2) | |
| 60 (Min) | Early | -0.2 | 3.5 | 159 (4.3) | 3682 |
| | Final | 0.8 | 4.0 | 243 (6.6) | |
| | Local | 0.6 | 3.7 | 180 (4.9) | |

Table 6.3. Same as Table 6.1 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° | Number of Cases |
|---|---|---|---|---|---|
| 24 (Max) | Early | -0.3 | 2.6 | 58 (1.7) | 3442 |
| | Final | -1.2 | 3.0 | 71 (2.1) | |
| | Local | 0.1 | 2.3 | 51 (1.5) | |
| 36 (Min) | Early | -0.2 | 2.8 | 65 (1.9) | 3438 |
| | Final | 0.2 | 2.9 | 76 (2.2) | |
| | Local | 0.4 | 2.6 | 50 (1.5) | |
| 48 (Max) | Early | -1.0 | 3.5 | 151 (4.4) | 3443 |
| | Final | -1.4 | 3.9 | 210 (6.1) | |
| | Local | 0.0 | 3.0 | 127 (3.7) | |
| 60 (Min) | Early | -0.5 | 3.2 | 118 (3.4) | 3438 |
| | Final | -0.0 | 3.5 | 136 (4.0) | |
| | Local | 0.4 | 3.1 | 107 (3.1) | |

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

| Forecast Projection (h) | Type of Forecast | Mean Algebraic Error (°F) | Mean Absolute Error (°F) | Number (%) of Absolute Errors ≥ 10° | Number of Cases |
|---|---|---|---|---|---|
| 24 (Max) | Early | 0.5 | 3.4 | 113 (4.1) | 2755 |
| | Final | -0.2 | 3.6 | 136 (4.9) | |
| | Local | 0.5 | 3.3 | 101 (3.7) | |
| 36 (Min) | Early | 0.4 | 3.3 | 80 (2.9) | 2755 |
| | Final | 0.5 | 3.6 | 94 (3.4) | |
| | Local | 0.9 | 3.5 | 119 (4.3) | |
| 48 (Max) | Early | 0.1 | 4.1 | 204 (7.4) | 2753 |
| | Final | -0.5 | 4.5 | 260 (9.4) | |
| | Local | 0.2 | 4.2 | 216 (7.8) | |
| 60 (Min) | Early | 0.2 | 3.9 | 150 (5.4) | 2755 |
| | Final | 0.5 | 4.2 | 209 (7.6) | |
| | Local | 0.4 | 4.0 | 181 (6.6) | |

Table 6.5. Same as Table 6.1 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° | Number of Cases |
|---|---|---|---|---|---|
| 24 (Max) | Early | 0.8 | 3.0 | 60 (3.1) | 1963 |
| | Final | -1.5 | 3.4 | 75 (3.8) | |
| | Local | -0.2 | 2.9 | 61 (3.1) | |
| 36 (Min) | Early | -0.2 | 2.7 | 18 (0.9) | 1964 |
| | Final | -0.8 | 3.0 | 29 (1.5) | |
| | Local | -0.2 | 2.9 | 37 (1.9) | |
| 48 (Max) | Early | 0.6 | 3.8 | 138 (7.0) | 1964 |
| | Final | -2.2 | 4.5 | 171 (8.7) | |
| | Local | -0.6 | 3.8 | 134 (6.8) | |
| 60 (Min) | Early | -0.7 | 3.1 | 48 (2.4) | 1964 |
| | Final | -1.1 | 3.4 | 81 (4.1) | |
| | Local | -0.6 | 3.2 | 62 (3.2) | |

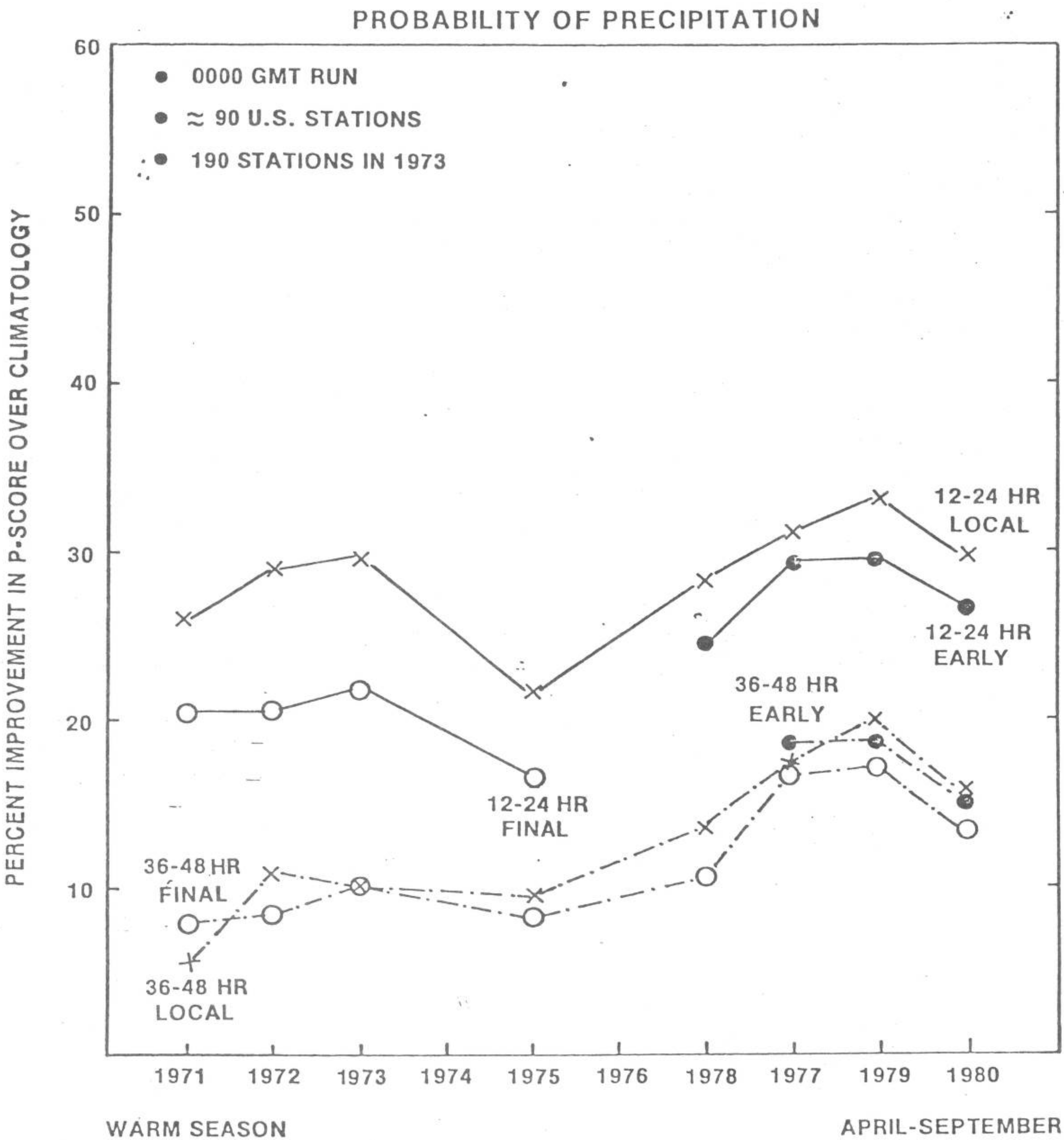


Figure 2.1. Percent improvement over climatology in the Brier score of the local and the early and final guidance PoP forecasts. Results during 1974 and 1976 were unavailable due to missing data.

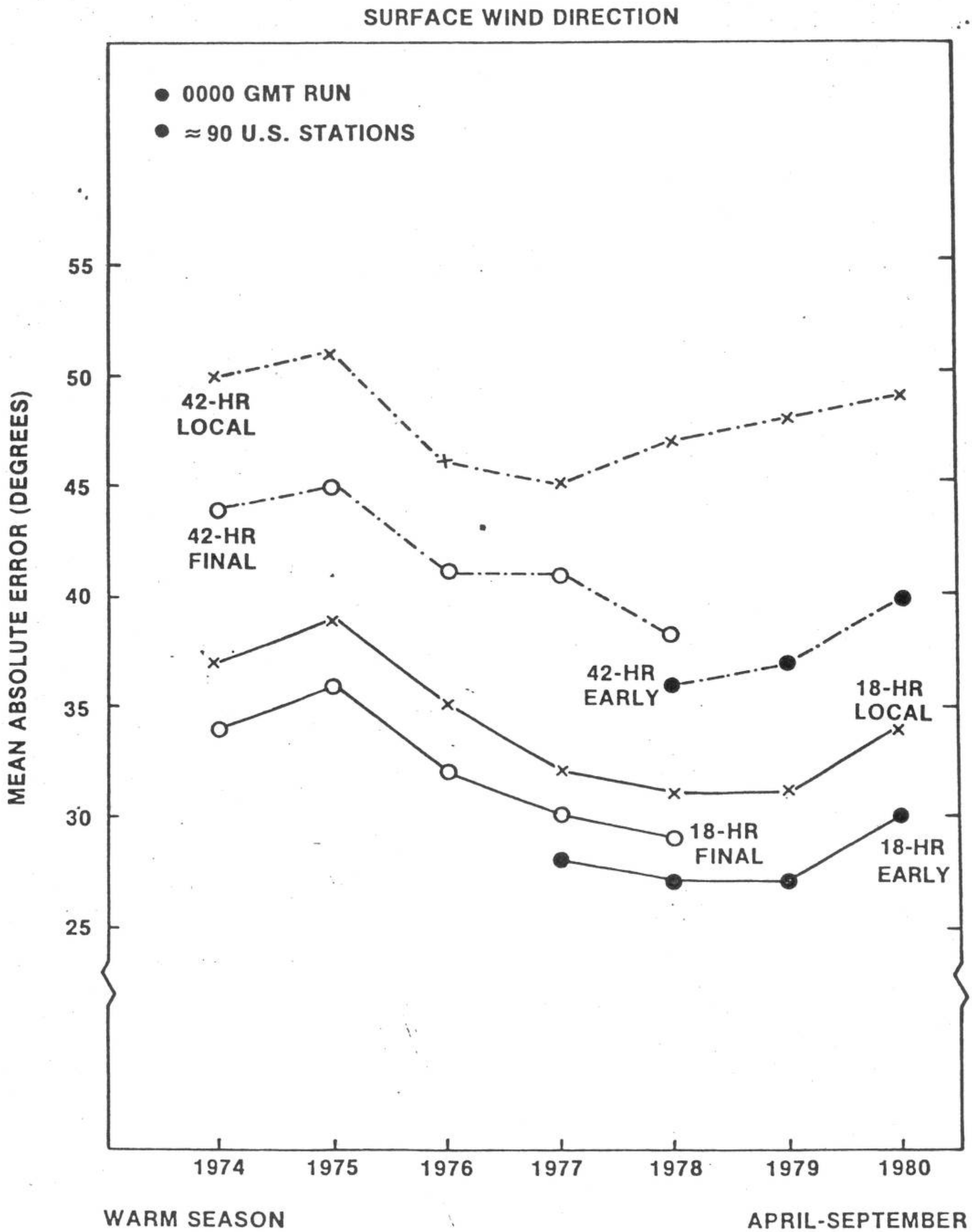


Figure 3.1. Mean absolute errors for the local and the early and final guidance surface wind direction forecasts.

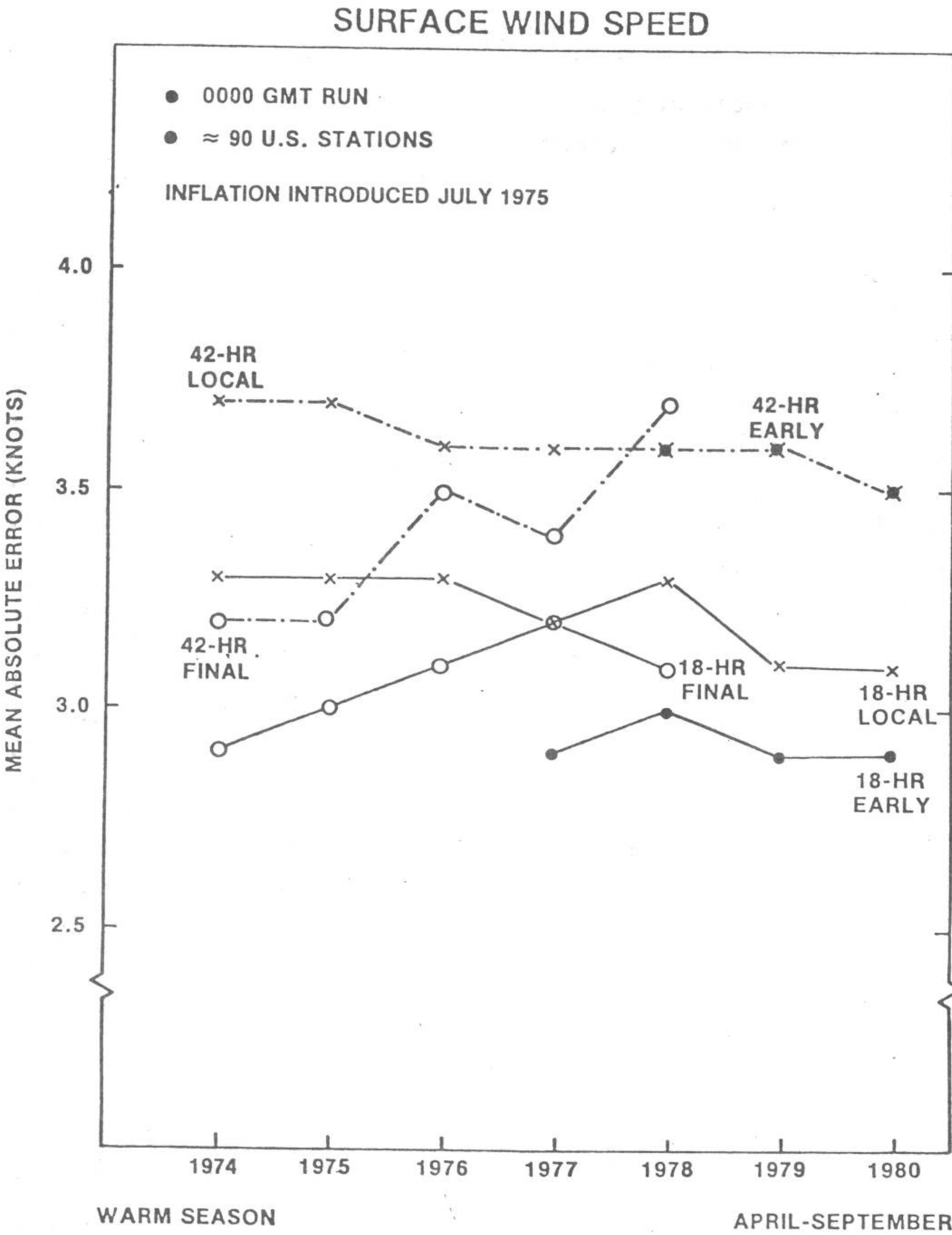


Figure 3.2. Same as Fig. 3.1 except for wind speed forecasts.

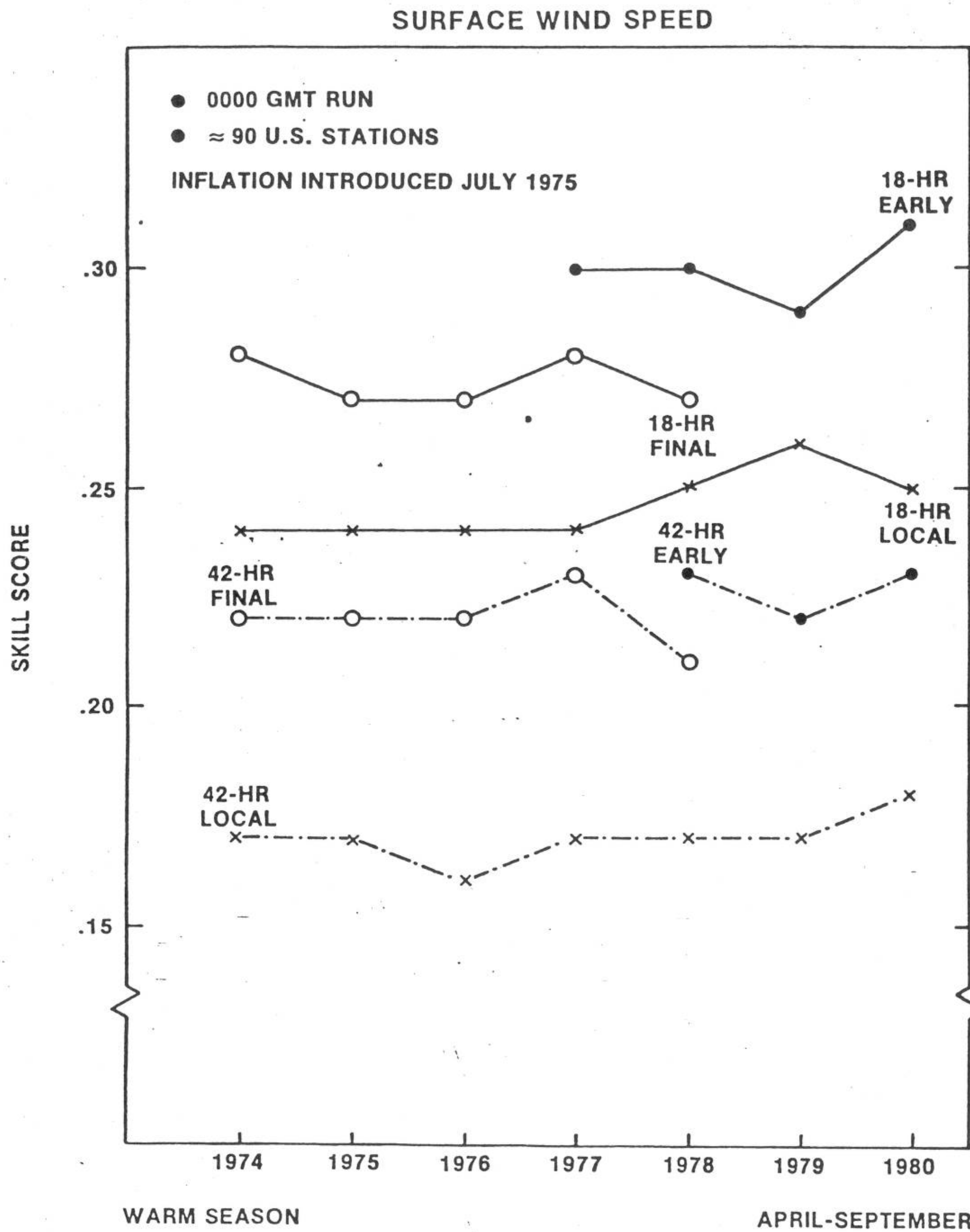


Figure 3.3. Skill scores computed from five-category contingency tables for the local and the early and final guidance surface wind speed forecasts.

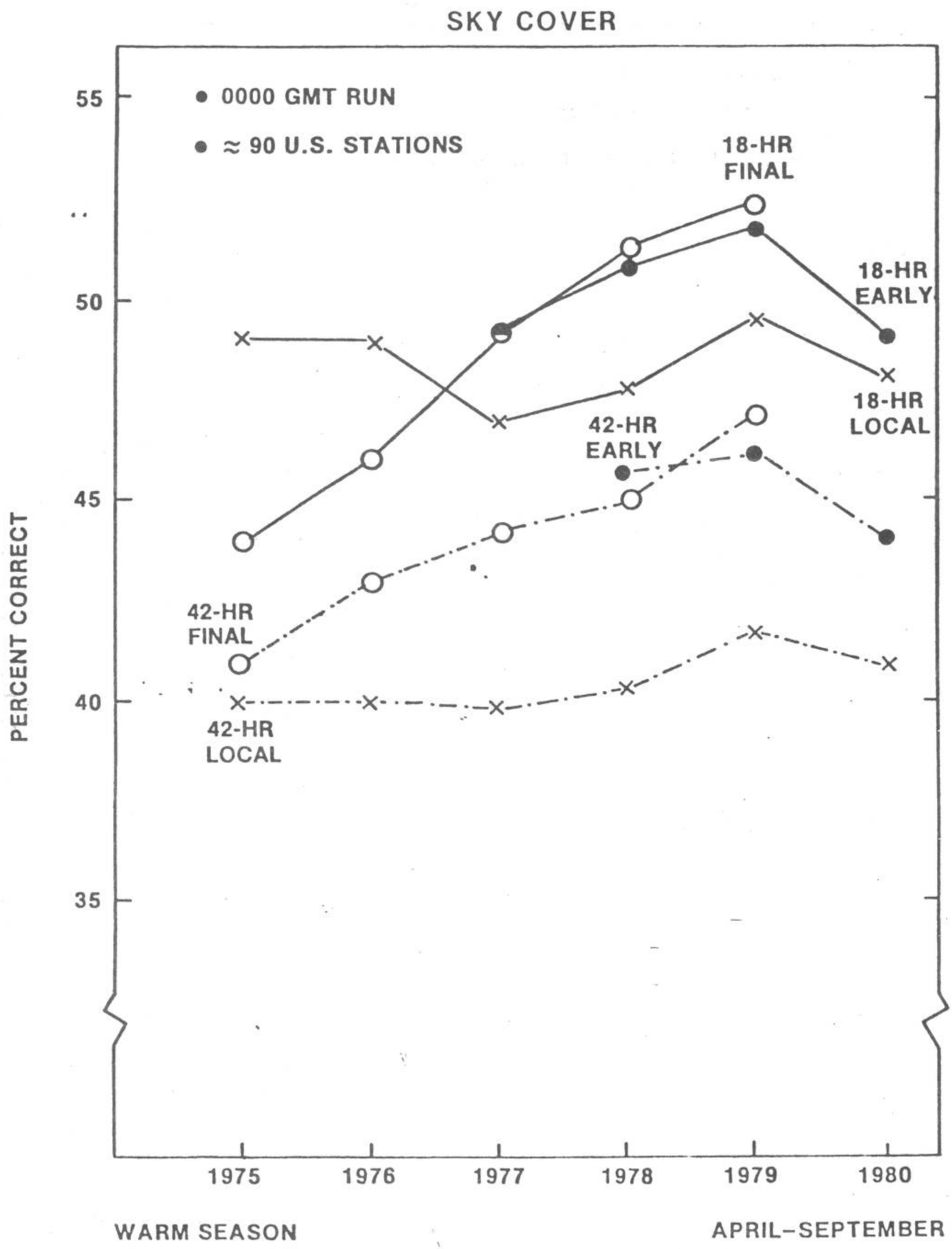


Figure 4.1. Percent correct for the local and the early and final guidance cloud amout forecasts.

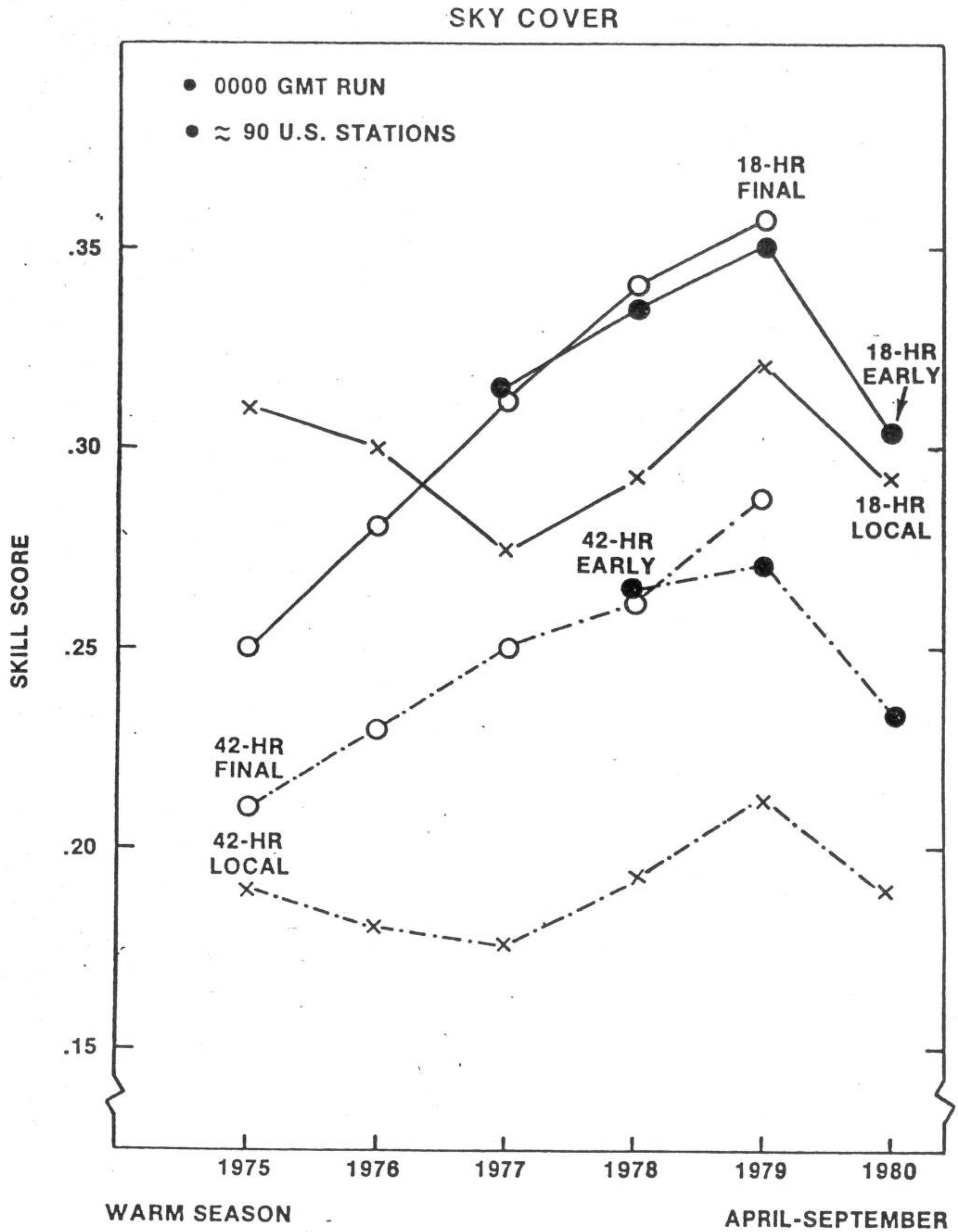


Figure 4.2. Skill score for the local and the early and final guidance cloud amount forecasts.

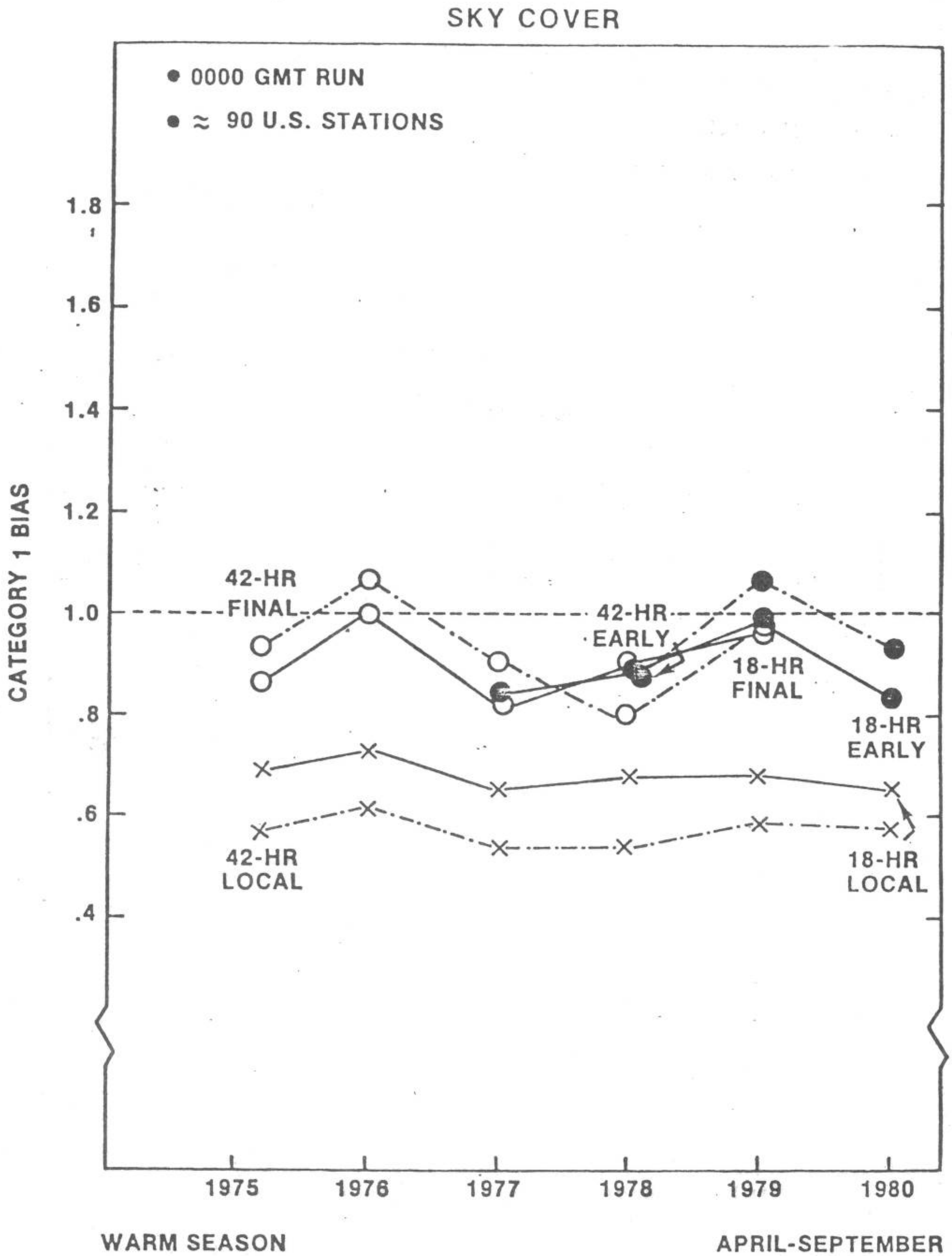


Figure 4.3. Category 1 bias for the local and the early and final guidance cloud amount forecasts.

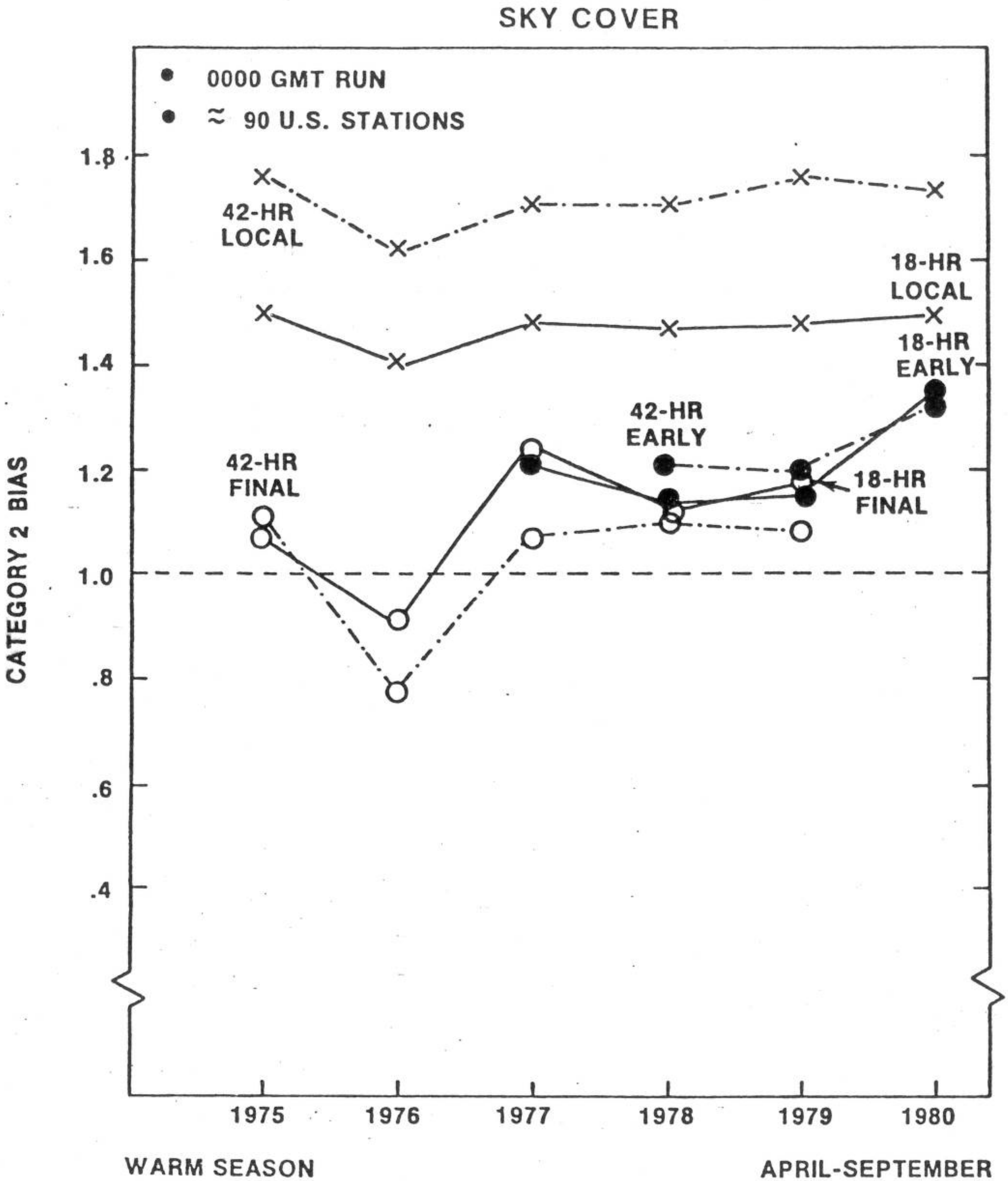


Figure 4.4. Same as Fig. 4.3 except for category 2 bias.

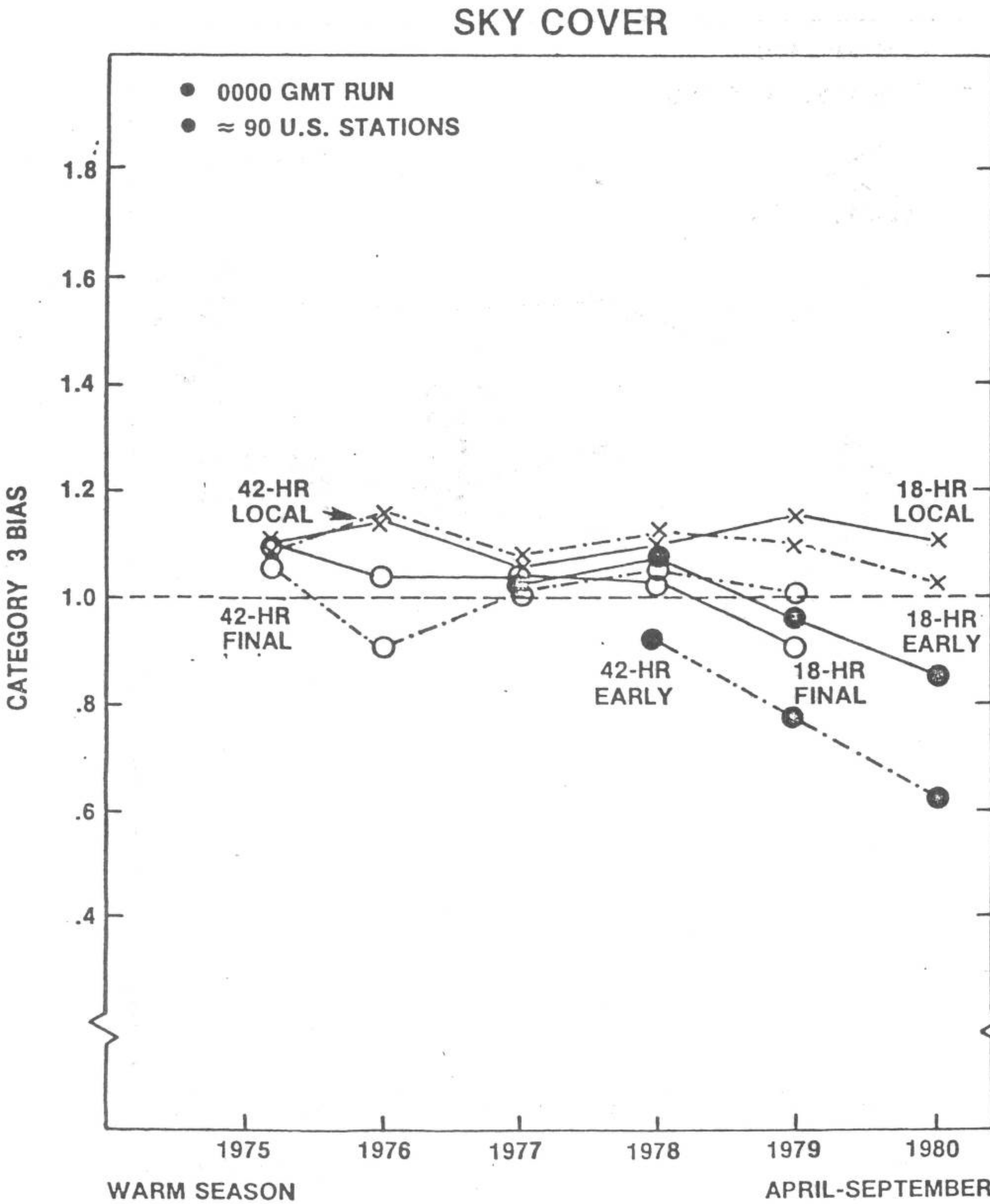


Figure 4.5. Same as Fig. 4.3 except for category 3 bias.

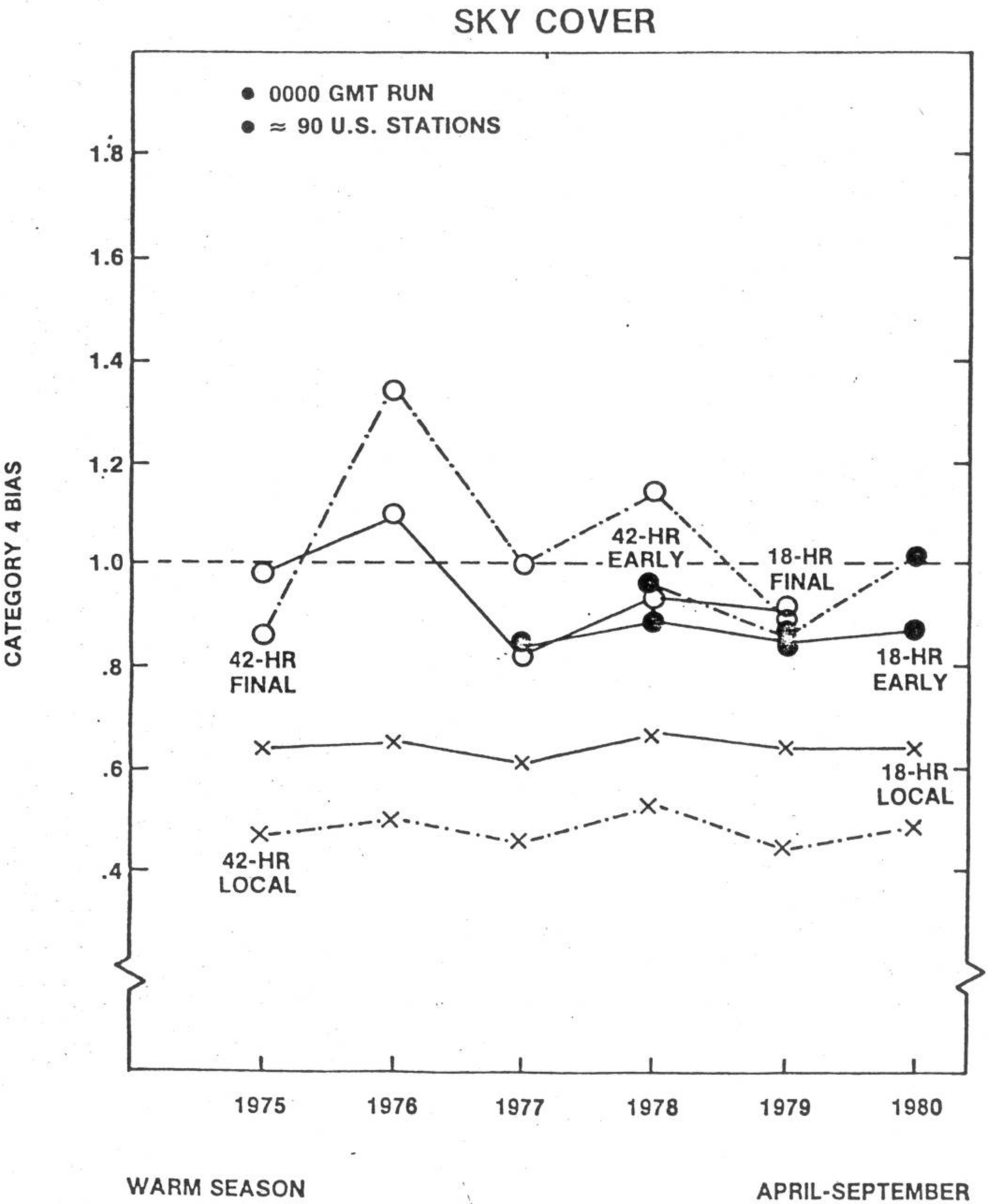


Figure 4.6. Same as Fig. 4.3 except for category 4 bias.

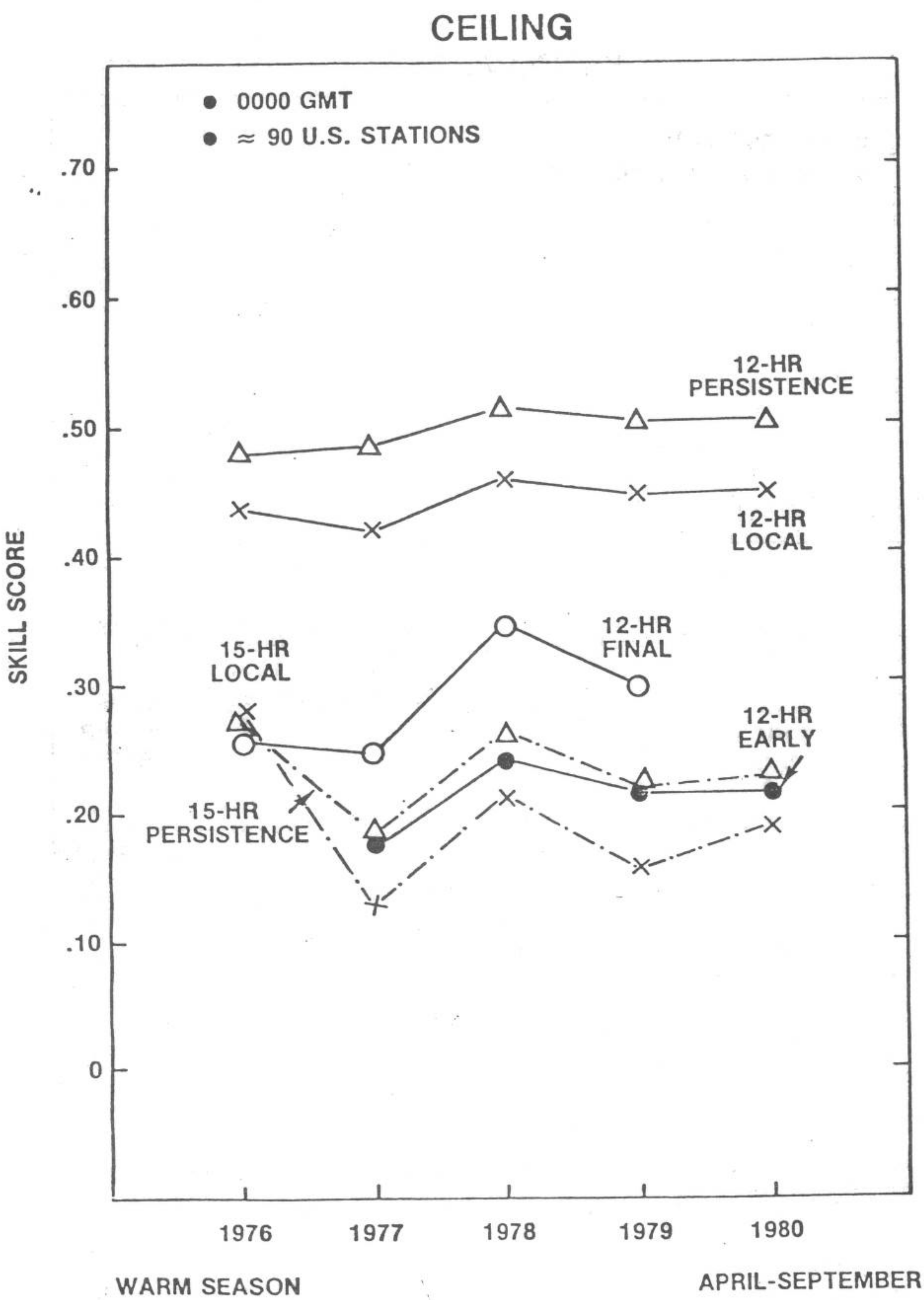


Figure 5.1. Skill score computed from two-category contingency tables for local, guidance, and persistence ceiling forecasts.

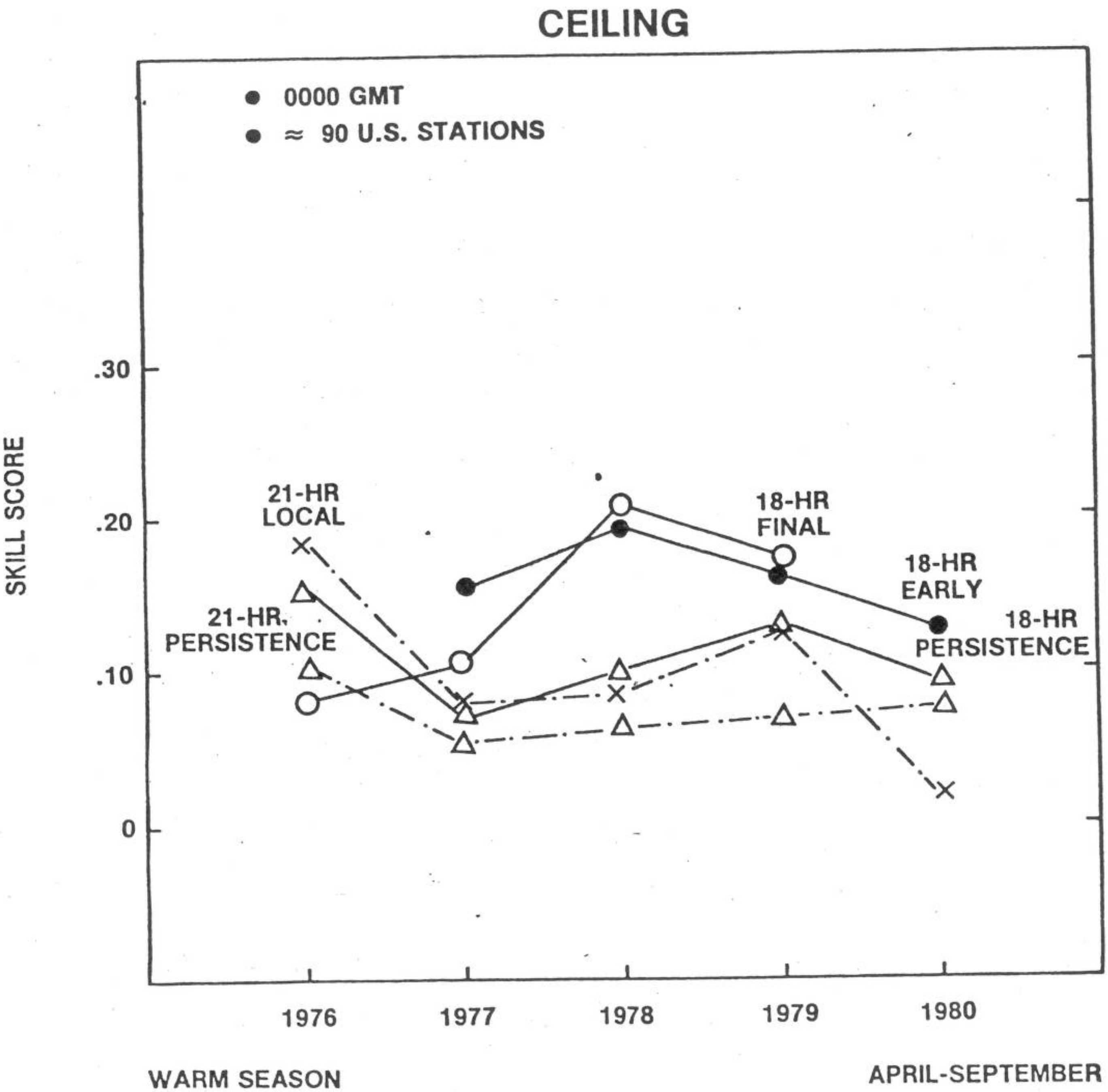


Figure 5.2. Same as Fig. 5.1 except for forecast projection.

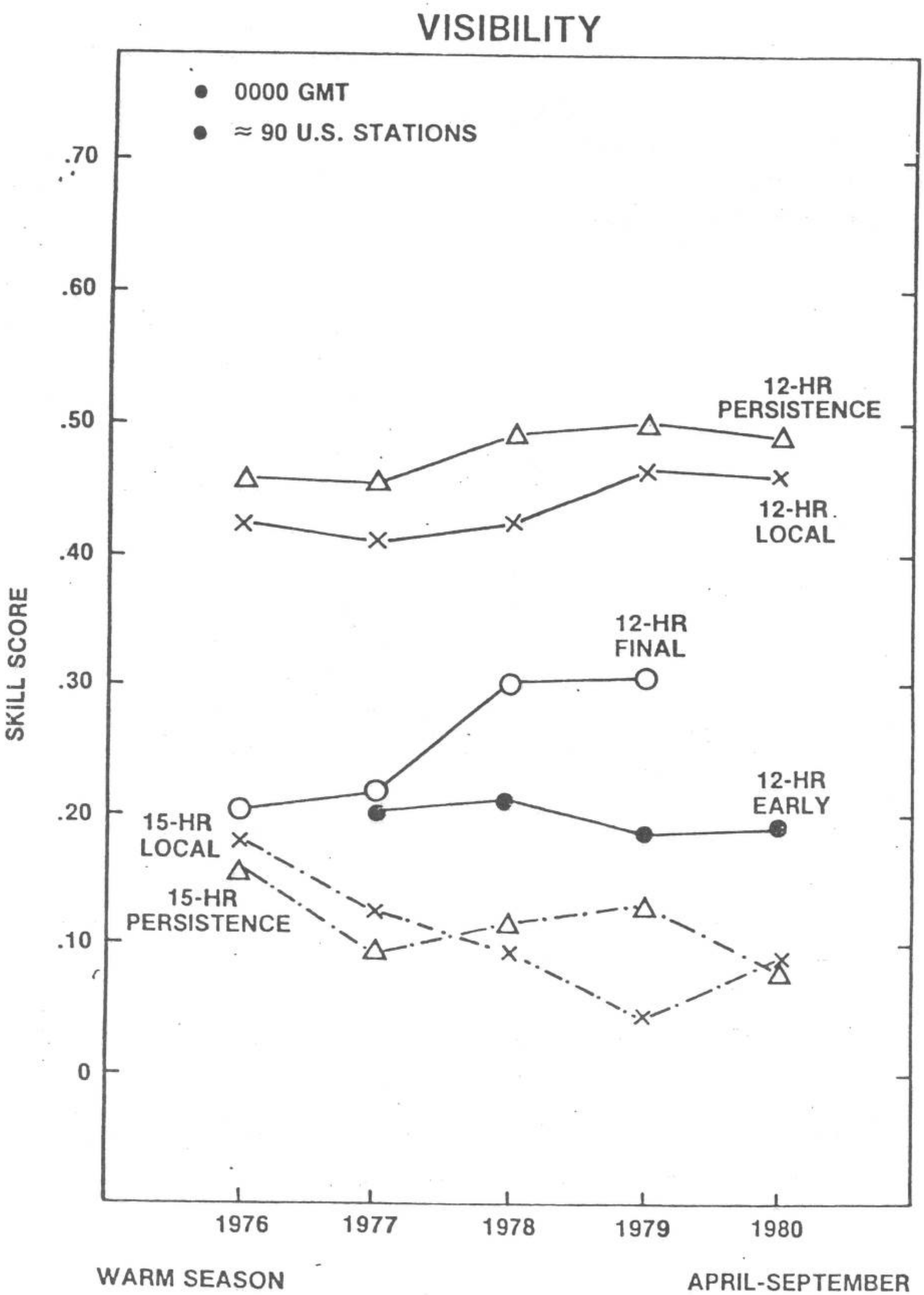


Figure 5.3. Same as Fig. 5.1 except for visibility forecasts.

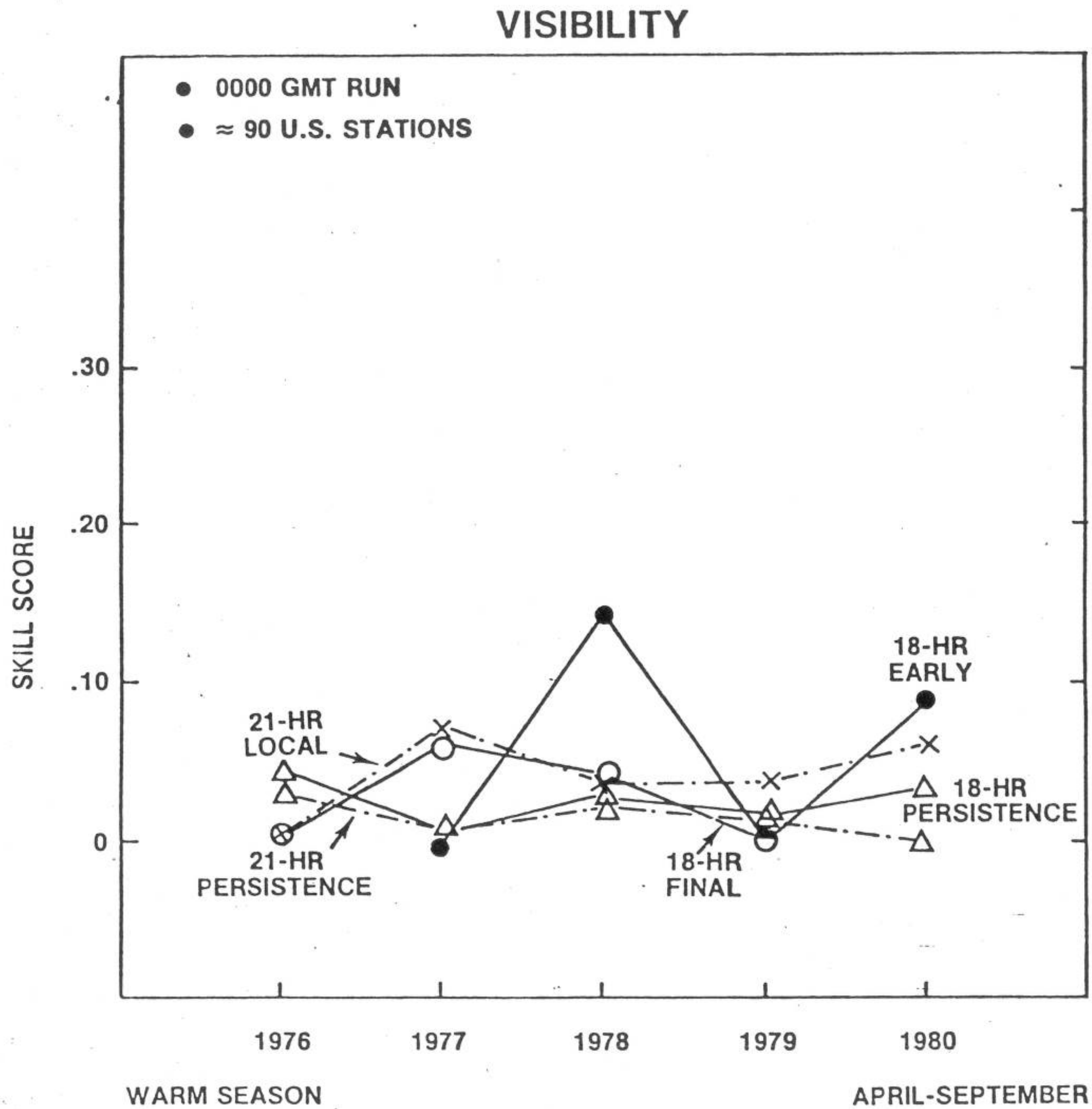


Figure 5.4. Same as Fig. 5.3 except for forecast projection.

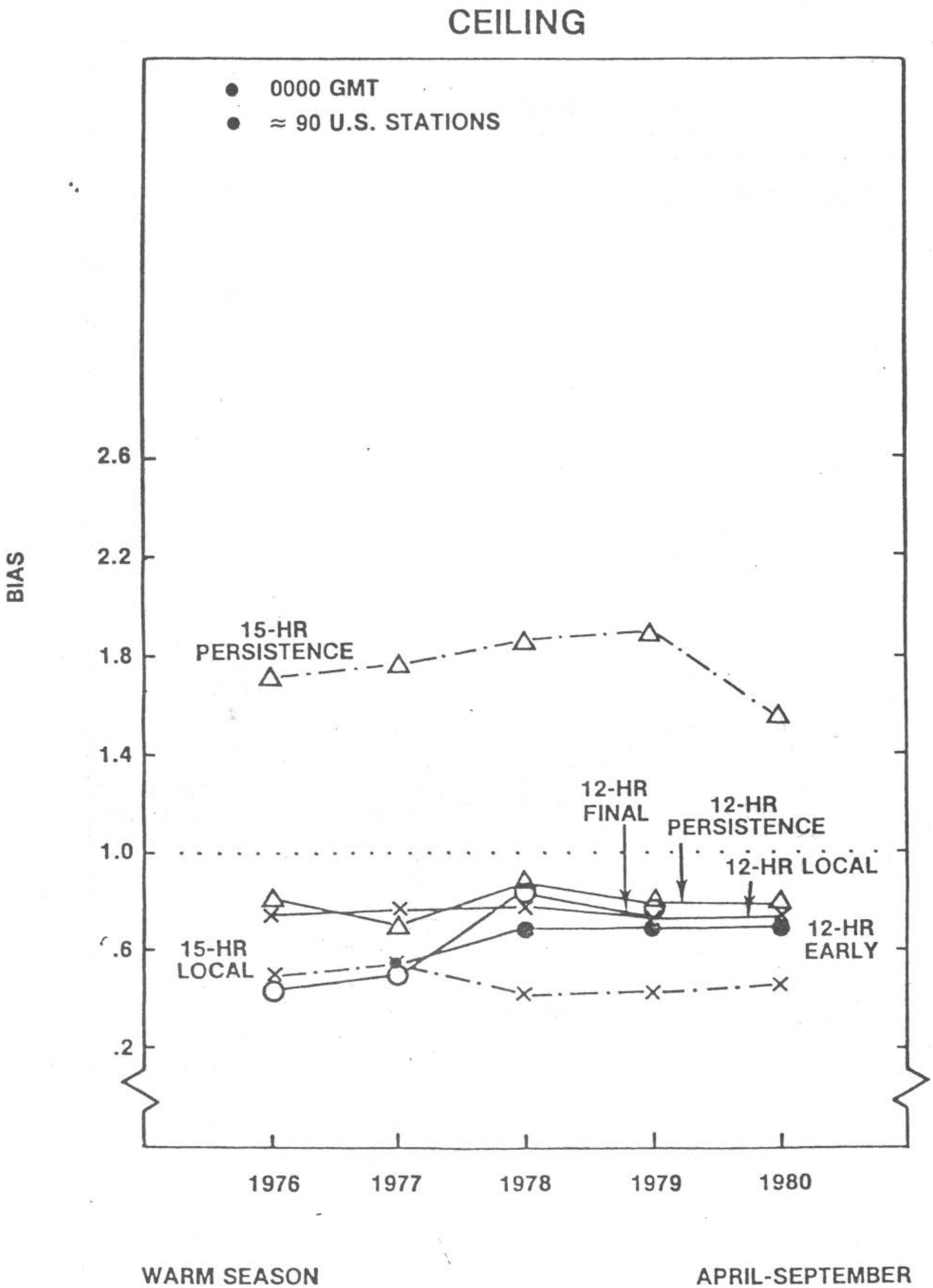


Figure 5.5. Bias for categories 1 and 2 combined for local, guidance, and persistence ceiling forecasts.

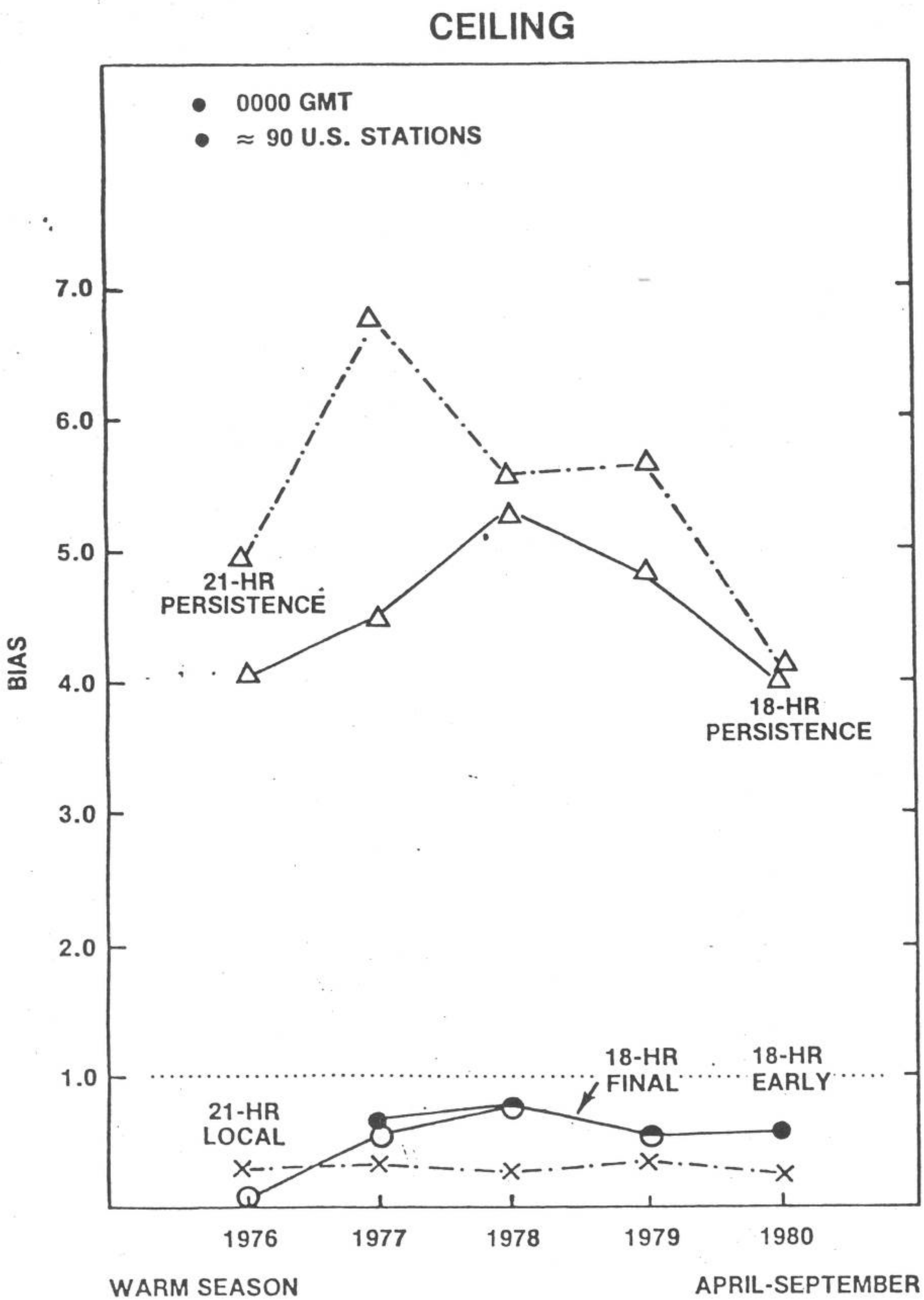


Figure 5.6. Same as Fig. 5.5 except for forecast projection.

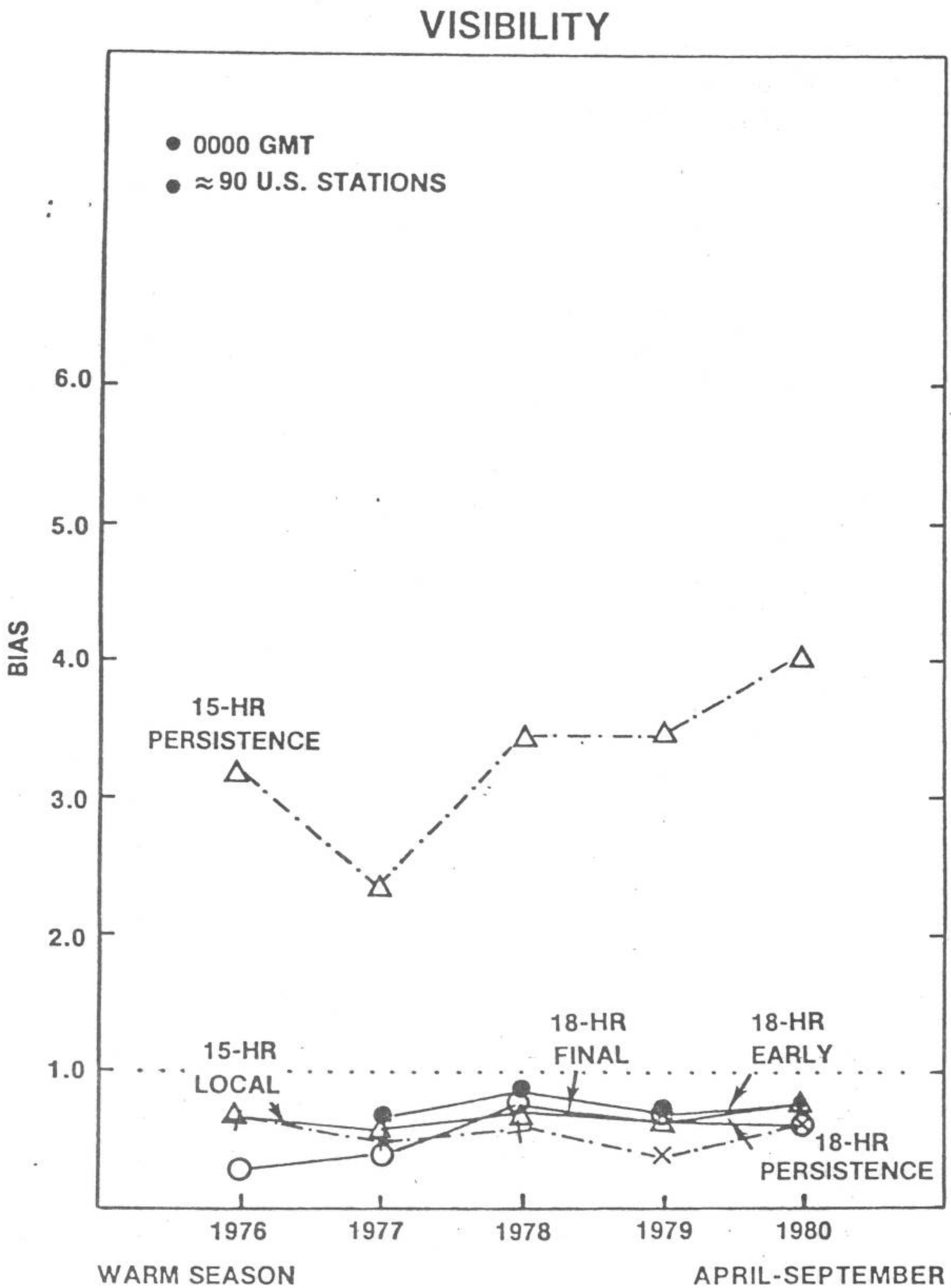


Figure 5.7. Same as Fig. 5.5 except for visibility forecasts.

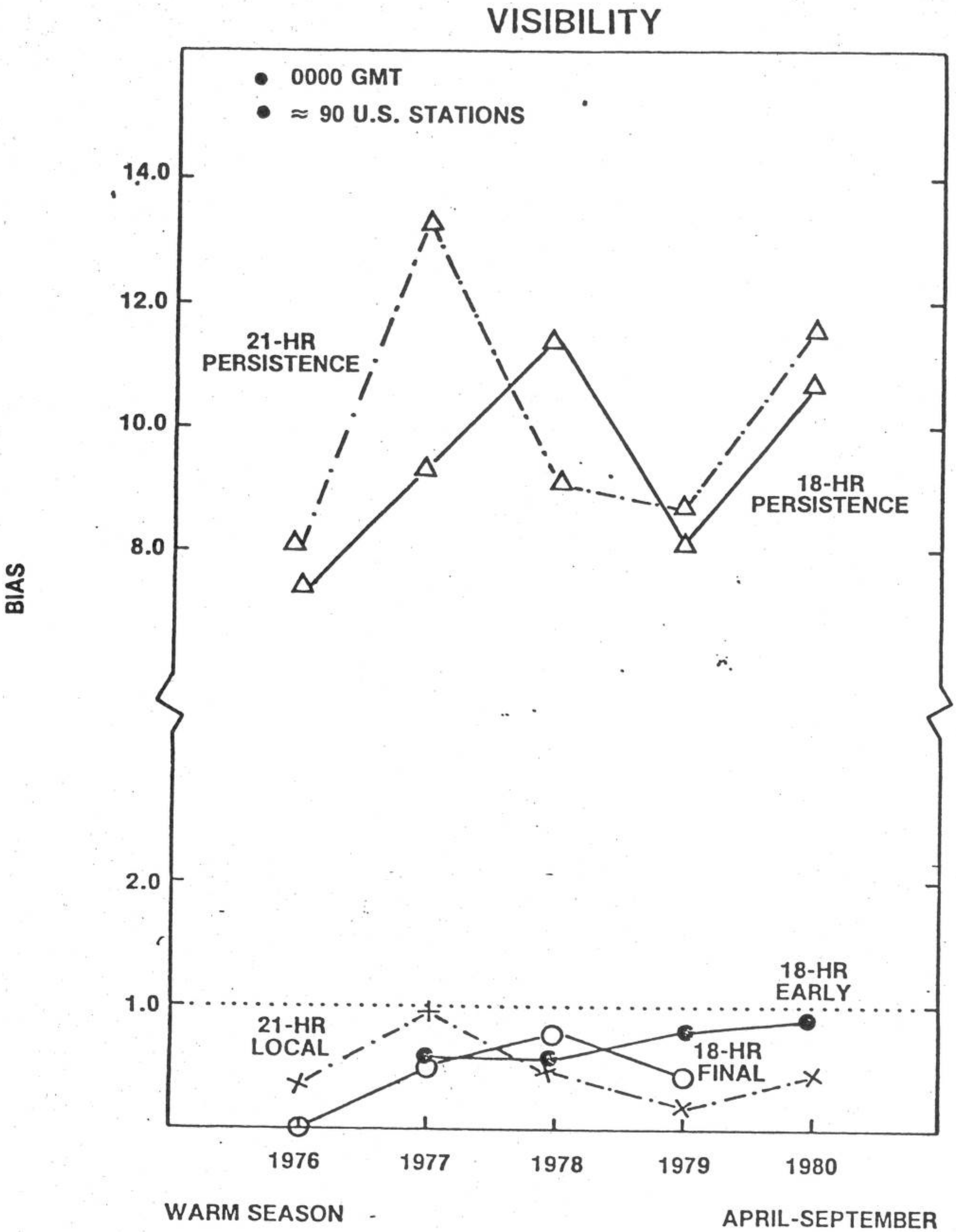


Figure 5.8. Same as Fig. 5.7 except for forecast projection.

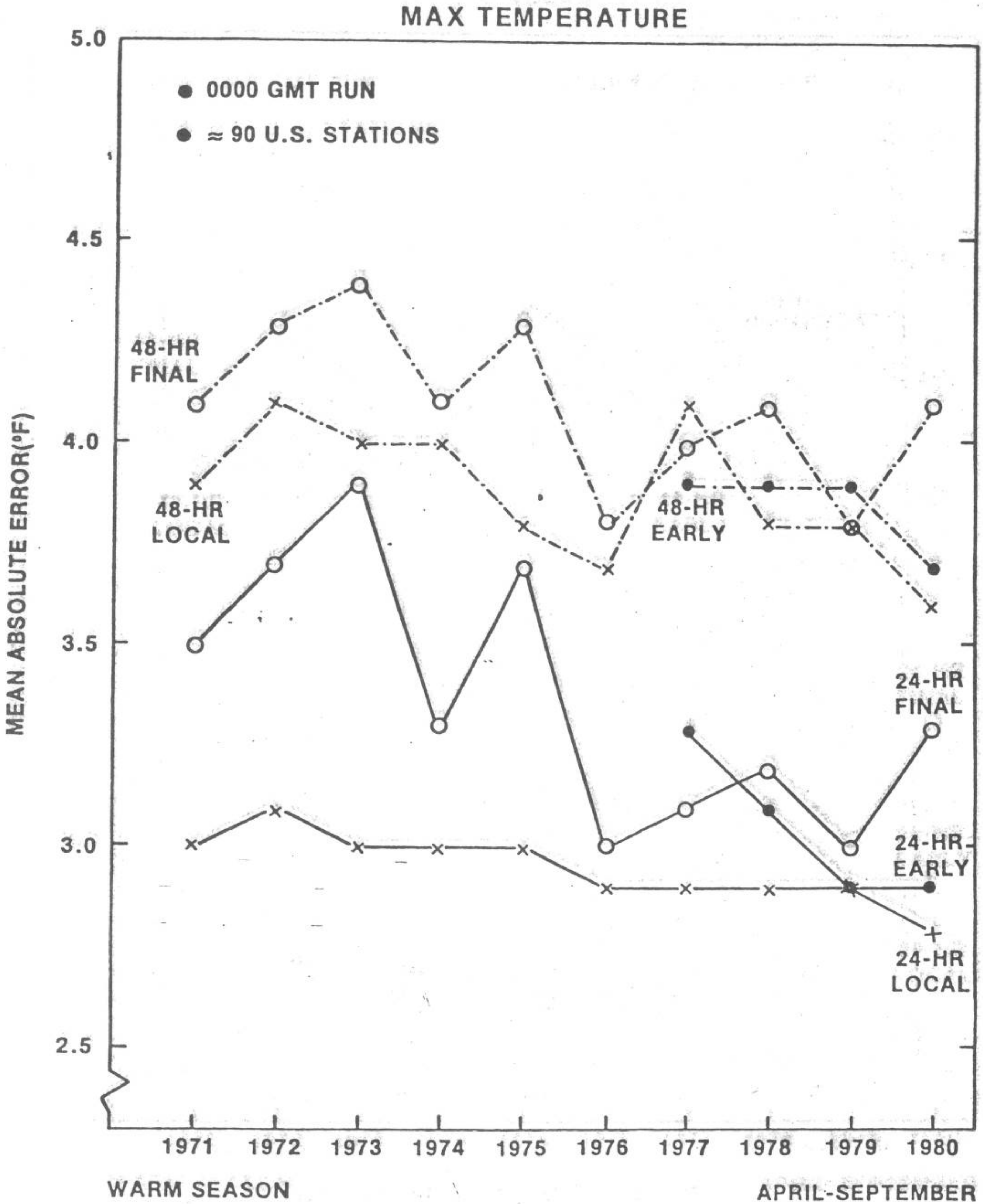


Figure 6.1. Mean absolute errors of the local and the early and final guidance max temperature forecasts.

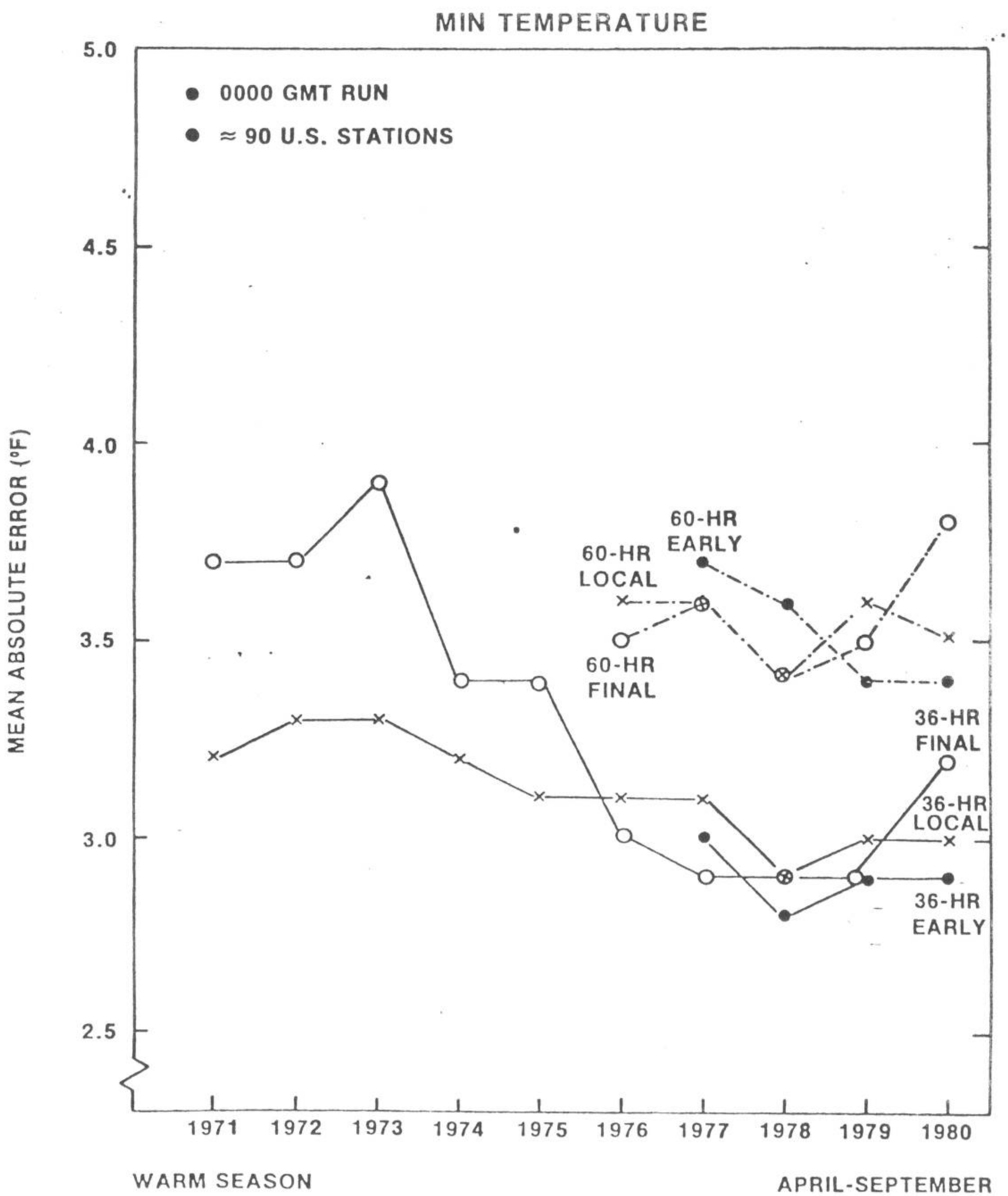


Figure 6.2. Same as Fig. 6.1 except for the min temperature forecasts.