Climate Data Continuity with ASOS
Report for the period September 1994 - March 1996

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Table of Contents

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1. Introduction

The first commissioning of the Automated Surface Observing System (ASOS) of the National Weather Service began in September 1992. From September 1992 until November 1993 the ASOS hygrothermometer was the original instrument placed in the field for ASOS. In November 1993, a modified version of the hygrothermometer began to be installed in the field. Modifications to the hygrothermometer included an increased rate of aspiration, reversal of air flow so that air comes in at the bottom, and more stable electrical components. By Spring 1994 fifteen core Climate Data Continuity Project (CDCP) sites had received the new instrument. The final 15 month temperature and humidity CDCP comparison began for the 15 sites identified in Table 1 and Figure 1 in June 1994. This report summarizes the results of this test.

It was originally intended that several more sites representing all regions of the country be included in the final CDCP temperature-humidity intercomparison.. However, a moratorium was placed on ASOS commissioning during Fall 1994. No NWS ASOS sites were commissioned for a period of several months. As a result, stations that were intended to be national expansion sites for the CDCP could not be a part of this 15-month study. Furthermore, NWS operational decisions closed, relocated or reduced the work force at some existing CDCP sites resulted in fewer comparison sites than had been planned. At the same time, the moratoriam on ASOS commisionings presented an interesting opportunity. Many stations across the country were still taking conventional observations (CONV) for many months after ASOS was installed and accepted.

An effort was initiated to have the National Climate Data Center (NCDC) collect hourly values of uncommissioned ASOS observations along with the conventional (CONV) observations for a set of sites to be used to expand the ASOS-CONV comparisons across the U.S. Data collection was started in September 1994 and continued through August 1995. Due to installation dates and commissioning dates, data were not complete for the entire 12-month period at all stations. A total of 31 locations across the U.S. had complete or nearly complete data for 12 months. An additional 35 stations had data for 3 seasons. Ten stations were complete for two seasons. Tables 2, 3 and 4 and Figures 2, 3 and 4 show the sites which have observations for 4 seasons, 3 seasons, and 2 seasons during the year respectively. Data from these sites will be used to extend the temperature portions of the CDCP to more regions of the U.S.

The primary focus of this report is the results of temperature comparisons. Humidity information is included but with less emphasis. A summary of activities from the wind study is also presented. Precipitation data were collected for all active CDCP sites through the end of August 1995. Comparisons of ASOS precipitation to CONV have been completed , but the results are of limited value.. Since modifications to the ASOS Heated Tipping Bucket raingage are currently being made that could alter the performance characteristics of the system, more extensive analysis will await the modified precipitation gage.

Several presentations on CDCP results have been or will be given. Extended abstracts for the American Meteorological Society meeting in Dallas, TX, in January 1995, and Atlanta, GA, in January 1996 are enclosed as appendices. A presentation was made in June 1995 to a committee of the National Academy of Science, and a presentation was given in December 1995 to the National Weather Association meeting in Houston, TX.

2. Data

Data for the CDCP sites in Table 1 consisted of hourly ASOS observations (SAOs), ASOS high resolution (one-minute) data, Summary of the Day (SOD) data and 6-hourly conventional (CONV) data. ASOS data were captured at the National Climatic Data Center (NCDC) and transferred electronically to the Colorado Climate Center (CCC). CONV observations were hand written on MF1-10B forms at each CDCP site by the observing staffs at each station. Reports included measurements of current temperature and dew point, cloud conditions, visibility, current weather at 6-hour intervals plus maximum and minimum temperatures, precipitation, snowfall and snowdepth. CONV data were digitized by NCDC and sent electronically to the CCC. Copies of the forms were also sent to CCC.

For many CDCP temperature comparisons, midnight-midnight observations of maximum and minimum temperatures were used. Other temperature analyses and all humidity comparisons utilized the 6-hourly CONV observations compared to the matching ASOS SAO. Preciptation comparisons were also based on 6-hour totals. CONV data were obtained from the Universal weighing bucket precipitation gages. ASOS observations were taken both from the one-minute data and also from the hourly totals contained in the PCPN remark in the SAOs. As in the previous years of this CDCP, difficulties were experienced in determining the actual ASOS precipitation totals. Frequent differences were noted between the one-minute data and the PCPN reports. There was also a relatively large frequency of missing one-minute data in the data set provided by NCDC. For example, during the summer of 1995, up to 30% of the hours had partially or totally missing one-minute data resulting in missing or incomplete daily precipitation totals for 25-50% of all days during the summer months.

Data collection from 15 primary CDCP sites was terminated at the end of August 1995. A few stations terminated earlier due to operational constraints, but most sites ended up with 15 months of data. One interesting exception was the weather station at LNK. ASOS instruments were moved on February 9-10, 1995 to a location that has the hygrothermometer essentially co-located with the CONV instrument. The data prior to the move will be handled separately.

Data collection for the locations in Table 2, 3 and 4 began in September 1994 and was terminated in August 1995. These data included 24 hourly SAO observations each day for ASOS and CONV but did not include midnight-midnight maximum and minimum temperature for each day. All of the ASOS hygrothermometers were the modified instruments. Since ASOS was not yet commissioned at these sites, the data will be viewed carefully recognizing that maintenance standards may not be the same as with a commissioned instrument.

All data collection for CDCP was terminated at the end of August 1995. Precipitation data collection will resume for a selected set of sites across the country when the modified tipping bucket gage is placed in service in early 1996.

3. Temperature and Humidity

Table 5 contains monthly and total period statistics for maximum and minimum temperature differences ASOS-CONV for the period June 1994 through August 1995. These data are based on midnight to midnight periods. Six hourly observations including temperature and humidity are given in Table 6 for June 1994 through August 1995.

The data still have occasional irregularities which remain unexplained. An example is shown in Figure 5. This figure is a graph of the accumulated sum of the temperature difference, ASOS-CONV, for observations taken every six hours for a three month period. Consequently, a persistent difference of 1°F ASOS- CONV would lead in 90 days to an accumulated sum of 360°F. The slope of the line is proportional to the bias. In Figure 5a the observations for LNK show a good straight line which accumulates approximately 500°F in 92 days of the three month period beginning on June 1, 1995. In Figure 5b for DDC the accumulation began in March 1995. The initial slope of the curve changes near day 35 (April 4). Another slope change occurs near day 89 (May 28). Changes of this type have been noted in the data sets ever since the beginning of the CDCP but with no uniquely identifiable pattern or cause.. Efforts to identify this type of change have led to the following possibilities. The changes that are noted could be in either the ASOS or the CONV instrument. The likely causes are a change of the sensor, electronic instability, an unintentional result of routine maintenance and electrical calibration, or a change (such as a very small crack) in the circuit on the board to which the sensor is attached. The CONV instrument is expected to have more electronic instabilities and larger differences from one sensor to another sensor. These data shifts complicate analyses and have led to reliance on seasonal and longer calculations of ASOS-CONV differences with no reliance on calculated differences for individual months.

Time series graphs of monthly values of maximum and minimum temperatures are presented in Figures 6 and 7 for the 15 month period, June 1994 through August 1995. The graphs show that ASOS is cooler than CONV for both maximum and minimum temperatures and that individual locations have a wide variation from the mean which is given by the solid line on each graph. Figures 6 and 7 do not show any tendency for a significant annual cycle. This is in contrast to a recent publication by Jones and Young (1995) which was based on CDCP data.

Near the end of the first year of the CDCP (1993), the CDCP data for the original ASOS hygrothermometer was given to a research group at the University of Arizona. This was consistent with the CDCP goal of providing data in the public domain. Information that the instrument was being modified and that the modified instrument could be different was provided as well. An article was published by Jones and Young (1995) using the data from the original ASOS hygrothermometer. We (the authors) were not contacted at any time to review or comment on the results of the analysis in the published article. The primary conclusion of the article was that a significant annual cycle exists in ASOS-CONV observations and also a smaller diurnal cycle. The results shown in Figs. 6 and 7 do not support the conclusions of Jones and Young (1995). Therefore, the modifications that were made to the ASOS hygrothermometer do appear to have been important and did have an effect on the data comparisons. The original ASOS instrument at a commissioned site was used only a short time and should not have a noticeable effect on long-term climate records.

The original goal for the CDCP temperature comparison was to observe and document the differences between ASOS and CONV so that climatologists and a wide variety of data users can utilize the ASOS data in appropriate historical perspective. We have learned along the way that understanding the causes of the ASOS-CONV differences is critical to interpretting and applying the results.

While the primary mission of this project was to determine relative differences between ASOS and CONV, it was extremely helpful to begin by determining to some extent the performance characteristics of ASOS with respect to "true" air temperature. For this purpose, a field standard has been prepared using an R.M. Young (RMY) aspirated temperature system. The sensor has been calibrated against a secondary standard maintained by the NWS at the test facility at Sterling, VA. The field standard has been placed directly beside the ASOS hygrothermometer at COS, OKC, and TUL for at least one 24 hour period. The results of the nighttime intercomparisons showed ASOS - RMY to be 0.3°F at COS, -0.3°F at OKC, and -0.1°F at TUL. These field results were quite consistent with tests performed by the NWS Sterling Group. They tested several ASOS hygrothermometers at their test facility and found a difference of ±0.2°F with more of the ASOS units being cool rather than warm. These tests all indicate that ASOS does not have a significant systematic bias and has a range between instruments of at least ±0.3°F.

Each of the ASOS instruments placed in the field is installed by the contractor. The sensors are not calibrated by comparison with a secondary standard during installation. The assumption has been that once a few have been tested by the NWS, all of them will be enough alike to meet all specifications.

From the perspective of the CDCP, it is important to remember that the introduction of ASOS not only included a change in weather instruments, but also a change of location of the instruments. Most ASOS installations are approximately mid-field airport location. By compariosn, CONV hygrothermometers had been at a variety of locations. Some were at mid-field and ended up being essentially co-located with ASOS. Many others, however, were quite far from the current ASOS locations and may have had significantly different exposures and surroundings.

Three issues should be considered in the transition from the CONV to ASOS. They include a change of instruments, a change in location and an expectation that the effect of solar heating will be larger for the CONV instrument. These effects are expressed in the following form:

$$\Delta T = \Delta T_i + \Delta T_\ell + \Delta T_s ,$$

where ΔT is the temperature difference of ASOS-CONV and the subscripts are *i* (instrument bias), ℓ (local effect), and *s* (solar heating effect). The local effect can be (and often is) different from day to night.

Two analyses have been conducted to determine the instrument bias of ASOS with respect to CONV. The first step is to consider observations at night when the ΔT_s is zero by definition. The local effects can then be made quite small by considering conditions with higher winds which will force mixing to be nearly uniform for sites less than 1 mile apart or by considering overcast skies at 12,000 feet or below which will provide a downward infrared radiation source at cloud base to reduce horizontal temperature differences. Each of these conditions were applied separately to observations at 0600 UTC and 1200 UTC for the entire data period. If high winds or overcast skies isolate the effect of the instrument bias, the frequency distribution of the observations should become narrow. Since the ASOS and CONV instruments both report in whole degrees of temperature (Fahrenheit), the fraction of observations that are contained in the central three values has been used as a measure of the width of the distribution. Three has been chosen simply by the logic that if the true value is near a whole degree, then that observation and one to either side should dominate the distribution. If the true value is near a half-degree point, one could argue for two points or four points. However, the number three has worked rather well. The results of the analysis with higher winds and overcast skies defined by ASOS showed that the condition of overcast skies yielded a narrower frequency distribution than higher winds. Thus, the overcast sky conditions was used to define the instrument bias which is given in Table 7 and identified as ΔT_I. The fraction of the overcast observations contained in the central three group ranged from 0.94 to 0.99. The instrument biases are all negative and are grouped by magnitude in Fig. 8. They range from -0.16 to -1.06°F and have a mean of -0.57°F. The confidence interval for the bias values at individual stations range from less than 0.1°F to nearly 0.3°F. The range of the values of the bias is much greater than the confidence intervals and is judged to be real. The four CONV instruments at BTR, OKC, LNK and TUL all have biases with a magnitude greater than 0.8°F. Three of the sites (COS, ICT, and SYR) were co-located for the entire test period which adds to our confidence in the bias. The LNK ASOS was moved to a co-located position in February 1995. The values of the ASOS-CONV minimum temperatures (Mn) for the entire test period are also given in Table 7 for comparison. It could be argued that the ΔT_{ℓ} is zero at a co-located site by definition. The comparison of the Mn values with the ΔT_i overcast values for the co-located sites shows ICT, LNK-2, and SYR to be 0.13°F or less. Only COS is larger with a difference of 0.25°F. The COS site is in an area with distinct nocturnal drainage flows which can vary horizontally and vertically in temperature. These results indicate that the ASOS predecessor, the CONV (HO-83), had a warm bias and differences among the instruments that approached 1°F.

If we now assume the instrument bias in Eq. 1 is known, then the nighttime local effect (ΔT_{ℓ}) can be estimated by subtracting the instrument bias from the observed ΔT for the minimum temperature. In the same manner, the combination of the daytime local effect and the solar heating effect can be estimated by subtracting the instrument bias from the difference in the maximum temperature. These results are also presented in Table 7 where the columns labeled "Bias Removed" are really daytime local effect plus solar heating for the maximum temperature and nighttime local effect for the minimum temperature.

Consider the nighttime local effects first which are shown in Fig. 9. They can be either positive or negative. The average of all 15 is -0.29°F. There are a few which are quite large. OKC and LNK-1 are the largest at -1.10°F and -1.04°F. Then GLD at -0.98°F and PWM at -0.71°F are next. On the positive side, TOP with 0.56°F and AST with 0.31°F are the largest. It is interesting to note that both LNK and OKC were locations where large temperature differences were noted as soon as ASOS was initially installed. It can now be shown that at these sites, large negative local effects at night were coupled with large negative biases to produce the very large total differences.

Examination of the daytime differences with the instrument bias removed (Fig. 10) shows ASOS to continue to be cooler than CONV at most sites. The dominant effect appears to be that the CONV instrument had a problem with solar heating to produce even warmer biases than it showed at night. All of the large negative values are at locations when solar heating might well be expected (COS, GLD, LNK, and TUL). BTR is high on the list probably because of the generally weak winds at that site. The column marked "Diurnal Range" is the change in diurnal range from CONV to ASOS. These values are not affected by the instrument bias. However, the largest negatives are all associated with solar heating in the maximums at BTR, COS, LNK-2, and TUL. The larger positives are produced by sites having a large negative local effect at night such as OKC and PWM.

The analyses above offer the following climatic perspective for the transition to ASOS. 1) The mean value of an instrument warm bias of the CONV instrument is 0.57°F for this set of stations. 2) The ASOS station moves have been, on average, to locations that are cooler at night, and 3) The ASOS maximum temperatures are cooler by an average of 0.60°F due to a reduction of solar heating. The largest variations have been explained in terms of what effect caused the largest variations. Overall, these analyses indicate the ASOS hygrothermometer is an improvement over the CONV instrument.

An examination of the daily time series of maximum and minimum ASOS-CONV temperature differences will further illustrate several key features of the data in addition to the quantitative values of the effects of ΔT_i, ΔT_ℓ, and ΔT_s. Figure 11 shows the daily time series for each of the 15 sites. Since each instrument reports temperature to the nearest whole degree Fahrenheit, the ASOS-CONV difference is also a whole degree unit. The graphs run from June 1, 1994 (day 152) through August 1995 which includes two summer seasons. Look first at the co-located sites of COS, ICT, and SYR (Figure 11e, i, and m). Each of the graphs show a minimum temperature that is quite stable with most data points located at two levels -- one on either side of the instrument bias (no local effect at night at co-located sites). A few data points are further apart and appear as spikes. No valid reason has been determined to eliminate these from our data set. A shift in the bias appears to have occurred after day 350 at ICT.

The maximum temperature differences are larger negative numbers (ΔT_s in Table 9) and show more variability with varying weather conditions. SYR did have data missing for a period near day 544 to day 574.

An examination of the LNK (Fig. 10j) is quite informative. LNK was moved from a site with a large night local effect of ΔT_ℓ = -1.02°F to a site essentially co-located on day 405. LNK also has a large instrument bias of -0.99°F. The large ΔT_ℓ is manifested here as a highly variable data structure for the minimum temperatures. This variable appearance from day 152 to day 405 is really the distinguishing character of a large ΔT_ℓ. A variety of meteorological conditions lead to a variety of differences in the minimums. Values of 0 to -2°F dominantly lead to the bias of -0.99°F which seems to be present throughout the 15 month period. Values of -5°F to -7°F occur prior to day 405 and are probably a result of calm, clear nights. The character of the maximums at LNK do not change appreciably during the test period. This seems to indicate that the boundary layer must be rather uniform at both sites. The LNK site has a large ΔT_s of -1.2°F to -1.4°F as well as a large instrument bias. Interestingly the ΔT_s did not change much when the site was relocated.

Most of the other sites have moderate local effects. Our exception is OKC which, like LNK-1 (Fig. 11j), has a large ΔT_ℓ. The variable structure of minimums looks quite similar to LNK-1 up to day 405. The OKC maximums are not nearly as variable as LNK and the reasons are not known. The data from TUL has an example of an apparent instrument shift after day 452 when both the maximum and minimum temperatures shifted to a larger negative value. The BTR site in Fig. 11d has an apparent annual cycle in which the winter season has smaller negative values of the maximums but not as much in the minimums. This would be consistent with a larger solar effect on ΔT_s in the summer season.

The other very striking feature of the data is in the coastal sites of AST (Fig. 11b) and BRO (Fig. 11c). These both have a very stable data structure in the minimums similar to co-located sites, but they also have a very similar structure in the maximums which are unlike any of the other locations. Perhaps the effect of the sea breeze is significant at these sites. Notice that PWM (Fig. 10) does not share the stable minimums but does share in the stable maximums.

In summary, the biases shown in Table 7 seem to agree with physical interpretations of the time series graphs of Fig. 11 and different geographic locations and the co-located sites seem to have definable traits.

Analysis of data for the expansion locations given in Tables 2, 3 and 4 has been started and may prove to be a very valuable addition to the CDCP. Results will be available later in 1996. The advantage is that 24 hourly values of temperature are available each day for this set of stations which provides six times the data volume. The disadvantage is that maximum and minimum temperatures for midnight to midnight are not routinely available in the data set.

The dewpoint temperature comparisons for summer 1995 are included in Table 6. These results continue to be similar to the observations through the 15 month period. No systematic bias has been found in dewpoint temperatures across the whole set of comparison sites. The fact that the temperatures have biases with ASOS being cooler means that the ASOS relative humidities are slightly higher on the order of 1% to 3% for seasonal averages. Previous reports have indicated both the ASOS and CONV dewpoint temperature measurements could occasionally have excursions to large differences and that the chilled-mirror measurement technique should be reconsidered if a better technology can be found.

Figure 12 shows all dewpoint temperatures (ASOS-CONV) observations for the 15-month period. There is one observation every six hours (four per day). A scan through the graphs from AMA (Fig. 12a) to TUL (Fig. 12o) reveals rather frequent observations in which ASOS-CONV exceed 5°F and often 10°F or more and can be either positive or negative Some locations have had really bad periods (OKC, PWM, SYR, TOP, and TUL) while a few have reasonably good records (AST and BRO). Co-located sites (COS, ICT, SYR) don't fare particularly well, and the location move at LNK on day 405 didn't seem to affect anything.

Combining four observations per day into a single daily average provide a different perspective (Figure 13). These graphs show that a dewpoint temperature difference of 5°F is quite unusual. However, longer periods of time from a few days to several weeks can occur with the observations being relatively higher or lower.

Interpretation of these results posses a considerable challenge. The ASOS observations are reliably at the same time each hour and each day. The CONV observation could easily have small time differences. The impacts of such occurrences are not determinable from the data. The recommendation that the technique of measurement be reconsidered has been made knowing that both the ASOS and CONV instruments have occasions where observations can depart from reality significantly.

4. Precipitation

Precipitation data were collected and compared for all available CDCP sites during the period ending with August 1995. One set of comparisons is shown in this report. ASOS had been shown previously to reliably undermeasure precipitation (with respect to the CONV measurements) during heavy rain events. To further evaluate this trait, all 6-hour periods when either ASOS or CONV precipitation equaled or exceeded 0.50" were extracted and compared for the period 1 September 1994 through 31 August 1995. There were a total of 221 such observations from all CDCP sites distributed by station as shown in Table 8. Figure 14 shows the observation in Table 8. Little bias was noted in the ASOS-CONV relationship at rainfalls up to 2.00 inches in six hours. Over the entire set of precipitation events, ASOS totalled 97.4% of CONV. However, when six-hour rainfall totals exceeded 2.00" inches, ASOS consistently reported lower accumulations than CONV. Based on 18 of these very large events, ASOS precipitation totaled 91.7% of CONV suggesting that a heavy rain bias still exists, but this bias appears considerably smaller than in the past.

Several changes are being made to the ASOS precipitation gage These include a change from a mercury switch to a Reed switch, an extension of the funnel, a change to polyethylene stops, and a magnet alignment. Several gages are now in the field that have some of the modifications. To our knowledge, no gages are in the field with all of the modifications. Since changes are being made, it is of little value to present other results at this time. Data and comparative results are available on request from the Colorado Climate Center.

A new NWS policy was announced during the fall of 1995 that the PCPN values reported in the SAOs were not to be changed from the original ASOS observation. During this and previous years of the CDCP there have been many occasions in which the ASOS six hourly values derived from the one minute observations do not agree with the PCPN values. This new policy may make future precipitaiton comparisons easier. At this point, no further precipitation comparisons will be made until the modified rain gages are placed into service some time in 1996. The final selection of stations across the country suitable for comparison based on data availability and distance between ASOS and CONV is currently being completed.

5. Wind

The status and progress of the wind study is summarized in three progress reports for the time periods July - September 1995 (#5), October - December 1995 (#6) and January - March (#7). These reports and attachments are included in this section.

Quarterly Report No. 5
July 1 through September 30, 1995

On August 2. 1995, a trip was made to Asheville, NC. The purpose of the trip was to present a paper to the annual meeting of the State Climatologists. During this trip, there was an opportunity to visit with Dr. Thomas B. McKee while driving from Charlotte to Asheville, NC. Various background subjects were covered. At NCDC some time was devoted to discussing the plans for data access after the list of stations is finalized and the various sensor and system modifications have been implemented.

During a visit to Michigan (8/15-22, 95), for non-project purposes, a visit to the Grand Rapids NWS office was made to examine the location of precipitation gages.

Some effort in September was devoted to the establishment of the final station list to be used during the project. The paper "*Wind Climate Data Continuity Study* - II" to be presented at the 12th IIPS meeting in Atlanta, GA was written. This required the completion of the analysis of fastest mile data from Billings, MT. Twelve months of data were available as MAPSO fastest mile reports and the daily summaries of the yet-to-be-commissioned ASOS system.

There were 101 direct labor hours expended during this quarter.

Quarterly Report No. 6
October 1 through December 31, 1995

This period was focused on the National Weather Association annual meeting held in Houston, Texas during December 4 to 8, 1995. I arrived on the 4th and left after my presentation on the 7th. A copy of my presentation "Wind Climate Data Continuity Study - II" was presented and will be presented also at the IIPS meeting in Atlanta, GA, on January 31, 1996.

A copy of this paper was sent by Andy Horvitz for review by several people at the National Weather Service headquarters. Questions and comments caused a further evaluation of the rounding error described in the paper. The note "Analysis of ASOS Wind Speed Rounding Error" is also attached to this report.

Copies of a series of e-mail messages brought up the question of the 5-second averaging time used by ASOS. Further reflection on the subject suggested that it was time to write the "white paper" which had been suggested earlier. A draft of this document "Wind Averaging: The 5-second vs. 3-second vs. ½-second Question" is also attached.

A list of proposed wind sites was prepared and forwarded to Andy Horvitz on December 12, 1995. A copy of this list is also attached.

Attachment 1.

Quarterly Progress Report #6

Analysis of ASOS Wind Speed Rounding Error

Assume the anemometer is tested in a wind tunnel. This hypothetical wind tunnel is operated over a range of 2.0 to 61.3 knots for each 0.1 knot. The true speed for this analysis is the wind tunnel speed in knots. Each speed is also expressed in miles per hour and this value is calculated by multiplying the wind tunnel speed by 1.1516.

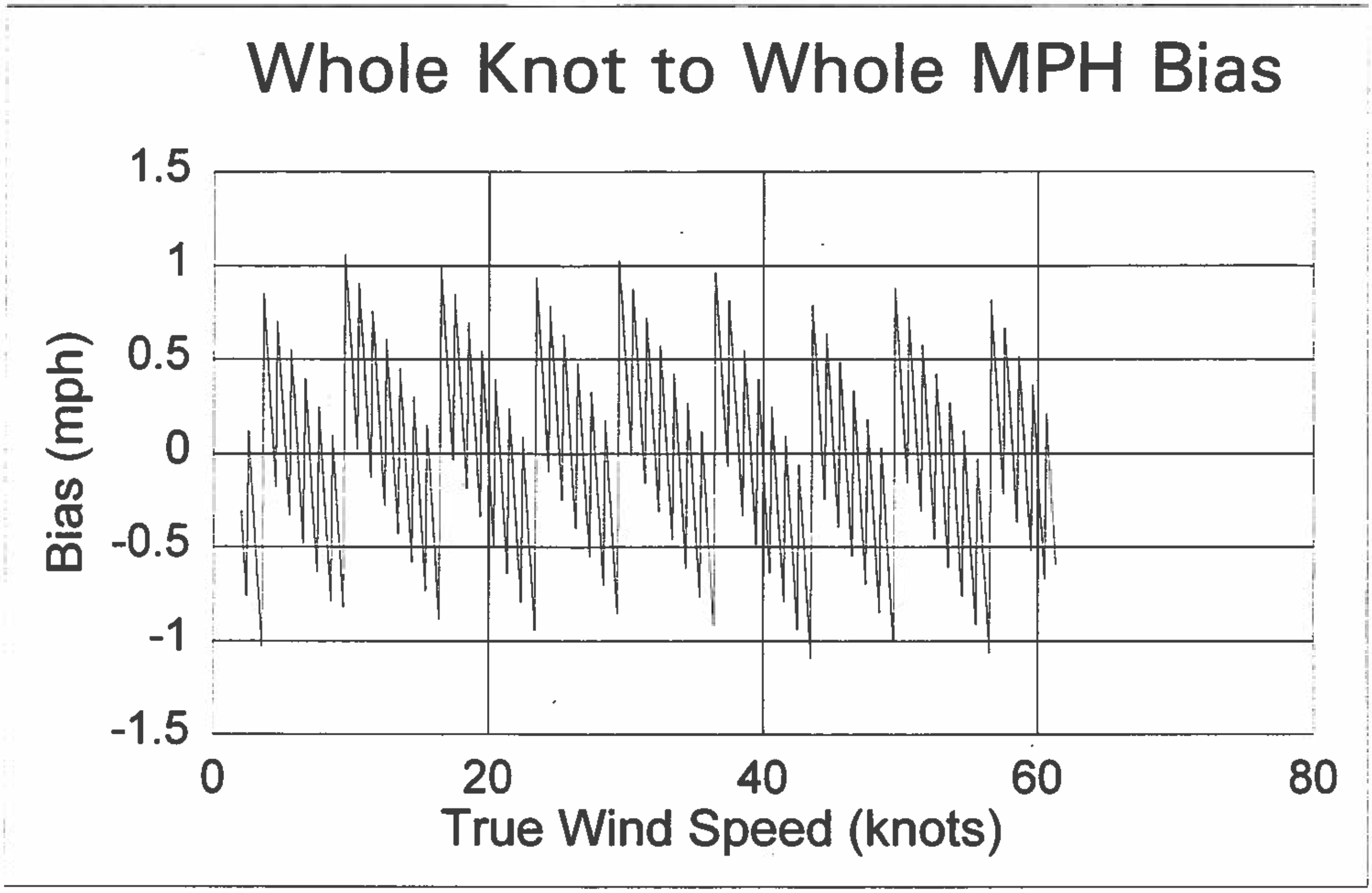
The ASOS output is in whole knots. Speeds ending in 0.6 to 0.9 were rounded up the next whole number. The whole knots were converted to whole miles per hour by multiplying by 1.15 and rounding to the nearest whole number. The results are consistent with Table A10-4 in FMH-1 where values of 4, 11, 19, 27, 34, 42, 50, 57, and 65 are not found.

The ASOS outputs in whole miles per hour are compared with the true wind tunnel speeds in miles per hour by subtracting the true speed from the ASOS output. The bias error, shown to the nearest 0.01 mph, is plotted in Figure 1. The average bias of the 594 simulated speeds is -0.02 mph. The standard deviation of the errors is 0.45 mph. The maximum bias error is 1.06 mph and the minimum is -1.09 mph.

One can discuss implications from the facts stated above. The rounding bias is a conditional bias. There is no random component. It is only a function of wind speed. While the average bias error is essentially zero, the standard deviation is nearly a half mile per hour. If it were a half mile per hour, 68% of the time the rounding bias would not cause the whole mph speed to be different from the "nearest whole mile per hour." But 32% of the time it would. For example, when the speed is 9.2 knots or 10.6 mph, the bias is -0.6 mph and the whole value reported would be 10 mph rather than the closer 11.

The range of uncertainty in mph products from the rounding bias is ±1.1 mph or ±1 knot. In terms of measurement accuracy, the ±2 knot specification (below 40 knots) will have to be met with a combination of ±1 knot from the measurement process (wind tunnel determined performance) and ±1 knot from the software-driven bias. I do not know if the manufacturing process will produce ±1 knot but I doubt if anyone is looking at the requirement as being that tight, hence the last sentence in the discussion section of my paper.

It is curious that ASOS drops 12 and 35 mph rather than the 11 and 34 mph values predicted by the table in FMH-1.


Whole Knot to Whole MPH Bias
1.5
1
0.5
0
-0.5
-1
-1.5
Bias (mph)
0
20
40
60
80
True Wind Speed (knots)

Attachment 2.

Quarterly Progress Report #6

Climate Data Continuity Project (CDCP)
Proposed Wind Sites as of 3/22/96

Sta ID	Station Name	Reg	Date Accept.	Date Commish.		Mods & Software	Type
ABI	Abilene, TX	S	3/24/95				
AST	Astoria, OR	W		3/1/93	*	-20 3.0/1	F420
AVP	Avoca, PA	E	11/22/95			(95)	Both
BRW	Barrow, AK	A	8/10/94			-10 2.07	F420
BIL	Billings, MT	W	9/17/93	5/1/95		-10 2.07	F102
BUF	Buffalo, NY	E	(6/27/95)			-20 3.0/11	Both
CYS	Cheyenne, WY	C	4/7/93			-10 2.05	F420
DDC	Dodge City, KS	C		9/1/92	*	-20 3.0/4	F420
GLD	Goodland, KS	C		9/1/92	*	-20 3.0/2	F420
GRR	Grand Rapids, MI	C	11/22/93			-10 2.05	F420
HLN	Helena, MT	W		11/1/94		-10 2.07	Both
ITO	Hilo, HI	P	3/18/94			-10 2.05	F420
LYN	Lynchburg, VA	E	8/17/95			-20 3.0/9	F102
OKC	Oklahoma City, OK	S	6/30/92	10/1/92	*	-20 3.0/6	F420
PWM	Portland, ME	E	11/5/92	8/1/94			
SLC	Salt Lake City, UT	W	8/17/95			-20 3.0/9	F104
SJU	San Juan, PR	S	12/28/94			-20 3.0/7	F420
SYR	Syracuse, NY	E	10/29/92	11/1/93		-10 2.07	F420
TOL	Toledo, OH	E	10/18/95	12/1/95		(95)	F102
TUS	Tucson, AZ	W	5/16/94	1/1/96		-10 2.05	Both

KEY: * indicates stations that are commissioned and have -20 3.0 modification
/n after the software version is the first month in 1995 with a full set of data
9 stations with fastest mile (F102) equipment (4 E region and 5 W region)
16 stations with gust recorder (F420) (3 E, 4 W, 4 C, 3 S, 1 A, 1 P region)

Quarterly Report No. 7
January 1 through March 30, 1996

The first activity of this quarter was a special trip to Silver Spring to attend a meeting at the ASOS Office and to visit the Test and Evaluation Branch at Sterling, VA. The purpose of the ASOS Office visit was to discuss the two papers which were prepared last quarter and were sent to Andy Horvitz for comment. The papers were "Analysis of ASOS Wind Speed Rounding Error" and "Wind Averaging: The 5-second vs. 3-second vs. ½-second Question (draft 3 dated 1/9/96)." This trip concluded with the following from the ASOS Office:

Agreement to supply a list of stations for finalizing the selections, and
Consideration of the removal of the rounding error.

The Sterling visit resulted in a list of action items which were summarized in a memorandum to Andy Horvitz dated 2/15/96.

During the period 1/27-2/2/96 a trip to the IIPS meeting in Atlanta included the presentation of the paper "Wind Climate Data Continuity Study - II" and several meetings of interest to this program.

On 2/23/96 I spent the day at the NOAA library at PMEL, Sand Point, and the Pacific Northwest Weather Workshop. The library research provided some background data for the revision of the paper considering peak gust averaging time. As a result of this effort and comments from Norm Canfield, a draft 7 was completed and the title changed to "Wind Averaging: The 5-second vs. 3-second Question." A copy of this draft, dated 3/26/96 is attached to this report.

A gust recorder was supplied by Joe Schiesl for response testing. A series of tests were conducted with data gathered on 3/18 and 3/20/96. A brief test report "Gust Recorder Response Tests" was prepared and sent to Andy Horvitz and Mike Sturgeon. A copy is attached to this report.

There were 173 hours of direct labor expended during this quarter.

Attachment 1.

Quarterly Progress Report #7

Wind Averaging
The 5-second vs. 3-second Question

by

Thomas J. Lockhart, CCM, CMet

1. BACKGROUND

When the design of the Automated Surface Observing System (ASOS) was being developed, the strategy seems to have been to digitize existing wind instruments. There was no action taken to change the design of the cup anemometer to improve performance to World Meteorological Organization (WMO) "standards" or better.

It was recognized that changes were required to digitize the outputs of the sensors for the new automatic system. The wind direction transducer was changed to a potentiometer system which would support a 1° output resolution. The design of the wind speed transducer was changed from a voltage generator to a light chopper. There is a significant difference between an instantaneous voltage driving an indicator and galvanometer recorder and a frequency measurement method requiring time averaging to generate a speed output. The nature of our wind speed data has been changed. Was it the right change?

1.1 Distance Constant and Averaging Time

The F420 was limited only by its dynamic response to wind forces. The response distance constant of 30 feet, longer than the 2 to 5 meters (7 to 16 feet) recommended by WMO, provides faithful (3 distance constants) representation of the peak speed each second when the wind speed is 53 kt or more. An observed value of 53 kt on a dial indicator (time constant unknown) might have been from a peak which lasted only ¼ second. The gust recorder indicates more than 85% of the peak speed in ½ second, 95% of the peak in 2 seconds and 100% of the peak in 5 seconds. A voltage corresponding to a cup speed of 53 kt which lasted ½ second would show 45 kt on the graph of a properly maintained gust recorder. If the peak speed lasted 2 seconds, the graph would show 50 kt.

For example, Figures 1 and 2 show as stars two sets of 60 1-second samples from anemometers operated on the test rack at NOAA/NWS Test and Evaluation Branch at Sterling, VA. The Young sensor has a distance constant of 9 feet and at 11 knots (19 feet per second) it will follow 90% (2 distance constants) of step-changes in speed. The F420C (roughly equivalent in dynamic performance to ASOS) has a distance constant of 30 feet and will follow about 30% of step changes in speed. The difference between the two sensors, with respect to the 5-second average shown as a thick grey line, is clear. As one would expect, the sensor which has the shortest distance constant follows changes best at this speed. At 53 kt (90 feet per second) the two traces should be about the same. The F420 will follow more than 95% of quick 1-second changes in wind speed. At such high speeds, then, the counts generated each second by the ASOS anemometer will accurately represent the 1-second average speed. Visualize this 1-second average at 53 kt as representing a 90 foot diameter eddy imbedded in the mean flow. Larger eddys are represented even better.

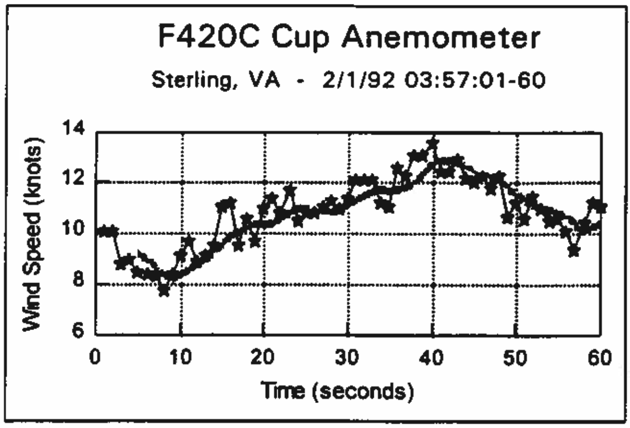


Figure 1

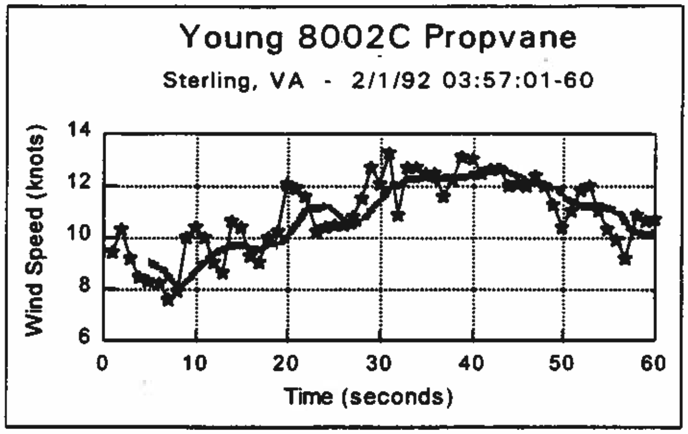


Figure 2

1.2 The "5-second" Decision

The decision to use a 5-second average as the basic input for AWOS, and later ASOS, was a result, in part, of a report by Stone and Bradley (1977) for the Federal Aviation Administration (FAA). A paper by Koren (1973) was quoted in this report as follows: "...for aviation purposes the use of a single sensor giving a five-second peak gust in the preceding ten-minute period provides an acceptable stable statistic for indicating wind variability." The purpose of this work by Oscar Koren at the Atmospheric Environment Service of Canada (AES) was to find an analog circuit for averaging wind speed for aviation operation and to evaluate the possibility of using a single peak speed measurement to characterize speed variability with respect to a 10-minute average. His paper compares 3.6-second averaged peak speeds to the 2-minute average within which the peak occurs. The 3.6-second average is from 0.19-second samples.

There is a reference in Koren's paper to Sparks and Keddie (1971). They state "There is no general agreement on this, but discussions with aviation experts suggest that the average wind over a period of 4 or 5 seconds just before touchdown when the aircraft is decending from about 30 m to 15 m is of critical importance." This may be one source of the 5-second decision. They say further "...any attempt to use an averaging period of less than the 4 minutes suggested by curve A would increase the errors even if the information were used immediately after the observation." A companion paper, Keddie (1971) looks at the ratios of maximum departures from a 4½ and a 9-minute mean wind to the mean over a 100-meter run (10 seconds at 10 m/s) as a function of peak averaging times (from 0.9 to 55 seconds). This paper does not recommend a peak averaging time but it does suggest from the data that the difference between a 5-second average and a 3-second average is on the order of 5% to 10%.

The first implementation by ASOS of the 5-second averaging method was really a weighted average. It was formed by adding 4/5 of the previous 5-second average to 1/5 of the latest 1-second average. Observers noted that ASOS peak speeds were always lower than the F420/gust recorder peak speeds. It was believed that this problem was a result of the weighted averaging method. The weighted average was changed to a true average of 5 samples, each sample being a 1-second average.

1.3 The Weighted Average Question - Astoria Data Analysis

One of the first stations with the new averaging algorithm was Astoria, OR. On December 19, 1994, a gusty storm passed Astoria. The ASOS 1-minute data for the times from 10:00 to 24:30 and the gust recorder strip chart were supplied for analysis. It was impossible to look at each gust as an independent event. The data expressed for 10-minute periods are shown in Table 1 and Figure 3.

Table 1 - Astoria, OR - ASOS vs. F420/gust recorder

	Average Speed (knots)	ASOS Ave. Peak Speed (knots)	F420 Ave. Peak Speed (knots)	Ave. Peak Difference (knots)	Max. Peak Difference (knots)
Average	27.9	43.8	47.4	-5.5	-12.9
Std. Dev.	2.5	4.3	5.0	3.0	7.0
Maximum	32.9	52	58	1.3	17
Minimum	21.9	34	34	-11.8	-27

Note: The average peak difference is not the same as the difference between average peak speeds. Minima and maxima may come from different periods for each sensor. The most negative average peak difference is not related to the minimum peak speed.

The ASOS sensors were mounted at 33 feet. The F420 was mounted at 20 feet, about 500 feet to the north northwest of ASOS.The wind was steady in direction (183° with a 12 hour σ_θ of just 3°) and a direct transport would take about 10 seconds to reach the F420 from the ASOS.

Since individual peaks did not correlate well even with a 10 second adjustment, further averaging was used. Each 10-minute time period was characterized for ASOS with an average speed (ten 2-minute averages shown as the solid line in Figure 3), an average of one minute peak speeds over 30 knots (shown as the thick grey line in Figure 3), and the largest peak speed in the ten minutes (see Table 1). The F420 gust recorder data were reduced in ten minute time periods synchronous to ASOS. Each period was characterized for the F420 by an average of "one minute" peak speeds over 30 knots (shown as stars in Figure 3) and the largest peak speed in the period (see Table 1). The ASOS peak speed minus the F420 peak speed was calculated for each 10-minute period for both the average peak and the maximum peak speed. A summary of these 86 data periods is shown in Table 1. Averages of 86 whole numbers are shown with one decimal place.

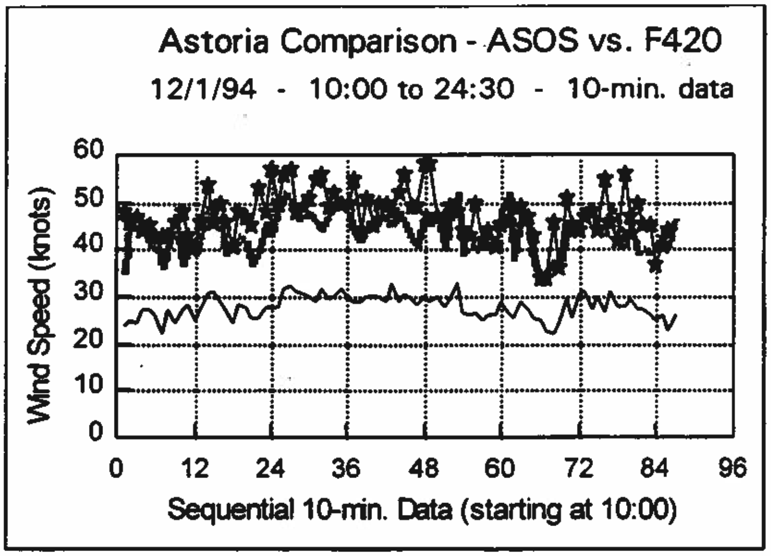


Figure 3

Assuming the F420 is correct and there is no height correction necessary, the difference in average peak speeds for the whole 14½ hours is -3.6 knots or -7.6%. If one looks at the average difference of each 10-minute period, the answer is -5.5 knots or -11.6%. If difference between the maximum peaks for each period is used, the answer is -12.9 knots or -27.2%. If the height difference is considered using a neutral stability and z_0 of 1 cm, an additional 7.5% must be added to each estimate yielding a difference of -16.4 knots or 34.7%. For this storm and this location, the ASOS underestimated the peak speed between 8% and 35% with respect to the conventional F420 peak speed.

The algorithm change did not solve the "problem" of ASOS under-reporting the peak wind speed.

1.4 The OFCM Workshop Consensus

Another background feature was the workshop held October 29-30, 1992, sponsored by the Office of the Federal Coordinator for Meteorological Services and

Supporting Research (OFCM). Dr. David R. Rodenhuis was the chairman of the workshop. The goal was to reach a consensus for a standard method for characterizing wind observations. Application fields that were represented included agriculture, air pollution, aviation, climatology, forecasting, international compatibility, meso-scale networks, oceanography, transport and diffusion, wind engineering, and wind energy. Representatives were from academic or theoretical backgrounds and operational backgrounds. Instrument manufacturers and independent testing facilities were also represented. A consensus was reached which took 1-second average samples and reported 3-second peaks and averages, 1-minute peaks and averages, 10-minute averages and standard deviations about the 10-minute averages.

Since the workshop, the OFCM wind committee members have rejected this consensus standard, presumably on the basis of cost of implementation. Since various organizations have decided to use the consensus as a standard, it was decided to formalize it as an American Society for Testing and Materials (ASTM) standard. Draft 5 of the Standard Practice for Characterizing Surface Wind Using a Wind Vane and Rotating Anemometer is in the ballot process and should be officially published as an ASTM standard this year.

1.5 Other Applications

In 1995 the American Society of Civil Engineers published ANSI/ASCE 7-95 Minimum Design Loads for Buildings and Other Structures. Their definition of *V is "basic wind speed obtained from [*a map of the United States*], in miles per hour (meters per second). The basic wind speed corresponds to a 3-sec. gust speed at 33 ft (10 m) above ground in exposure category C and is associated with an annual probability of 0.02 of being equaled or exceeded (50-year mean recurrence interval)."

2. DISCUSSION and RECOMMENDATIONS

A significant change has been made in the way wind speed is measured by the National Weather Service. All applications of maximum wind speed which relate to warnings have been based in the past on "instantaneous" values. This includes building codes and airline operations. Dr. Mark Powell of NOAA/AOML said at the OFCM workshop that Dr. Fujita reported a roof in Hawaii had been lifted off during hurricane Iniki by a gust with an estimated duration of 1½ seconds. Pilots have been given gust levels measured by instruments with estimated ½ to 2 second response capability. Operators are unsure of the accuracy of ASOS winds because they "know" the reported values are too low. Logic tells us that when we change from "instantaneous" observations to averaging for 5 seconds for each "sample," the peak speed will be lower. Initial data suggest that the amount of decrease in ASOS peak winds is site and storm specific and might range from 5% to 35%.

The international aviation community will follow WMO recommendations. The WMO Commission for Instruments and Methods of Observation (CIMO) stated in 1989 (WMO No. 727) "...filtering characteristics of a wind measuring chain should be such that the reported peak gust should represent a three-second average. The highest three-second average should be reported." All participants at the OFCM workshop agreed that a 3-second wind speed average would be acceptable for their needs. This consensus included Dr. Jon Wieringa, an international wind measurement expert from The Netherlands. He had suggested earlier the use of 5-second averaging for aircraft applications, but agreed that the WMO suggested 3-second average was acceptable for all applications, including aviation (see Wieringa, 1994). There is no technical reason for not using a 3-second average for aviation.

Assume an aircraft with a scale size of 100 feet lands into a 20 kt. (34 fps) wind with gusts to 35 kt. (59 fps). The scale size of the peak gust measured with a 5-second average is 295 feet and with a 3-second average is 177 feet. Perhaps it is even more important that pilots have been used to flying with gust information based on measurements with effective averages of ½ to 2 second. The important question for aviation applications is how will pilots "feel" the difference between the instantaneous gust and the 5-second averaged gust. Even if the NWS chose to change the averaging time from five seconds to the developing international standard of three seconds, lower peak gusts will change our weather information. It will be necessary to educate the users, including the public, about the size and consequence of this change.

3. REFERENCES

Keddie, B., 1971: Some aspects of wind information required in the landing of aircraft. *Meteor. Mag.,* **100**, 134-143.

Koren, O., 1973: Digital output wind systems for airport use. *Journal of Applied Meteorology,* **12**, 529-536.

Sparks, W.R. and B. Keddie, 1971: A note on the optimum average time of wind information for conventional aircraft landings. *Meteor. Mag.,* **100**, 129-131.

Stone, R.J. and J.T. Bradley, 1977: Survey of Anemometers. Federal Aviation Administration. Report No. FAA-RD-77-49.

Wieringa, J., 1994: Does representative wind information exist? Eastern European Conference on Wind Engineering, Warszawa, July.

Attachment 2.

Quarterly Progress Report #7

Gust Recorder Response Tests

by

Thomas J. Lockhart, CCM, CMet

1. INTRODUCTION

The purpose of this brief study is to estimate the effective "averaging time" of the conventional F420-gust recorder combination as compared to the digitally averaged ASOS anemometer.

The F420 has a distance constant of 9 m (30 ft.). If an F420 cup is restrained in a wind tunnel operating at 5 m/s or 10 m/s and then quickly released, the output from the anemometer will reach 63% of the tunnel speed (U_f) in one time constant. During that one time constant, 9 m of air will have passed the anemometer (see ASTM D5096-95, Standard Method for Determining the Performance of a Cup Anemometer or Propeller Anemometer). The 9 m of air passing in one time constant will be the same at any tunnel speed. The dynamic response of the anemometer is constant in distance and not in time. The time constant used in this method is between 0.30 U_f and 0.74 U_f to avoid the stall effect at the moment of release. The method simulates a step change in speed from zero to U_f. At 61 knots, the F420 will reach 95% of a step change in one second. The 1-second average during such a change will be less than the 95% final value. Fortunately there are few step changes in nature, but it is equally true that the peak value of a gust lasting one second will be under-reported by the F420. The under-reporting will be greater if a 1-second average (light chopper) is used than if an "instantaneous" output generator is used. One such "instantaneous" output recorder is the Esterline Angus Model AW galvanometer device called the gust recorder. Serial number 146313 was provided for this test.

2. TEST PLAN

A simple challenge was devised. A d.c. voltage from a 6-volt lantern cell across a 20 KΩ potentiometer was attached to the input terminals of the recorder. A volt meter monitored the output from the potentiometer. Three voltages were used; 0.5 volts (10 kts), 1 volt (21 kts), and 1.5 volts (42 kts). The voltage selected was switched on and off to the recorder by one of two methods. The automatic method used a Young anemometer calibrator which provided known rates of rotation starting at 10 RPM with increases in 10 RPM steps using a digital switch. A sensitive microswitch was operated by a cam on the calibrator motor. The on-off portion of each revolution was adjusted by moving the relative position of the microswitch arm and the cam.

At the lowest automatic speed, 10 RPM or 6 seconds per revolution, the voltage was on for 3 seconds and off for 3 seconds. At the highest speed used, 200 RPM or 0.3 seconds per revolution, the voltage was on for 0.15 seconds and off for 0.15 seconds. The 50% on-off position was found by setting the "dither" at this high speed to the mid-point of the range. The first test (3/18/96) used the recorder with the pen set to 0 at no voltage. The second test (3/20/96) used the recorder with the pen set to 30 at no voltage simulating a speed of 30 with gusts to 40, 51 and 62.

Manual switching at 5 seconds on - 5 seconds off and 10 seconds on - 10 seconds off were used. Also a one minute off and on were used to mark the zero and full scale positions.

3. RESULTS

It was interesting to note the differences in the response of the galvanometer between moving in response to the impressed voltage and moving when the voltage was removed. It was also interesting to see the differences with voltage level. It took 5 to 10 seconds to reach full scale. At the lower voltage it took 15 seconds to reach full scale and the response was generally more sluggish. There was never an overshoot when the voltage was turned on. There was an inertial overshoot when the voltage was turned off. It was largest with the largest voltage.

Clearly there were several factors at work. The pen weight and surface friction were more noticeable at low voltages. The graphs in Figures 1 and 2 show some usefull information. One could generalize that the chart trace will represent about 85% of the peak in 0.5 seconds; 95% is reached in about 2 seconds.

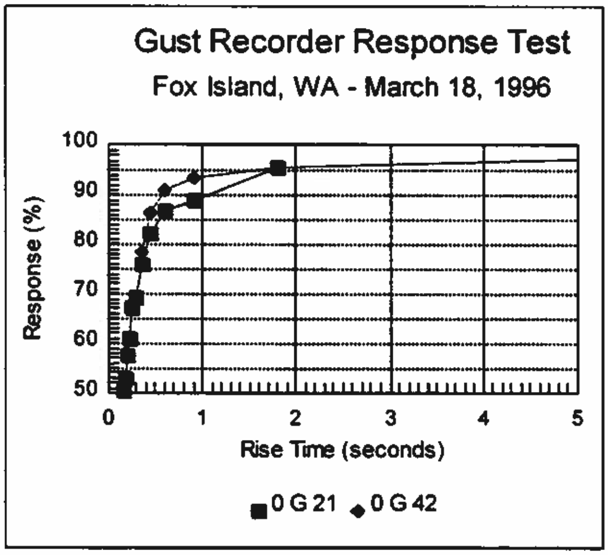


Figure 1

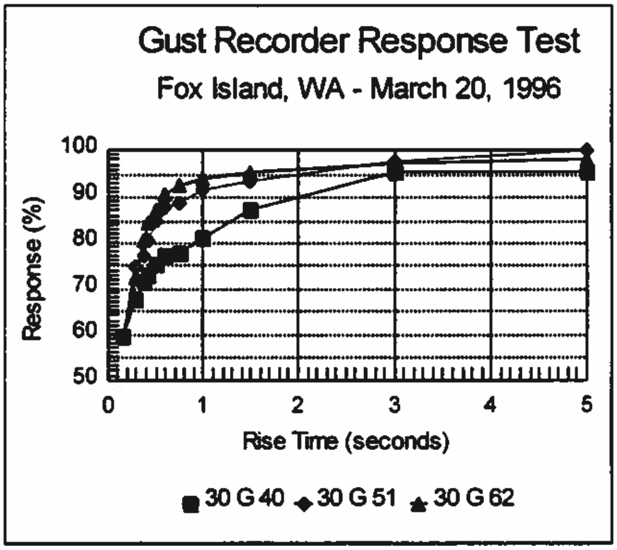


Figure 2

4. DISCUSSION

Assume a 2-minute mean speed of 35 mph with gusts to 45 mph. A calibrated F420 will represent the 2-minute mean quite well, at least within 1mph (3%). If the gust of 10 mph (14.7 fps) is "instantaneous" lasting for nine seconds, the F420 will reach 6.3 mph above the mean in two seconds (63.2% in one distance constant), 9 mph above the mean in five seconds (90% in 2.3 distance constants), and 10 mph in nine seconds (99% in 4.5 distance constants). The average gust speed for these three time periods is estimated by the area ratios under the "1-1/e" curve for the three distance constant values. The ratios are 63%, 69%, and 82%. When these ratios are applied to the speeds at the end of the distance constant slices, the average gust values become 4.0, 6.2, and 8.1 mph of the 10 mph gust. Therefore the 5-second average peak speed will be 41 mph (ASOS) while the peak speed provided by the sensor to the gust recorder would be 44 mph at the end of five seconds. At the end of five seconds the gust recorder will have reached 98% of the change and will read 44 mph.

Assume, however, that the gust lasted only two seconds. The shape of the gust is "square" with a step up and a step down within the five seconds of interest. The 5-second average then would be 36.6 mph (2/5 of the 4.0 mph gust average reached in two seconds added to the mean). The 5-second peak speed from the gust recorder would be 95% of the 6.3 mph the F420 will report in two seconds or 6.0 mph added to the mean of 35 mph or 41 mph. With this assumption, the true 45 mph gust lasting 2 seconds would be reported as 37 mph by ASOS and 41 mph by the F420-gust recorder. If "truth" is taken to be the gust recorder value, the ASOS report would be 10% low. If the assumed value is used as truth, the gust recorder value would be 9% low and the ASOS would be 18% low.

This hypothetical analysis shows clearly how important the size and shape of the gust is to the difference found between the ASOS 5-second average and the conventional F420-gust recorder combination.

5. CONCLUSION

This analysis shows that one cannot characterize the F420-gust recorder with an equivalent averaging time. At high speeds where the sensor is not degrading the measurement, the output on the gust recorder represents about 85% of the peak of a 0.5-second gust, about 95% of the peak of a 2-second gust, and all of the peak of a 5-second gust. The dominant cause of differences between the ASOS 5-second average peak wind and the F420-gust recorder peak wind is the length of time the wind is at maximum speed within the 5-second averaging window.

6. Conclusions

The results of the data analysis for temperature and humidity are now quite clear. The analyses have resolved several characteristics of the data and instruments. The first is that the CONV instrument (the HO-83) has a warm bias. The average for 15 sites is 0.57°F and the range is 0.3°F to 1.2°F, which shows that the variation among the instruments is rather large. A comparative statement about ASOS is that no systematic bias has been found and the instruments do vary by at least ±0.3°F with respect to a calibration standard. The effect of station moves has been determined for the minimum temperatures.. These location biases are quite variable; they can be positive or negative, and a few are such that ASOS is cooler by more than 1°F. This means that the effect of the move is often as large or larger than the difference due to the change in instruments. The combination of the effect of the station move and solar heating on the maximum temperatures is also shown as another bias. This bias is usually negative which is consistent with the CONV instrument having a problem with solar heating. This daytime bias is also quite variable among the stations. Direct comparisons at co-located sites show this effect can be at least 1°F .

The humidity comparisons show no instrument bias in the dewpoint temperatures so the cooler temperatures of ASOS lead to a slight increase in relative humidity. Both CONV and ASOS have periods of excursions in dewpoint temperature observations. A recommendation is that the chilled-mirror technique be replaced with a measurement technique that will be more stable in the field.

Precipitation has been monitored during this period but the major CDCP comparison will occur after the modified ASOS rain gage in spring of 1996.

The study of wind has now identified a set of 20 sites to be included. An analysis of 5-second wind averaging indicates ASOS peak winds are lower than the previous instrument. A brief study of gust recorders has also been included.

Reference:

Jones, C.G., and K.C. Young, 1995: An investigation of temperature discontinuities introduced by the installation of the HO-83 thermometer. ***J. of Climate***, **8**(5), pp. 1394-1402.

Table 1.
Climate Data Continuity Study (CDCP) Comparison Sites
for daily maximum and minimum temperatures

Number	Site ID	Station Name
1.	AMA	Amarillo, TX
2.	AST	Astoria, OR
3.	BRO	Brownsville, TX
4.	BTR	Baton Rouge, LA
5.	COS	Colorado Springs, CO
6.	DDC	Dodge City, KS
7.	GLD	Goodland, KS
8.	GRI	Grand Island, NE
9.	ICT	Wichita, KS
10.	LNK	Lincoln, NE
11.	OKC	Oklahoma City, OK
12.	PWM*	Portland, ME
13.	SYR	Syracuse, NY
14.	TOP	Topeka, KS
15.	TUL	Tulsa, OK

* Station commissioned in August 1994.

Table 2.
4-Season Stations

Number	Site ID	Station Name
1.	ACY	Atlantic City, NJ
2.	BGM	Binghamton, NY
3.	BIS	Bismarck, ND
4.	CAE	Columbia, SC
5.	CLE	Cleveland, OH
6.	COU	Columbia, MO
7.	CYS	Cheyenne, WY
8.	DSM	Des Moines, IA
9.	ERI	Erie, PA
10.	FAR	Fargo, ND
11.	FSD	Sioux Falls, SD
12.	GRB	Green Bay, WI
13.	JAX	Jacksonville, FL
14.	JKL	Jackson, KY
15.	LAS	Las Vegas, NV
16.	LEX	Lexington, KY
17.	MCO	Orlando, FL
18.	MHS	Mount Shasta, CA
19.	MOB	Mobile, AL
20.	RAP	Rapid City, SD
21.	RDD	Redding, CA
22.	RSL	Russell, KS
23.	SAV	Savannah, GA
24.	SBN	South Bend, IN
25.	SGF	Springfield, MO
26.	SLN	Salina, KS
27.	SPI	Springfield, IL
28.	TLH	Tallahassee, FL
29.	TUS	Tucson, AZ
30.	VTN	Valentine, NE
31.	YNG	Youngstown, OH

Table 3.
3-Season Stations

Number	Site ID	Station Name
1.	ABE	Allentown, PA
2.	ABQ	Albuquerque, NM
3.	ALB	Albany, NY
4.	ALO	Waterloo, IA
5.	APN	Alpena, MI
6.	ATL	Atlanta, GA
7.	AUS	Austin, TX
8.	BFF	Scottsbluff, NE
9.	DAB	Daytona Beach, FL
10.	DAY	Dayton, OH
11.	DTW	Detroit, MI
12.	EUG	Eugene, OR
13.	FWA	Fort Wayne, IN
14.	GJT	Grand Junction, CO
15.	HON	Huron, SD
16.	INL	International Falls, MN
17.	INW	Winslow, AZ
18.	LAN	Lansing, MI
19.	LBB	Lubbock, TX
20.	LCH	Lake Charles, LA
21.	MCI	Kansas City, MO
22.	MGM	Montgomery, AL
23.	MKE	Milwaukee, WI
24.	MKG	Muskegon, MI
25.	MLI	Moline, IL
26.	MSO	Missoula, MT
27.	OFK	Norfolk, NE
28.	ORH	Worcester, MA
29.	PAH	Paducah, KY
30.	PDT	Pendleton, OR
31.	PDX	Portland, OR
32.	PIA	Peoria, IL
33.	RFD	Rockford, IL
34.	RST	Rochester, MN
35.	SUX	Sioux City, IA

Table 4.
2-Season Stations

Number	Site ID	Station Name
1.	BIL	Billings, MT
2.	CAK	Akron, OH
3.	DRA	Mercury, NV
4.	FNT	Flint, MI
5.	GEG	Spokane, WA
6.	ISN	Williston, ND
7.	LBF	North Platte, NE
8.	MSN	Madison, WI
9.	SJT	San Angelo, TX
10.	TRI	Bristol, TN

Table 5.

Monthly statistical summaries of ASOS-CONV maximum and minimum temperature differences for June 1994 through August 1995.

ama - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6	29	-0.41	0.91	0.3073	3.1840	0.9826
94	7	31	-0.90	1.01	-0.3720	2.8905	1.3440
94	8	30	-1.03	0.67	0.0332	2.1597	1.2247
94	9	30	-0.87	0.86	-0.5578	2.2743	1.2111
94	10	31	-0.68	0.70	0.0618	2.6051	0.9672
94	11	30	-0.70	0.99	0.0249	4.2917	1.1972
94	12	31	-0.71	0.97	1.7354	7.5990	1.1914
95	1	31	-0.81	0.79	0.4432	2.8165	1.1216
95	2	28	-0.64	0.83	-0.6980	3.6173	1.0351
95	3	31	-0.45	1.09	1.9698	9.4908	1.1640
95	4	30	-0.43	1.19	2.9587	14.5056	1.2517
95	5	31	-0.71	1.24	-2.5529	11.1450	1.4142
95	6	30	-0.97	1.38	-0.2874	2.4276	1.6633
95	7	31	-1.26	1.15	0.3665	3.2024	1.6944
95	8	31	-0.84	1.13	-0.7099	3.2124	1.3912
Season		455	-0.76	1.02	0.1282	7.6018	1.2762

ama - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6	29	-0.72	0.96	-0.7783	3.0101	1.1890
94	7	31	-0.81	0.91	-0.1133	2.7492	1.2048
94	8	30	-0.83	0.65	-0.1499	6.7729	1.0488
94	9	30	-0.70	1.18	-0.4493	3.9267	1.3540
94	10	31	-0.81	1.19	0.4329	2.3508	1.4256
94	11	30	-0.50	1.53	0.6195	3.7401	1.5811
94	12	31	-0.39	1.09	0.1729	2.0935	1.1359
95	1	31	-0.06	1.53	1.0848	5.0138	1.5027
95	2	28	-0.07	1.63	1.3442	5.3675	1.6036
95	3	30	-0.63	1.10	-1.1818	4.2898	1.2517
95	4	30	-1.07	1.87	-1.8208	6.9143	2.1292
95	5	31	-0.81	0.91	-0.8841	6.2284	1.2048
95	6	30	-0.60	0.93	-1.0765	3.6594	1.0954
95	7	31	-0.29	1.13	0.8289	3.6362	1.1500
95	8	31	-0.58	0.72	-0.2461	2.4512	0.9158
Season		454	-0.59	1.21	-0.0290	8.3082	1.3491

ast - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-1.00	1.05	1.3804	8.1034	1.4376
94	7	31	-0.55	0.57	0.7101	2.3504	0.7829
94	8	28	0.04	0.74	0.4670	3.0363	0.7319
94	9	30	-0.80	0.76	0.1270	2.4410	1.0954
94	10	31	-0.90	0.75	-0.6114	3.2346	1.1640
94	11	30	-0.70	0.75	-0.9872	3.8966	1.0165
94	12	31	-0.52	0.68	-0.2560	2.5763	0.8424
95	1	31	-0.26	0.58	0.0380	2.3894	0.6222
95	2	28	-0.46	0.64	-0.1278	2.5552	0.7792
95	3	31	-0.74	0.82	0.2402	2.4643	1.0925
95	4	30	-1.00	0.53	0.0000	3.5042	1.1255
95	5	29	-0.79	0.73	-0.3079	1.8598	1.0667
95	6	30	-0.87	0.94	0.2326	2.9484	1.2649
95	7	31	-0.26	0.63	0.2279	2.2262	0.6720
95	8	31	0.03	0.98	1.9785	9.0408	0.9672
Season		452	-0.59	0.82	0.4130	5.7577	1.0033

ast - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	0.43	0.86	-0.2750	2.1438	0.9487
94	7	31	-0.10	0.54	-0.0914	3.1904	0.5388
94	8	29	0.66	0.55	0.0073	2.0472	0.8510
94	9	30	0.27	0.83	0.2080	2.3864	0.8563
94	10	31	0.29	0.69	-0.4166	2.0317	0.7405
94	11	30	-0.33	0.96	-1.8229	7.8669	1.0000
94	12	31	-0.48	0.68	0.2560	2.5763	0.8231
95	1	31	-0.58	0.62	1.1055	3.0751	0.8424
95	2	28	-0.18	0.72	0.2569	1.8594	0.7319
95	3	31	-0.19	0.87	0.0722	3.1154	0.8799
95	4	30	0.30	0.53	0.1567	2.2019	0.6055
95	5	29	0.14	0.88	0.3625	2.3302	0.8710
95	6	30	-0.20	0.85	-0.6190	2.8469	0.8563
95	7	31	0.00	0.68	0.0000	2.0737	0.6720
95	8	31	0.42	0.67	0.6026	2.8843	0.7829
Season		453	0.03	0.81	-0.2232	3.8402	0.8097

bro - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6	29	-1.21	1.18	-1.0097	3.0689	1.6713
94	7	31	-0.55	0.81	-0.2135	2.3229	0.9672
94	8	31	-0.74	0.63	-0.2279	2.2262	0.9672
94	9	30	-1.60	1.07	0.0065	1.6525	1.9149
94	10	31	-0.68	0.79	-0.6001	3.7745	1.0318
94	11	30	-1.13	0.63	0.0882	2.3705	1.2910
94	12	31	-1.10	0.70	0.1220	1.9688	1.2952
95	1	31	-1.00	0.58	0.0000	2.9032	1.1500
95	2	27	-1.00	0.78	-0.4603	2.7384	1.2620
95	3	31	-0.71	0.94	2.0045	8.6690	1.1640
95	4	30	-0.97	0.72	-0.0448	4.8766	1.1972
95	5	25	-0.48	0.65	-0.9314	2.6493	0.8000
95	6		data missing				
95	7		data missing				
95	8		data missing				
Season		357	-0.93	0.85	-0.3181	4.6998	1.2625

bro - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6	29	0.03	0.94	0.6724	4.6219	0.9285
94	7	31	0.03	0.60	-0.0091	8.4326	0.5957
94	8	31	-0.10	0.54	-0.0914	3.1904	0.5388
94	9	30	-0.40	0.62	-0.3667	2.7390	0.7303
94	10	31	-0.19	0.54	-1.3400	5.5100	0.5680
94	11	30	-0.30	0.65	0.3475	2.1441	0.7071
94	12	31	-0.29	0.64	1.0392	5.7598	0.6956
95	1	31	-0.29	0.97	2.4701	12.6197	1.0000
95	2	28	-0.64	0.49	0.5646	1.2605	0.8018
95	3	31	-0.39	0.56	0.1226	1.9633	0.6720
95	4	30	-0.63	0.96	-1.1948	4.0032	1.1402
95	5	25	-0.72	0.46	0.9218	1.8066	0.8485
95	6		data missing				
95	7		data missing				
95	8		data missing				
Season		358	-0.32	0.72	0.5060	8.3352	0.7879

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 5. continued.

btr - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-2.60	0.67	0.0261	2.6025	2.6833
94	7	31	-2.26	0.68	0.3384	2.0515	2.3555
94	8	31	-2.32	0.75	0.0983	2.3561	2.4363
94	9	30	-2.27	0.52	-0.2684	2.3910	2.3238
94	10	31	-1.65	0.84	-0.7025	3.3136	1.8404
94	11	30	-1.83	0.75	0.2225	2.6204	1.9748
94	12	31	-1.48	0.81	-0.0502	2.3807	1.6848
95	1	31	-1.19	0.83	0.3524	3.0867	1.4480
95	2	28	-1.18	0.94	0.0878	2.5913	1.5000
95	3	31	-1.32	0.75	-0.3647	2.7955	1.5134
95	4	30	-1.60	0.72	-0.1897	2.4384	1.7512
95	5	31	-2.61	0.95	-1.9104	6.6172	2.7766
95	6	30	-2.73	0.94	0.8997	3.7104	2.8868
95	7	31	-2.42	1.36	0.3735	2.6190	2.7650
95	8		data missing				
Season		426	-1.96	0.99	-0.0992	3.5487	2.1996

btr - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-1.33	0.71	-1.6888	7.2400	1.5055
94	7	31	-1.10	0.94	-2.1203	9.9346	1.4368
94	8	31	-1.13	0.92	2.7165	13.2984	1.4480
94	9	30	-0.97	0.56	0.0198	3.1124	1.1106
94	10	31	-1.03	0.91	-0.1947	2.8061	1.3678
94	11	30	-0.97	1.54	2.8912	14.1577	1.7981
94	12	31	-1.16	1.00	0.8862	4.0815	1.5240
95	1	31	-0.71	1.01	0.1827	1.8458	1.2181
95	2	28	-1.18	1.31	-0.6424	3.6432	1.7423
95	3	31	-0.90	1.16	-0.5479	3.1726	1.4591
95	4	30	-1.37	0.81	-0.7977	2.8516	1.5811
95	5	31	-1.74	1.09	-0.6485	3.5680	2.0478
95	6	30	-1.63	0.81	0.4196	2.6023	1.8166
95	7	31	-1.39	0.99	-0.0037	1.8442	1.6944
95	8		data missing				
Season		426	-1.19	1.03	0.5801	9.3960	1.5724

cos - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-1.50	0.94	0.1213	2.0209	1.7607
94	7	31	-1.39	1.02	-0.2956	3.3061	1.7133
94	8	31	-1.48	0.85	-0.2053	2.2820	1.7039
94	9	30	-1.57	0.94	0.0645	2.0310	1.8166
94	10	31	-1.23	0.80	0.0317	2.1126	1.4591
94	11	30	-1.13	0.94	0.0104	2.5680	1.4606
94	12	31	-1.26	0.86	-0.1282	2.2043	1.5134
95	1	31	-1.32	0.70	-0.0618	2.6051	1.4919
95	2	28	-1.79	0.88	-0.7224	2.4201	1.9821
95	3	31	-1.23	1.36	-2.3781	10.8213	1.8139
95	4	30	-1.27	1.31	-1.0280	3.4316	1.8074
95	5	31	-1.00	1.00	-0.7742	3.2903	1.4028
95	6	30	-1.17	0.95	-0.6136	4.4258	1.4944
95	7	31	-1.45	0.99	0.3627	2.5836	1.7506
95	8	31	-1.97	1.02	0.3076	2.3467	2.2070
Season		457	-1.38	1.00	-0.6312	4.8128	1.7040

cos - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-0.67	0.66	-0.4362	2.1355	0.9309
94	7	31	-0.42	0.50	-0.3112	1.0366	0.6476
94	8	31	-0.32	0.98	2.5030	12.6145	1.0160
94	9	30	-0.57	0.82	-0.1599	2.2916	0.9832
94	10	31	-0.32	0.48	-0.7226	1.4761	0.5680
94	11	30	-0.43	0.86	-0.9900	4.0105	0.9487
94	12	31	-0.45	0.72	0.8621	5.1694	0.8424
95	1	31	-0.42	1.06	-2.4143	11.7156	1.1216
95	2	28	-0.50	1.58	-0.7126	7.8400	1.6257
95	3	31	-0.13	1.26	3.6359	18.2725	1.2443
95	4	30	-0.43	0.97	1.1279	6.0965	1.0488
95	5	31	-0.35	0.66	-0.1871	2.7487	0.7405
95	6	30	-0.23	0.63	-0.6333	3.6553	0.6583
95	7	31	-0.55	0.77	0.3705	2.5730	0.9333
95	8	29	-0.38	1.18	1.3676	7.7315	1.2177
Season		455	-0.41	0.91	0.6364	15.2077	0.9997

ddc - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	0.10	0.96	-0.4166	2.5879	0.9487
94	7	31	0.74	1.09	-0.2374	3.2722	1.3075
94	8	31	0.26	1.24	-0.8870	3.1272	1.2443
94	9	30	-0.30	0.95	-0.5604	3.2881	0.9832
94	10	31	-0.16	0.73	-0.2468	2.7118	0.7405
94	11	30	-0.13	1.68	3.7285	18.5775	1.6533
94	12	31	-0.52	0.57	-0.4626	2.0652	0.7620
95	1	31	-0.84	0.58	-0.0102	2.6343	1.0160
95	2	27	-0.52	0.64	0.0658	2.5393	0.8165
95	3	31	-0.35	0.55	0.0133	2.0116	0.6476
95	4	30	-1.33	0.80	0.2438	2.1097	1.5492
95	5	31	-1.35	0.88	0.7149	2.9557	1.6064
95	6	30	-0.33	1.09	-0.2607	2.8199	1.1255
95	7	31	-1.29	1.55	-0.1996	2.9212	2.0000
95	8	31	-1.23	0.80	-0.3399	2.6192	1.4591
Season		456	-0.48	1.16	0.7089	9.2136	1.2539

ddc - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6	29	-1.38	1.15	-0.4917	2.1522	1.7811
94	7	31	-0.87	0.88	-0.5197	3.3378	1.2313
94	8	31	-0.52	1.34	0.6387	4.1004	1.4142
94	9	30	-0.73	0.74	-0.4334	1.8587	1.0328
94	10	31	-1.03	1.11	-0.7882	3.2388	1.5027
94	11	30	-0.70	1.37	-0.5292	3.6914	1.5166
94	12	31	-1.00	1.03	-0.3514	2.2681	1.4256
95	1	31	-0.84	1.00	-0.6946	4.3403	1.2952
95	2	27	-0.67	1.18	0.0455	2.7819	1.3333
95	3	31	-0.52	0.93	-0.5633	3.0670	1.0473
95	4	30	-0.83	1.18	-0.9248	6.7493	1.4259
95	5	31	-1.06	0.57	-1.0394	6.0140	1.2048
95	6	30	-1.20	0.76	-0.5806	3.1561	1.4142
95	7	31	-1.13	0.85	-0.4055	2.5106	1.4028
95	8	31	-1.13	0.76	-0.6645	3.3729	1.3560
Season		455	-0.91	1.03	-0.2578	4.6614	1.3702

gld - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-1.77	0.77	0.0332	2.3057	1.9235
94	7	31	-1.68	0.98	-0.0304	2.6244	1.9344
94	8	31	-1.45	0.89	-0.1410	2.1853	1.6944
94	9	30	-1.53	1.01	-0.2051	1.8028	1.8257
94	10	31	-0.87	0.76	-0.6405	3.1156	1.1500
94	11	30	-1.47	1.22	-0.0744	2.0792	1.8974
94	12	31	-0.71	0.97	-2.6804	12.4384	1.1914
95	1	31	-0.81	1.08	-0.5272	2.4867	1.3320
95	2	28	-0.75	1.11	-1.2642	4.2106	1.3229
95	3	31	-0.65	0.75	0.2561	2.6564	0.9837
95	4	30	-0.67	1.35	-0.5145	5.9314	1.4832
95	5	31	-0.35	1.33	-0.5082	2.8396	1.3560
95	6	30	0.17	1.74	-0.2089	1.6893	1.7224
95	7	31	-1.94	1.34	0.6108	3.4103	2.3418
95	8	31	-2.81	1.05	0.3016	2.4307	2.9892
Season		457	-1.16	1.32	-0.0346	3.3033	1.7515

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 5. continued.

gld - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-1.83	1.15	-0.8439	3.4274	2.1525
94	7	31	-1.58	0.96	-1.3176	6.0927	1.8404
94	8	31	-1.32	1.30	-1.1695	3.6821	1.8404
94	9	30	-1.33	1.30	-0.5861	2.0385	1.8439
94	10	31	-2.10	1.25	-0.7208	2.7620	2.4297
94	11	30	-1.33	1.40	-0.0759	2.5279	1.9149
94	12	31	-1.29	1.32	0.3549	2.3883	1.8316
95	1	31	-1.61	1.17	0.0833	2.2689	1.9838
95	2	28	-1.21	1.47	-0.3784	1.8325	1.8898
95	3	31	-1.10	1.33	-1.1589	3.6955	1.7039
95	4	30	-0.83	1.12	-0.4601	2.2238	1.3784
95	5	31	-0.77	1.23	-0.9373	3.0105	1.4368
95	6	30	-0.37	1.25	-2.9359	14.1798	1.2780
95	7	31	-0.16	1.32	-1.0629	4.3061	1.3075
95	8	31	-1.03	1.05	-0.4427	1.7831	1.4591
Season		457	-1.19	1.32	-0.5784	3.2220	1.7817

gri - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-1.40	0.81	-0.3119	2.4894	1.6125
94	7	30	-1.17	0.70	-0.3688	3.0866	1.3540
94	8	31	-1.61	0.76	-1.1695	4.0871	1.7780
94	9	30	-0.93	0.64	-0.0487	2.3461	1.1255
94	10	31	-0.84	0.69	0.3967	3.1966	1.0776
94	11	30	-1.13	0.82	-0.1298	2.1284	1.3904
94	12	31	-1.97	0.84	0.2744	3.7130	2.1327
95	1	31	-1.87	0.76	0.2295	2.5274	2.0161
95	2	28	-2.00	0.54	0.0000	3.2545	2.0702
95	3	31	-1.32	0.87	0.0527	2.0621	1.5760
95	4	29	-0.90	0.94	0.5541	4.5195	1.2865
95	5	31	-0.84	1.00	0.6473	3.0953	1.2952
95	6	30	-0.87	0.78	0.2098	2.4404	1.1547
95	7	30	-1.13	0.82	-0.4935	2.7794	1.3904
95	8	31	-0.81	0.87	-0.9463	3.2232	1.1778
Season		454	-1.25	0.89	0.0201	3.2823	1.5338

gri - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6	29	-0.72	0.70	-0.4013	1.9857	1.0000
94	7	31	-0.65	0.71	-1.1255	4.6855	0.9504
94	8	31	-0.74	0.82	-0.1171	3.7933	1.0925
94	9	30	-0.43	0.63	-0.2421	2.6138	0.7528
94	10	31	0.23	1.12	2.6235	11.3860	1.1216
94	11	29	-0.59	1.18	0.9529	4.6798	1.2999
94	12	31	-1.39	0.88	0.5128	3.1518	1.6363
95	1	31	-1.26	0.68	0.3384	2.0515	1.4256
95	2	28	-1.64	0.68	-1.2112	5.5898	1.7728
95	3	30	-0.87	0.90	-0.2499	2.4638	1.2383
95	4	30	-0.67	0.76	-0.1360	2.3099	1.0000
95	5	31	-0.65	0.95	1.3066	8.4098	1.1359
95	6	30	-0.43	0.63	-0.2421	2.6138	0.7528
95	7	30	-0.23	0.57	-0.0113	2.4901	0.6055
95	8	31	-0.35	1.02	2.1851	7.7003	1.0626
Season		453	-0.69	0.94	0.7627	7.4005	1.1638

ict - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-1.37	0.72	-0.4547	2.8742	1.5384
94	7	31	-1.68	0.91	-0.3875	2.8301	1.9008
94	8	31	-1.45	0.62	-0.1758	2.5611	1.5760
94	9	30	-1.07	0.64	0.0487	2.3461	1.2383
94	10	31	-1.35	0.66	-0.8581	3.3384	1.5027
94	11	30	-0.93	0.64	0.7154	4.4165	1.1255
94	12	31	-0.61	0.67	-0.5764	2.1999	0.8980
95	1	31	-0.29	1.16	2.7866	14.2935	1.1778
95	2	28	-0.21	0.63	-0.6910	3.8201	0.6547
95	3	31	-0.58	0.62	-0.5152	2.2324	0.8424
95	4	30	-0.43	1.04	2.3178	11.4023	1.1106
95	5	31	-0.87	0.72	-0.7012	3.7061	1.1216
95	6	29	-0.17	1.54	1.8746	9.9337	1.5200
95	7	31	-0.29	0.69	-0.1662	2.7375	0.7405
95	8	31	-0.42	0.76	0.3867	2.3118	0.8614
Season		456	-0.79	0.96	1.2198	11.8914	1.2381

ict - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-0.47	0.51	-0.1270	0.9511	0.6831
94	7	31	-0.52	0.51	0.0615	0.9404	0.7184
94	8	30	-0.90	0.40	0.7970	5.1917	0.9832
94	9	30	-0.63	0.61	1.3557	3.6688	0.8756
94	10	31	-0.68	0.79	-0.2091	4.1253	1.0318
94	11	30	-0.20	1.19	2.6511	12.6360	1.1832
94	12	31	-0.39	0.84	0.7841	3.3555	0.9158
95	1	31	0.10	0.47	0.3123	4.0137	0.4752
95	2	28	0.00	0.72	-0.5739	3.4537	0.7071
95	3	31	-0.16	0.45	-0.6441	3.6357	0.4752
95	4	30	0.10	0.55	0.0730	3.0856	0.5477
95	5	31	-0.29	0.53	-0.2044	2.2496	0.5957
95	6	29	0.10	0.56	0.0541	2.9811	0.5571
95	7	31	-0.16	1.04	-3.1714	15.6151	1.0318
95	8	30	0.13	0.35	2.0503	5.2832	0.3651
Season		454	-0.27	0.74	0.1957	11.7108	0.7829

lnk-1 - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-2.17	1.26	-0.6933	2.6757	2.4967
94	7	31	-2.61	1.33	0.5201	2.7956	2.9238
94	8	31	-2.55	0.89	0.1410	2.1853	2.6941
94	9	30	-2.23	0.97	0.0196	2.5630	2.4290
94	10	31	-1.87	1.38	0.8718	6.3545	2.3141
94	11	30	-1.67	1.15	-0.6447	2.3917	2.0166
94	12	30	-1.83	1.15	-0.8439	3.4274	2.1525
95	1	30	-2.13	0.90	-1.1239	4.7037	2.3094
95	2	27	station moved				
95	3	31	data not available				
95	4	30	data not available				
95	5	31	data not available				
95	6	30	data not available				
95	7	30	data not available				
95	8	31	data not available				
Season		243	-2.14	1.17	-0.0126	3.9440	2.4352

lnk-1 - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-1.40	1.38	-1.3434	5.0131	1.9494
94	7	31	-1.52	1.18	-0.3755	2.2267	1.9092
94	8	31	-2.10	1.51	-0.5121	2.0407	2.5716
94	9	30	-2.17	1.62	-0.3977	1.7707	2.6895
94	10	31	-2.65	1.92	-0.4103	2.2093	3.2528
94	11	30	-2.23	2.06	-1.0419	3.1988	3.0166
94	12	31	-2.06	1.90	-0.7339	2.8874	2.7824
95	1	31	-1.84	1.55	-0.9856	3.5611	2.3895
95	2	27	station moved				
95	3	31	data not available				
95	4	30	data not available				
95	5	31	data not available				
95	6	30	data not available				
95	7	30	data not available				
95	8	31	data not available				
Season		245	-2.00	1.68	-0.9057	3.3713	2.6104

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 5. continued.

lnk-2 - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	no data taken				
94	7	31	no data taken				
94	8	31	no data taken				
94	9	30	no data taken				
94	10	31	no data taken				
94	11	30	no data taken				
94	12	30	no data taken				
95	1	30	no data taken				
95	2	27	station relocated				
95	3	31	-2.29	1.19	-0.9474	3.9115	2.5716
95	4	30	-1.63	1.38	0.3456	3.2144	2.1213
95	5	31	-2.84	1.46	-0.7028	3.1489	3.1826
95	6	30	-2.33	1.18	0.0357	4.1850	2.6077
95	7	30	-2.70	1.09	0.0342	3.2561	2.9040
95	8	31	-2.48	0.85	-0.2053	2.2820	2.6213
Season		183	-2.38	1.25	-0.1907	4.3274	2.6898

lnk-2 - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	no data taken				
94	7	31	no data taken				
94	8	31	no data taken				
94	9	30	no data taken				
94	10	31	no data taken				
94	11	30	no data taken				
94	12	31	no data taken				
95	1	31	station relocated				
95	2	27	-1.26	0.90	0.5009	2.7140	1.5396
95	3	31	-1.19	0.83	-0.6506	6.1664	1.4480
95	4	30	-0.87	0.51	0.2404	3.3647	1.0000
95	5	31	-1.23	1.36	-0.6822	4.2349	1.8139
95	6	30	-0.97	0.67	0.6357	4.0271	1.1690
95	7	30	-1.03	0.67	-0.6357	4.0271	1.2247
95	8	31	-0.87	0.99	3.7254	19.0021	1.3075
Season		183	-1.03	0.89	0.1942	11.6094	1.3604

okc - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-0.10	0.96	-0.4890	2.2104	0.9487
94	7	27	0.63	1.45	-0.1019	2.2464	1.5516
94	8	31	0.19	0.75	-0.3070	1.7683	0.7620
94	9	30	-0.20	1.35	1.7357	8.0808	1.3416
94	10	31	-0.71	0.74	-0.4819	1.8916	1.0160
94	11	29	-0.76	0.58	-0.0269	2.4300	0.9469
94	12	31	-1.03	0.71	-0.5081	3.3940	1.2443
95	1	29	-0.93	0.80	-0.1154	3.5554	1.2177
95	2	28	-0.57	0.69	-0.0799	2.5430	0.8864
95	3	31	-0.87	0.88	-0.7991	2.8691	1.2313
95	4	30	-1.23	0.82	-0.3092	2.5308	1.4720
95	5	31	-1.03	0.60	-0.8665	5.3496	1.1914
95	6	29	-1.10	0.82	0.1791	1.4681	1.3646
95	7	30	-1.17	1.21	-1.0604	4.1429	1.6633
95	8		data missing				
Season		417	-0.64	1.05	0.5049	5.8499	1.2272

okc - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6	29	-2.52	1.72	-0.5773	2.0356	3.0343
94	7	27	-2.11	1.31	-1.2842	4.1536	2.4721
94	8	31	-2.48	1.61	-0.1905	2.4710	2.9457
94	9	30	-2.17	1.98	-0.5709	3.8601	2.9155
94	10	31	-1.45	1.55	-0.7165	3.7115	2.1022
94	11	29	-1.97	1.59	-0.2080	2.5222	2.5120
94	12	31	-1.77	1.63	-1.1171	4.3605	2.3895
95	1	29	-1.97	1.64	-0.3838	1.7183	2.5393
95	2	28	-2.25	1.90	-0.5623	2.0228	2.9216
95	3	30	-1.47	1.61	-0.6773	2.4353	2.1602
95	4	30	-2.13	1.81	-0.6125	2.0033	2.7809
95	5	31	-1.23	1.59	-0.9513	4.5715	1.9838
95	6	29	-2.48	1.55	-0.3090	1.9253	2.9125
95	7	30	-2.57	1.65	0.1574	1.8935	3.0386
95	8		data missing				
Season		415	-2.03	1.69	-0.5545	2.8968	2.6422

pwm - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6		data missing				
94	7		data missing				
94	8	31	-0.71	0.86	-0.8636	4.0259	1.1072
94	9	30	-0.67	0.71	0.0206	2.5485	0.9661
94	10	31	-0.81	0.60	-0.0770	2.4519	1.0000
94	11	30	-0.37	0.49	-0.5259	1.2206	0.6055
94	12	31	-0.61	0.62	-0.4134	2.1878	0.8614
95	1	31	-0.55	0.68	-1.4027	5.9213	0.8614
95	2	28	-1.11	0.99	-0.8869	3.6107	1.4760
95	3	31	-0.48	0.68	-0.3683	2.6358	0.8231
95	4	29	-0.83	0.80	-0.2996	3.5223	1.1447
95	5	31	-0.94	1.18	-2.3498	11.3261	1.4919
95	6	30	-1.23	0.73	-1.7165	7.7586	1.4259
95	7	31	-0.97	1.14	0.9855	3.8415	1.4811
95	8	31	-0.97	0.75	0.4063	2.8440	1.2181
Season		395	-0.78	0.84	-0.9144	7.5035	1.1452

pwm - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6		data missing				
94	7		data missing				
94	8	31	-0.71	1.07	-1.9901	8.8218	1.2700
94	9	30	-1.43	1.22	-0.4773	2.1718	1.8708
94	10	31	-1.65	1.33	-0.5604	2.3732	2.1022
94	11	30	-1.20	1.35	-2.4976	11.6043	1.7889
94	12	31	-0.94	0.89	-0.6648	2.6075	1.2826
95	1	31	-0.90	1.19	-0.8627	2.8359	1.4811
95	2	28	-1.21	1.23	-0.2999	2.5349	1.7113
95	3	31	-0.77	1.12	-1.6836	7.1562	1.3440
95	4	29	-1.07	1.36	-0.8654	4.4333	1.7120
95	5	30	-0.90	1.73	0.5092	3.4542	1.9235
95	6	30	-1.33	1.32	0.8628	3.3149	1.8619
95	7	30	-1.37	1.27	0.8756	5.7440	1.8529
95	8	31	-1.87	1.41	-1.3297	3.8847	2.3280
Season		393	-1.18	1.31	-0.5906	5.0415	1.7598

syr - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-1.10	0.71	0.1330	1.9059	1.3038
94	7	31	-1.19	0.70	-0.2930	2.9239	1.3796
94	8	30	-0.97	0.81	-0.8128	3.4751	1.2517
94	9	30	-0.63	0.56	-0.0663	1.9967	0.8367
94	10	31	-0.77	0.56	0.0481	2.5526	0.9504
94	11	30	-0.20	0.66	-2.5099	11.1586	0.6831
94	12	31	-0.45	0.68	-0.4835	2.7373	0.8032
95	1	31	-0.32	0.87	-1.7031	6.1789	0.9158
95	2	28	-1.39	1.47	-0.5367	2.0291	2.0089
95	3	31	-0.90	0.98	-1.2185	4.4054	1.3198
95	4	30	-0.90	0.88	-0.1848	1.2606	1.2517
95	5	31	-0.65	1.11	0.2844	2.1787	1.2700
95	6	30	-0.43	0.82	-0.2066	2.4112	0.9129
95	7	7	-1.29	0.49	-0.7528	1.3959	1.3628
95	8	31	-1.26	0.68	-0.2729	2.9196	1.4256
Season		432	-0.80	0.90	-0.6962	4.0105	1.2086

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 5. continued.

syr - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-0.47	0.68	-0.4317	2.6791	0.8165
94	7	31	-0.68	0.60	-0.2199	2.2085	0.8980
94	8	30	-0.60	0.62	0.3667	2.7390	0.8563
94	9	30	-0.30	0.53	-0.1567	2.2019	0.6055
94	10	31	-0.29	0.59	0.1275	2.2770	0.6476
94	11	30	-0.50	1.41	-1.1103	5.5526	1.4720
94	12	31	-0.35	1.14	-2.0381	9.3363	1.1778
95	1	31	-0.19	0.54	-1.3400	5.5100	0.5680
95	2	28	-0.54	0.64	0.1278	2.5552	0.8238
95	3	31	-0.13	0.62	0.8870	5.7689	0.6222
95	4	30	-0.27	0.94	2.8990	14.0341	0.9661
95	5	31	-0.45	0.62	0.6212	2.3139	0.7620
95	6	30	-0.30	0.53	-0.1567	2.2019	0.6055
95	7	5	-1.00	0.71	0.0000	1.6000	1.1832
95	8	31	-0.77	0.72	0.1924	2.7129	1.0473
Season		430	-0.42	0.78	-0.5785	10.7835	0.8882

top - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-0.17	1.26	1.4973	5.7271	1.2517
94	7	31	0.10	1.30	0.3560	2.0634	1.2826
94	8	30	0.20	1.16	-0.5066	2.9320	1.1547
94	9	30	-0.73	0.78	-0.0594	2.2082	1.0646
94	10	31	-0.77	0.72	0.1924	2.7129	1.0473
94	11	30	-0.83	0.75	-0.2580	1.7623	1.1106
94	12	31	-0.90	0.70	-0.1220	1.9688	1.1359
95	1	31	-1.23	0.96	-0.4455	2.2254	1.5450
95	2	28	-1.07	0.81	-0.2764	2.3076	1.3363
95	3	31	-1.13	0.92	-0.7445	2.7770	1.4480
95	4	30	-0.83	1.02	-0.5097	2.2415	1.3038
95	5	31	-0.71	0.64	-0.3097	2.1709	0.9504
95	6		data missing				
95	7	31	-0.19	1.54	0.4210	2.3414	1.5240
95	8	31	1.52	1.48	-0.1199	1.7976	2.1022
Season		426	-0.48	1.25	0.8643	4.4177	1.3357

top - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-0.10	0.96	-0.2626	4.6642	0.9487
94	7	31	0.39	1.26	-1.2165	5.4962	1.2952
94	8	29	0.28	1.25	-0.9317	5.9226	1.2594
94	9	30	0.33	0.80	0.1434	2.4315	0.8563
94	10	31	0.23	0.76	0.4989	3.0052	0.7829
94	11	30	-0.23	1.07	-0.3582	3.0123	1.0801
94	12	31	-0.58	0.99	0.9088	3.7464	1.1359
95	1	31	-0.55	0.96	-0.3041	2.8019	1.0925
95	2	27	-0.19	0.88	-0.3099	2.2761	0.8819
95	3	31	-0.10	0.70	-0.4417	3.2673	0.6956
95	4	30	-0.23	0.82	0.4238	3.3679	0.8367
95	5	31	-0.13	1.38	2.7768	12.7756	1.3678
95	7	31	0.39	1.05	-0.2898	2.1822	1.1072
95	8	31	1.26	1.21	0.7181	2.5204	1.7321
Season		424	0.06	1.11	0.4245	5.7131	1.1131

tul - Daily Max Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-2.17	0.99	-0.0967	2.4887	2.3735
94	7	31	-2.35	1.02	-0.0156	1.7500	2.5590
94	8	31	-2.03	0.75	0.0488	1.7120	2.1627
94	9	30	-1.97	1.03	-0.4259	2.3584	2.2136
94	10	31	-1.58	0.67	0.6026	2.8843	1.7133
94	11	30	-1.37	1.07	0.9005	4.2789	1.7224
94	12	31	-1.42	1.18	1.4162	7.1011	1.8316
95	1	31	-1.77	0.92	0.0589	2.9591	1.9919
95	2	28	-1.54	1.32	-0.3926	3.4207	2.0089
95	3	31	-1.77	1.20	-0.5330	2.9201	2.1327
95	4	30	-3.03	1.00	0.2637	3.0022	3.1885
95	5	31	-2.90	1.04	1.3452	7.1848	3.0796
95	6	30	-3.53	1.41	-0.2569	3.0867	3.7947
95	7	31	-2.90	0.94	-0.1836	3.0663	3.0480
95	8		data missing				
Season		426	-2.17	1.23	-0.0883	4.1169	2.4913

tul - Daily Min Temperatures

Year	Mn	N	d	s	M	k	C
94	6	30	-1.63	0.96	-0.5257	2.5229	1.8886
94	7	31	-1.35	0.88	-0.1446	2.2184	1.6064
94	8	31	-1.45	0.72	-0.1626	2.6088	1.6164
94	9	30	-1.20	0.81	0.3525	3.4785	1.4376
94	10	31	-1.23	0.96	0.2190	2.3899	1.5450
94	11	30	-0.93	0.94	-1.3130	4.9506	1.3166
94	12	31	-0.74	0.86	0.1282	3.6524	1.1216
95	1	31	-1.19	1.19	0.1342	3.6675	1.6752
95	2	28	-1.21	1.55	-0.0012	3.7301	1.9457
95	3	31	-1.29	1.37	0.0610	2.9577	1.8665
95	4	30	-2.23	1.10	0.4489	2.5614	2.4833
95	5	31	-2.26	0.68	-0.2729	2.9196	2.3555
95	6	30	-2.57	0.77	-0.0013	2.4544	2.6771
95	7	31	-2.35	1.11	-0.0029	2.0317	2.5965
95	8		data missing				
Season		426	-1.55	1.15	0.0212	3.4040	1.9255

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 6.

Monthly statistical summaries of ASOS - CONV computed from six-hourly temperature, dewpoint temperature, dewpoint depression and relative humidity differences, June 1994 through August 1995 for CDCP sites.

AMA - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	116	-0.26	1.24	0.1670	4.1651	1.2594
1994	7	121	-0.58	1.33	0.5598	4.7262	1.4431
1994	8	124	-0.63	0.98	0.6896	4.9577	1.1640
1994	9	120	-0.68	1.02	-0.6080	6.6536	1.2247
1994	10	122	-0.66	1.40	0.5414	7.0168	1.5418
1994	11	120	-0.22	1.30	1.2805	6.2994	1.3166
1994	12	124	-0.27	1.70	0.8963	5.5077	1.7157
1995	1	124	-0.17	2.23	1.6431	8.4195	2.2270
1995	2	112	-0.40	1.45	1.3903	9.2115	1.5030
1995	3	123	-0.28	1.15	0.8708	5.3415	1.1756
1995	4	120	-0.41	1.24	0.5390	6.0123	1.3006
1995	5	116	-0.44	0.93	0.2485	5.7086	1.0213
1995	6	120	-0.78	1.02	-0.9790	5.7976	1.2748
1995	7	116	-0.88	1.50	1.8619	12.6055	1.7370
1995	8	124	-0.76	1.02	-1.0332	6.9426	1.2700
Season		1803	-0.49	1.36	1.1881	10.2871	1.4431

AMA - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6	33	-0.58	0.71	0.2590	2.6982	0.9045
1994	7	29	-0.55	1.40	0.4761	5.6203	1.4856
1994	8	27	-0.67	0.88	-0.3294	3.3383	1.0887
1994	9	26	-0.54	0.58	0.7281	2.3916	0.7845
1994	10	31	-0.52	0.93	-0.8068	4.1015	1.0473
1994	11	31	-0.45	0.77	0.9132	4.4790	0.8799
1994	12	26	0.23	1.61	1.1380	3.8218	1.5933
1995	1	31	-0.39	0.99	-0.8036	3.0180	1.0473
1995	2	31	-0.42	0.76	-1.3438	5.3043	0.8614
1995	3	36	-0.17	1.16	0.9580	4.1270	1.1547
1995	4	31	-0.35	0.98	0.9240	5.3961	1.0318
1995	5	37	-0.41	0.69	0.6746	5.1832	0.7884
1995	6	37	-0.46	0.56	-0.6221	2.1959	0.7166
1995	7	14	-0.57	1.16	0.5747	2.5001	1.2536
1995	8	32	-0.22	0.55	-0.0835	2.6171	0.5863
Season		452	-0.40	0.95	0.7860	7.5874	1.0278

AMA - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	115	0.15	1.59	2.6238	11.6707	1.5907
1994	7	120	-0.56	1.17	-1.8617	15.4118	1.2942
1994	8	123	-0.04	0.77	0.4919	3.3980	0.7704
1994	9	120	-0.53	1.57	2.0853	18.3146	1.6482
1994	10	121	-0.98	1.02	-1.5439	11.8388	1.4113
1994	11	120	-0.71	1.23	-3.1965	28.9609	1.4113
1994	12	124	-0.24	1.32	-1.4417	14.1261	1.3380
1995	1	122	-0.42	0.81	-0.3092	3.4783	0.9099
1995	2	111	0.21	1.75	1.4098	6.7351	1.7579
1995	3	122	0.55	1.85	2.6174	11.7813	1.9269
1995	4	120	0.55	1.78	1.2539	8.3827	1.8574
1995	5	115	1.03	1.03	0.8992	4.5908	1.4536
1995	6	120	0.62	1.30	1.7590	7.2365	1.4318
1995	7	116	-0.20	1.11	-0.1824	4.7460	1.1180
1995	8	124	0.01	0.86	2.9506	21.2120	0.8567
Season		1794	-0.04	1.42	1.1689	13.3047	1.4225

AMA - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6	116	-0.32	2.24	-0.9268	9.3262	2.2533
1994	7	119	-0.12	1.48	-0.2039	5.1496	1.4781
1994	8	123	-0.59	1.30	-0.2368	2.9724	1.4200
1994	9	120	-0.15	1.86	-1.3823	11.2857	1.8619
1994	10	121	0.33	1.49	0.4764	5.8108	1.5212
1994	11	120	0.49	1.76	1.1993	9.6580	1.8235
1994	12	124	-0.02	1.86	0.3289	5.9873	1.8513
1995	1	123	0.15	1.96	1.4017	8.3775	1.9569
1995	2	111	-0.61	2.05	-0.8404	5.5482	2.1351
1995	3	123	-0.92	2.10	-1.9020	7.8025	2.2864
1995	4	120	-0.96	1.96	-0.5098	5.6199	2.1737
1995	5	115	-1.48	1.48	-0.2739	5.7295	2.0893
1995	6	120	-1.39	1.82	-1.3830	5.1458	2.2822
1995	7	116	-0.68	1.90	1.3175	11.0448	2.0150
1995	8	123	-0.76	1.39	-1.1198	5.5170	1.5773
Season		1795	-0.46	1.88	-0.3172	8.0775	1.9335

AMA - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6	114	0.41	2.21	0.3459	3.4017	2.2415
1994	7	119	0.16	2.75	0.2838	5.2784	2.7421
1994	8	123	0.75	2.43	-0.2981	3.1715	2.5385
1994	9	116	-0.02	2.13	-0.2050	4.7198	2.1256
1994	10	118	-0.70	2.68	0.2199	4.5338	2.7617
1994	11	117	-1.08	2.85	-0.3731	3.5932	3.0390
1994	12	119	0.27	2.90	0.3018	3.6384	2.9027
1995	1	118	-0.04	2.98	-0.3589	3.7374	2.9673
1995	2	109	0.58	2.93	0.0432	4.0833	2.9707
1995	3	114	0.70	2.55	-0.0393	4.0970	2.6325
1995	4	116	1.43	2.95	0.2079	2.9978	3.2710
1995	5	114	3.14	2.59	-0.1982	3.4116	4.0648
1995	6	117	2.24	2.68	0.3992	2.4228	3.4847
1995	7	114	1.24	2.23	-0.3438	2.9962	2.5417
1995	8	122	1.07	2.23	0.0735	3.8842	2.4678
Season		1751	0.67	2.81	0.0096	3.8234	2.8866

AST - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	119	-0.44	0.99	-0.1997	3.2532	1.0769
1994	7	124	-0.26	0.76	-0.6215	3.7774	0.8032
1994	8	124	-0.08	0.77	-0.7067	4.0575	0.7725
1994	9	120	-0.12	0.93	0.9287	5.9505	0.9354
1994	10	124	-0.27	0.76	-0.4226	2.9813	0.7982
1994	11	120	-0.54	0.62	0.5754	4.1516	0.8216
1994	12	120	-0.29	0.63	0.7071	4.3472	0.6892
1995	1	124	-0.35	0.63	0.9962	8.0405	0.7128
1995	2	112	-0.44	0.64	-0.1297	2.7495	0.7734
1995	3	117	-0.50	0.89	-0.0975	3.5660	1.0170
1995	4	120	-0.42	0.99	1.1730	9.3805	1.0763
1995	5	120	-0.59	0.77	-0.1833	4.1491	0.9704
1995	6	120	-0.42	0.87	-0.4600	4.2188	0.9618
1995	7	114	-0.20	0.73	0.1903	3.5941	0.7551
1995	8	124	-0.03	0.74	-0.3035	3.9620	0.7405
Season		1803	-0.33	0.80	0.1063	5.2432	0.8691

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 6. continued.

AST - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6	4	-0.25	0.50	-0.7500	1.3125	0.5000
1994	7	11	0.00	0.45	0.0000	4.5455	0.4264
1994	8		data missing				
1994	9	3	-0.33	0.58	-0.3849	0.6667	0.5774
1994	10	6	0.17	0.41	1.3608	2.9167	0.4082
1994	11	12	-0.58	0.67	-0.5616	2.0327	0.8660
1994	12	19	-0.37	0.76	1.3702	5.1918	0.8272
1995	1	12	-0.42	0.51	-0.2967	0.9363	0.6455
1995	2	14	-0.50	0.65	0.7787	2.3445	0.8018
1995	3	12	-0.33	0.98	0.6206	3.3874	1.0000
1995	4		data missing				
1995	5	3	0.00	1.00	0.0000	0.6667	0.8165
1995	6	3	0.00	0.00	0.0000	0.0000	0.0000
1995	7	6	-0.50	0.55	0.0000	0.6944	0.7071
1995	8	11	-0.18	0.40	-1.4301	3.0762	0.4264
Season		118	-0.31	0.65	0.4048	4.5238	0.7241

AST - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	119	0.61	0.77	-1.0606	6.5143	0.9788
1994	7	124	0.21	0.62	0.4703	3.6091	0.6476
1994	8	124	0.48	0.68	0.4415	3.6758	0.8328
1994	9	120	0.55	0.91	-0.3492	4.0336	1.0567
1994	10	124	-0.06	0.87	1.7298	11.1735	0.8707
1994	11	120	-0.08	0.60	0.0328	4.2104	0.6055
1994	12	120	-0.16	0.73	0.5045	4.1619	0.7472
1995	1	124	0.03	0.61	-0.0157	5.4373	0.6091
1995	2	112	-0.11	1.09	-4.6660	39.6490	1.0938
1995	3	117	0.18	0.81	1.0443	7.2041	0.8217
1995	4	120	0.18	0.83	0.6149	5.9439	0.8466
1995	5	120	-0.03	0.69	0.8184	6.3460	0.6831
1995	6	119	-0.08	0.97	4.7789	41.6366	0.9658
1995	7	114	0.25	0.80	1.9620	12.2909	0.8377
1995	8	123	0.02	0.58	-0.2509	5.5945	0.5774
Season		1801	0.13	0.81	0.1893	18.3331	0.8250

AST - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6	119	-1.04	0.99	0.0318	3.5720	1.4378
1994	7	124	-0.47	0.91	-0.5838	3.7059	1.0160
1994	8	124	-0.56	0.84	-0.2083	3.0938	1.0080
1994	9	120	-0.68	0.99	-0.6254	3.9091	1.1937
1994	10	124	-0.20	0.87	-1.1977	9.2306	0.8935
1994	11	120	-0.46	0.83	-0.7456	5.1005	0.9443
1994	12	120	-0.13	0.89	0.4024	6.5359	0.8944
1995	1	124	-0.38	0.94	1.2719	10.4627	1.0120
1995	2	112	-0.33	1.20	2.9665	22.5201	1.2356
1995	3	117	-0.68	1.23	-1.3297	11.5504	1.4021
1995	4	120	-0.61	1.20	-0.3197	5.1909	1.3447
1995	5	120	-0.56	0.93	-0.6628	4.3031	1.0840
1995	6	118	-0.26	0.96	-0.0856	4.0123	0.9958
1995	7	114	-0.45	1.05	-1.5999	8.5508	1.1355
1995	8	123	-0.05	0.81	-0.1897	3.5133	0.8065
Season		1800	-0.46	1.01	-0.1898	9.0256	1.1065

AST - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6	119	2.89	2.67	-0.4395	3.5927	3.9253
1994	7	124	1.40	2.65	0.4934	3.4780	2.9876
1994	8	124	1.64	2.44	-0.0666	2.6865	2.9303
1994	9	119	1.85	2.67	0.0751	3.1528	3.2369
1994	10	123	0.39	2.26	-0.2571	3.3206	2.2875
1994	11	120	1.43	2.59	0.1938	3.1648	2.9494
1994	12	120	0.39	2.58	-0.0544	3.1903	2.5961
1995	1	123	1.17	2.11	0.2655	2.9569	2.4042
1995	2	111	1.18	2.68	-0.3084	3.6722	2.9126
1995	3	115	1.83	2.52	0.2441	3.1308	3.1057
1995	4	115	1.53	2.87	0.1626	2.7879	3.2446
1995	5	120	1.51	2.63	0.2518	3.4231	3.0221
1995	6	118	0.56	2.64	-0.3504	3.7939	2.6903
1995	7	114	1.15	2.64	0.6357	3.3279	2.8645
1995	8	123	0.05	2.29	-0.1409	3.6940	2.2822
Season		1789	1.26	2.63	0.0989	3.3682	2.9194

BRO - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	117	-0.67	1.04	-0.7802	4.6894	1.2334
1994	7	124	-0.19	0.76	-1.3081	7.2920	0.7829
1994	8	123	-0.31	0.80	-1.5799	11.4729	0.8554
1994	9	117	-0.69	1.01	-1.4754	5.9033	1.2230
1994	10	124	-0.32	0.73	-0.1852	4.1635	0.7931
1994	11	119	-0.50	0.78	-0.6774	5.8140	0.9258
1994	12	124	-0.47	0.81	-0.3302	5.6537	0.9333
1995	1	124	-0.64	0.73	-0.2820	3.8247	0.9630
1995	2	111	-0.77	0.88	-0.4474	4.2975	1.1702
1995	3	124	-0.65	0.71	-0.4669	4.5325	0.9630
1995	4	118	-0.75	0.91	-1.5245	11.7503	1.1753
1995	5	102	-0.36	0.69	0.5957	4.3374	0.7733
1995	6		data missing				
1995	7		data missing				
1995	8		data missing				
Season		1428	-0.53	0.84	-0.9124	6.7733	0.9947

BRO - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6	6	0.00	0.63	0.0000	2.0833	0.5774
1994	7	12	0.17	0.58	0.0481	2.4792	0.5774
1994	8	7	-0.71	1.89	-1.6198	3.7959	1.8898
1994	9		data missing				
1994	10	11	-0.27	0.47	-0.8847	1.6873	0.5222
1994	11	12	-0.42	0.51	-0.2967	0.9363	0.6455
1994	12	11	-0.73	0.47	0.8847	1.6873	0.8528
1995	1	16	-0.62	0.72	-0.5995	1.9874	0.9354
1995	2	20	-0.60	0.88	-0.8029	3.7036	1.0488
1995	3	21	-0.57	0.51	0.2683	0.9826	0.7559
1995	4	25	-0.56	0.51	0.2274	0.9755	0.7483
1995	5	23	-0.30	0.47	-0.7956	1.5766	0.5517
1995	6		data missing				
1995	7		data missing				
1995	8		data missing				
Season		165	-0.45	0.71	-1.8285	12.2837	0.8456

BRO - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	117	-0.33	0.85	-0.0647	4.6508	0.9105
1994	7	121	-0.31	0.62	-0.7610	5.0093	0.6863
1994	8	111	-0.45	0.75	1.1907	6.4632	0.8699
1994	9	110	-0.68	1.12	-0.7985	4.0896	1.3038
1994	10	124	1.07	0.84	0.2763	3.4433	1.3590
1994	11	118	0.80	0.90	0.6825	4.0545	1.2003
1994	12	124	0.26	0.65	1.4723	10.3613	0.6956
1995	1	123	0.42	0.75	0.5555	9.7575	0.8554
1995	2	111	-0.41	0.88	-2.9640	18.0815	0.9633
1995	3	124	-0.30	0.85	3.0809	26.5367	0.8935
1995	4	117	-0.23	0.76	-0.6525	9.5079	0.7899
1995	5	101	0.83	0.97	0.0110	1.8502	1.2743
1995	6		data missing				
1995	7		data missing				
1995	8		data missing				
Season		1402	0.06	1.00	0.1081	6.3239	1.0042

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 6. continued.

BRO - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6	118	-0.25	1.48	2.1995	22.2818	1.4929
1994	7	121	0.12	0.89	-0.1534	3.0246	0.8907
1994	8	110	0.15	1.06	-0.6585	4.8314	1.0617
1994	9	111	-0.02	1.43	-0.4710	5.7561	1.4206
1994	10	124	-1.40	1.05	-0.7978	3.8188	1.7437
1994	11	118	-1.31	1.19	-0.5031	2.8037	1.7684
1994	12	124	-0.73	0.98	-0.4610	4.4802	1.2181
1995	1	123	-1.07	0.97	-0.7189	5.4071	1.4399
1995	2	111	-0.47	1.20	-3.0827	24.5171	1.2805
1995	3	124	-0.35	1.02	-1.1630	7.7777	1.0776
1995	4	117	-0.48	1.09	0.3843	8.7006	1.1839
1995	5	101	-1.20	1.22	0.0150	2.4359	1.7032
1995	6		data missing				
1995	7		data missing				
1995	8		data missing				
Season		1403	-0.59	1.25	-0.1290	9.0698	1.3811

BRO - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6	116	0.58	2.50	0.1920	3.4601	2.5532
1994	7	121	-0.39	2.05	0.0659	3.6064	2.0779
1994	8	109	-0.65	2.55	0.3611	4.4670	2.6173
1994	9	109	-0.33	2.99	0.0287	3.1575	2.9914
1994	10	123	3.58	2.46	0.2639	2.4371	4.3360
1994	11	115	3.21	2.72	0.1457	2.8100	4.2046
1994	12	124	2.02	2.53	0.0811	2.9655	3.2352
1995	1	122	2.78	2.33	0.2572	2.9010	3.6168
1995	2	109	0.90	2.08	-0.0493	2.9923	2.2583
1995	3	123	0.69	2.19	-0.0485	3.2239	2.2873
1995	4	117	1.02	2.48	-0.9896	5.7281	2.6755
1995	5	101	3.09	3.11	0.1277	2.4205	4.3701
1995	6		data missing				
1995	7		data missing				
1995	8		data missing				
Season		1390	1.39	2.88	0.1182	3.3397	3.1970

BTR - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	113	-1.58	1.05	-0.5815	2.9928	1.8908
1994	7	123	-1.54	1.00	-0.6539	4.1102	1.8391
1994	8	124	-1.51	0.97	-0.3521	2.8828	1.7893
1994	9	120	-1.30	1.07	-0.0487	3.1991	1.6783
1994	10	123	-1.14	1.10	-0.3448	6.5407	1.5824
1994	11	119	-1.28	1.15	0.2834	4.1871	1.7150
1994	12	123	-1.14	1.00	-0.1115	3.5334	1.5142
1995	1	123	-0.93	0.88	-0.2700	3.6755	1.2783
1995	2	112	-1.04	1.42	1.9555	16.9027	1.7602
1995	3	122	-1.00	0.84	-0.0821	3.5373	1.3057
1995	4	119	-1.62	0.99	-0.1812	2.8429	1.8987
1995	5	124	-1.63	0.94	0.3719	5.9289	1.8794
1995	6	115	-2.11	1.13	-0.3948	3.4481	2.3938
1995	7	115	-1.72	1.35	-0.0403	4.2047	2.1829
1995	8		data missing				
Season		1676	-1.39	1.11	0.0946	6.9645	1.7825

BTR - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6	5	-1.60	0.89	-0.6037	1.3300	1.7889
1994	7		data missing				
1994	8		data missing				
1994	9		data missing				
1994	10		data missing				
1994	11		data missing				
1994	12		data missing				
1995	1	6	-1.33	0.52	-0.5379	1.0417	1.4142
1995	2		data missing				
1995	3	7	-0.71	0.49	0.7528	1.3959	0.8452
1995	4	4	-1.00	0.00	0.0000	0.0000	1.0000
1995	5		data missing				
1995	6		data missing				
1995	7	3	-0.67	0.58	0.3849	0.6667	0.8165
1995	8		data missing				
Season		34	-1.06	0.60	-0.8026	5.0737	1.2341

BTR - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	114	0.26	1.50	1.1272	3.9131	1.5160
1994	7	124	0.02	1.52	0.9524	4.2196	1.5134
1994	8	124	-1.28	1.16	0.3402	3.6039	1.7251
1994	9	120	0.40	2.17	0.4772	3.3025	2.2023
1994	10	124	0.65	1.52	2.4669	14.1826	1.6486
1994	11	119	1.34	1.49	0.9239	5.7821	1.9937
1994	12	123	1.01	1.50	1.2250	6.6711	1.7988
1995	1	122	0.36	2.26	-1.3378	8.1789	2.2796
1995	2	102	0.81	2.43	-0.9993	7.7114	2.5534
1995	3	121	1.40	1.59	0.8232	3.9065	2.1145
1995	4	120	0.87	1.84	1.0021	4.5203	2.0290
1995	5	124	-0.21	1.59	0.5478	2.7559	1.5964
1995	6	114	0.30	2.20	-0.0224	2.4843	2.2124
1995	7	115	-0.17	2.31	0.4470	3.0559	2.3012
1995	8		data missing				
Season		1669	0.40	1.94	0.1844	5.3598	1.9770

BTR - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6	113	-1.84	2.14	-0.9581	3.5407	2.8159
1994	7	124	-1.64	2.10	-1.1589	4.4534	2.6564
1994	8	124	-0.23	1.60	-0.7130	2.9245	1.6064
1994	9	120	-1.70	2.50	-0.7349	3.0590	3.0166
1994	10	121	-1.61	1.61	-0.8378	3.7376	2.2764
1994	11	120	-2.59	1.89	-1.2203	5.0095	3.2003
1994	12	123	-2.05	1.72	-1.0813	3.8003	2.6687
1995	1	123	-1.22	2.46	1.1641	7.1603	2.7379
1995	2	103	-1.69	2.87	1.1862	7.6057	3.3210
1995	3	122	-2.39	1.73	-0.7557	3.1799	2.9407
1995	4	119	-2.50	2.13	-0.9282	3.5442	3.2733
1995	5	124	-1.42	1.93	-0.3488	3.3925	2.3861
1995	6	115	-2.39	2.63	-0.4607	2.0892	3.5447
1995	7	115	-1.56	2.39	-0.5835	3.5199	2.8422
1995	8		data missing				
Season		1667	-1.77	2.22	-0.2837	5.0740	2.8336

BTR - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6	101	3.17	3.59	0.1969	2.0767	4.7773
1994	7	113	2.73	3.44	-0.2457	2.6420	4.3797
1994	8	124	-0.03	3.81	0.3160	2.5551	3.7977
1994	9	108	2.44	4.36	-0.5108	2.9582	4.9781
1994	10	113	3.60	3.08	-0.1875	2.2885	4.7348
1994	11	99	5.63	2.77	-0.5932	2.5156	6.2699
1994	12	109	4.54	2.79	-0.1323	1.9862	5.3236
1995	1	109	3.25	3.68	-0.7538	3.7755	4.8973
1995	2	96	4.23	3.20	-0.8377	4.8380	5.2927
1995	3	106	5.24	3.05	-0.1330	1.8278	6.0548
1995	4	103	4.69	2.89	-0.1970	2.1805	5.4975
1995	5	115	2.81	3.74	0.0140	2.2541	4.6684
1995	6	97	3.67	4.35	-0.0693	1.7530	5.6756
1995	7	98	2.23	4.14	-0.2710	2.5784	4.6813
1995	8		data missing				
Season		1492	3.38	3.80	-0.4005	2.7979	5.0821

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 6. continued.

COS - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	118	-0.85	1.22	-0.4313	4.3738	1.4787
1994	7	124	-0.98	0.95	-0.4217	3.3357	1.3678
1994	8	123	-0.79	1.07	-0.1859	5.2224	1.3282
1994	9	120	-1.02	1.21	0.0193	4.1449	1.5838
1994	10	124	-0.76	1.21	0.0772	5.5111	1.4256
1994	11	120	-0.65	1.38	-0.0688	7.3083	1.5221
1994	12	123	-0.50	1.15	-0.1801	2.9656	1.2559
1995	1	124	-0.76	1.19	-1.4697	6.2287	1.4085
1995	2	112	-0.68	1.34	0.4011	6.7870	1.5000
1995	3	124	-0.40	1.37	-0.3036	5.7417	1.4256
1995	4	117	-0.70	1.17	1.7847	12.6110	1.3587
1995	5	124	-0.56	1.07	-0.3096	6.6989	1.2015
1995	6	118	-0.74	1.21	-1.0844	4.9952	1.4112
1995	7	119	-0.76	1.16	-0.4786	4.2889	1.3781
1995	8	124	-0.70	1.13	0.4339	5.4090	1.3290
Season		1815	-0.72	1.20	-0.1127	6.0753	1.3999

COS - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6	13	-0.15	0.69	0.1588	1.9142	0.6794
1994	7	10	-0.40	1.17	-0.0297	1.3208	1.1832
1994	8	7	-0.29	0.76	0.3645	1.5459	0.7559
1994	9	10	-0.60	0.70	1.1936	2.9254	0.8944
1994	10	9	0.22	0.67	-0.1759	1.8796	0.6667
1994	11	13	-0.46	0.88	0.2348	2.0038	0.9608
1994	12	4	0.00	1.15	0.0000	0.5625	1.0000
1995	1	15	-0.13	0.64	-1.4426	5.7079	0.6325
1995	2	10	0.10	0.74	1.3741	4.8907	0.7071
1995	3	12	0.75	1.29	1.3600	3.6022	1.4434
1995	4	15	-0.47	0.52	-0.1205	0.8867	0.6831
1995	5	23	-0.30	0.63	0.2967	2.1399	0.6916
1995	6	8	-0.12	0.64	0.0445	2.0566	0.6124
1995	7	6	-0.83	1.33	-0.2445	1.8060	1.4720
1995	8	7	-0.14	0.38	-1.6198	3.7959	0.3780
Season		162	-0.19	0.85	0.6704	6.3583	0.8763

COS - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	118	0.96	1.25	0.3656	3.3864	1.5704
1994	7	124	1.63	1.77	1.7636	7.3665	2.3996
1994	8	123	0.84	1.18	0.4340	4.5284	1.4399
1994	9	120	1.27	1.93	1.4536	6.1988	2.3058
1994	10	120	0.04	1.49	-2.0667	14.5998	1.4804
1994	11	119	-0.26	1.36	0.4928	5.9562	1.3811
1994	12	123	0.41	1.02	0.3648	4.0973	1.0969
1995	1	124	0.11	0.81	-0.5708	5.3715	0.8132
1995	2	111	0.16	1.12	-1.0178	6.1505	1.1231
1995	3	123	-0.01	1.54	-1.3914	8.5089	1.5328
1995	4	117	-0.03	1.26	0.5657	7.5194	1.2506
1995	5	123	0.15	1.04	0.2761	6.1346	1.0438
1995	6	118	0.50	1.30	0.6723	6.8386	1.3870
1995	7	119	0.66	1.45	0.9873	6.5889	1.5904
1995	8	124	1.03	1.14	0.7212	5.9475	1.5345
Season		1807	0.50	1.44	0.6176	9.1099	1.5218

COS - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6	118	-1.81	1.99	-0.4812	5.1157	2.6792
1994	7	123	-2.54	2.09	-1.1478	4.5363	3.2846
1994	8	124	-1.56	2.00	0.1306	5.9290	2.5305
1994	9	119	-2.22	2.44	-0.5709	3.8924	3.2899
1994	10	120	-0.74	2.08	1.0125	6.9101	2.2004
1994	11	119	-0.34	1.99	0.1756	4.5099	2.0105
1994	12	123	-0.91	1.45	0.0362	2.7951	1.7108
1995	1	124	-0.87	1.40	-0.8242	4.8636	1.6461
1995	2	111	-0.85	1.70	0.1389	5.6846	1.8888
1995	3	123	-0.39	2.21	0.3274	4.5744	2.2306
1995	4	117	-0.68	1.72	1.3462	10.7332	1.8421
1995	5	123	-0.70	1.62	-0.1571	6.3691	1.7623
1995	6	117	-1.15	1.82	-0.1296	4.6969	2.1503
1995	7	119	-1.42	2.09	-0.7051	5.2381	2.5222
1995	8	123	-1.75	1.78	-0.2757	3.4743	2.4906
Season		1804	-1.20	2.01	-0.2171	5.8232	2.3383

COS - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6	118	2.06	2.41	-0.4888	5.3171	3.1574
1994	7	120	3.17	2.35	0.2269	3.5105	3.9432
1994	8	121	2.44	2.25	-0.1617	4.0774	3.3131
1994	9	117	2.49	2.61	-0.5706	4.4024	3.5970
1994	10	116	1.36	3.04	-0.5433	4.9246	3.3199
1994	11	113	0.25	3.49	-0.5057	4.0399	3.4790
1994	12	121	1.28	2.79	-0.5667	3.7780	3.0576
1995	1	123	1.28	2.41	0.1297	6.6814	2.7236
1995	2	109	1.26	2.77	0.0942	4.0386	3.0265
1995	3	112	0.32	2.96	-0.6123	3.3509	2.9591
1995	4	111	1.10	2.75	-0.4186	3.8535	2.9527
1995	5	122	1.15	2.81	-0.3603	3.4724	3.0288
1995	6	117	1.94	2.97	-0.0025	2.4999	3.5349
1995	7	117	2.02	2.83	-0.5334	4.5458	3.4661
1995	8	121	2.54	2.69	-0.8029	6.4953	3.6897
Season		1759	1.66	2.85	-0.4649	4.4376	3.3001

DDC - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	119	-0.72	1.12	-1.3454	6.8149	1.3284
1994	7	124	-0.23	1.06	0.3725	3.2889	1.0776
1994	8	124	-0.13	1.14	-0.2710	5.7250	1.1430
1994	9	121	-0.40	1.36	2.7737	20.9360	1.4113
1994	10	124	-0.44	1.07	-0.9573	5.3372	1.1535
1994	11	120	-0.62	1.18	-1.4321	7.2240	1.3292
1994	12	123	-0.82	1.19	-2.0327	8.5521	1.4455
1995	1	124	-0.78	1.51	-1.2895	7.3250	1.6920
1995	2	112	-0.54	1.00	-0.7503	4.7478	1.1339
1995	3	124	-0.35	0.77	-0.1947	4.3707	0.8376
1995	4	118	-1.05	1.12	-0.0445	7.2762	1.5349
1995	5	120	-1.18	0.82	0.2341	3.9573	1.4289
1995	6	117	-0.76	1.00	1.1697	5.3999	1.2506
1995	7	124	-1.23	1.30	-0.2863	3.4167	1.7825
1995	8	124	-1.12	0.78	-1.1052	6.7919	1.3649
Season		1819	-0.69	1.16	-0.3036	8.5856	1.3485

DDC - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6	30	-0.83	0.46	0.6043	3.5118	0.9487
1994	7	32	-0.50	0.51	0.0000	0.9385	0.7071
1994	8	29	-0.21	0.56	-0.0605	2.6231	0.5872
1994	9	25	-0.48	0.59	-0.6700	2.3116	0.7483
1994	10	30	-0.10	0.71	0.6872	3.7740	0.7071
1994	11	33	-0.12	0.60	0.0345	2.5969	0.6030
1994	12	23	-0.65	0.78	-1.1913	4.3149	1.0000
1995	1	27	-0.44	1.05	1.6825	5.7421	1.1222
1995	2	30	-0.37	1.19	-0.9620	4.6159	1.2247
1995	3	38	-0.34	0.81	-0.5004	5.5681	0.8736
1995	4	33	-0.85	0.62	-0.0870	2.4240	1.0445
1995	5	31	-0.94	0.51	0.1124	3.6000	1.0626
1995	6	26	-0.96	0.60	-0.0064	2.6717	1.1266
1995	7	18	-0.39	1.04	0.4676	2.6240	1.0801
1995	8	26	-0.69	0.47	0.7857	1.5666	0.8321
Season		431	-0.52	0.76	0.1906	5.5664	0.9257

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 6. continued.

DDC - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	119	-0.61	0.86	-0.1193	5.8101	1.0572
1994	7	124	-1.06	0.80	0.0053	3.1905	1.3229
1994	8	124	-0.81	0.84	-0.5339	4.7145	1.1640
1994	9	121	-0.74	1.12	-3.7048	25.9928	1.3423
1994	10	123	-0.25	0.79	0.8708	9.9769	0.8215
1994	11	120	-0.13	1.16	1.6068	10.9388	1.1619
1994	12	123	-0.50	1.09	0.1424	6.4053	1.1962
1995	1	124	-0.40	0.90	-0.9825	5.8217	0.9837
1995	2	112	0.09	0.84	0.6341	4.6575	0.8452
1995	3	124	0.48	1.32	1.9992	9.6058	1.3970
1995	4	115	0.18	1.23	2.9140	25.6057	1.2336
1995	5	120	0.32	0.70	1.5472	8.4978	0.7638
1995	6	117	1.03	1.18	1.8325	12.2408	1.5662
1995	7	124	0.98	1.47	0.5619	5.8780	1.7575
1995	8	124	0.88	1.34	2.4463	13.7500	1.5989
Season		1815	-0.04	1.25	0.9879	10.9064	1.2491

DDC - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6	119	-0.11	1.54	-1.4775	8.0906	1.5367
1994	7	124	0.83	1.36	0.0743	4.3950	1.5888
1994	8	124	0.68	1.57	0.7494	6.4402	1.7039
1994	9	119	0.14	1.27	0.5690	4.7754	1.2735
1994	10	123	-0.19	1.26	-1.4666	7.2233	1.2656
1994	11	120	-0.48	1.71	-1.3092	5.9479	1.7654
1994	12	124	-0.28	1.45	-1.1837	7.9765	1.4729
1995	1	124	-0.38	1.38	-1.3385	7.6639	1.4284
1995	2	112	-0.62	1.30	-0.7588	4.0619	1.4392
1995	3	124	-0.83	1.53	-1.5966	7.2805	1.7390
1995	4	115	-1.27	1.43	-1.4216	9.6905	1.9065
1995	5	120	-1.49	1.17	-0.2825	3.6169	1.8952
1995	6	118	-1.75	1.76	-0.0087	5.7537	2.4787
1995	7	123	-2.13	2.21	-0.4889	4.5802	3.0657
1995	8	123	-1.93	1.50	-0.7601	4.6280	2.4378
Season		1813	-0.65	1.75	-0.6745	5.6122	1.8655

DDC - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6	117	0.27	2.51	1.1536	5.1227	2.5118
1994	7	123	-1.53	2.44	0.0304	4.8728	2.8769
1994	8	122	-1.15	2.65	0.1444	4.0155	2.8802
1994	9	119	-0.35	2.44	0.1519	3.4687	2.4529
1994	10	121	0.17	2.41	0.4113	3.3448	2.4097
1994	11	114	0.26	2.88	-0.0736	4.1523	2.8792
1994	12	118	0.20	2.88	0.0256	3.5225	2.8721
1995	1	121	0.57	3.17	-0.3753	2.9826	3.2052
1995	2	111	1.16	2.71	0.2073	3.1034	2.9404
1995	3	124	1.67	2.94	0.3626	3.0858	3.3687
1995	4	113	2.76	2.74	-0.1659	3.2838	3.8836
1995	5	118	3.74	2.79	-0.4497	4.0491	4.6589
1995	6	110	3.91	3.18	-0.7975	3.7003	5.0334
1995	7	117	3.93	3.35	-0.3084	2.6015	5.1504
1995	8	119	3.25	2.30	0.0580	2.3924	3.9770
Season		1768	1.23	3.29	0.1232	2.9383	3.5079

GLD - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	119	-1.37	1.56	1.9201	18.4806	2.0682
1994	7	124	-1.51	1.02	-0.0010	3.7888	1.8206
1994	8	124	-0.88	1.02	0.3116	4.1797	1.3410
1994	9	120	-1.04	1.02	-0.4424	3.0402	1.4520
1994	10	124	-1.25	1.75	0.7088	9.5988	2.1421
1994	11	119	-1.20	1.29	-1.1429	4.7702	1.7609
1994	12	124	-1.23	1.64	-1.0543	4.5221	2.0498
1995	1	124	-1.03	1.48	-1.6312	6.7171	1.7961
1995	2	112	-0.75	1.39	-2.2556	12.6083	1.5755
1995	3	125	-0.64	1.29	-0.7539	9.5011	1.4311
1995	4	120	-0.27	1.11	0.1344	5.5145	1.1402
1995	5	124	-0.32	0.91	-1.0823	5.7838	0.9588
1995	6	120	-0.04	1.22	-0.8049	4.4477	1.2145
1995	7	118	-0.69	1.34	0.0925	3.8417	1.5042
1995	8	121	-1.54	1.56	-1.0480	6.6798	2.1856
Season		1819	-0.92	1.40	-0.5038	7.9685	1.6715

GLD - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6	27	-1.04	1.06	-2.0092	8.0978	1.4657
1994	7	19	-1.79	1.13	-0.3896	2.3817	2.1026
1994	8	22	-0.68	0.78	0.0095	2.3210	1.0225
1994	9	22	-0.73	0.88	-0.9142	2.8199	1.1282
1994	10	23	-0.87	0.92	0.7639	5.7101	1.2511
1994	11	28	-1.00	1.15	-2.6445	13.0179	1.5119
1994	12	19	-0.89	1.20	-1.2941	3.5392	1.4690
1995	1	35	-0.83	1.22	-1.4381	5.6233	1.4639
1995	2	24	-0.25	0.90	-0.5632	2.5258	0.9129
1995	3	41	-0.61	1.45	-2.2257	10.2142	1.5539
1995	4	34	-0.15	0.82	0.5801	4.0399	0.8225
1995	5	30	-0.23	0.68	-0.9866	4.0637	0.7071
1995	6	24	0.12	0.61	1.0376	5.1337	0.6124
1995	7	26	-0.12	1.42	0.6744	4.0313	1.4005
1995	8	32	-1.00	2.02	-2.1280	9.4770	2.2220
Season		406	-0.65	1.23	-1.6988	11.7677	1.3911

GLD - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	119	-0.21	1.81	-0.4762	9.7643	1.8173
1994	7	124	-0.35	1.04	0.6782	5.2007	1.0888
1994	8	124	-0.31	0.78	0.3980	5.2174	0.8376
1994	9	118	-0.62	0.90	-1.1669	8.1876	1.0853
1994	10	124	-0.13	1.15	-1.4790	13.9804	1.1500
1994	11	120	-0.24	1.22	-0.3415	9.2876	1.2349
1994	12	124	-0.32	1.06	0.0991	5.3656	1.1072
1995	1	124	-0.21	1.16	0.7226	4.5541	1.1709
1995	2	112	0.54	1.65	2.1296	11.7459	1.7269
1995	3	124	0.79	1.94	0.5706	4.3368	2.0907
1995	4	117	0.44	1.56	1.2487	5.3622	1.6093
1995	5	124	0.01	1.32	1.6395	8.6679	1.3168
1995	6	120	0.37	1.58	-1.0700	13.0946	1.6125
1995	7	117	0.10	1.93	1.4502	6.8537	1.9260
1995	8	122	0.02	1.38	1.0383	3.7927	1.3760
Season		1814	-0.01	1.45	0.8548	9.6736	1.4489

GLD - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6	119	-1.16	2.21	-0.3138	5.7964	2.4869
1994	7	124	-1.16	1.61	-0.1192	4.5884	1.9838
1994	8	124	-0.56	1.21	0.0815	5.5691	1.3320
1994	9	118	-0.42	1.22	-0.1480	3.3053	1.2822
1994	10	124	-1.12	2.21	1.2456	10.2996	2.4675
1994	11	120	-1.04	1.54	-0.7089	4.7812	1.8552
1994	12	124	-0.91	1.91	-1.5428	6.2780	2.1118
1995	1	124	-0.82	1.73	-1.3468	6.3680	1.9092
1995	2	112	-1.29	2.11	-1.4915	6.1346	2.4604
1995	3	124	-1.43	2.23	-0.7377	3.3535	2.6412
1995	4	117	-0.74	1.73	-1.1646	4.9145	1.8765
1995	5	124	-0.33	1.41	-1.5264	6.8159	1.4396
1995	6	120	-0.41	1.84	0.3648	8.8637	1.8775
1995	7	116	-0.66	2.30	-1.0312	4.6224	2.3799
1995	8	122	-1.52	2.58	-0.6780	3.6237	2.9891
Season		1813	-0.91	1.92	-0.7591	6.5526	2.1260

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 6. continued.

GLD - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6	112	1.81	2.66	0.3030	3.3949	3.2021
1994	7	123	2.06	3.04	0.0330	3.2873	3.6566
1994	8	124	1.04	2.43	-0.4582	5.2710	2.6326
1994	9	118	0.66	2.22	0.4042	3.7041	2.3057
1994	10	116	2.25	2.93	-0.1933	3.8832	3.6857
1994	11	111	1.94	2.76	-0.0178	3.8202	3.3585
1994	12	113	1.56	3.44	0.4232	2.6635	3.7591
1995	1	120	1.46	3.46	0.0307	2.7573	3.7456
1995	2	110	2.01	3.66	-0.0194	2.3231	4.1561
1995	3	119	2.08	3.95	-0.2276	2.8093	4.4533
1995	4	116	1.06	3.31	-0.3048	2.6944	3.4565
1995	5	123	0.37	3.19	0.2479	2.3899	3.2022
1995	6	116	0.63	3.06	0.4419	3.4856	3.1150
1995	7	116	0.52	3.64	0.0376	2.8283	3.6665
1995	8	118	1.47	3.30	-0.3283	3.4250	3.5989
Season		1756	1.39	3.21	0.0298	3.1913	3.5000

GRI - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	118	-1.01	0.92	-1.3555	7.7984	1.3623
1994	7	123	-0.92	0.83	0.0237	4.7591	1.2330
1994	8	124	-1.02	0.88	-0.4533	3.0190	1.3470
1994	9	120	-0.82	0.92	0.0972	4.6420	1.2349
1994	10	124	-0.33	1.06	-0.3426	6.5425	1.1035
1994	11	119	-0.74	1.10	0.8019	8.2238	1.3221
1994	12	124	-1.34	1.11	1.0416	6.7995	1.7367
1995	1	124	-1.51	1.19	-1.1787	7.4573	1.9198
1995	2	112	-1.80	1.35	-1.0448	7.6510	2.2520
1995	3	124	-1.17	1.22	-1.8295	15.7767	1.6872
1995	4	116	-0.57	1.01	-0.6757	6.5402	1.1522
1995	5	124	-0.63	0.91	-0.3977	8.2238	1.0999
1995	6	117	-0.48	0.95	0.7114	6.4734	1.0622
1995	7	114	-0.59	1.17	0.2269	4.6389	1.3011
1995	8	122	-0.61	0.89	0.4526	5.3137	1.0751
Season		1806	-0.90	1.11	-0.5204	8.0865	1.4306

GRI - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6	20	-0.90	0.31	2.4692	7.3203	0.9487
1994	7	13	-0.54	0.52	0.1368	0.8724	0.7338
1994	8	12	-0.42	0.67	0.5616	2.0327	0.7638
1994	9	20	-0.60	0.68	0.3426	2.7000	0.8944
1994	10	19	-0.63	1.16	-2.6958	10.4664	1.2978
1994	11	30	-0.57	0.82	-0.5264	2.1720	0.9832
1994	12	18	-1.44	0.70	0.7680	2.2275	1.5986
1995	1	14	-1.50	0.65	-0.7787	2.3445	1.6257
1995	2	20	-1.65	0.75	0.8538	3.0901	1.8028
1995	3	33	-1.00	1.00	1.6364	8.6061	1.4035
1995	4	25	-0.60	0.76	-1.2928	4.5798	0.9592
1995	5	24	-0.54	0.51	0.1569	0.9441	0.7360
1995	6	23	-0.39	0.50	-0.4167	1.0965	0.6255
1995	7	12	-0.33	0.49	-0.6206	1.2604	0.5774
1995	8	26	-0.46	0.51	-0.1455	0.9466	0.6794
Season		309	-0.77	0.81	-0.4815	5.9805	1.1154

GRI - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	117	-1.14	1.01	1.5251	14.7380	1.5163
1994	7	123	-0.61	1.20	3.9826	34.3589	1.3404
1994	8	124	-0.31	0.83	-0.0693	4.0018	0.8799
1994	9	120	-0.57	1.28	2.7690	13.2185	1.3994
1994	10	123	-1.01	0.93	0.0770	3.9212	1.3674
1994	11	118	-1.43	1.01	-0.1094	4.4653	1.7491
1994	12	123	-1.43	1.30	0.9376	6.2514	1.9297
1995	1	124	-1.10	1.19	0.4272	4.6959	1.6239
1995	2	111	-1.86	1.40	0.0935	4.2227	2.3308
1995	3	124	-1.15	1.33	-0.1680	3.0569	1.7506
1995	4	117	-0.91	0.93	0.1358	3.3940	1.2943
1995	5	123	-1.37	1.06	-1.1920	9.2623	1.7321
1995	6	117	-2.27	1.14	-0.4564	4.6679	2.5420
1995	7	113	-1.40	2.11	1.1907	7.9642	2.5207
1995	8	125	-1.84	1.27	0.8195	5.9733	2.2343
Season		1803	-1.22	1.32	0.6334	9.2511	1.8005

GRI - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6	118	0.16	1.40	-0.8277	8.2401	1.3992
1994	7	124	-0.30	1.31	-3.1870	25.0002	1.3410
1994	8	124	-0.72	1.25	-0.3149	4.1360	1.4340
1994	9	120	-0.25	1.66	-1.9037	8.4429	1.6733
1994	10	123	0.67	1.39	-0.2599	6.4067	1.5434
1994	11	118	0.69	1.17	0.4762	5.9053	1.3592
1994	12	123	0.08	1.14	-0.7467	5.4161	1.1405
1995	1	124	-0.40	1.35	-1.7512	10.0290	1.4028
1995	2	112	0.14	1.70	-0.3203	3.8604	1.6956
1995	3	124	-0.02	1.32	-1.1291	7.8364	1.3168
1995	4	116	0.33	1.46	-0.3900	4.9906	1.4856
1995	5	123	0.74	1.45	0.9693	10.0554	1.6205
1995	6	118	1.79	1.44	0.2679	4.0778	2.2941
1995	7	113	0.81	2.15	-0.5787	8.7558	2.2908
1995	8	122	1.27	1.34	-1.0331	9.1890	1.8399
Season		1803	0.33	1.58	-0.4670	7.8733	1.6154

GRI - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6	116	-0.52	2.30	0.2852	4.1769	2.3530
1994	7	123	0.46	2.45	-0.0858	2.6035	2.4795
1994	8	124	1.55	2.71	-0.4083	4.1074	3.1144
1994	9	116	-0.00	2.52	0.9533	5.0997	2.5094
1994	10	122	-1.88	2.93	-0.2247	3.6576	3.4719
1994	11	117	-1.83	3.05	0.4459	3.4184	3.5463
1994	12	121	-0.68	3.40	0.0258	2.7139	3.4500
1995	1	119	0.63	3.41	0.1224	2.5782	3.4573
1995	2	109	-0.70	3.52	0.1807	2.8149	3.5769
1995	3	122	-0.23	3.23	0.1123	2.8346	3.2230
1995	4	115	-1.23	3.29	0.1346	3.2920	3.4996
1995	5	118	-2.06	2.73	0.5257	4.6346	3.4047
1995	6	115	-4.11	3.01	0.5074	3.2035	5.0847
1995	7	108	-2.04	3.35	0.5562	3.5680	3.9132
1995	8	121	-3.13	2.78	0.7575	5.7454	4.1774
Season		1767	-1.03	3.32	0.1309	3.1111	3.4731

ICT - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	118	-0.86	0.81	-0.8306	4.3846	1.1789
1994	7	122	-1.00	0.90	-0.2024	2.5741	1.3429
1994	8	126	-1.21	0.99	-1.4642	9.4100	1.5660
1994	9	120	-0.88	1.14	2.3452	15.4380	1.4376
1994	10	124	-0.85	1.16	-0.5129	10.6269	1.4340
1994	11	118	-0.65	0.94	1.7395	8.9442	1.1387
1994	12	122	-0.34	0.83	0.5969	5.5948	0.8917
1995	1	124	-0.13	1.16	-2.9928	20.6633	1.1640
1995	2	112	-0.08	0.92	1.1154	6.2724	0.9210
1995	3	124	-0.26	0.71	-0.1376	3.5371	0.7513
1995	4	121	-0.31	0.66	0.2302	4.5696	0.7216
1995	5	120	-0.44	1.03	2.1962	14.8004	1.1143
1995	6	110	-0.15	0.84	0.0126	5.0460	0.8475
1995	7	118	-0.08	0.77	-0.1930	4.7428	0.7702
1995	8	123	-0.18	0.68	0.0727	4.2773	0.6984
Season		1803	-0.50	0.99	-0.1158	9.9772	1.1046

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 6. continued.

ICT - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6	23	-0.48	0.51	-0.0814	0.9219	0.6916
1994	7	23	-0.70	0.76	-1.1077	4.2598	1.0215
1994	8	21	-0.81	0.51	0.3061	2.8987	0.9512
1994	9	18	-0.89	0.58	0.0138	2.6680	1.0541
1994	10	20	-0.90	0.31	2.4692	7.3203	0.9487
1994	11	33	-0.73	0.63	1.2426	4.3843	0.9535
1994	12	14	-0.50	0.65	0.7787	2.3445	0.8018
1995	1	18	0.00	0.34	0.0000	8.0278	0.3333
1995	2	26	0.08	0.93	2.6813	12.2748	0.9199
1995	3	30	-0.17	0.46	-0.6043	3.5118	0.4830
1995	4	23	-0.26	0.45	-1.0189	2.0003	0.5108
1995	5	23	-0.35	0.49	-0.5978	1.2885	0.5898
1995	6	11	0.18	0.60	-0.0206	2.2707	0.6030
1995	7	13	0.23	0.73	0.9029	3.5687	0.7338
1995	8	14	0.00	0.00	0.0000	0.0000	0.0000
Season		310	-0.39	0.67	0.7751	8.6740	0.7790

ICT - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	117	0.20	0.92	3.4751	26.5867	0.9383
1994	7	123	0.50	0.99	0.9276	4.1373	1.1080
1994	8	126	0.81	1.05	0.6706	7.7618	1.3214
1994	9	120	0.35	0.87	2.1163	16.4769	0.9309
1994	10	122	0.55	0.79	-0.0124	4.0022	0.9624
1994	11	113	0.77	1.59	-1.6887	25.8032	1.7624
1994	12	103	1.69	1.57	1.6090	9.7583	2.2982
1995	1	124	0.80	0.91	0.5950	5.0095	1.2082
1995	2	112	0.51	0.71	0.2679	3.5297	0.8712
1995	3	124	0.38	1.00	1.3210	8.2923	1.0663
1995	4	120	0.06	1.33	-2.6119	31.3425	1.3260
1995	5	118	0.03	1.20	-4.7379	41.6748	1.1967
1995	6	111	0.16	0.79	0.7950	5.6772	0.8054
1995	7	117	0.41	1.00	-0.4191	4.9992	1.0781
1995	8	119	0.44	1.52	-2.3470	17.2107	1.5718
Season		1770	0.50	1.17	-0.4384	22.0440	1.2747

ICT - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6	118	-1.08	1.32	-1.9104	12.6145	1.7000
1994	7	122	-1.50	1.49	-0.7216	3.0806	2.1097
1994	8	125	-1.95	1.44	0.5577	6.6200	2.4232
1994	9	120	-1.23	1.37	1.4118	13.3269	1.8394
1994	10	123	-1.30	1.43	0.3145	6.0154	1.9254
1994	11	116	-1.28	2.05	1.5142	10.3038	2.4158
1994	12	105	-1.82	1.96	0.1383	10.0055	2.6637
1995	1	124	-0.93	1.38	-2.1897	12.1632	1.6583
1995	2	112	-0.59	1.09	-0.0647	3.3369	1.2320
1995	3	124	-0.64	1.17	-0.4548	4.5332	1.3290
1995	4	120	-0.36	1.38	1.9004	20.8191	1.4230
1995	5	118	-0.47	1.55	2.2701	15.5832	1.6156
1995	6	110	-0.24	1.31	0.3884	7.6580	1.3280
1995	7	117	-0.49	1.30	-0.1203	4.3896	1.3868
1995	8	118	-0.63	1.84	1.3083	9.8583	1.9398
Season		1773	-0.97	1.57	0.3536	9.9851	1.8468

ICT - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6	116	1.80	1.98	-0.4384	3.3330	2.6700
1994	7	120	2.71	2.57	0.1107	3.3823	3.7290
1994	8	124	3.62	2.20	-1.1646	7.1714	4.2292
1994	9	119	2.61	2.16	0.0226	3.1868	3.3866
1994	10	122	2.88	2.54	-0.3671	3.7268	3.8349
1994	11	109	3.76	3.53	-1.6234	6.5052	5.1458
1994	12	87	4.90	3.16	-0.6507	2.7919	5.8220
1995	1	118	2.13	2.82	-0.0786	3.1580	3.5251
1995	2	112	1.05	2.53	-0.7033	3.7391	2.7262
1995	3	124	1.45	2.62	0.1611	3.2570	2.9807
1995	4	118	0.75	2.33	-0.5700	5.2497	2.4406
1995	5	116	1.39	2.78	-0.5675	3.4641	3.0993
1995	6	109	0.42	2.60	-0.0705	3.6559	2.6204
1995	7	116	0.81	2.43	-0.4473	3.8833	2.5514
1995	8	116	1.19	2.82	-0.2536	4.1571	3.0551
Season		1727	2.06	2.87	-0.2538	3.7219	3.5294

LNK-1 - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	119	-1.19	0.98	-0.5311	2.9748	1.5394
1994	7	124	-1.69	1.16	-0.5323	3.1858	2.0458
1994	8	116	-1.83	1.14	-0.7248	3.6295	2.1496
1994	9	120	-1.87	1.43	-0.7438	4.2853	2.3488
1994	10	123	-1.78	1.82	-1.1221	5.7573	2.5423
1994	11	120	-1.34	1.45	-2.1724	13.1884	1.9685
1994	12	121	-1.57	1.71	-0.2224	7.8263	2.3177
1995	1	124	-1.60	1.46	-0.7916	5.3797	2.1590
1995	2		station moved				
1995	3		no data avail				
1995	4		no data avail				
1995	5		no data avail				
1995	6		no data avail				
1995	7		no data avail				
1995	8		no data avail				
Season		967	-1.61	1.43	-0.9654	7.4014	2.1541

LNK-1 - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6	11	-0.45	0.52	-0.1583	0.8540	0.6742
1994	7	7	-0.71	0.49	0.7528	1.3959	0.8452
1994	8	7	-0.71	0.49	0.7528	1.3959	0.8452
1994	9	14	-0.86	0.36	1.8265	4.4549	0.9258
1994	10	10	-0.90	0.32	2.2768	6.5700	0.9487
1994	11	19	-0.84	0.37	1.7302	4.0575	0.9177
1994	12	5	-1.00	0.00	0.0000	0.0000	1.0000
1995	1	9	-1.11	0.33	-2.0741	5.6296	1.1547
1995	2		station moved				
1995	3		no data avail				
1995	4		no data avail				
1995	5		no data avail				
1995	6		no data avail				
1995	7		no data avail				
1995	8		no data avail				
Season		82	-0.82	0.42	1.1024	3.6070	0.9315

LNK-1 - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	118	-1.37	1.62	-2.7385	12.7879	2.1153
1994	7	123	-0.99	1.66	-1.9426	9.3536	1.9254
1994	8	116	-0.51	0.84	0.2895	3.2310	0.9782
1994	9	120	-0.37	1.14	2.1718	16.4175	1.1902
1994	10	120	-0.37	1.43	-1.6911	14.4078	1.4663
1994	11	120	-0.25	1.42	2.5299	18.0145	1.4376
1994	12	123	-0.84	1.43	0.1963	8.3371	1.6552
1995	1	124	-0.71	1.49	0.0601	5.9887	1.6412
1995	2		station moved				
1995	3		no data avail				
1995	4		no data avail				
1995	5		no data avail				
1995	6		no data avail				
1995	7		no data avail				
1995	8		no data avail				
Season		964	-0.68	1.44	-0.7216	13.0726	1.5919

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 6. continued.

LNK-1 - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6	118	0.18	1.69	1.7459	8.3308	1.6950
1994	7	124	-0.61	2.44	1.2025	6.4300	2.5081
1994	8	116	-1.32	1.36	-0.5848	2.7871	1.8915
1994	9	119	-1.39	1.55	-0.3654	3.0559	2.0783
1994	10	119	-1.40	1.99	-0.4718	6.4347	2.4271
1994	11	120	-1.09	1.58	-1.7367	7.9609	1.9127
1994	12	122	-0.70	1.44	-0.8943	6.3462	1.5966
1995	1	124	-0.89	1.29	-1.2700	6.2912	1.5606
1995	2		station moved				
1995	3		no data avail				
1995	4		no data avail				
1995	5		no data avail				
1995	6		no data avail				
1995	7		no data avail				
1995	8		no data avail				
Season		962	-0.90	1.77	0.2526	8.0027	1.9882

LNK-1 - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6	114	-0.08	3.07	-0.4027	5.0148	3.0569
1994	7	117	1.65	3.95	-0.2830	2.6511	4.2643
1994	8	114	2.70	2.73	0.0581	2.4732	3.8261
1994	9	113	2.42	3.02	-0.3939	3.9405	3.8556
1994	10	105	2.26	2.60	-0.0035	3.1881	3.4346
1994	11	115	2.14	3.10	0.3110	2.5853	3.7583
1994	12	116	1.66	3.34	-0.1948	3.0027	3.7205
1995	1	118	2.11	3.17	-0.1986	3.4950	3.8000
1995	2		station moved				
1995	3		no data avail				
1995	4		no data avail				
1995	5		no data avail				
1995	6		no data avail				
1995	7		no data avail				
1995	8		no data avail				
Season		912	1.85	3.24	-0.2295	3.4775	3.7340

LNK-2 - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6		no data avail				
1994	7		no data avail				
1994	8		no data avail				
1994	9		no data avail				
1994	10		no data avail				
1994	11		no data avail				
1994	12		no data avail				
1995	1		no data avail				
1995	2		station relocated from previous site				
1995	3	123	-1.33	1.00	-1.4190	7.5110	1.6626
1995	4	120	-1.21	0.96	-0.2002	5.2516	1.5411
1995	5	116	-1.37	1.51	-2.4283	12.3281	2.0363
1995	6	119	-1.42	0.95	-0.1977	2.8296	1.7076
1995	7	112	-1.33	1.49	-1.6764	12.6262	1.9933
1995	8	124	-1.39	1.12	-0.2289	5.5412	1.7825
Season		715	-1.34	1.19	-1.5555	12.2263	1.7920

LNK-2 - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6		no data avail				
1994	7		no data avail				
1994	8		no data avail				
1994	9		no data avail				
1994	10		no data avail				
1994	11		no data avail				
1994	12		no data avail				
1995	1		no data avail				
1995	2		station relocated from previous site				
1995	3	24	-0.83	0.38	1.6782	3.8573	0.9129
1995	4	16	-1.00	0.37	0.0000	7.0313	1.0607
1995	5	14	-0.50	0.65	0.7787	2.3445	0.8018
1995	6	12	-1.00	0.60	0.0000	2.5208	1.1547
1995	7	6	-0.67	0.52	0.5379	1.0417	0.8165
1995	8	9	-0.89	0.33	2.0741	5.6296	0.9428
Season		81	-0.83	0.49	0.9614	4.9254	0.9737

LNK-2 - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6		no data avail				
1994	7		no data avail				
1994	8		no data avail				
1994	9		no data avail				
1994	10		no data avail				
1994	11		no data avail				
1994	12		no data avail				
1995	1		no data avail				
1995	2		station relocated from previous site				
1995	3	123	-0.95	0.65	-0.5770	7.3810	1.1512
1995	4	119	-0.52	1.90	2.9902	14.6602	1.9618
1995	5	110	-0.66	1.67	-0.9081	15.0549	1.7914
1995	6	119	-0.33	0.77	0.5167	3.1652	0.8352
1995	7	112	0.13	1.09	1.1151	4.5975	1.0897
1995	8	124	-0.28	1.26	-1.7880	11.3662	1.2858
Season		708	-0.44	1.33	0.9834	18.0389	1.4042

LNK-2 - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6		no data avail				
1994	7		no data avail				
1994	8		no data avail				
1994	9		no data avail				
1994	10		no data avail				
1994	11		no data avail				
1994	12		no data avail				
1995	1		no data avail				
1995	2		station relocated from previous site				
1995	3	124	-0.37	0.99	-0.7038	4.2507	1.0549
1995	4	118	-0.61	1.84	-2.3470	10.9691	1.9266
1995	5	110	-0.65	1.90	-1.5766	7.8770	1.9977
1995	6	119	-1.09	1.28	-0.1400	2.9604	1.6803
1995	7	112	-1.31	1.89	-0.0745	4.2130	2.2932
1995	8	124	-1.10	1.70	0.0138	4.3894	2.0181
Season		708	-0.85	1.65	-1.0332	6.8749	1.8604

LNK-2 - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6		no data avail				
1994	7		no data avail				
1994	8		no data avail				
1994	9		no data avail				
1994	10		no data avail				
1994	11		no data avail				
1994	12		no data avail				
1995	1		no data avail				
1995	2		station relocated from previous site				
1995	3	124	0.73	2.39	0.0509	3.5766	2.4887
1995	4	113	0.51	2.79	0.0144	4.7521	2.8258
1995	5	105	0.63	3.33	-0.2798	2.8256	3.3759
1995	6	119	2.03	2.52	-0.0454	3.8381	3.2264
1995	7	109	2.21	2.75	-0.3788	4.1179	3.5185
1995	8	122	2.03	2.86	-0.2980	2.8911	3.5027
Season		693	1.37	2.87	-0.2043	3.5739	3.1773

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 6. continued.

OKC - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	117	-1.33	1.74	0.1153	3.4715	2.1878
1994	7	108	-1.16	1.54	-0.3974	3.8955	1.9173
1994	8	124	-1.39	1.60	-0.7749	3.9128	2.1099
1994	9	120	-1.46	1.60	-1.1915	6.3308	2.1622
1994	10	124	-1.28	1.75	-0.1402	5.9032	2.1609
1994	11	119	-1.50	1.62	-0.0162	6.3066	2.2058
1994	12	124	-1.58	1.72	-1.2272	8.2810	2.3314
1995	1	116	-1.65	1.80	-1.1166	5.3812	2.4336
1995	2	111	-1.50	1.82	-0.6214	5.5187	2.3577
1995	3	123	-1.33	1.28	-1.7147	7.2695	1.8479
1995	4	120	-1.39	1.48	-0.1635	4.7905	2.0269
1995	5	124	-1.40	1.37	-1.7248	8.3163	1.9531
1995	6	116	-1.88	1.63	-1.0822	3.9449	2.4810
1995	7	120	-1.88	1.62	-0.3644	2.9692	2.4749
1995	8		data missing				
Season		1666	-1.48	1.62	-0.7070	5.6353	2.1969

OKC - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6	16	-1.25	0.93	0.4648	3.2504	1.5411
1994	7	15	-1.40	0.51	-0.3681	1.0163	1.4832
1994	8	9	-1.00	0.50	0.0000	3.5556	1.1055
1994	9	12	-1.00	0.85	-0.8062	3.1510	1.2910
1994	10	21	-0.95	1.32	2.2674	9.7536	1.6036
1994	11	27	-1.00	0.68	0.0000	2.0864	1.2019
1994	12	16	-1.38	1.02	-2.7556	9.8208	1.6956
1995	1	25	-1.16	1.03	-0.8000	4.1623	1.5362
1995	2	23	-0.96	1.02	-0.0814	2.8385	1.3831
1995	3	34	-1.00	1.04	-3.0976	15.7181	1.4349
1995	4	30	-1.13	1.17	2.7684	12.7082	1.6125
1995	5	28	-1.11	1.26	-3.5807	17.3623	1.6583
1995	6	14	-0.79	0.58	0.0225	2.3638	0.9636
1995	7	14	-1.29	1.07	-0.8734	3.4758	1.6475
1995	8		data missing				
Season		284	-1.09	1.00	-0.5833	13.4606	1.4801

OKC - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	118	-0.02	0.97	0.1450	3.5963	0.9655
1994	7	108	-0.22	0.87	0.0136	3.5628	0.8924
1994	8	123	-0.24	0.86	-0.2774	4.1772	0.8926
1994	9	120	-0.12	0.77	0.3082	3.1955	0.7746
1994	10	124	-0.02	0.86	1.5274	9.0554	0.8614
1994	11	116	0.33	1.86	2.4776	12.2510	1.8846
1994	12	123	0.34	1.76	2.8634	15.2328	1.7852
1995	1	114	0.38	1.44	0.5384	6.5282	1.4779
1995	2	111	0.70	1.10	1.0461	6.5105	1.3014
1995	3	123	0.95	1.74	1.4612	5.3099	1.9775
1995	4	120	0.83	1.57	1.2231	5.9448	1.7748
1995	5	124	0.68	1.66	0.0499	8.3097	1.7871
1995	6	116	0.66	1.57	2.1783	9.6969	1.6943
1995	7	119	0.30	1.07	0.6179	3.4472	1.1077
1995	8		data missing				
Season		1659	0.33	1.40	1.8051	11.5743	1.4388

OKC - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6	117	-1.32	1.59	0.0003	2.8154	2.0652
1994	7	108	-0.94	1.60	-0.6858	3.3402	1.8484
1994	8	123	-1.15	1.65	-0.4652	3.4091	2.0020
1994	9	120	-1.34	1.66	-1.3578	7.9409	2.1311
1994	10	124	-1.27	2.07	-0.4817	6.8525	2.4180
1994	11	117	-1.83	2.08	-1.6507	5.9720	2.7611
1994	12	121	-1.77	2.12	-1.1705	6.1215	2.7514
1995	1	114	-2.01	2.09	-1.4753	5.6269	2.8943
1995	2	111	-2.21	2.14	-0.2473	3.5885	3.0654
1995	3	123	-2.28	2.32	-1.1573	3.8575	3.2473
1995	4	120	-2.23	1.93	-0.4278	3.0860	2.9397
1995	5	124	-2.07	2.06	-1.1515	4.8084	2.9196
1995	6	116	-2.54	2.00	-0.9920	4.7617	3.2284
1995	7	119	-2.15	1.99	-0.1253	2.8159	2.9248
1995	8		data missing				
Season		1657	-1.79	2.01	-0.9235	5.0130	2.6974

OKC - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6	112	2.89	3.34	-0.0065	2.2113	4.4057
1994	7	103	1.78	3.08	0.5249	2.7735	3.5455
1994	8	115	2.21	3.09	0.3574	2.6569	3.7838
1994	9	112	2.53	2.87	0.1156	2.5594	3.8223
1994	10	113	2.48	3.08	-0.4803	4.5414	3.9449
1994	11	101	3.04	2.92	0.2998	2.7471	4.2044
1994	12	105	3.54	2.81	0.0006	2.5918	4.5057
1995	1	98	3.30	2.81	-0.0316	2.9605	4.3254
1995	2	99	3.16	3.07	-0.7010	5.1599	4.4013
1995	3	112	3.79	2.97	-0.2243	3.2604	4.8116
1995	4	109	4.05	3.17	-0.5719	3.4952	5.1393
1995	5	113	3.86	2.73	-0.6811	4.6547	4.7227
1995	6	92	4.22	3.08	-0.1956	2.5333	5.2147
1995	7	104	3.22	3.28	-0.2403	3.0323	4.5830
1995	8		data missing				
Season		1488	3.14	3.09	-0.1408	3.0719	4.4040

PWM - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6		data missing				
1994	7		data missing				
1994	8	150	-0.60	1.00	-0.1293	6.7084	1.1605
1994	9	141	-0.69	1.03	-0.9962	3.8769	1.2348
1994	10	124	-0.74	0.91	-0.9744	4.8870	1.1709
1994	11	121	-0.74	1.19	-1.4014	6.7551	1.3936
1994	12	126	-0.72	1.06	0.1094	10.6269	1.2817
1995	1	128	-0.47	0.90	-0.9738	7.5955	1.0078
1995	2	136	-0.79	1.11	-0.6158	14.4918	1.3585
1995	3	152	-0.53	1.05	-4.8973	43.6894	1.1754
1995	4	129	-0.78	0.96	-1.3860	8.4362	1.2358
1995	5	123	-0.71	0.86	-0.9793	5.2261	1.1080
1995	6	120	-1.17	0.88	-0.6198	4.1006	1.4606
1995	7	116	-1.16	1.38	-1.8656	10.7451	1.7956
1995	8	121	-1.21	1.33	-1.1227	4.7291	1.7907
Season		1687	-0.78	1.08	-1.4212	11.4239	1.3304

PWM - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6		data missing				
1994	7		data missing				
1994	8	5	-0.40	0.55	-0.2921	0.7467	0.6325
1994	9	6	-0.17	0.41	-1.3608	2.9167	0.4082
1994	10		data missing				
1994	11	4	-0.75	0.96	-0.3205	0.9158	1.1180
1994	12	7	-0.57	0.79	-0.6824	1.7367	0.9258
1995	1	3	-0.67	0.58	0.3849	0.6667	0.8165
1995	2	9	-0.67	0.50	0.5926	1.1852	0.8165
1995	3	4	0.00	0.00	0.0000	0.0000	0.0000
1995	4	11	-0.64	0.67	-0.4413	1.9207	0.9045
1995	5	9	-0.44	0.53	-0.1874	0.8296	0.6667
1995	6	3	-1.33	0.58	-0.3849	0.6667	1.4142
1995	7		data missing				
1995	8	5	-0.40	0.55	-0.2921	0.7467	0.6325
Season		69	-0.54	0.61	-0.6367	2.4012	0.8194

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 6. continued.

PWM - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6		data missing				
1994	7		data missing				
1994	8	150	0.85	0.77	0.0802	5.1783	1.1489
1994	9	141	0.53	1.00	-0.0444	2.9651	1.1267
1994	10	124	-0.25	1.36	-1.2223	8.6107	1.3766
1994	11	118	0.53	1.64	0.0071	6.9130	1.7173
1994	12	126	0.61	1.41	-1.3697	9.7905	1.5353
1995	1	127	0.33	0.96	-0.4254	3.8528	1.0117
1995	2	136	0.02	1.28	0.7810	5.6575	1.2748
1995	3	144	0.29	1.42	1.7068	12.6623	1.4482
1995	4	124	0.81	1.85	1.6341	8.3145	2.0101
1995	5	82	1.57	1.58	0.3223	3.4161	2.2224
1995	6	119	0.34	1.62	1.4846	8.9509	1.6501
1995	7	117	-0.01	1.23	1.0955	15.3349	1.2230
1995	8	122	-0.33	0.94	-1.2693	6.9439	0.9918
Season		1630	0.38	1.40	0.6326	9.1529	1.4518

PWM - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6		data missing				
1994	7		data missing				
1994	8	153	-1.32	1.51	1.2295	10.5710	2.0033
1994	9	141	-1.22	1.36	-0.4509	3.1067	1.8219
1994	10	124	-0.49	1.53	-0.4632	5.2353	1.5989
1994	11	118	-1.26	1.96	-0.2967	4.1562	2.3234
1994	12	126	-1.33	1.84	1.3443	10.9841	2.2643
1995	1	127	-0.82	1.14	-0.1941	2.9658	1.3974
1995	2	136	-0.81	1.49	-0.3133	5.1399	1.6891
1995	3	142	-0.80	1.45	-1.3084	9.5701	1.6509
1995	4	124	-1.61	2.14	-1.4135	7.4116	2.6700
1995	5	85	-2.13	1.71	-0.5919	4.2562	2.7246
1995	6	118	-1.42	1.61	-0.5334	3.5446	2.1432
1995	7	115	-1.04	1.51	-1.4953	9.1104	1.8321
1995	8	121	-0.79	1.70	1.3369	11.4730	1.8719
Season		1630	-1.13	1.66	-0.3412	7.7464	2.0082

PWM - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6		data missing				
1994	7		data missing				
1994	8	145	3.54	2.65	-0.9345	6.1280	4.4178
1994	9	134	2.81	3.25	-0.2133	2.6970	4.2866
1994	10	122	1.02	3.30	-0.0498	3.5163	3.4450
1994	11	108	2.13	3.67	-0.2419	3.5907	4.2307
1994	12	118	3.42	2.96	-0.2048	3.8604	4.5153
1995	1	122	2.20	3.03	0.2955	2.4197	3.7362
1995	2	132	1.78	3.16	-0.0811	3.1071	3.6206
1995	3	136	1.92	3.25	-0.1606	2.9983	3.7606
1995	4	117	2.62	3.19	-0.7865	4.1975	4.1204
1995	5	65	4.27	2.41	-0.3354	2.5242	4.8946
1995	6	109	2.66	2.90	0.1968	3.3960	3.9271
1995	7	111	2.17	2.77	-0.4814	4.9229	3.5113
1995	8	114	1.76	2.97	-0.1639	3.9040	3.4382
Season		1533	2.43	3.16	-0.2808	3.5239	3.9878

SYR - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	117	-0.89	0.87	-1.3079	6.9476	1.2403
1994	7	124	-0.89	0.67	-0.1264	3.2094	1.1072
1994	8	123	-0.62	0.89	-0.9524	7.2267	1.0820
1994	9	120	-0.49	0.82	-1.4327	10.4685	0.9531
1994	10	124	-0.46	0.73	-0.3289	3.4472	0.8567
1994	11	119	-0.20	0.66	-0.1198	3.9356	0.6860
1994	12	122	-0.20	0.67	-0.5746	6.6206	0.6954
1995	1	124	-0.17	0.79	0.6933	7.3371	0.8082
1995	2	112	-0.62	0.78	-0.6424	6.6182	1.0000
1995	3	123	-0.24	0.91	0.0375	4.7629	0.9370
1995	4	120	-0.49	1.19	-4.3271	35.0140	1.2813
1995	5	124	-0.42	0.85	-0.3706	3.2361	0.9419
1995	6	110	-0.33	0.88	-0.0463	9.8692	0.9342
1995	7	25	-0.84	2.21	-2.4134	12.7091	2.3238
1995	8	124	-0.94	1.10	-3.3405	24.0543	1.4424
Season		1711	-0.50	0.92	-1.9611	21.7040	1.0505

SYR - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6	11	-0.64	0.50	0.4914	1.0921	0.7977
1994	7	4	-1.00	0.82	0.0000	1.1250	1.2247
1994	8	6	-0.17	0.75	0.1736	1.4634	0.7071
1994	9	10	-0.20	0.63	0.0949	2.0700	0.6325
1994	10	5	-0.40	0.55	-0.2921	0.7467	0.6325
1994	11	26	-0.19	0.40	-1.4722	3.1787	0.4385
1994	12	12	-0.33	0.49	-0.6206	1.2604	0.5774
1995	1	18	-0.28	0.57	0.0181	2.2253	0.6236
1995	2	22	-0.59	0.50	0.3449	1.0358	0.7687
1995	3	7	-0.43	0.53	-0.2291	0.7959	0.6547
1995	4	21	-0.43	0.60	-0.9289	2.7189	0.7237
1995	5	13	-0.23	0.44	-1.1334	2.2438	0.4804
1995	6	5	0.00	0.00	0.0000	0.0000	0.0000
1995	7		data missing				
1995	8		data missing				
Season		164	-0.37	0.54	-0.4026	2.4926	0.6628

SYR - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	114	0.22	0.89	-1.2577	7.4024	0.9129
1994	7	124	-0.17	0.62	-1.6931	8.9255	0.6413
1994	8	123	-0.09	0.70	0.1223	2.8209	0.7042
1994	9	119	-0.09	0.70	0.2726	2.5110	0.7041
1994	10	124	-0.66	0.73	-0.4878	4.2060	0.9837
1994	11	117	-0.23	1.15	4.1860	36.6688	1.1658
1994	12	122	-0.23	0.65	-0.6190	4.7857	0.6895
1995	1	123	-0.36	1.47	0.1663	20.7945	1.5088
1995	2	111	-0.42	1.16	-0.2896	9.9395	1.2266
1995	3	123	-0.20	0.68	-0.5206	4.4417	0.7042
1995	4	119	-0.28	1.03	-3.1874	19.8351	1.0651
1995	5	124	0.24	0.90	2.1367	15.8482	0.9246
1995	6	110	-0.14	0.76	0.1042	13.0998	0.7687
1995	7	25	-0.08	0.81	-0.7599	3.3178	0.8000
1995	8	123	-0.10	1.00	5.8916	55.3960	1.0041
Season		1701	-0.18	0.94	0.6660	26.2415	0.9569

SYR - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6	116	-0.98	1.47	2.4046	19.7706	1.7617
1994	7	124	-0.72	0.88	0.3518	3.4150	1.1324
1994	8	124	-0.52	0.99	-0.4767	3.3088	1.1144
1994	9	119	-0.39	1.05	-1.4253	8.4220	1.1190
1994	10	124	0.20	0.90	-0.4676	4.4773	0.9202
1994	11	117	0.03	1.28	-2.9040	22.5051	1.2743
1994	12	122	0.02	1.06	0.4110	6.6230	1.0519
1995	1	123	0.17	1.70	0.1137	16.8449	1.6989
1995	2	111	-0.18	1.38	-0.2788	5.3743	1.3820
1995	3	124	0.02	1.24	1.6336	10.2123	1.2378
1995	4	119	-0.21	1.46	-0.4618	17.0337	1.4696
1995	5	124	-0.66	1.17	-0.7924	5.0515	1.3440
1995	6	110	-0.19	1.18	1.5493	15.4117	1.1947
1995	7	80	3.76	3.85	-0.3207	2.3492	5.3631
1995	8	122	-0.84	1.45	-3.4546	21.8210	1.6718
Season		1759	-0.12	1.73	1.5637	13.6427	1.7342

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 6. continued.

SYR - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6	114	2.31	2.42	-0.4374	4.0317	3.3376
1994	7	124	1.69	2.19	-0.4890	3.4239	2.7557
1994	8	124	1.12	2.31	0.1440	2.8878	2.5603
1994	9	118	0.87	2.45	0.1507	2.4988	2.5908
1994	10	124	-0.77	2.65	0.0803	4.4268	2.7520
1994	11	116	-0.50	2.59	-0.5307	3.7347	2.6291
1994	12	121	-0.10	2.64	-0.0011	2.8273	2.6349
1995	1	118	-0.56	2.66	-0.7246	3.9671	2.7046
1995	2	108	0.38	3.40	-0.0300	2.9928	3.4106
1995	3	123	-0.05	2.71	-0.6625	3.7713	2.6948
1995	4	116	0.48	2.19	-0.6534	4.3187	2.2304
1995	5	123	1.31	2.23	0.3459	3.2711	2.5804
1995	6	109	0.26	2.04	-1.4999	9.6036	2.0466
1995	7	35	-1.52	4.26	-0.6180	2.0063	4.4648
1995	8	120	1.40	2.02	-0.3164	3.7445	2.4525
Season		1693	0.52	2.69	-0.4413	4.0669	2.7371

TOP - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	118	-0.03	1.23	0.6157	3.6944	1.2213
1994	7	123	0.28	1.29	0.2607	3.0269	1.3159
1994	8	121	0.42	1.10	0.5692	4.5029	1.1748
1994	9	117	-0.01	1.15	0.0842	4.5276	1.1435
1994	10	121	-0.20	0.92	0.3966	2.9657	0.9360
1994	11	120	-0.61	0.95	0.4575	3.9795	1.1218
1994	12	124	-0.72	0.92	-0.0898	3.7308	1.1674
1995	1	124	-0.81	1.15	-1.2525	8.8301	1.4056
1995	2	111	-0.44	1.19	0.5061	6.3476	1.2628
1995	3	124	-0.65	1.01	-0.6975	5.4414	1.1981
1995	4	120	-0.59	0.88	-0.3750	4.3588	1.0607
1995	5	123	-0.61	0.94	-0.8963	7.4353	1.1153
1995	6		data missing				
1995	7	117	0.23	1.22	-0.0755	3.1682	1.2369
1995	8	124	1.23	1.39	0.3627	2.7139	1.8513
Season		1689	-0.18	1.24	0.3663	4.8532	1.2474

TOP - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6	5	-0.20	0.45	-1.0733	2.0800	0.4472
1994	7	3	-0.67	2.08	-0.2874	0.6667	1.8257
1994	8	6	0.00	0.00	0.0000	0.0000	0.0000
1994	9	6	0.17	0.41	1.3608	2.9167	0.4082
1994	10	9	-0.33	0.71	0.4190	1.7778	0.7454
1994	11	11	-0.45	0.52	-0.1583	0.8540	0.6742
1994	12	4	-0.75	0.96	-0.3205	0.9158	1.1180
1995	1	12	-0.75	0.75	-0.3648	1.6738	1.0408
1995	2	12	0.00	1.41	1.7678	5.4583	1.3540
1995	3	13	-0.31	0.48	-0.7391	1.4438	0.5547
1995	4	15	-0.33	0.49	-0.6376	1.3067	0.5774
1995	5	10	0.00	0.47	0.0000	4.0500	0.4472
1995	6		data missing				
1995	7		data missing				
1995	8		data missing				
Season		108	-0.27	0.80	0.9405	10.2516	0.8512

TOP - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	115	0.30	1.20	-1.5145	8.3683	1.2301
1994	7	123	-1.00	1.40	-1.0077	4.1092	1.7179
1994	8	121	-0.30	1.22	0.0598	5.7813	1.2531
1994	9	117	-1.20	1.61	1.7665	25.0662	2.0043
1994	10	121	-0.51	0.93	-0.4237	4.4519	1.0602
1994	11	120	-1.32	1.02	-0.4500	6.2751	1.6708
1994	12	123	-1.73	1.38	-0.0193	5.6377	2.2105
1995	1	117	0.00	1.35	0.0623	2.9684	1.3461
1995	2	111	-0.57	2.78	0.3175	3.7863	2.8268
1995	3	123	-1.36	1.55	-1.5409	6.1202	2.0541
1995	4	118	-1.56	1.47	-1.0993	5.0570	2.1392
1995	5	124	-0.16	1.48	1.5643	6.7865	1.4811
1995	6		data missing				
1995	7	112	-1.21	1.44	-1.3272	5.6339	1.8732
1995	8	123	-1.22	1.85	-1.5653	6.0988	2.2123
Season		1670	-0.85	1.64	-0.1683	7.5354	1.8466

TOP - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6	116	-0.32	1.98	1.3605	7.2305	1.9978
1994	7	124	1.29	1.93	0.8907	3.7202	2.3141
1994	8	123	0.77	1.77	0.4057	4.4705	1.9233
1994	9	118	1.39	1.78	1.3140	7.8032	2.2512
1994	10	123	0.36	1.37	0.5683	4.2995	1.4142
1994	11	120	0.72	1.30	0.8220	6.9552	1.4832
1994	12	123	1.02	1.54	0.5322	4.6773	1.8413
1995	1	117	-0.81	1.63	-1.5586	10.2214	1.8140
1995	2	111	0.13	2.87	-0.6031	4.5459	2.8601
1995	3	123	0.72	1.62	0.8193	4.4490	1.7623
1995	4	118	0.97	1.55	0.7295	4.9725	1.8180
1995	5	124	-0.35	1.82	-0.7035	7.0785	1.8448
1995	6		data missing				
1995	7	112	1.38	2.11	0.9810	4.4849	2.5160
1995	8	121	2.28	2.34	1.2952	4.6377	3.2626
Season		1675	0.68	2.02	0.3912	6.5321	2.1292

TOP - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6	111	1.20	3.54	-0.3001	3.1551	3.7246
1994	7	121	-2.51	3.39	-0.1623	2.1884	4.2056
1994	8	120	-1.46	3.39	0.4026	2.6383	3.6820
1994	9	113	-3.00	3.23	0.2396	3.5889	4.3966
1994	10	119	-0.84	3.04	-0.2999	2.5664	3.1366
1994	11	118	-1.99	3.01	-0.0973	2.8550	3.5937
1994	12	113	-2.59	3.49	0.3620	2.7865	4.3331
1995	1	112	1.78	3.75	-0.2078	2.4339	4.1331
1995	2	91	-0.25	4.65	0.3153	2.2001	4.6310
1995	3	112	-1.15	3.18	0.2782	3.3534	3.3631
1995	4	118	-2.24	3.07	0.1341	2.7378	3.7913
1995	5	117	0.32	3.33	0.2158	3.6107	3.3268
1995	6		data missing				
1995	7	106	-2.57	3.63	-0.0332	2.2595	4.4332
1995	8	109	-3.89	3.31	0.0227	2.2335	5.0934
Season		1582	-1.38	3.76	0.1845	2.8653	4.0035

TUL - All Hourly Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	119	-1.66	1.04	0.0746	5.9865	1.9575
1994	7	124	-1.42	1.07	-0.2285	2.6842	1.7735
1994	8	123	-1.35	0.97	-0.0011	3.8507	1.6626
1994	9	120	-1.26	1.10	-0.5240	5.1589	1.6708
1994	10	124	-1.10	1.27	1.2628	9.7065	1.6752
1994	11	120	-1.12	0.98	-0.7224	4.7969	1.4860
1994	12	124	-1.06	1.25	-1.8906	11.5692	1.6412
1995	1	124	-1.12	1.45	-1.0548	6.6129	1.8250
1995	2	112	-1.32	1.33	-0.5419	4.6455	1.8708
1995	3	122	-1.57	1.44	-0.8439	6.0692	2.1252
1995	4	120	-2.35	1.10	0.3381	4.9992	2.5917
1995	5	124	-2.52	0.90	-0.6895	3.3585	2.6700
1995	6	120	-2.73	1.12	-0.7805	4.2167	2.9524
1995	7	122	-2.45	1.12	0.9762	5.7882	2.6933
1995	8		data missing				
Season		1699	-1.65	1.30	-0.2599	5.0540	2.0939

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 6. continued.

TUL - Hourly Temperatures - WS >9 kts 5z,11z

Year	Mn	N	d	s	M	k	C
1994	6	15	-0.93	0.59	0.0028	2.6124	1.0954
1994	7	10	-1.10	0.57	-0.0656	2.6746	1.2247
1994	8	6	-1.00	0.63	0.0000	2.0833	1.1547
1994	9	3	-1.33	1.53	-0.2078	0.6667	1.8257
1994	10	13	-1.00	0.58	0.0000	2.7692	1.1435
1994	11	20	-0.90	0.64	1.0721	5.1248	1.0954
1994	12	9	-0.89	0.33	2.0741	5.6296	0.9428
1995	1	18	-0.72	0.75	-1.2278	5.0201	1.0274
1995	2	16	-0.75	0.77	-0.4034	1.6602	1.0607
1995	3	17	-1.00	0.50	0.0000	3.7647	1.1114
1995	4	24	-2.08	0.58	-1.2636	6.3448	2.1602
1995	5	16	-2.12	0.50	-0.2812	3.3633	2.1794
1995	6	9	-2.00	0.50	0.0000	3.5556	2.0548
1995	7	6	-1.83	0.75	-0.1736	1.4634	1.9579
1995	8		data missing				
Season		182	-1.26	0.81	-0.2455	3.1860	1.4993

TUL - All Hourly Dewpoint Temperatures

Year	Mn	N	d	s	M	k	C
1994	6	119	0.52	1.01	0.9054	4.7601	1.1302
1994	7	124	0.59	1.00	1.1278	6.2188	1.1535
1994	8	123	1.24	1.51	1.3242	5.4370	1.9527
1994	9	120	0.30	1.42	0.9232	18.4042	1.4491
1994	10	124	-0.14	1.25	0.6029	6.1186	1.2540
1994	11	120	0.30	2.07	0.4480	12.2660	2.0857
1994	12	123	0.21	1.78	2.0008	11.0253	1.7852
1995	1	124	0.10	1.82	2.2626	11.5227	1.8139
1995	2	112	-0.74	1.41	-0.2312	3.0654	1.5896
1995	3	101	-0.34	2.55	1.3944	7.4602	2.5602
1995	4	119	-0.87	1.74	0.7961	4.2255	1.9446
1995	5	124	-1.01	1.54	1.7770	11.0959	1.8382
1995	6	119	0.22	2.38	1.3359	4.6090	2.3799
1995	7	122	-1.84	1.06	-0.1213	4.9147	2.1194
1995	8		data missing				
Season		1677	-0.10	1.82	1.0370	8.2503	1.8268

TUL - All Hourly Dewpoint Depressions

Year	Mn	N	d	s	M	k	C
1994	6	119	-2.18	1.42	-0.8021	3.9993	2.6025
1994	7	124	-2.01	1.55	-1.1216	5.6326	2.5352
1994	8	124	-2.56	1.91	-1.2728	5.0743	3.1902
1994	9	119	-1.45	1.72	0.4120	5.3035	2.2379
1994	10	124	-0.96	1.98	0.2764	5.4287	2.1905
1994	11	119	-1.34	2.27	-0.2051	7.8001	2.6266
1994	12	121	-1.10	1.72	-1.3277	6.8632	2.0389
1995	1	123	-1.13	2.22	-0.6260	3.7768	2.4874
1995	2	112	-0.58	1.79	-0.1786	4.1908	1.8732
1995	3	98	-1.07	2.49	-0.2794	4.9500	2.7011
1995	4	119	-1.49	2.11	-0.2333	5.7345	2.5782
1995	5	123	-1.43	1.75	-0.5593	3.2561	2.2560
1995	6	115	-2.61	2.38	-1.0421	3.9642	3.5263
1995	7	122	-0.61	1.69	0.8098	7.3412	1.7902
1995	8		data missing				
Season		1663	-1.47	2.04	-0.4207	5.7558	2.5114

TUL - All Hourly Relative Humidities (percent)

Year	Mn	N	d	s	M	k	C
1994	6	114	4.26	2.38	0.0175	3.2553	4.8799
1994	7	120	4.05	2.81	0.1328	2.2066	4.9241
1994	8	111	4.62	2.67	-0.2002	2.7087	5.3324
1994	9	114	3.07	3.28	-0.3317	3.3574	4.4825
1994	10	119	1.99	3.39	-0.2664	3.3507	3.9215
1994	11	108	2.71	3.23	-0.1966	3.8324	4.2065
1994	12	111	1.93	3.11	-0.5584	4.8077	3.6492
1995	1	115	1.84	4.22	-0.2290	2.0722	4.5824
1995	2	110	0.95	3.13	0.0897	2.4467	3.2581
1995	3	93	1.90	4.20	-0.1945	2.5047	4.5931
1995	4	110	2.42	3.39	-0.1054	3.0311	4.1503
1995	5	116	2.71	3.64	-0.2637	2.9333	4.5281
1995	6	91	4.00	3.37	-0.2587	2.7089	5.2189
1995	7	121	1.15	3.12	0.1906	2.8849	3.3123
1995	8		data missing				
Season		1554	2.67	3.48	-0.2785	3.0589	4.3876

Mn = Month; N = number of occurrences; d = systematic differences; s = estimated standard deviation of the difference; M = skewness; k = kurtosis; C = operational comparability.

Table 7.
ASOS - CONV, °F
June 1994 through August 1995

	Station	Mx	Mn	ΔT_ℓ	Bias Removed Mx ($\Delta T_s + \Delta T_\ell$)	Bias Removed Mn (ΔT_ℓ)	ASOS - CONV Diurnal Range
	AMA	-0.76	-0.59	-0.35	-0.41	-0.24	-0.17
	AST	-0.59	0.03	-0.28	-0.31	0.31	-0.62
	BRO	-0.93	-0.32	-0.45	-0.48	0.13	-0.61
	BTR	-1.96	-1.19	-0.89	-1.07	-0.30	-0.77
*	COS	-1.38	-0.41	-0.16	-1.22	-0.25	-0.97
	DDC	-0.48	-0.91	-0.61	0.13	-0.30	0.43
	GLD	-1.16	-1.19	-0.21	-0.95	-0.98	0.03
	GRI	-1.25	-0.69	-0.67	-0.58	-0.02	-0.56
*	ICT	-0.79	-0.27	-0.29	-0.50	0.02	-0.52
	LNK-1	-2.14	-2.00	-0.96	-1.18	-1.04	-0.14
*	LNK-2	-2.38	-1.03	-0.96	-1.42	-0.07	-1.35
	OKC	-0.64	-2.03	-0.93	0.29	-1.10	1.39
	PWM	-0.78	-1.18	-0.47	-0.31	-0.71	0.40
*	SYR	-0.80	-0.42	-0.29	-0.51	-0.13	-0.38
	TOP	-0.48	0.06	-0.50	0.02	0.56	-0.54
	TUL	-2.17	-1.55	-1.06	-1.11	-0.49	-0.62
	Average	-1.17	-0.86	-0.57**	-0.60	-0.29	-0.31

* Co-located sites

** Value has LNK twice.

Table 8.
Comparison of CONV and ASOS Precipitation Totals
for all six-hour periods when precipitation from either or both gage was ≥ 0.50 inches

Station	Number of Occurrences	Total Precipitation for events ≥ 0.50"		ASOS as % of CONV
		CONV	ASOS	
AMA	10	8.11	7.96	98.2%
AST	36	26.06	25.17	96.6
BRO	5	6.83	7.05	103.2
BTR	34	45.70	43.12	94.4
CNK	11	8.89	9.19	103.4
COS	8	7.53	8.07	107.2
DDC	12	11.09	11.72	105.7
GLD	9	5.74	6.28	109.4
GRI	3	2.30	2.19	95.2
ICT	23	23.40	22.06	94.3
OKC	23	23.21	20.29	87.4
PWM	2	1.25	1.14	91.2
TOP	20	18.58	18.96	102.0
TUL	25	28.13	27.91	99.2
Total	221	216.82	211.11	97.4%
Totals when precipitation ≥ 0.75"	125	163.48	156.74	95.9%
Totals when precipitation ≥ 2.00"	18	48.54	44.53	91.7%

Station Locations

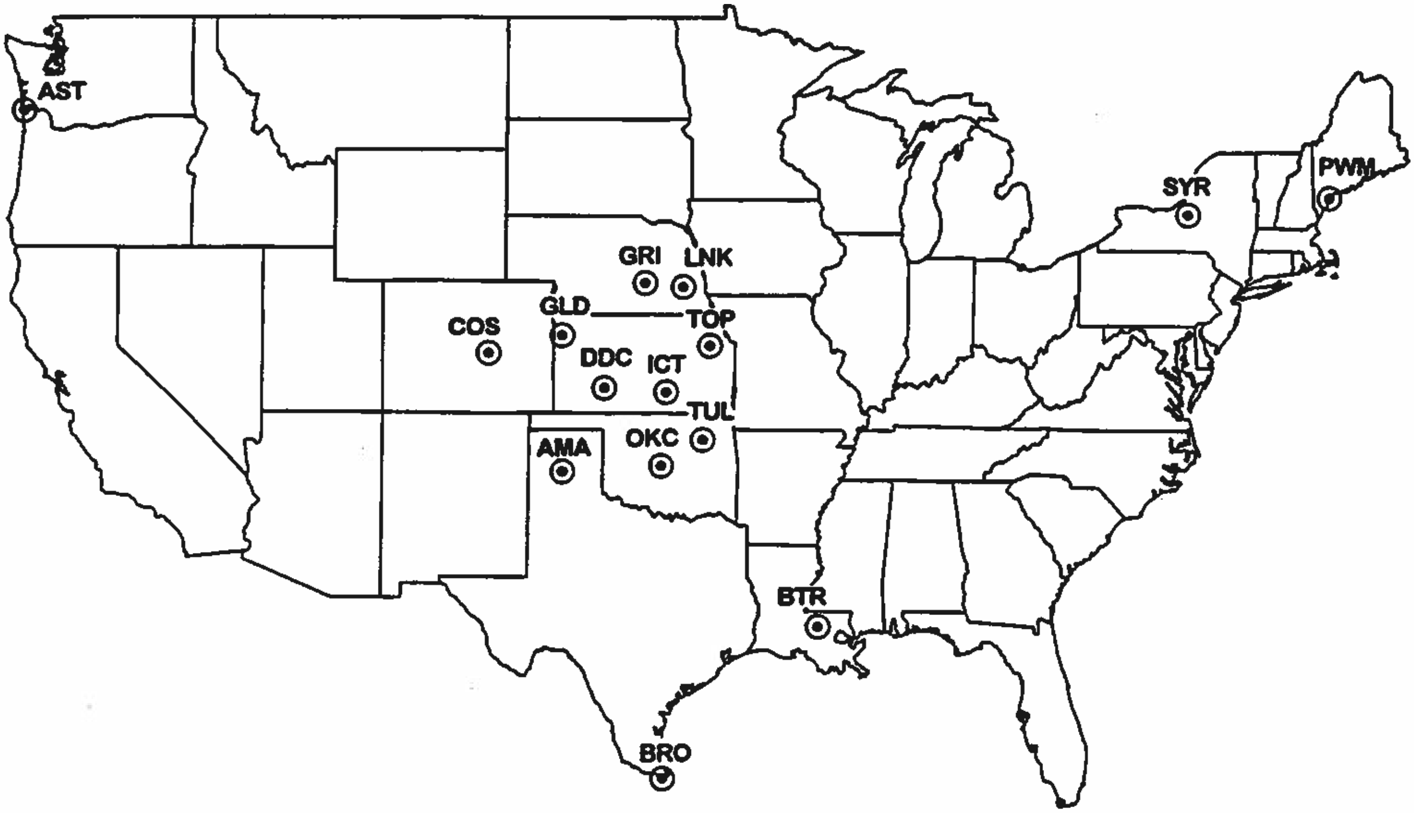


Figure 1. Location of 15 CDCP core sites.

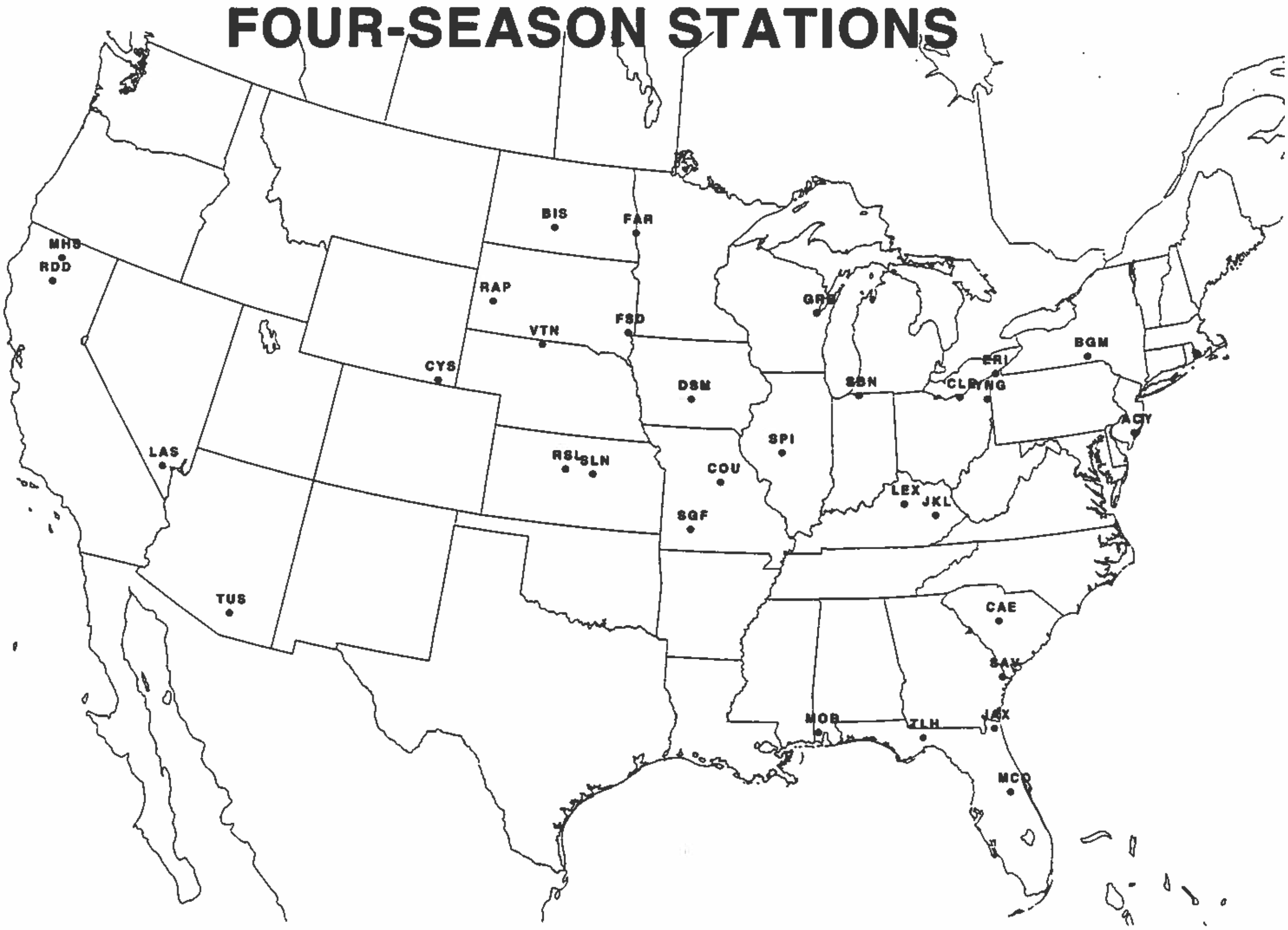


Figure 2. Location of CDCP four season expansion sites.

Figure 3. Location of CDCP three season expansion sites.

Figure 4. Location of CDCP two season expansion sites.

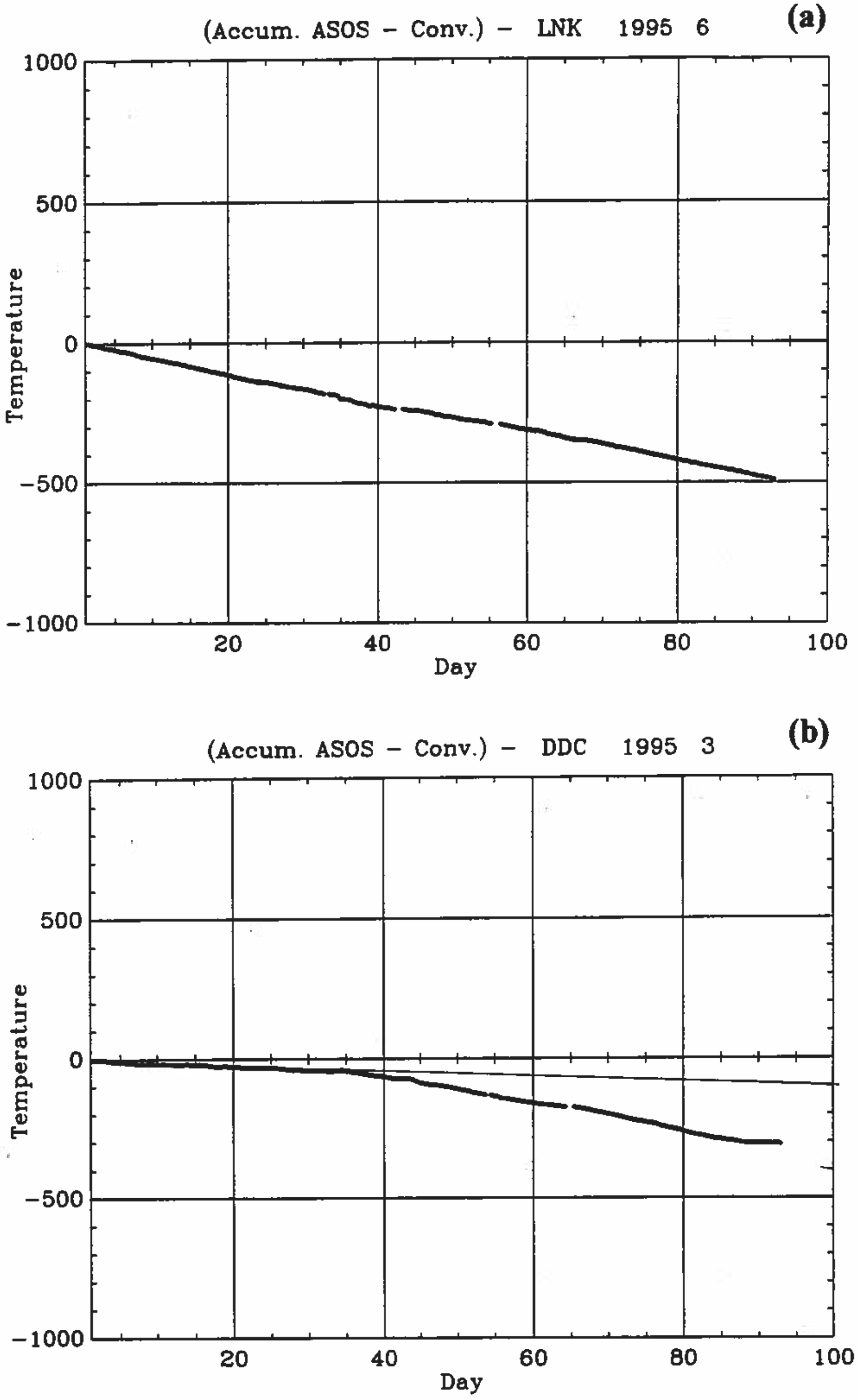


Figure 5. Accumulated temperatures for ASOS - CONV for (a) LNK summer 1995 and (b) DDC spring 1995.

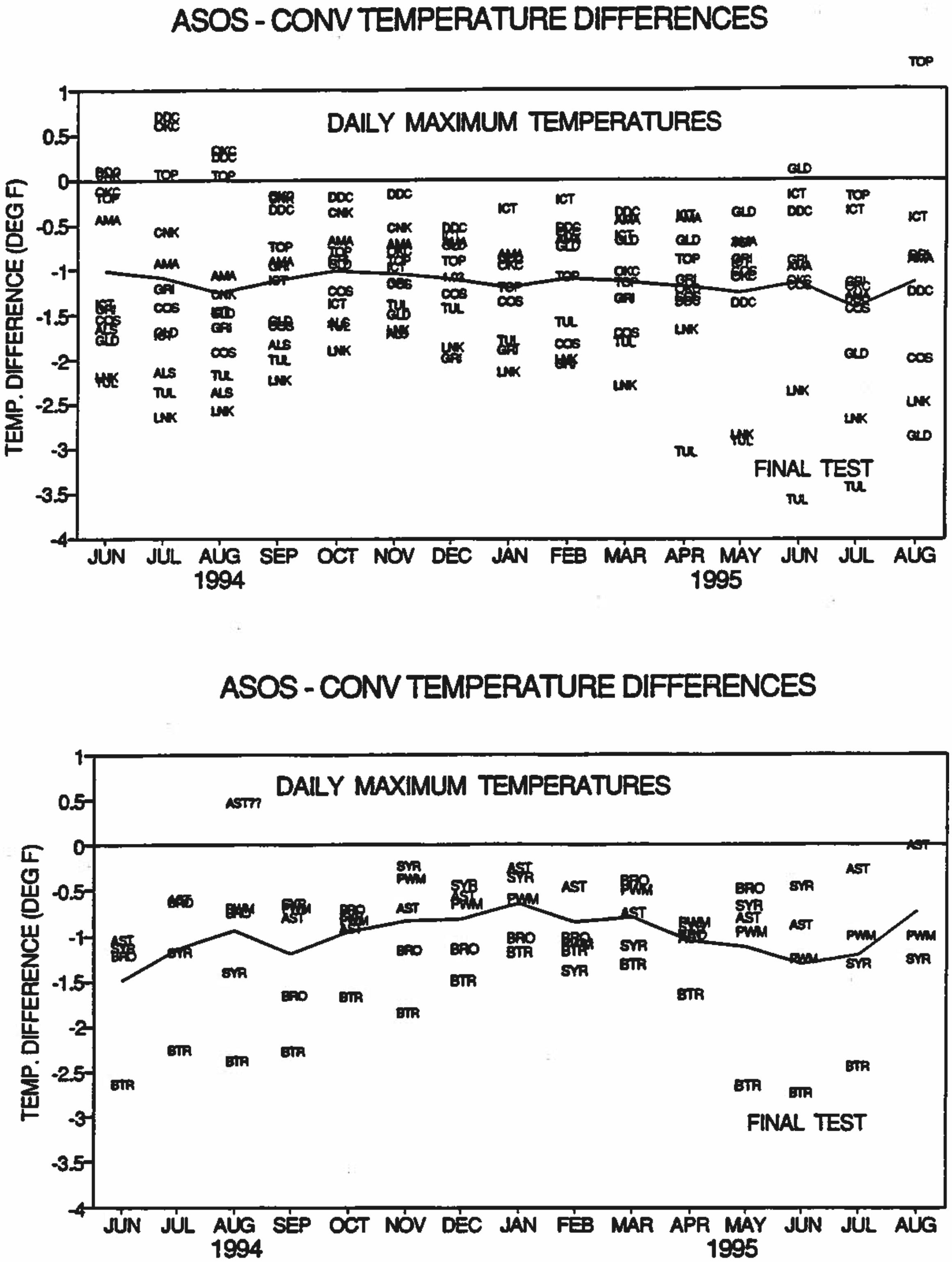


Figure 6. The composite mean ASOS-CONV systematic difference (°F), June 1994 through August 1995 for daily maximum temperature (solid line) with the actual monthly systematic differences plotted for the 15 final test sites.

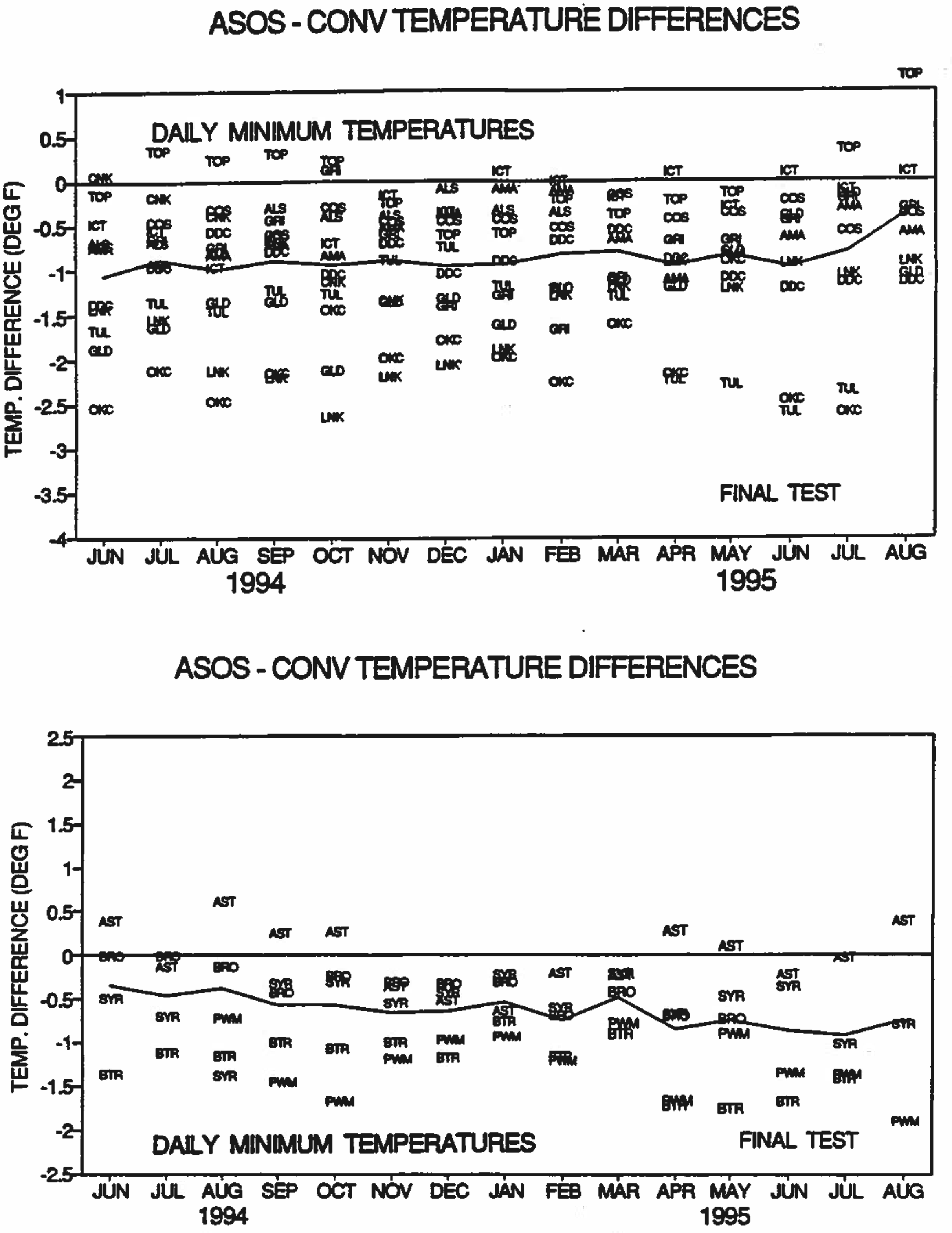


Figure 7. The composite mean ASOS-CONV systematic difference (°F), June 1994 through August 1995 for daily minimum temperature (solid line) with the actual monthly systematic differences plotted for the 15 final test sites.

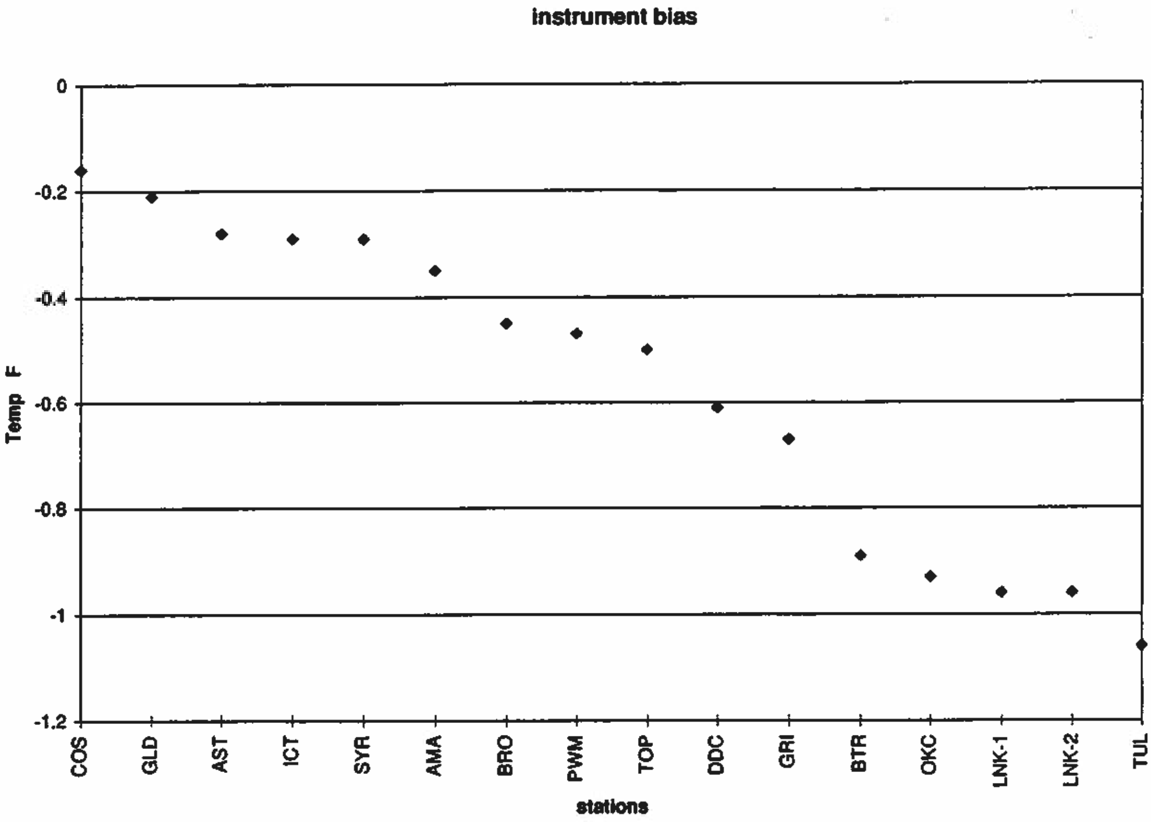


Figure 8. Instrument bias for 16 CDCP sites ranked in order of magnitude for ASOS - CONV.

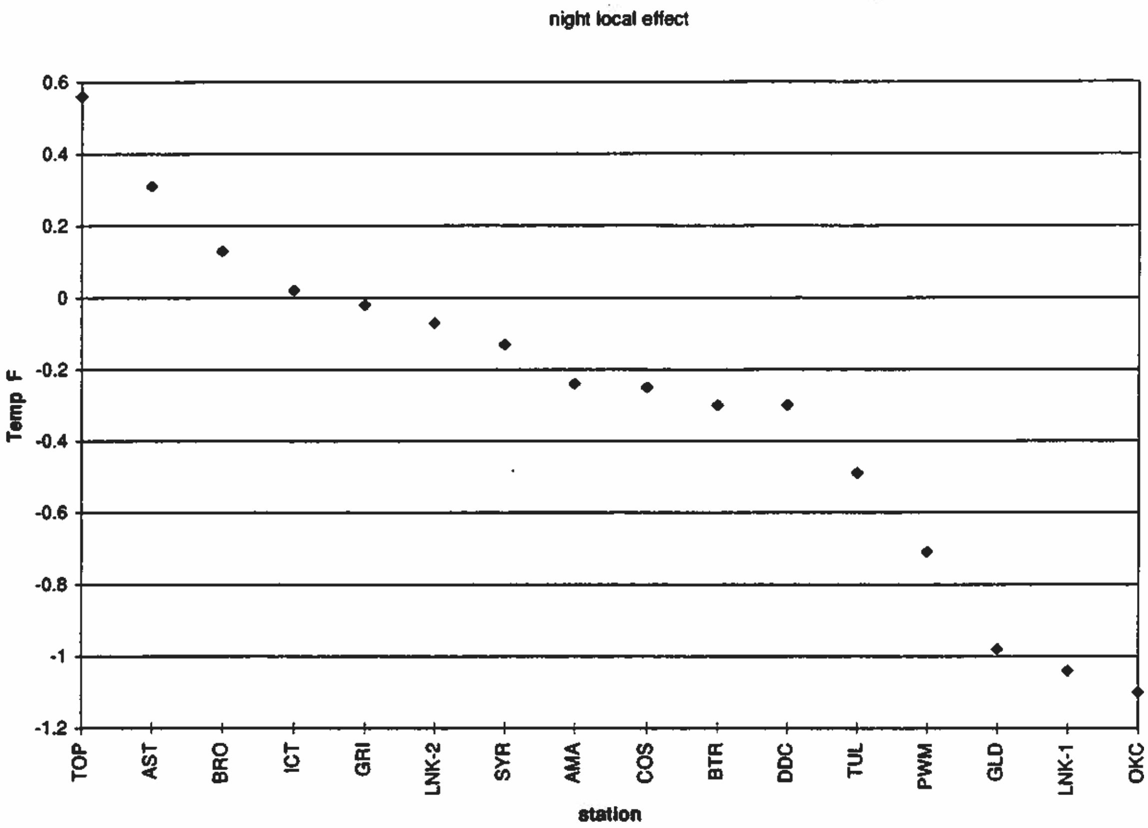


Figure 9. Night local effect of change in instrument location from 16 CDCP sites ranked in order of magnitude for ASOS - CONV.

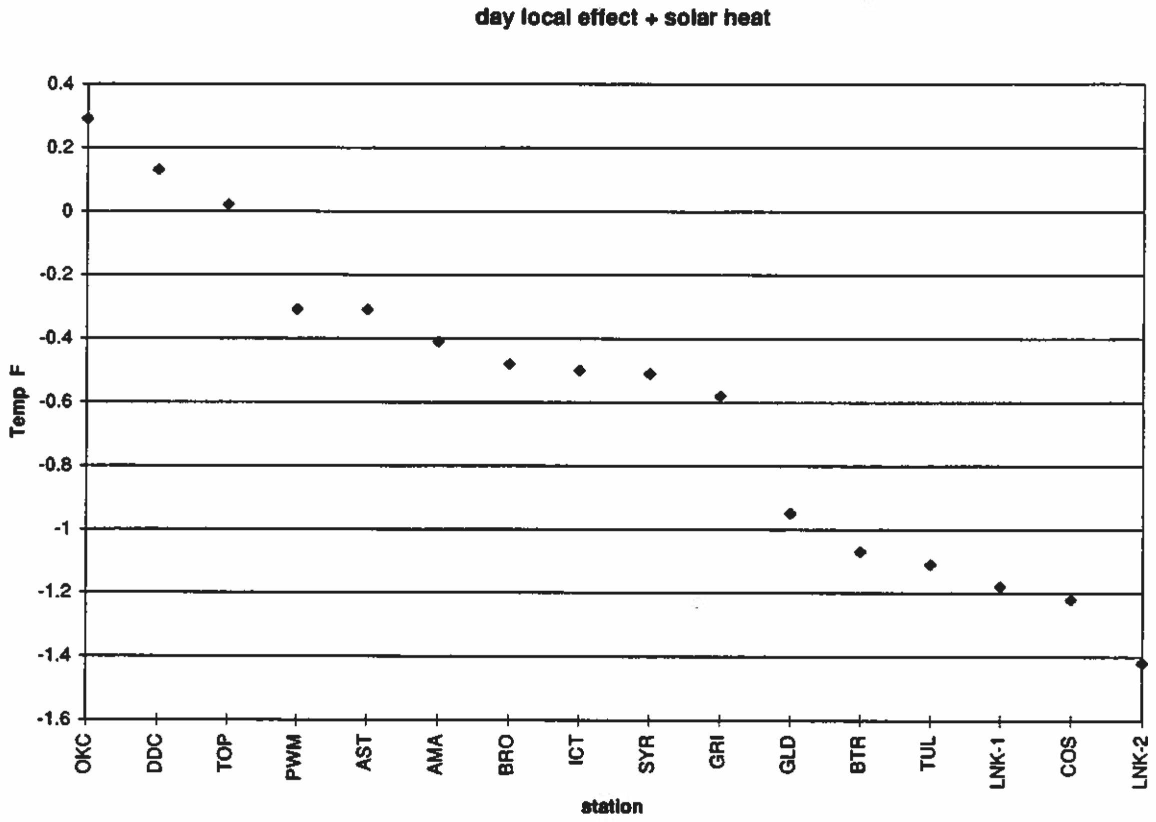


Figure 10. Combination of day local effect of change in instrument location and solar heating effect for 16 CDCP sites ranked in order of magnitude for ASOS - CONV.

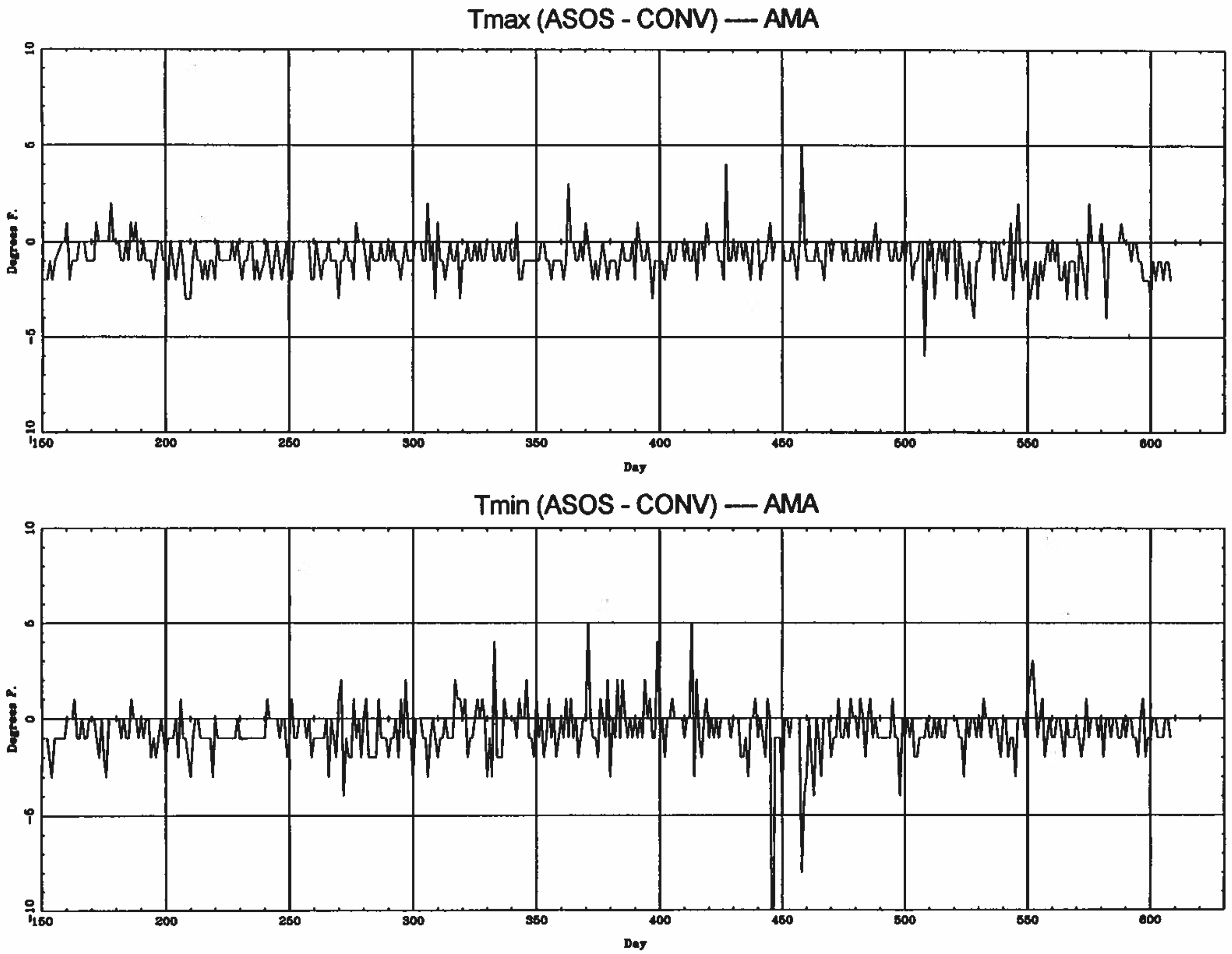
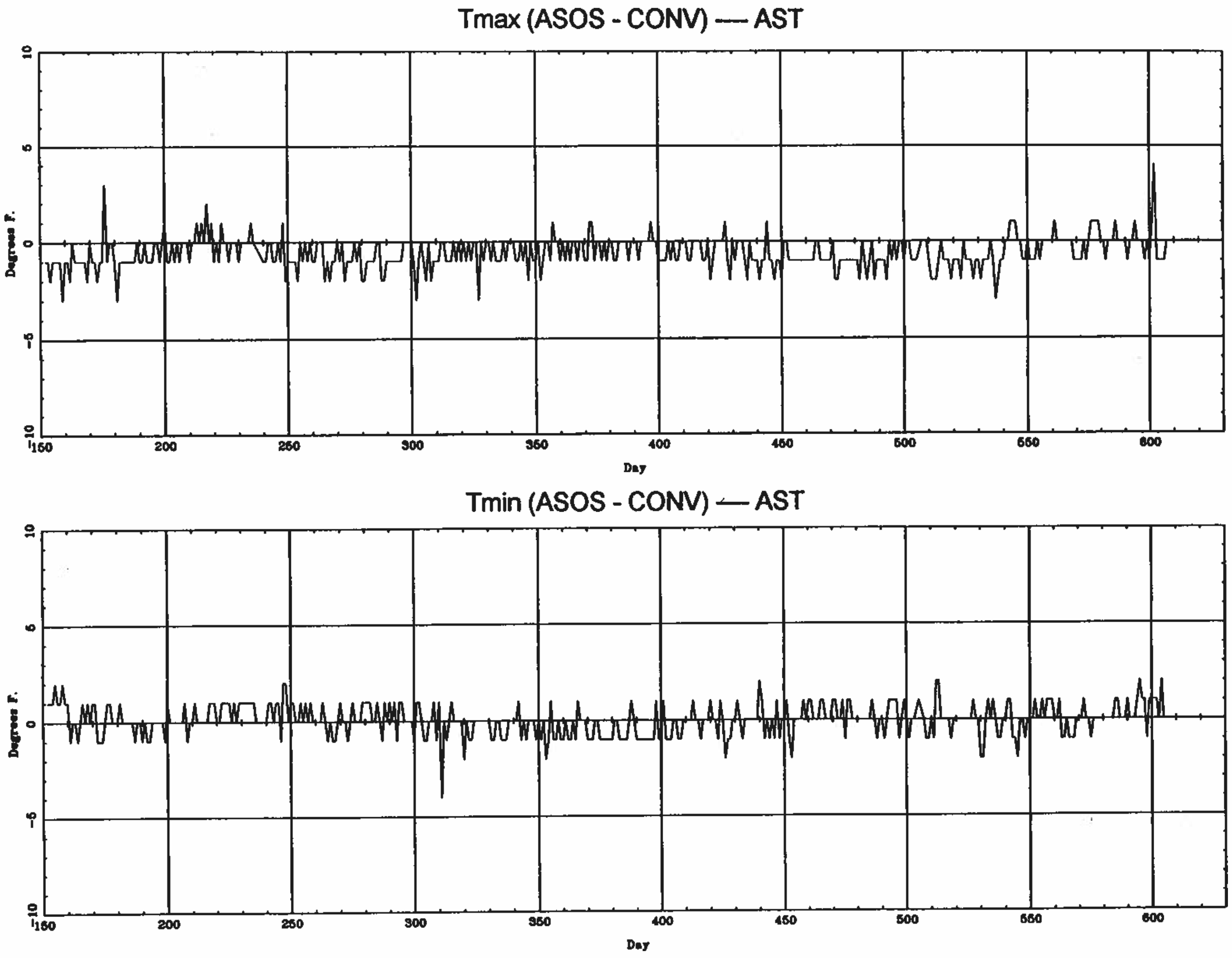


Figure 11a. Temperature time series of ASOS-CONV for maximum and minimum from June 1994 through August 1995 for AMA.


Tmax (ASOS - CONV) — AST

Tmin (ASOS - CONV) — AST

Figure 11b. Temperature time series of ASOS-CONV for maximum and minimum from June 1994 through August 1995 for AST.

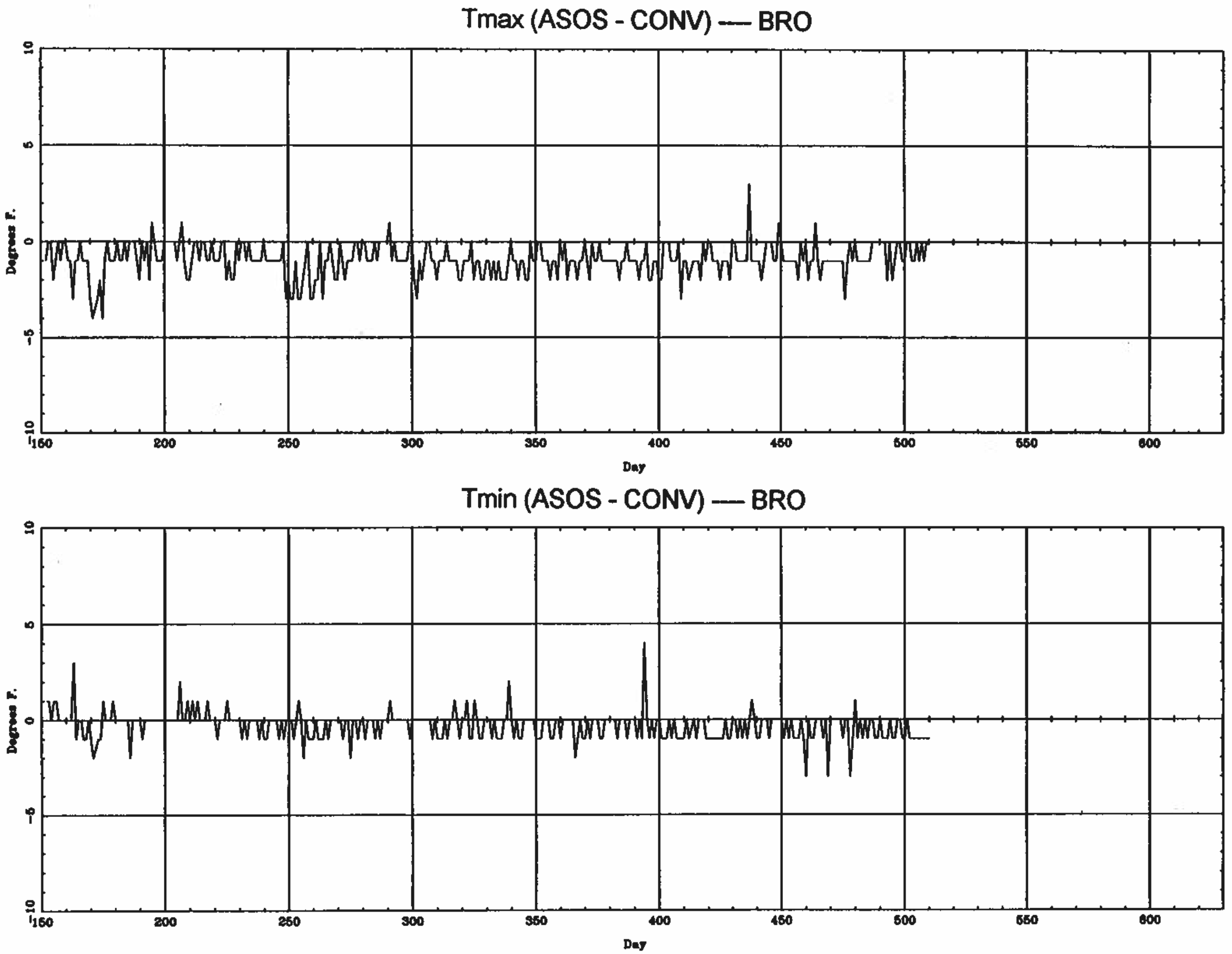


Figure 11c. Temperature time series of ASOS-CONV for maximum and minimum from June 1994 through August 1995 for BRO.

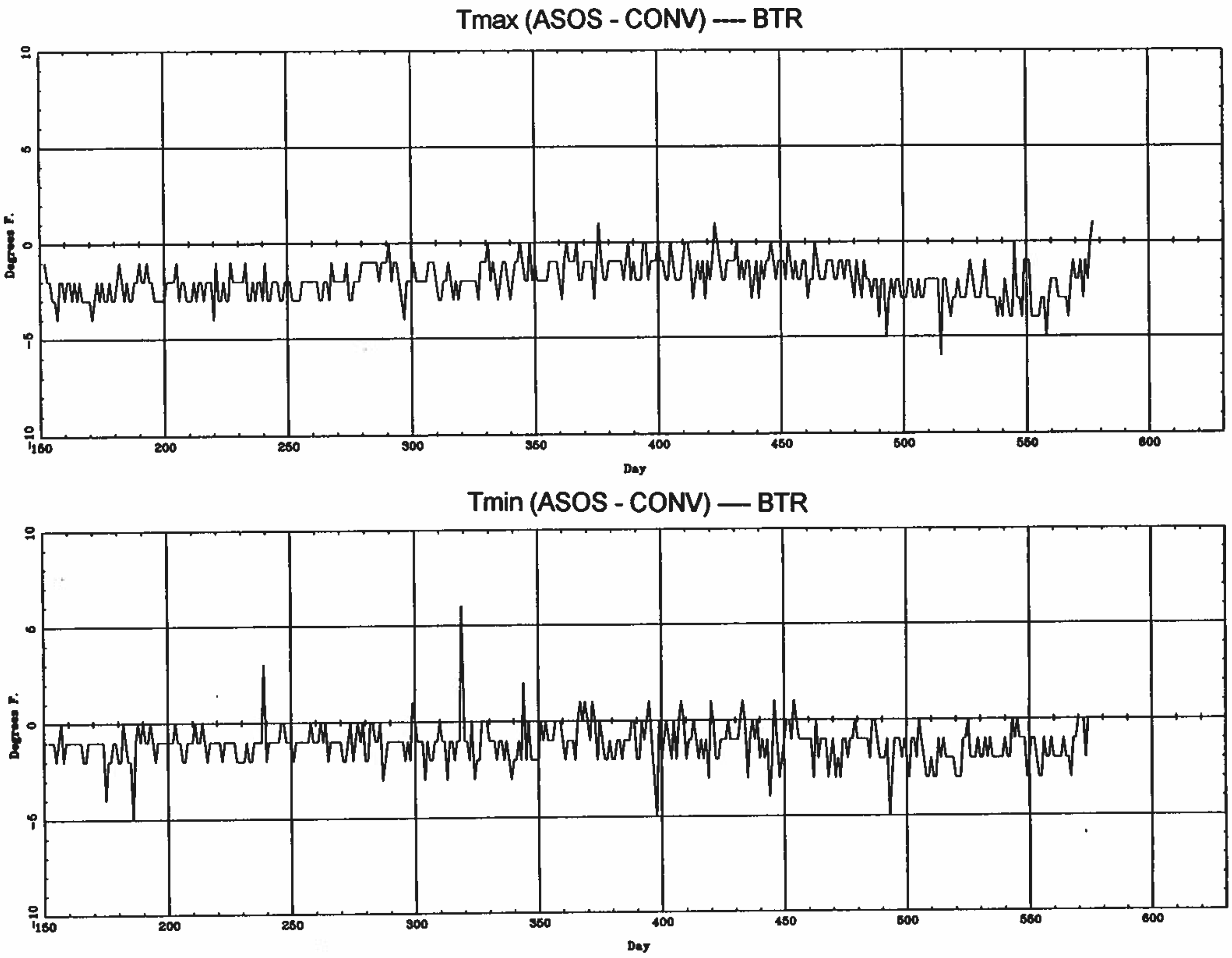


Figure 11d. Temperature time series of ASOS-CONV for maximum and minimum from June 1994 through August 1995 for BTR.

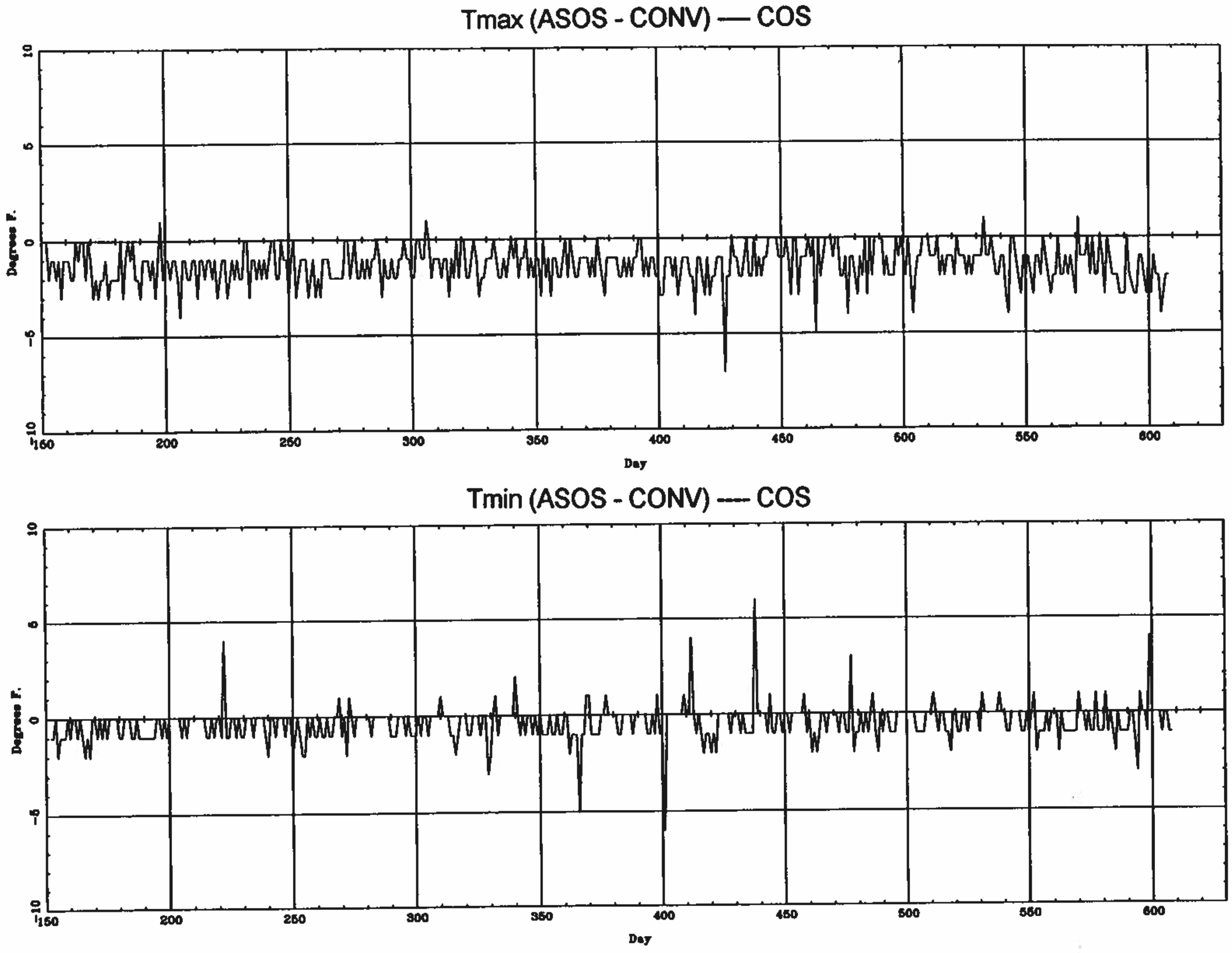
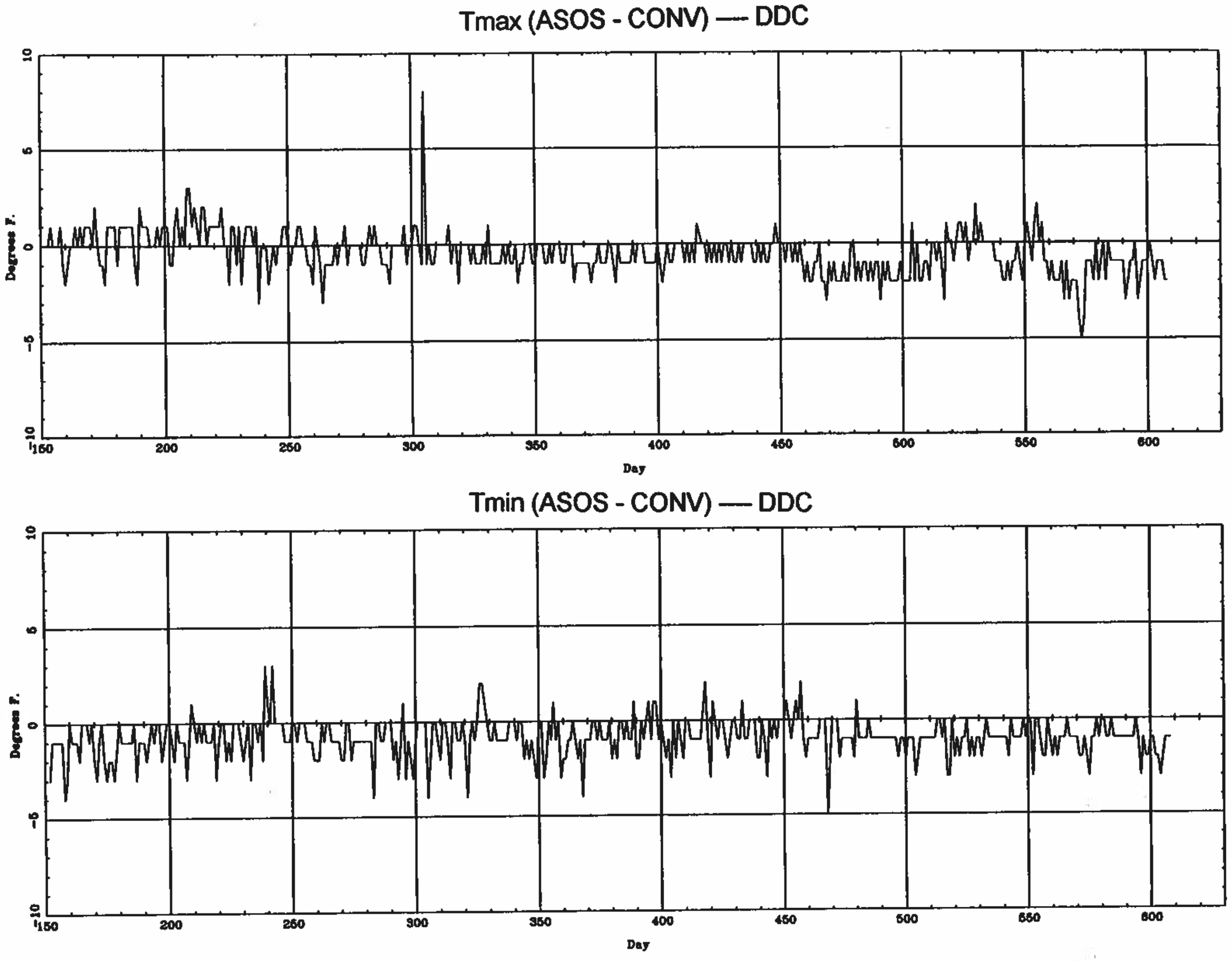


Figure 11e. Temperature time series of ASOS-CONV for maximum and minimum from June 1994 through August 1995 for COS.


Tmax (ASOS - CONV) — DDC

Tmin (ASOS - CONV) — DDC

Figure 11f. Temperature time series of ASOS-CONV for maximum and minimum from June 1994 through August 1995 for DDC.

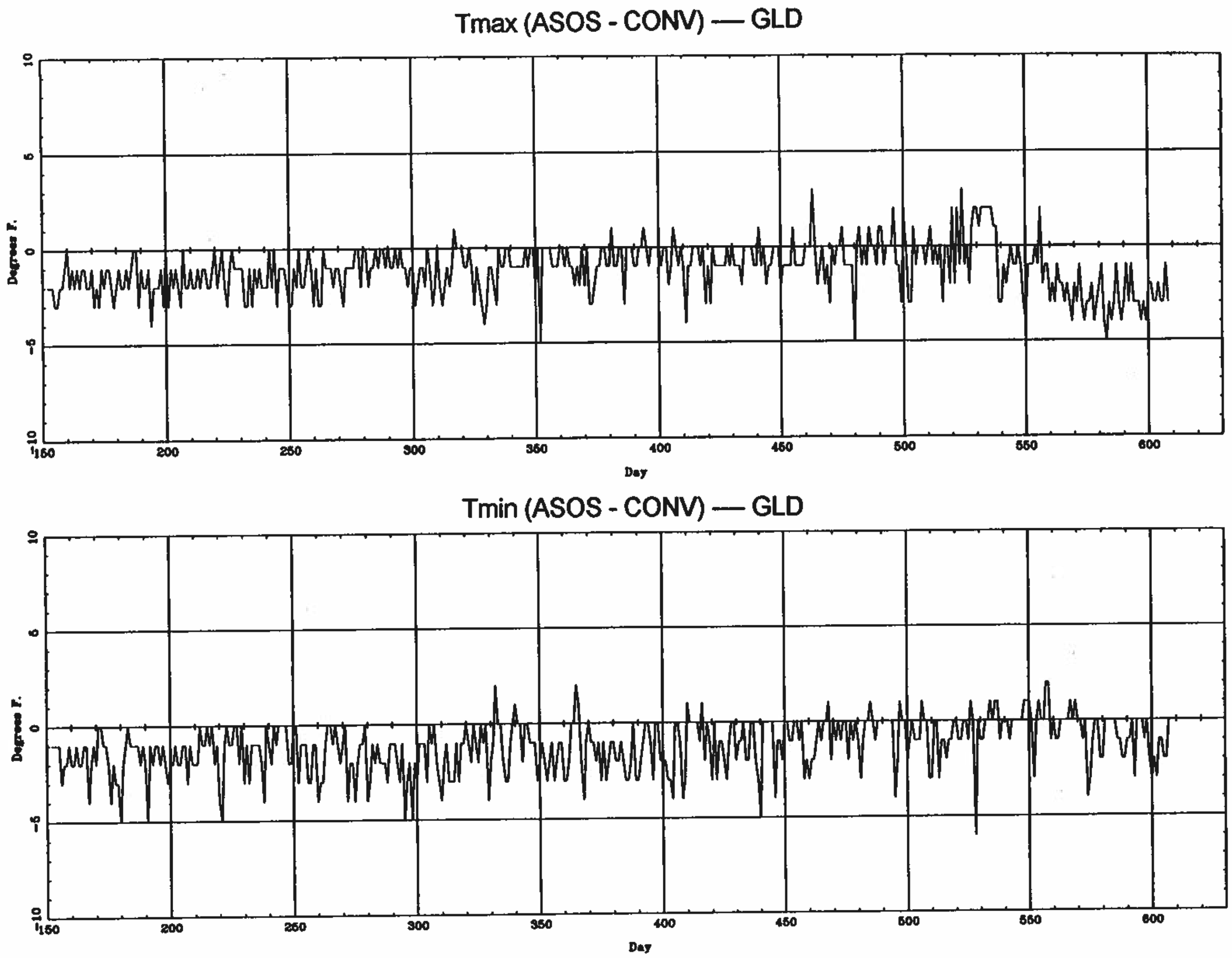


Figure 11g. Temperature time series of ASOS-CONV for maximum and minimum from June 1994 through August 1995 for GLD.

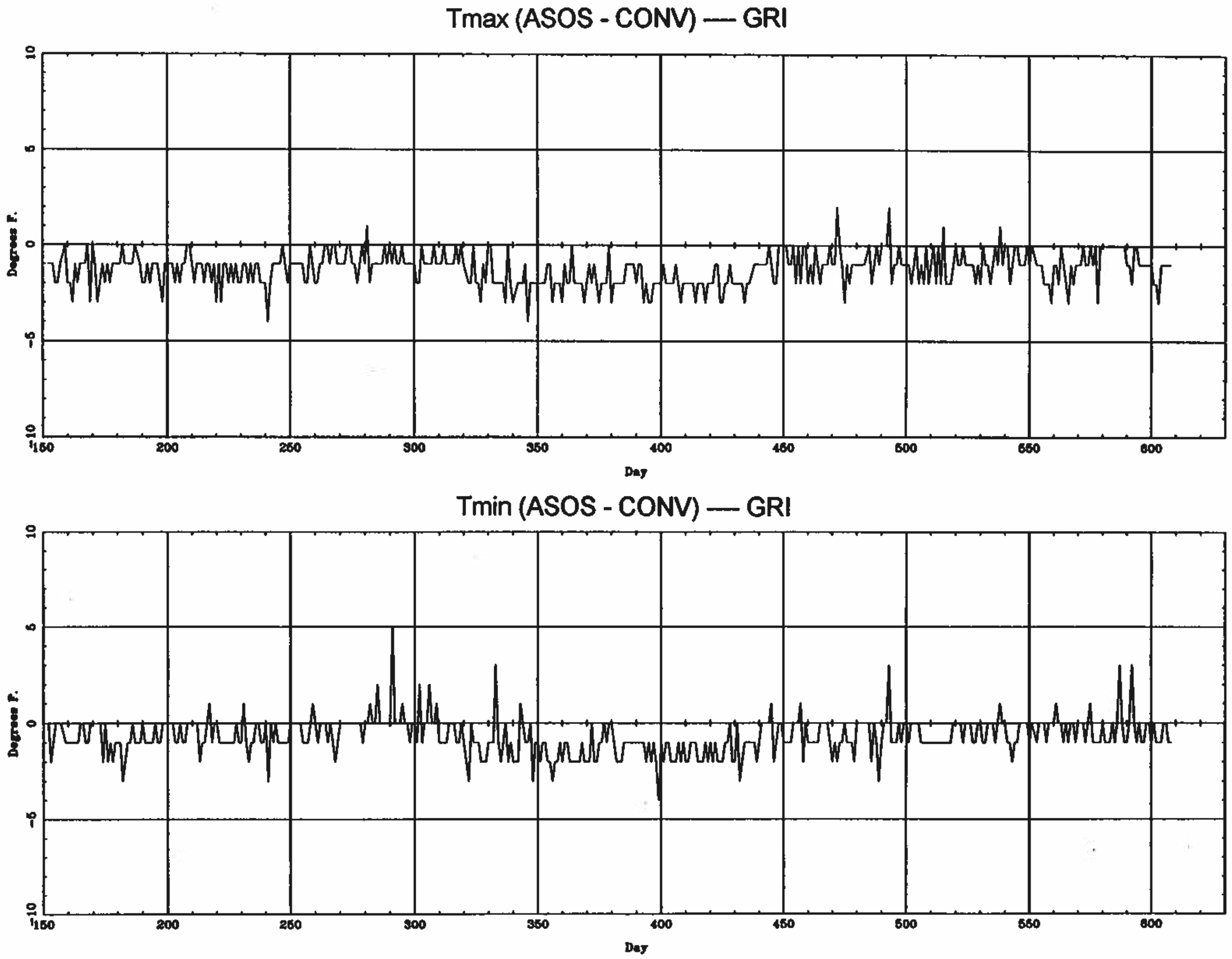


Figure 11h. Temperature time series of ASOS-CONV for maximum and minimum from June 1994 through August 1995 for GRI.

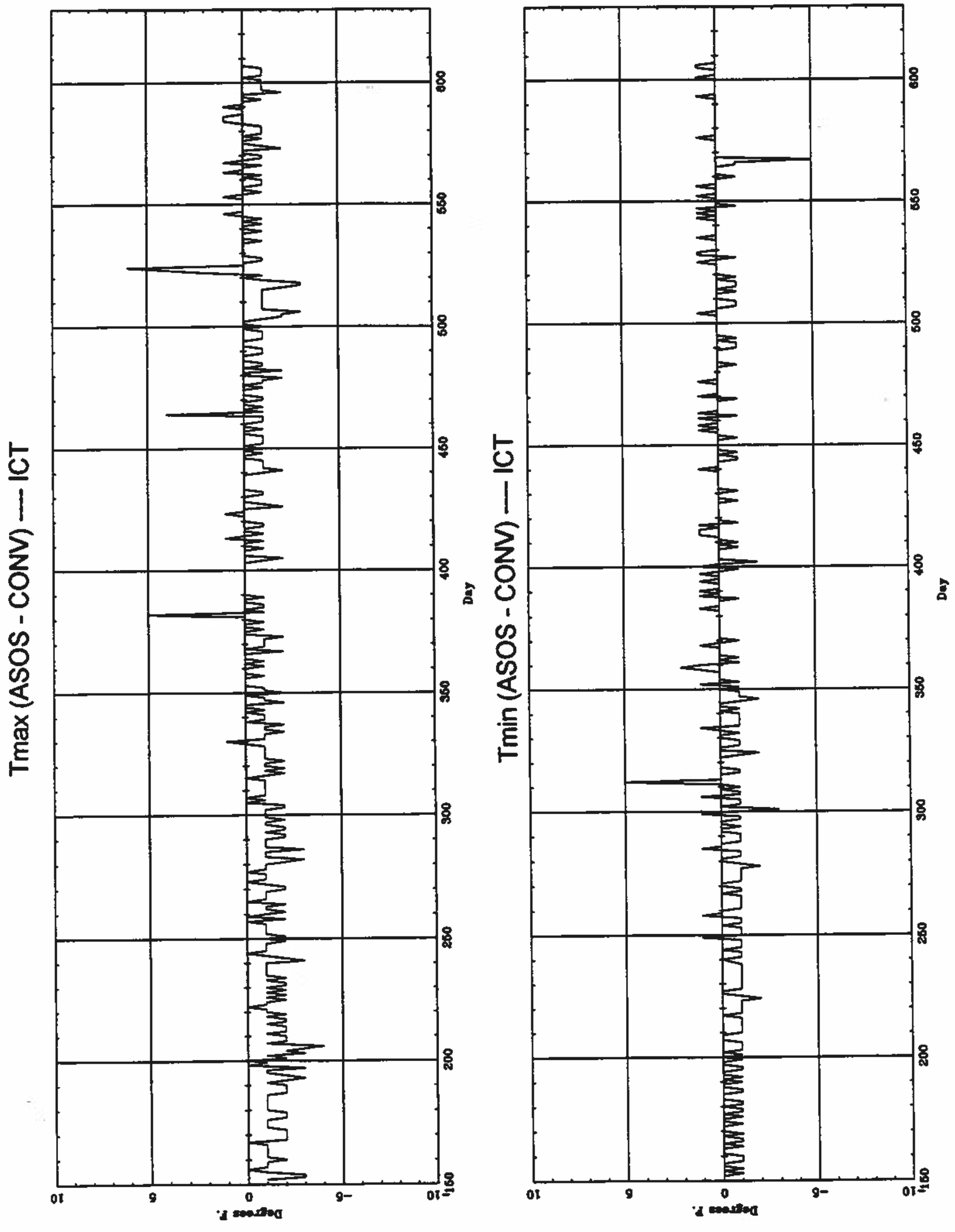


Figure 11*i*. Temperature time series of ASOS-CONV for maximum and minimum from June 1994 through August 1995 for ICT.

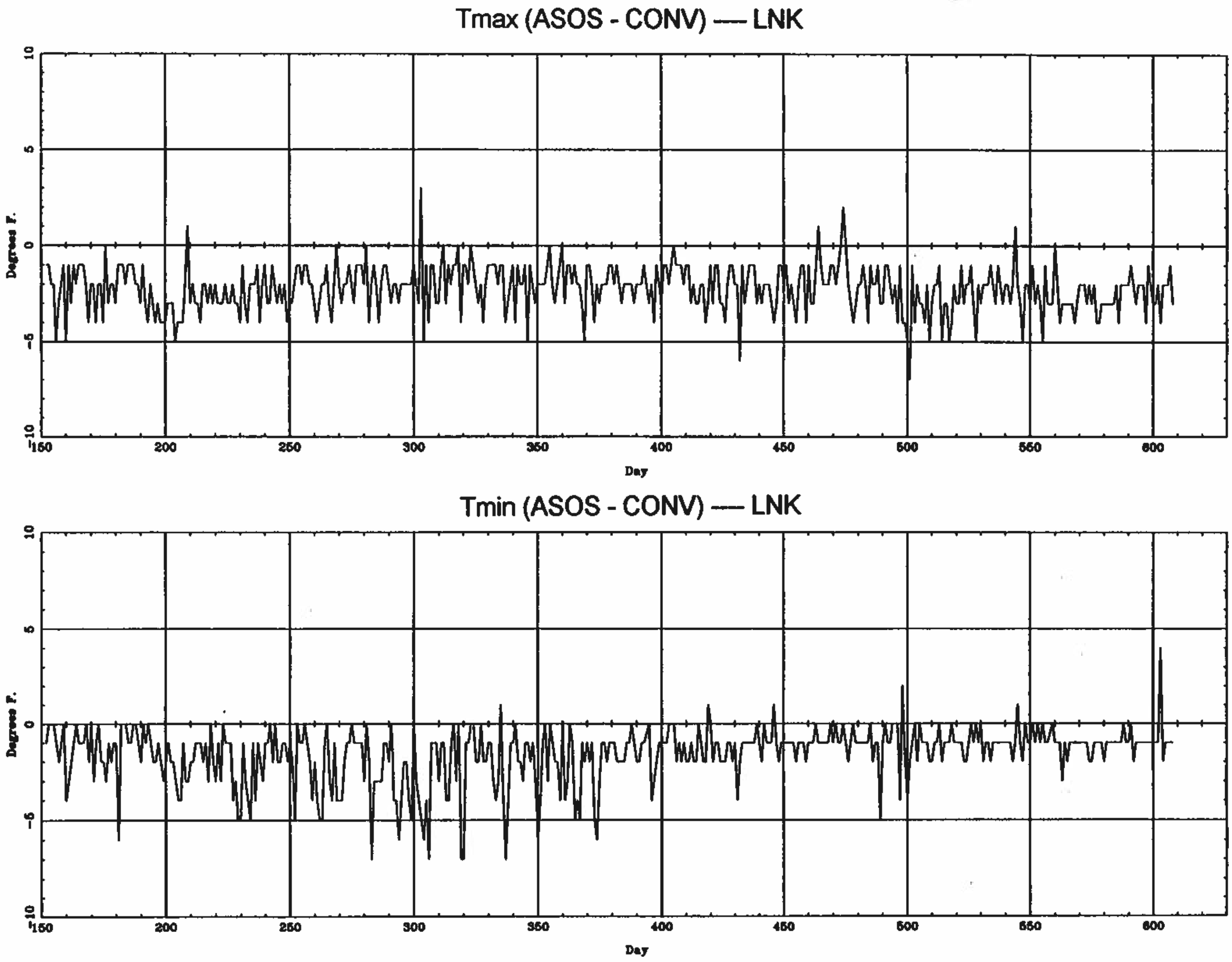
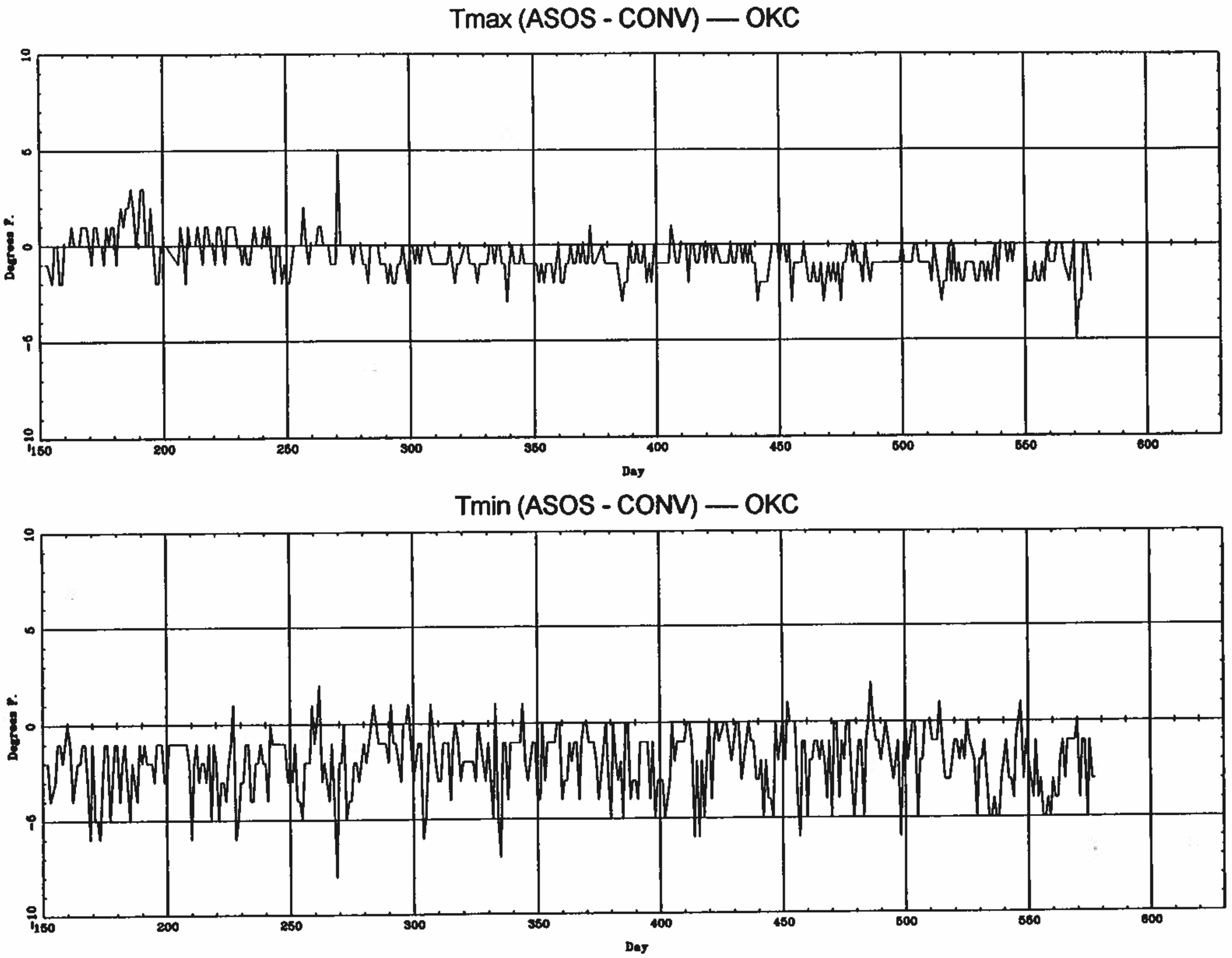


Figure 11j. Temperature time series of ASOS-CONV for maximum and minimum from June 1994 through August 1995 for LNK.



Tmax (ASOS - CONV) — OKC

Tmin (ASOS - CONV) — OKC

Figure 11k. Temperature time series of ASOS-CONV for maximum and minimum from June 1994 through August 1995 for OKC.

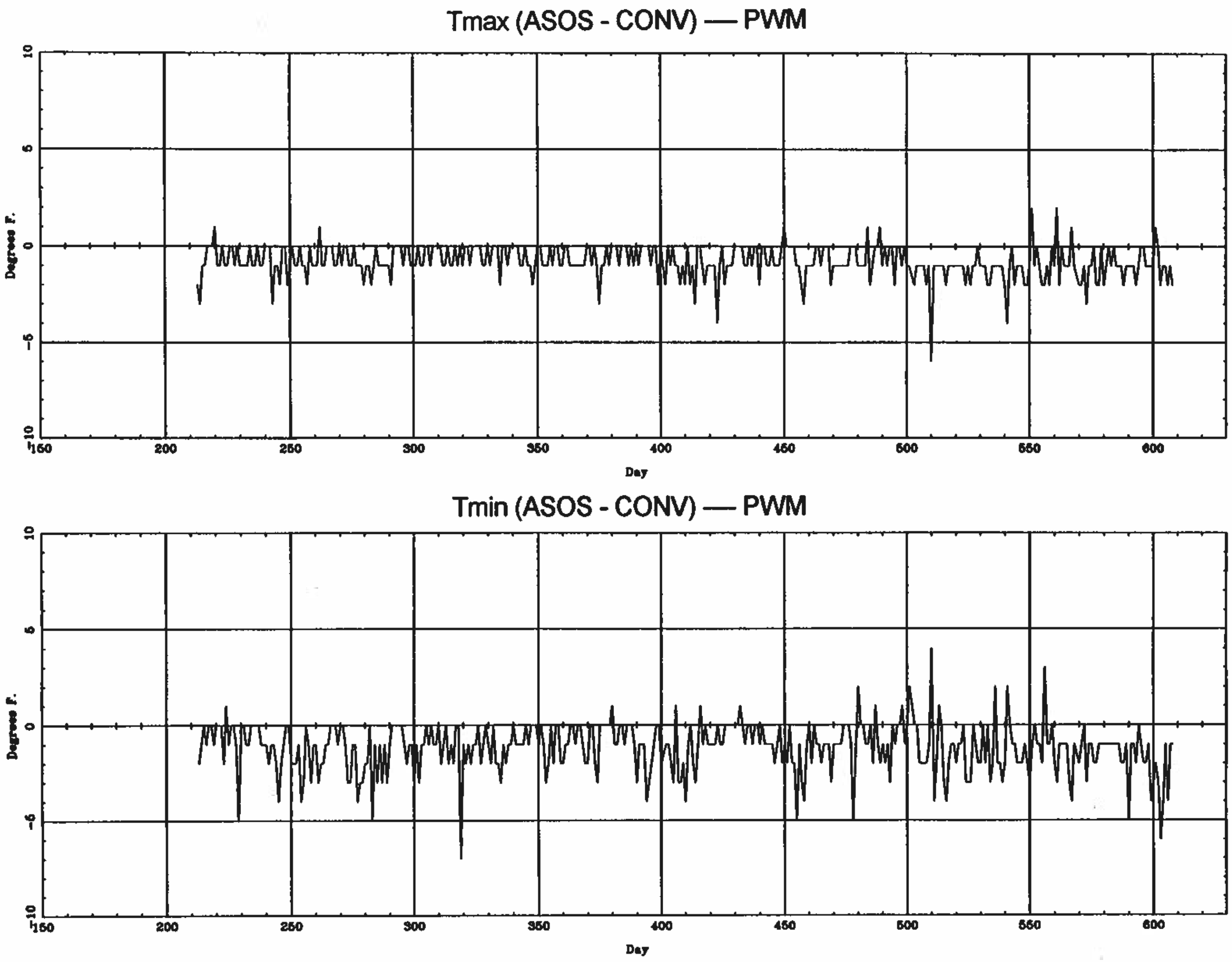


Figure 11ℓ. Temperature time series of ASOS-CONV for maximum and minimum from June 1994 through August 1995 for PWM.

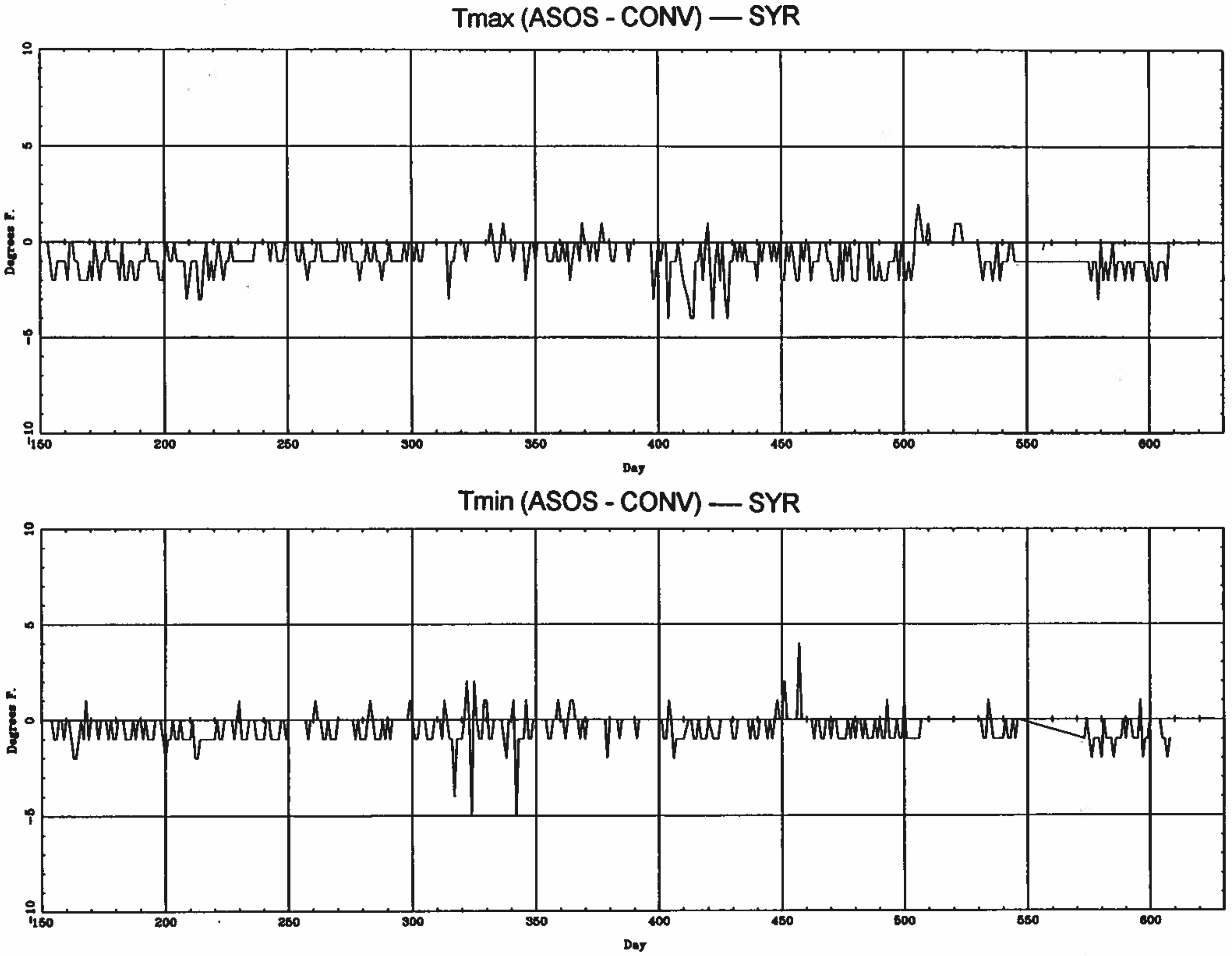


Figure 11m. Temperature time series of ASOS-CONV for maximum and minimum from June 1994 through August 1995 for SYR.

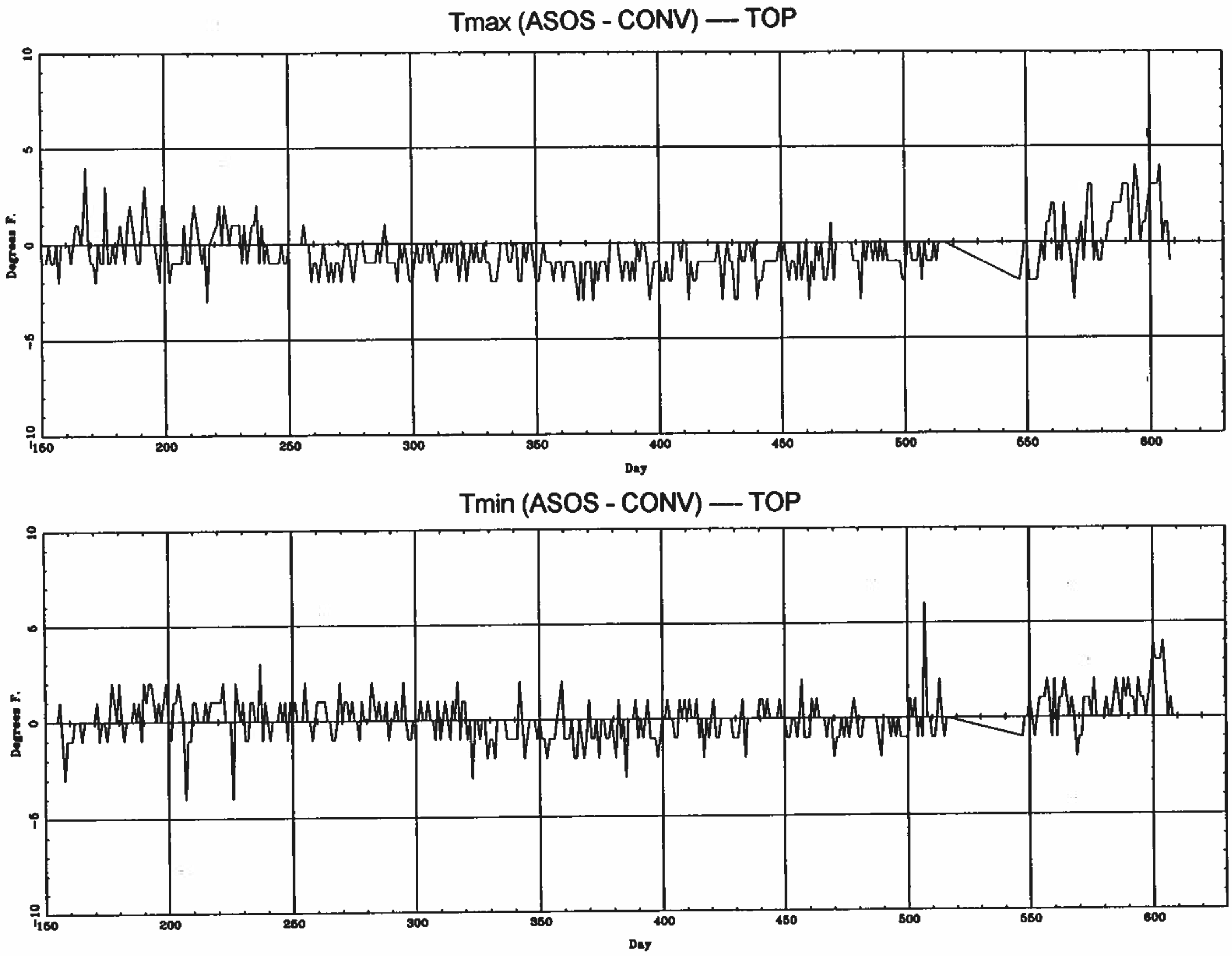


Figure 11n. Temperature time series of ASOS-CONV for maximum and minimum from June 1994 through August 1995 for TOP.

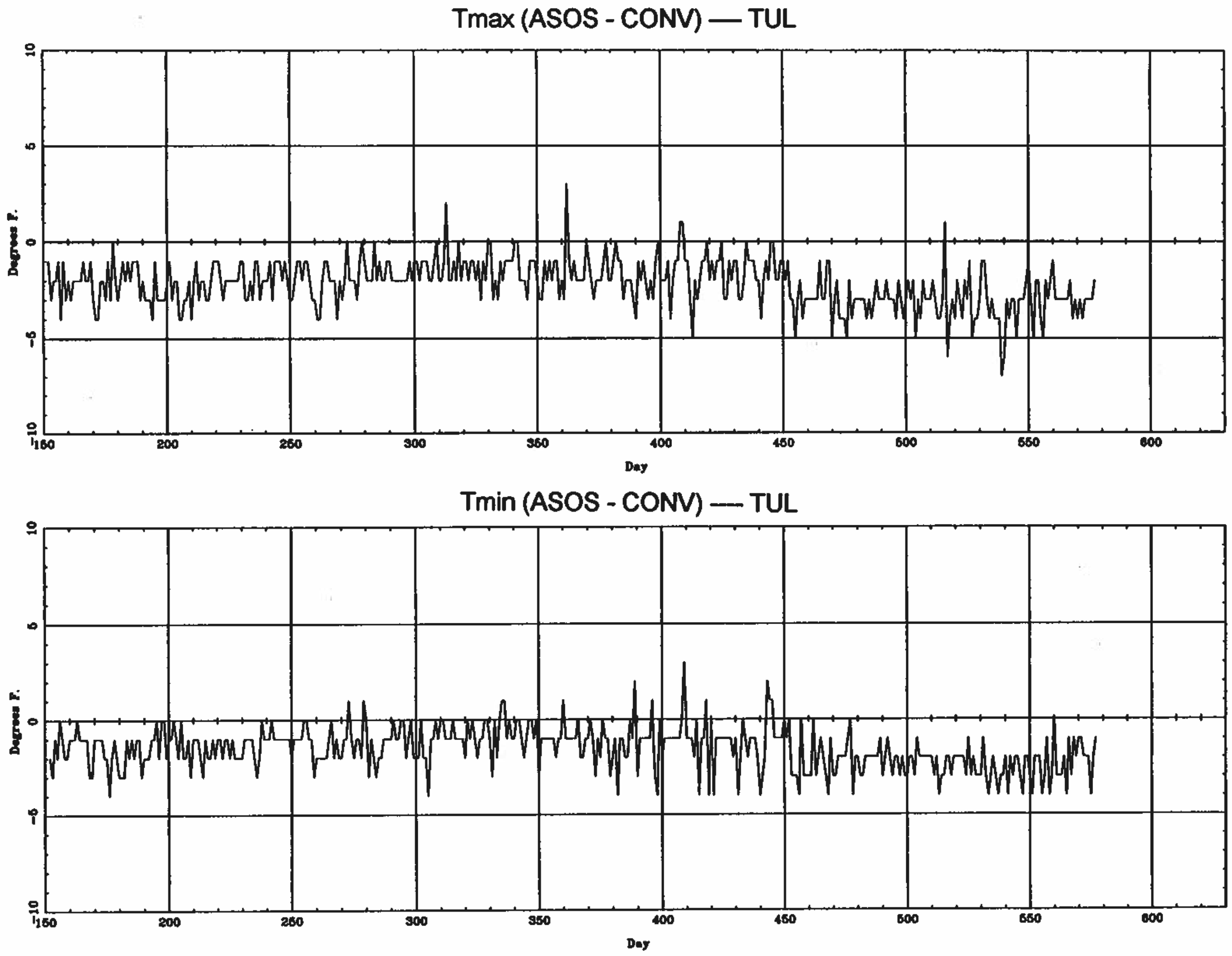


Figure 11o. Temperature time series of ASOS-CONV for maximum and minimum from June 1994 through August 1995 for TUL.

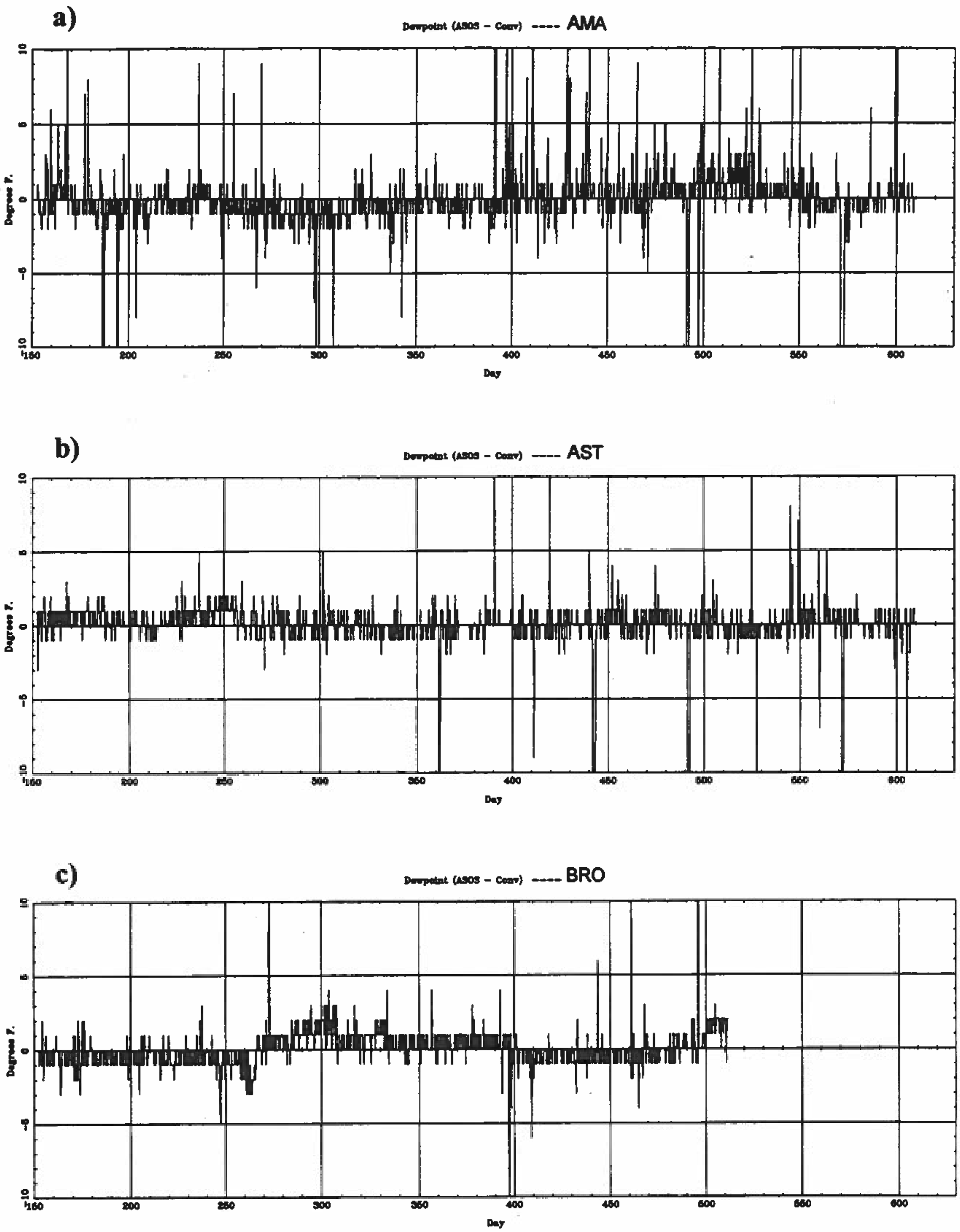


Figure 12a-c. Dewpoint temperature time series for 6 hourly ASOS-CONV observations for June 1994 through August 1995 for a) AMA, b) AST, c) BRO.

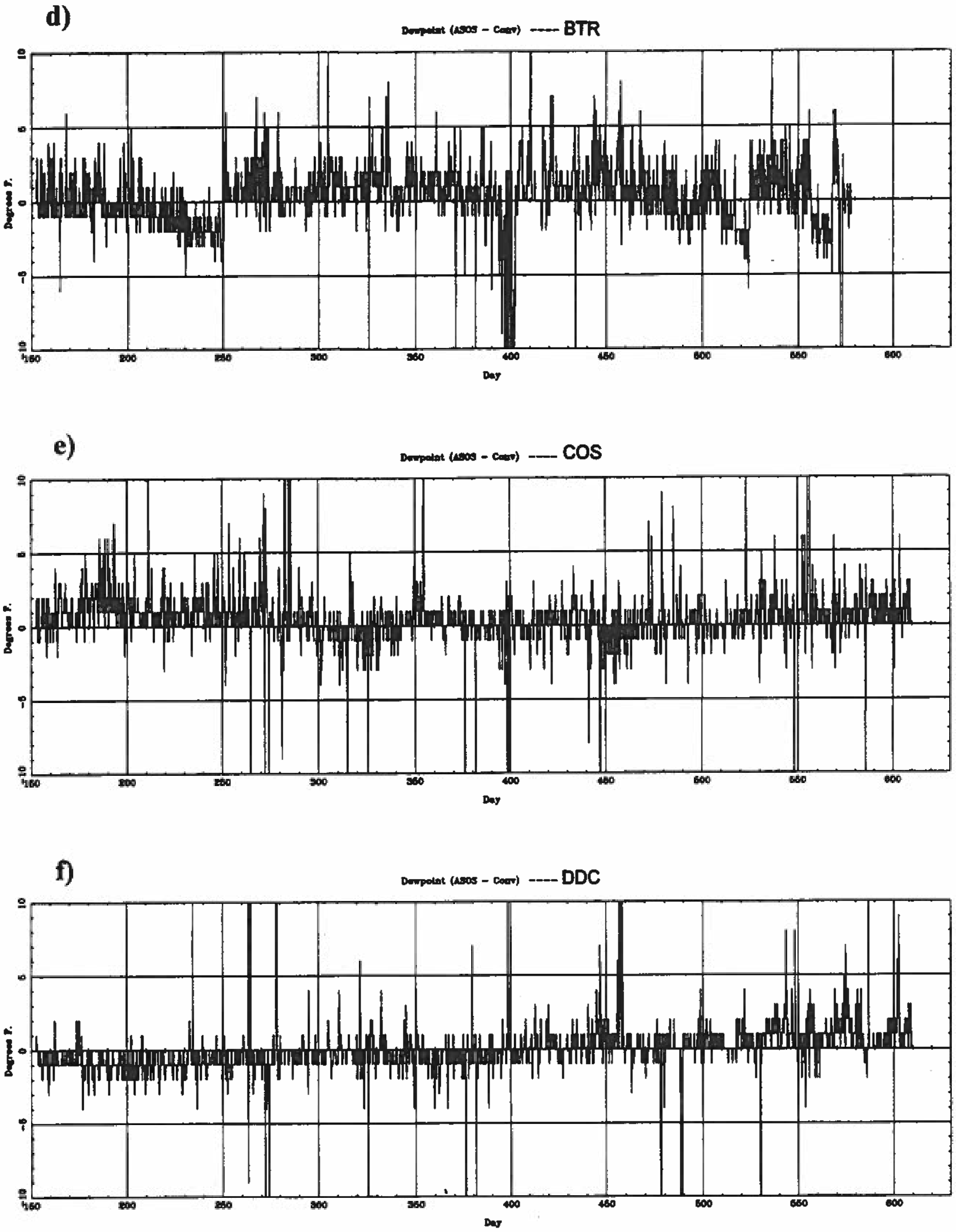


Figure 12d-f. Dewpoint temperature time series for 6 hourly ASOS-CONV observations for June 1994 through August 1995 for d) BTR, e) COS, f) DDC.

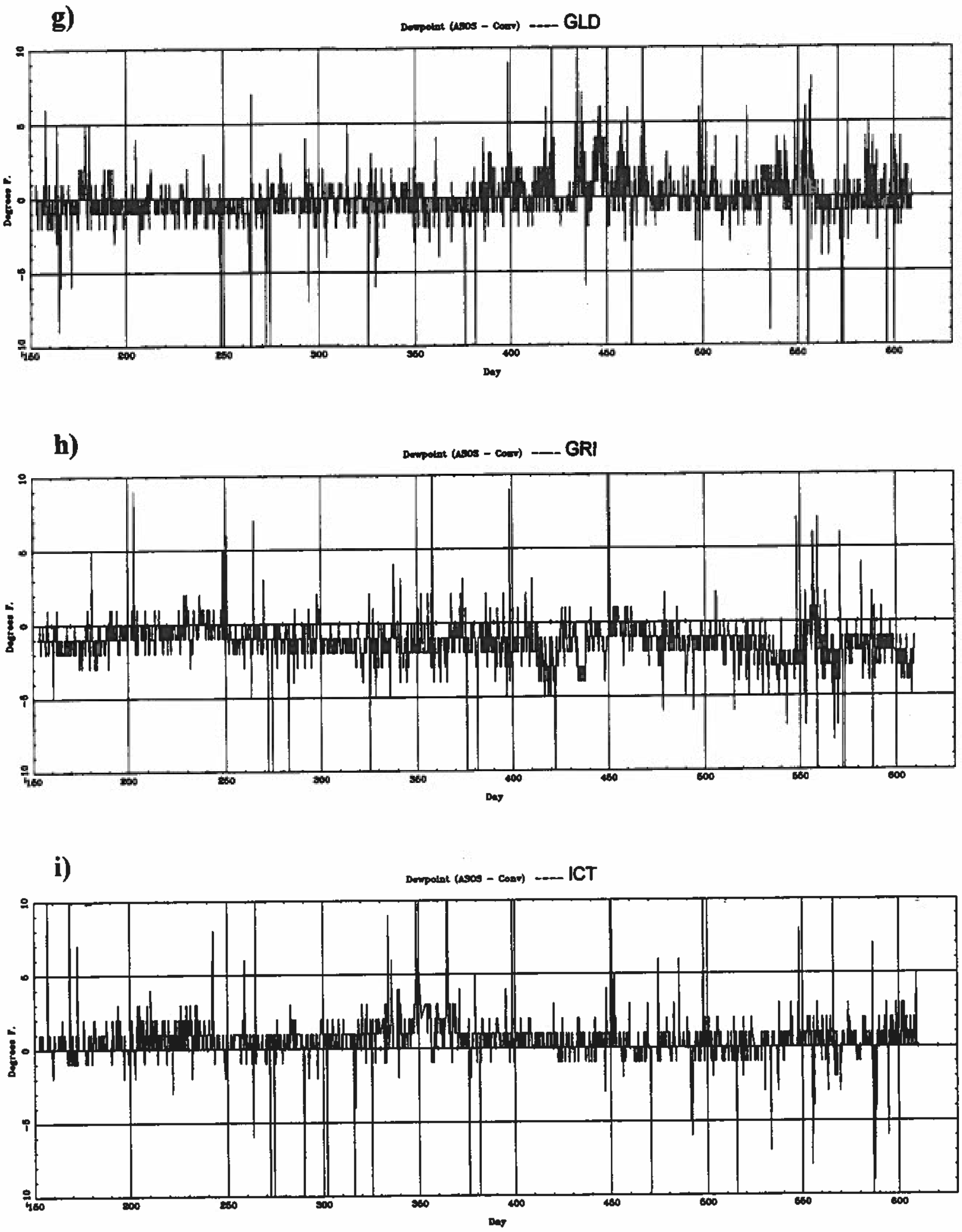


Figure 12g-i. Dewpoint temperature time series for 6 hourly ASOS-CONV observations for June 1994 through August 1995 for g) GLD, h) GRI, i) ICT.

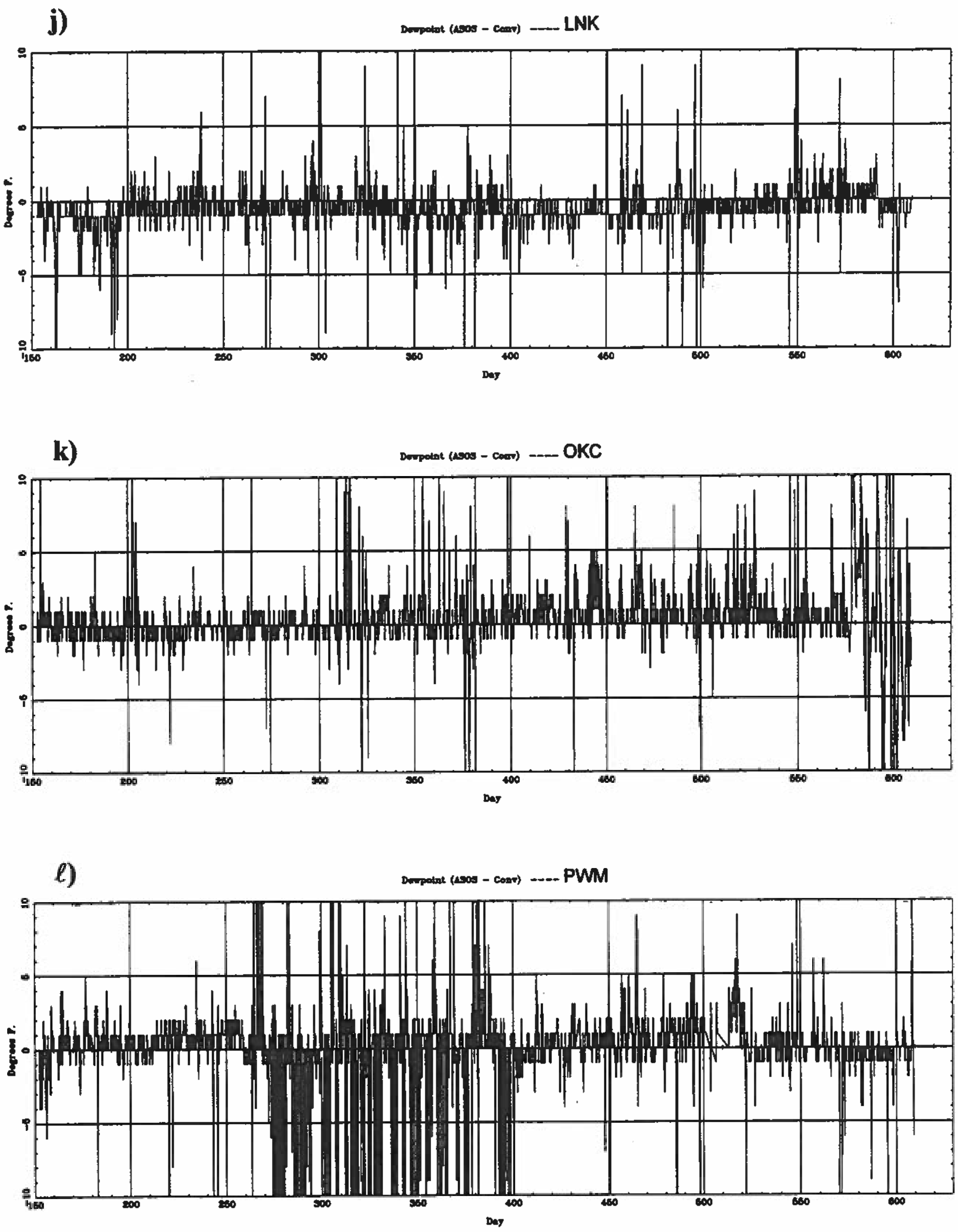


Figure 12j-ℓ. Dewpoint temperature time series for 6 hourly ASOS-CONV observations for June 1994 through August 1995 for j) LNK, k) OKC, ℓ) PWM.

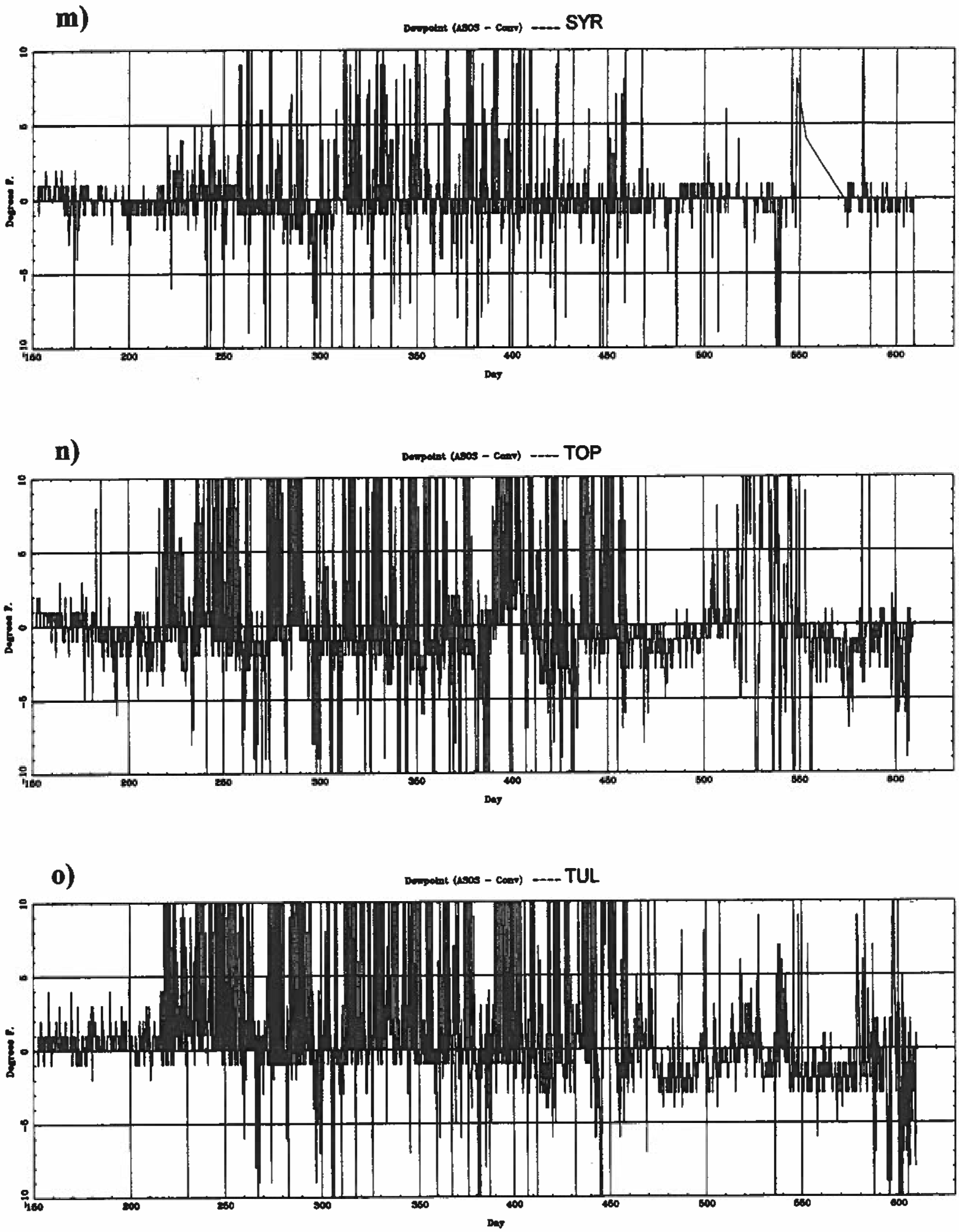


Figure 12m-o. Dewpoint temperature time series for 6 hourly ASOS-CONV observations for June 1994 through August 1995 for m) SYR, n) TOP, o) TUL.

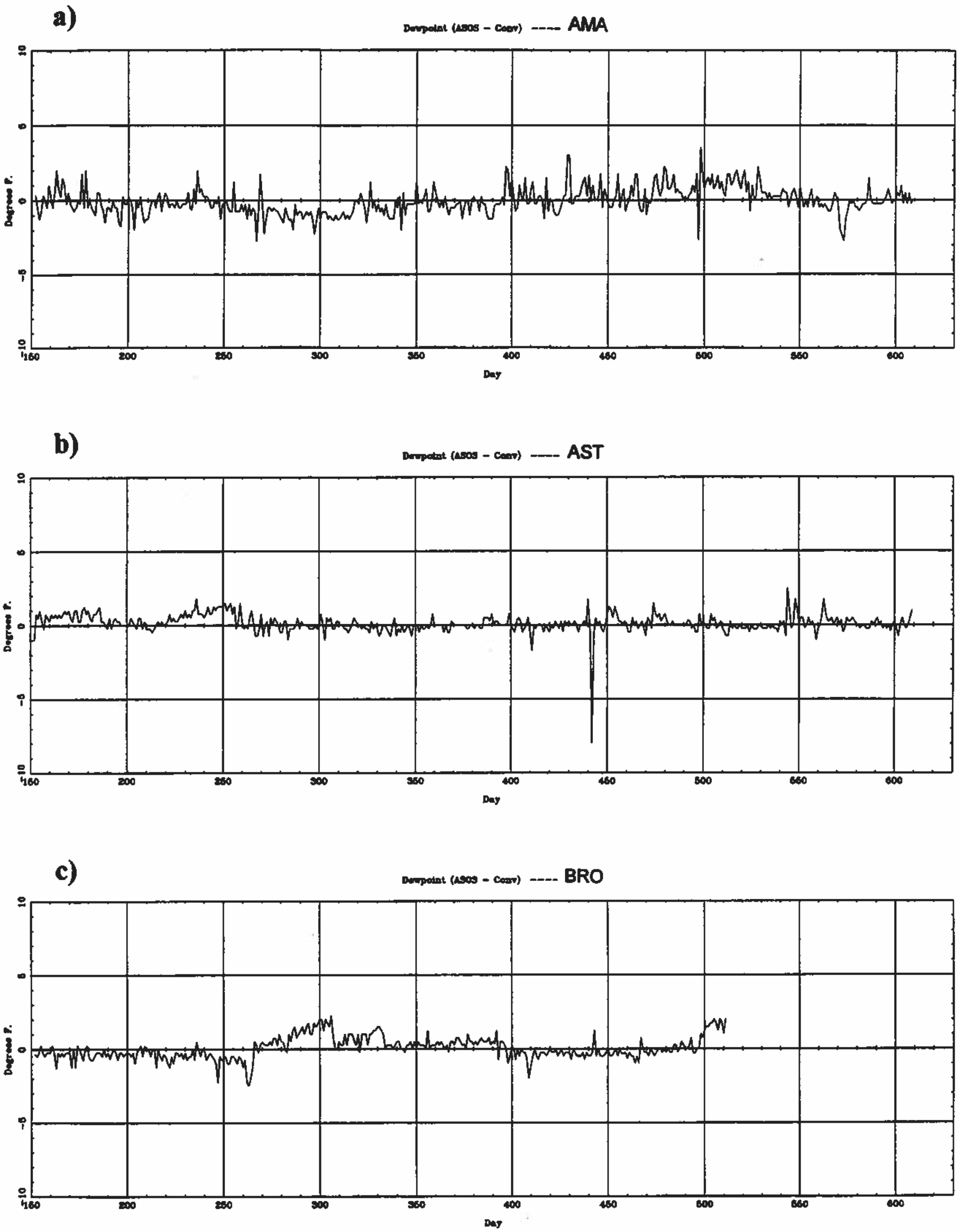


Figure 13a-c. Dewpoint temperature time series for daily average of 6 hourly ASOS-CONV observation for June 1994 through August 1995 for a) AMA, b) AST, c) BRO.

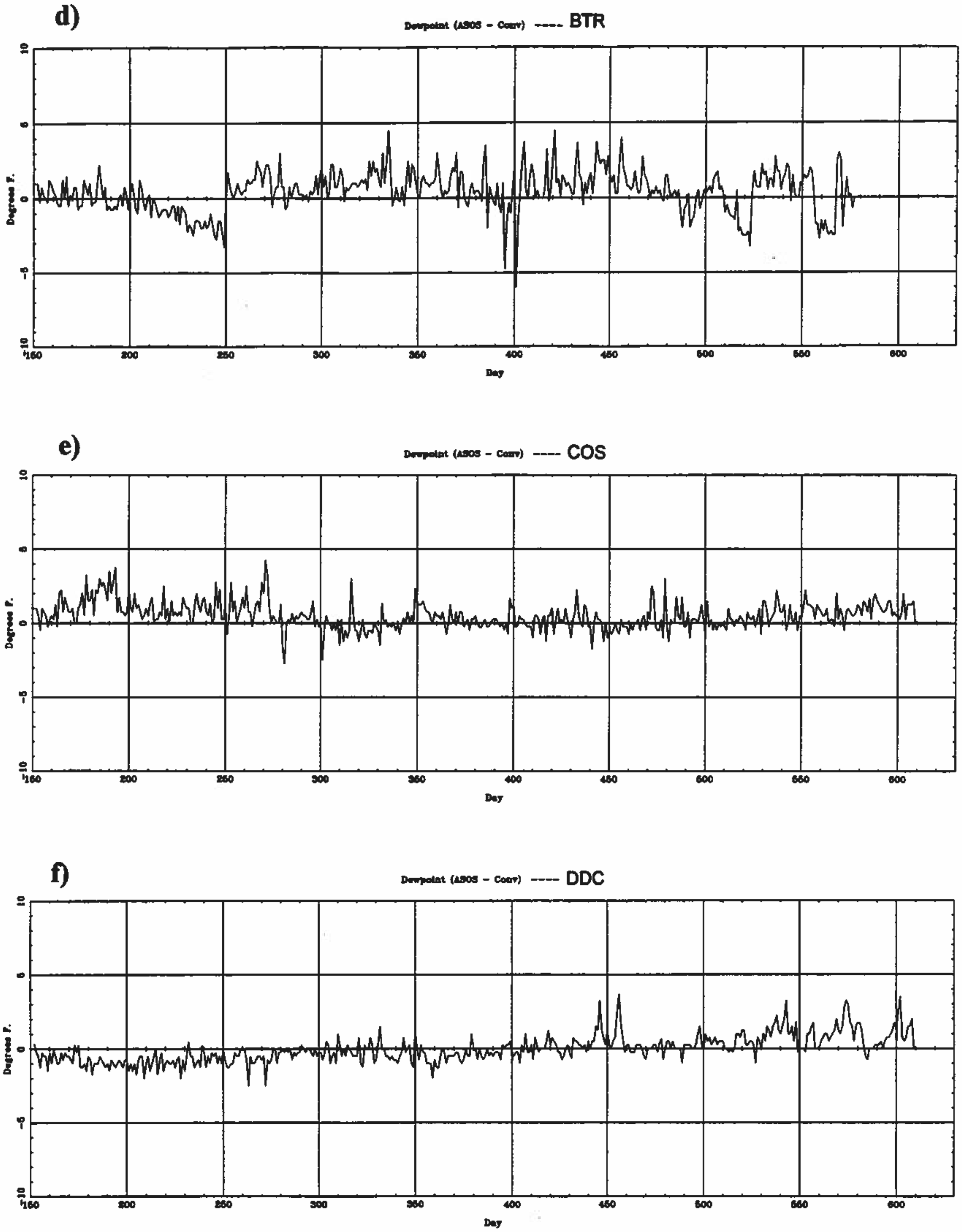


Figure 13d-e. Dewpoint temperature time series for daily average of 6 hourly ASOS-CONV observation for June 1994 through August 1995 for d) BTR, e) COS , f) DDC.

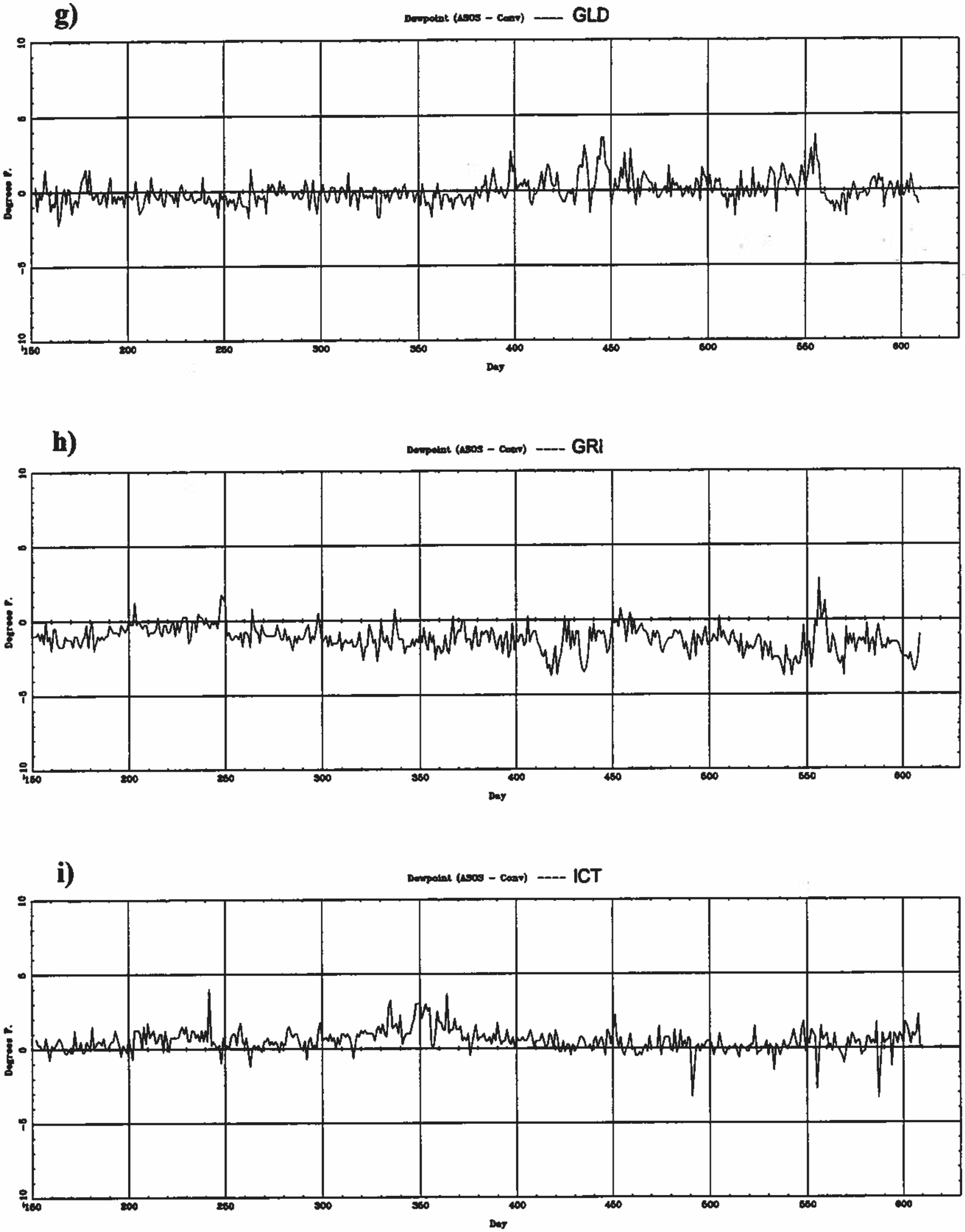


Figure 13g-i. Dewpoint temperature time series for daily average of 6 hourly ASOS-CONV observation for June 1994 through August 1995 for g) GLD, h) GRI, i) ICT.

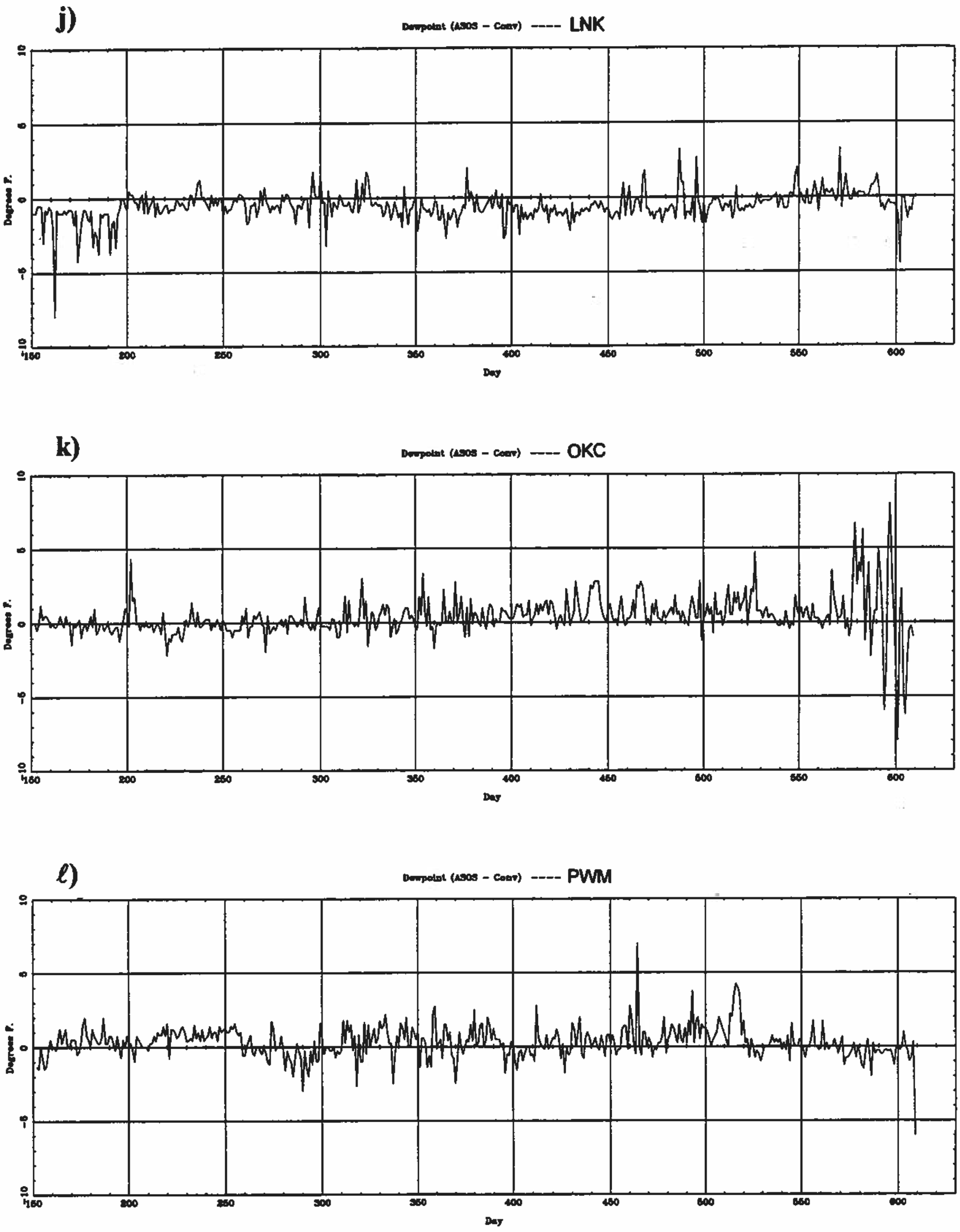


Figure 13j-ℓ. Dewpoint temperature time series for daily average of 6 hourly ASOS-CONV observation for June 1994 through August 1995 for j) LNK, k) OKC, ℓ) PWM.

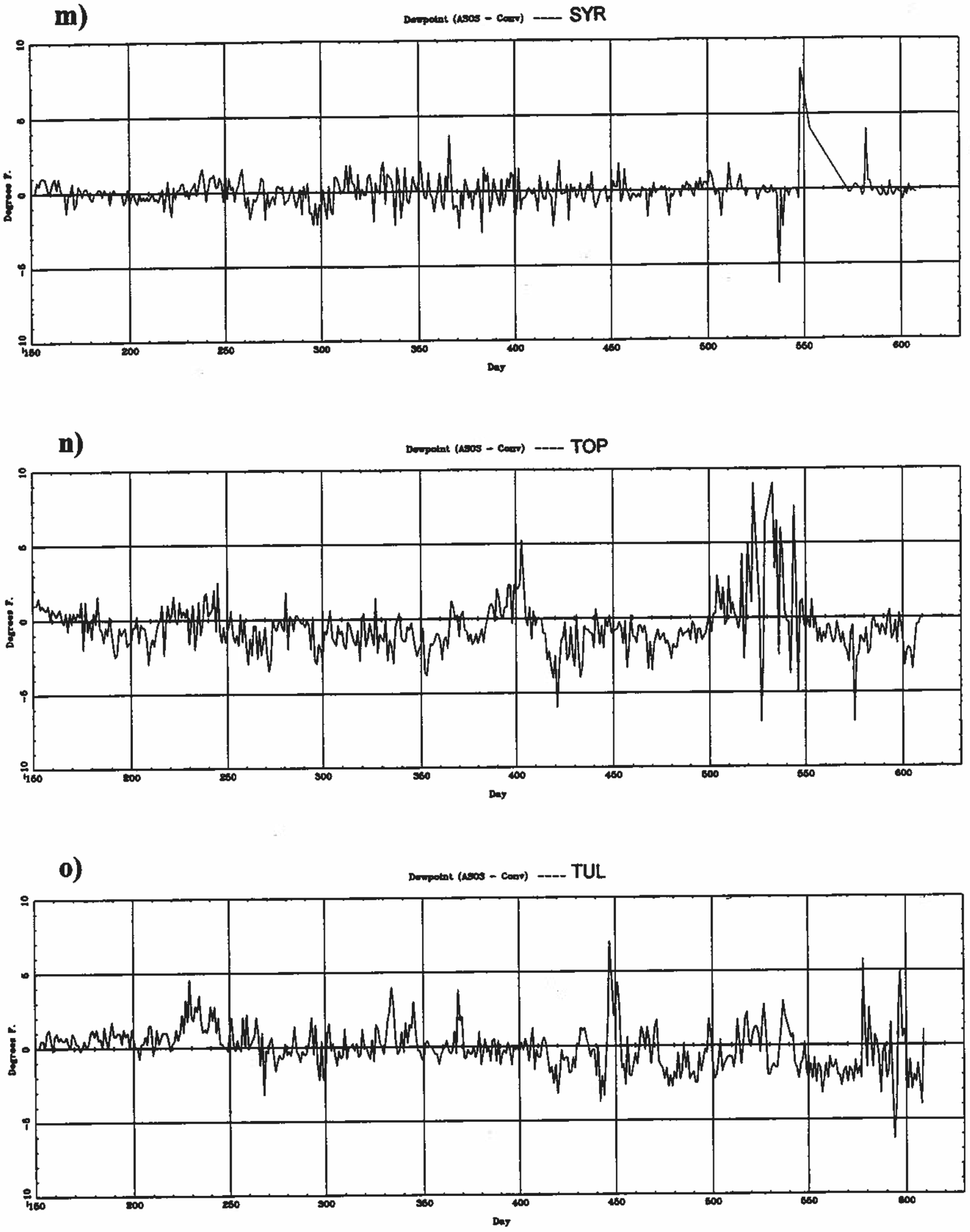


Figure 13m-o. Dewpoint temperature time series for daily average of 6 hourly ASOS-CONV observation for June 1994 through August 1995 for m) SYR, n) TOP, o) TUL.

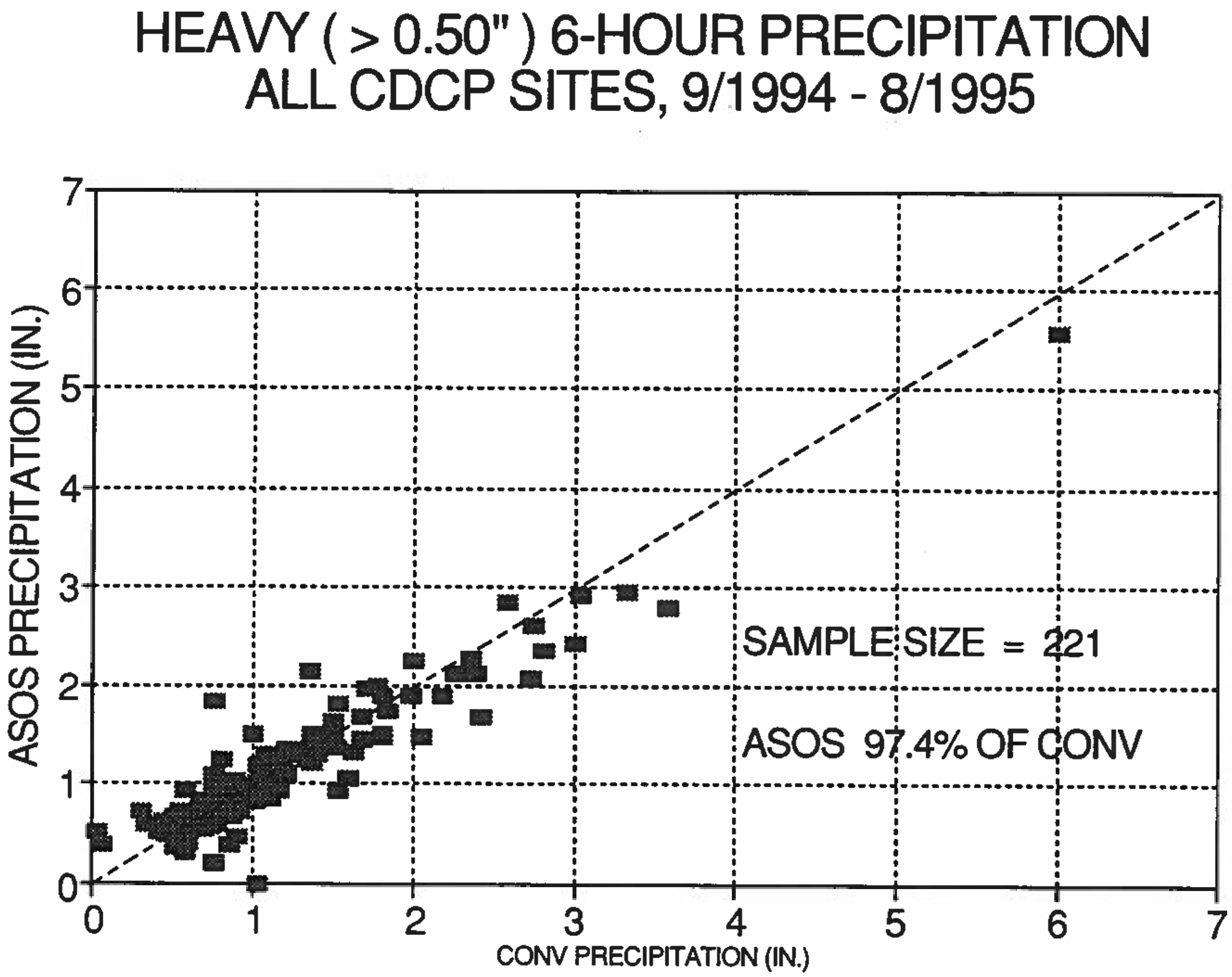


Figure 14. Comparison of ASOS and CONV six hourly precipitation for amounts larger than 0.5 inch for either ASOS or CONV for the period September 1994 through August 1995.

Appendix A.

Early Results of Climate Data Continuity with ASOS

Preprints, 11th AMS International Conference on
Interactive Information and Processing Systems (IIPS)
for Meteorology, Oceanography and Hydrology
15-20 January 1995, Dallas, TX

FA 16.3 EARLY RESULTS OF CLIMATE DATA CONTINUITY WITH ASOS

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1.0 INTRODUCTION AND PURPOSE

The introduction of the National Weather Service's (NWS) Automated Surface Observing System (ASOS), beginning in the fall of 1991, has attracted considerable attention. Users and providers of climatic information along with operational data users have become exceedingly interested in the accuracy of ASOS measurements and their consistency with respect to the conventional surface observations that they are replacing.

The Climate Data Continuity Project (CDCP) was initiated by the National Oceanic and Atmospheric Administration (NOAA) late in 1991 to ease the transition to ASOS for the many users of NWS surface weather observations. The goal for the CDCP was to identify and quantify biases and variations introduced by ASOS into the climate record. The project has matured to include the following six components: 1) Develop an extensive data set in the public domain of coincident ASOS and conventional (CONV) observations from selected sites in the U.S., 2) Make quantitative comparisons of ASOS temperature, humidity and precipitation measurements to previous CONV data (and other elements as needed), 3) Evaluate the effects of the transition to ASOS on the continuity of climatological data, 4) Assess the accuracy of ASOS temperature observations by comparison with a calibrated field standard, 5) Present results to the scientific community and 6) Provide recommendations to the NWS.

Previous papers have focused on ASOS-CONV comparisons made prior to ASOS commissioning (McKee et al., 1993) and during the first year of commissioned ASOS operations (McKee et al., 1994). During these periods only sites in the Central U.S. were included in the CDCP. During 1994, the commissioning of ASOS sites nationwide has accelerated. Additionally, various modifications and upgrades to ASOS have been proposed and implemented. Most noteably, a modified version of the hygrothermometer used to measure temperature and dew point has been developed and recently installed at most field sites. The modifications included an increased rate of aspiration, reversed direction of aspiration and increased stability in the electronics. With these modifications in place, the final phases of the temperature portion of the CDCP are now underway.

2.0 DATA

Sixteen sites in the Central U.S. were originally selected for the CDCP. Of these, only 13 sites were commissioned (Table 1) and included in analyses to date. Nationally, 18 sites have been approved for CDCP analysis (Table 2). As of August 1994, six of these have been commissioned. Commissioning of the remaining sites will continue gradually. Upon commissioning, these sites will be added to CDCP analyses.

Table 1.
Climate Data Continuity Study (CDCP) Comparison Sites in the Central United States

Site ID	Station Name	Modified Hygrotherm Installed	Commissioned Date
ALS	Alamosa, CO	12/8/93	9/1/92
AMA	Amarillo, TX	1/10/94	11/1/92
COS	Colo. Springs, CO	11/30/93	11/1/92
CNK	Concordia, KS	1/7/94	9/1/92
DDC	Dodge City, KS	1/11/94	9/1/92
GLD	Goodland, KS	2/11/94	9/1/92
GRI	Grand Island, NE	12/21/93	10/1/92
ICT	Wichita, KS	12/6/93	11/1/92
LNK	Lincoln, NE	5/20/94	11/1/92
OKC	Oklahoma City, OK	11/1/93	10/1/92
PUB	Pueblo, CO	3/31/94	10/1/92
SGF	Springfield, MO	2/17/94	delayed
TOP	Topeka, KS	12/1093	12/1/92
TUL	Tulsa, OK	11/22/93	10/1/92

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* *Corresponding author's address:* Thomas B. McKee, Colorado Climate Center, Atmospheric Science Dept, Colorado State University, Fort Collins, CO 80523.

Table 2.
Climate Data Continuity Study (CDCP)
National Expansion Sites

Site ID	Station Name	Modified Hygrotherm Installed	Commis-sioned Date
ACY	Atlantic City, NJ		
AST	Astoria, OR	4/28/94	3/1/93
BIL	Billings, MT	9/17/93	
BIS	Bismarck, ND		
BRO	Brownsville, TX	11/15/93	5/1/94
BRW	Barrow, AK	8/10/94	
BTR	Baton Rouge, LA	3/2/94	11/93
DAB	Daytona Beach, FL	12/14/93	
ELY	Ely, NV	12/16/93	6/1/94
GRR	Grand Rapids, MI	11/15/93	
ITO	Hilo, HI	3/18/94	
ADQ	Kodiak, AK	7/1/93	
PAH	Paducah, KY	6/30/94	
PWM	Portland, ME	3/25/94	8/1/94
SJU	San Juan, PR		
SMX	Santa Maria, CA	3/20/94	
SYR	Syracuse, NY	1/15/94	12/93
TUS	Tucson, AZ	5/16/94	

Data for the CDCP consists of ASOS high resolution 1-minute data, hourly surface observations (SAOs) and ASOS-generated summary of the day data sets from each commissioned CDCP site. Upon commissioning, CDCP sites continue reading and recording conventional (CONV) data but on a much more limited basis. Observations every 6 hours (0000, 0600, 1200 and 1800 UTC) of current temperature, dew point, visibility, cloudcover and weather conditions along with 6-hour maximum and minimum temperature, precipitation, snowfall and snowdepth are recorded manually and provided to the National Climatic Data Center and the Colorado Climate Center. Together these data sets provide what is needed to compare ASOS with conventional climate data.

The value of data comparisons and climate data continuity studies is reduced when system and instrument changes occur frequently. This was the case with temperature and humidity comparisons earlier in the CDCP. However, since modified hygrothermometers have been deployed at most comparison sites, results now become more significant. A 15-month final comparison period for evaluating ASOS-CONV temperature and dew point biases and relationships has been established. For all commissioned CDCP sites with the modified hygrothermometer, 1 June 1994 was chosen as the

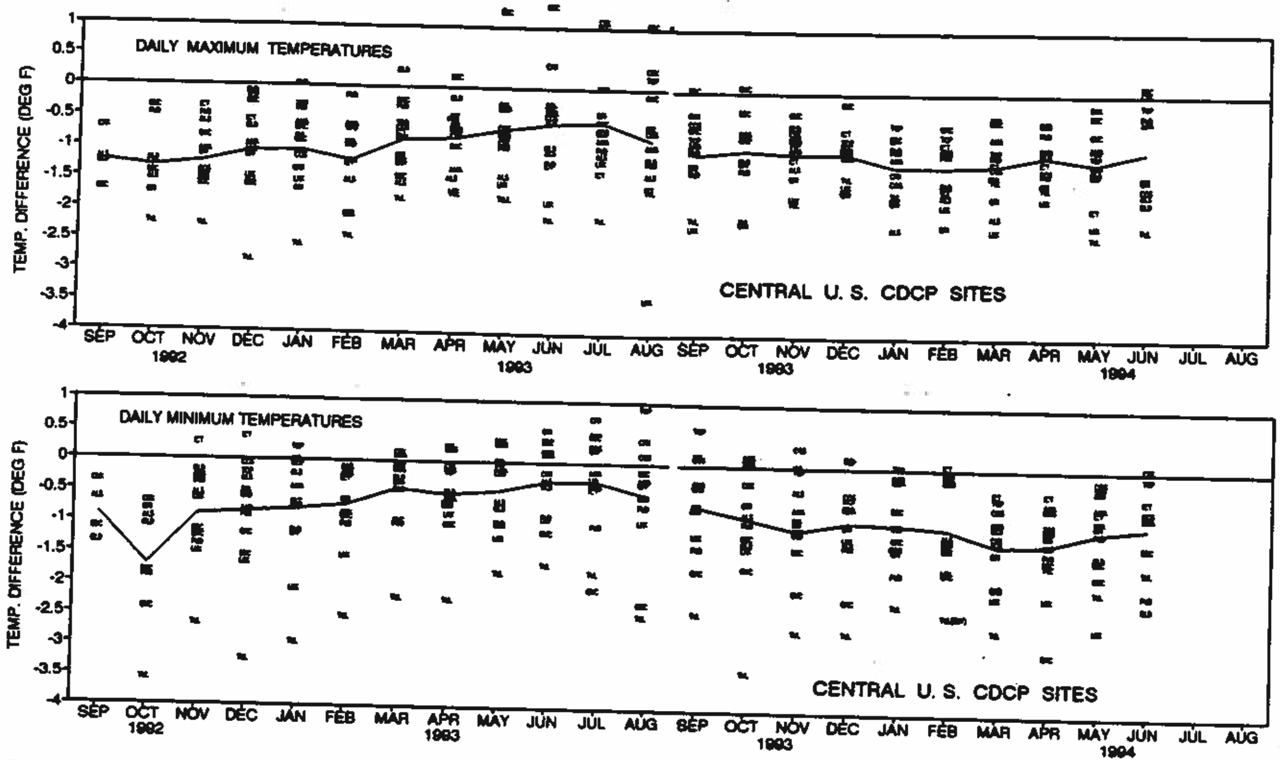

Figure 1. Mean monthly ASOS-CONV temperature differences (Deg. Fahrenheit) for daily maximum temperatures (top) and minimum temperatures (bottom) for all 13 commissioned ASOS CDCP sites in the Central U.S. from date of commissioning through June 1994. Individual monthly station differences are shown along with a composite average (solid line).

beginning of the 15-month test. Other stations will begin their final 15-month comparisons as they meet these two conditions.

3.0 RESULTS

3.1 Temperature

The general tendency for ASOS to read cooler than CONV has persisted from the very beginning. Figure 1 shows mean monthly differences for the 13 Central U.S. comparison sites since commissioning. Relationships vary from station to station and have changed over time at individual stations. Overall, daily maximum temperatures have averaged about 1.0°F cooler with ASOS than CONV while minimum temperatures have averaged 0.8°F cooler. So far, only limited data are available nationally (Figure 2). The same general results have been observed except that there may be more sites in the national comparison where ASOS minimum temperatures are equal to or warmer than CONV.

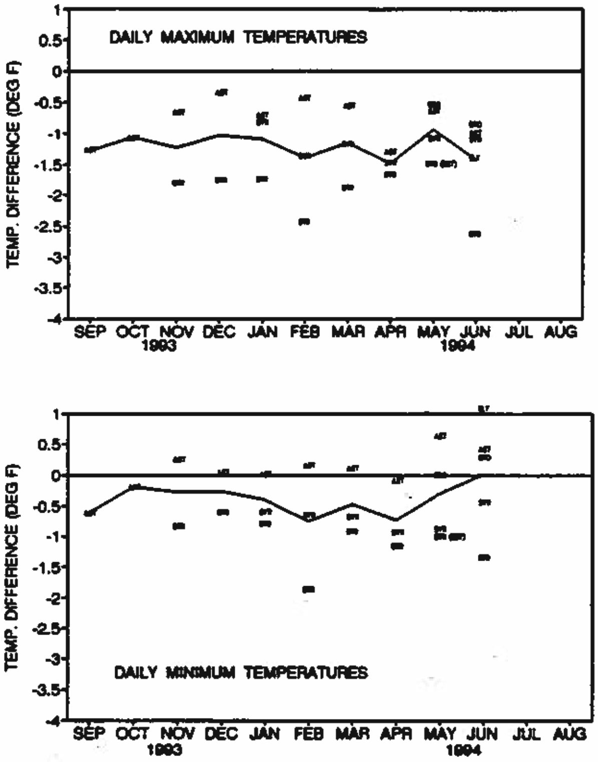

Figure 2. Mean monthly ASOS-CONV temperature differences (Deg. Fahrenheit) for daily maximum temperatures (top) and minimum temperatures (bottom) for commissioned ASOS national CDCP expansion sites from date of commissioning through June 1994. Individual monthly station differences are shown along with a composite average (solid line).

During the first year of commissioned ASOS intercomparisons, numerous discontinuities in the ASOS-CONV temperature relationship were observed. These discontinuities, many of which could be traced to modifications or servicing of either the ASOS or the CONV hygrothermometer, contributed considerably to variability in the ASOS-CONV relationship. Since the installation of modified hygrothermometers, fewer discontinuities have been observed. Large station-to-station differences continue, however.

ASOS-CONV data continuity results are complicated by the fact that instruments are not co-located. Instrument separation ranges from just a few hundred feet to more than one mile. Since all CDCP sites are at airports, little elevation differences are noted. However, local exposure and vegetation differences can be significant. Therefore, the observed ASOS-CONV differences are composed of actual instrument biases in combination with station location differences. To better quantify the roles of these two factors, side-by-side measurements are needed. For this purpose, an R. M. Young calibrated aspirated precision thermometer has been acquired. Direct intercomparisons at three sites, OKC, TUL and COS were performed prior to the beginning of the 15-month comparison. Early results suggest that ASOS temperatures have been cooler than the calibrated field instrument. More intercomparisons are planned during the 15-month test following further calibration of field sensors at the NWS Test Facility in Sterling, Virginia during September 1994.

3.2 Dew Point and Relative Humidity

Table 3 shows ASOS-CONV differences for 6-hourly temperatures, dew points and relative humidities based on data collected since the modified hygrothermometers have been installed. Early comparisons of dewpoint temperatures have shown very small differences at most stations. Only GRI has shown an average dew point difference of more than one degree. Among the Central U.S. sites, the average ASOS-CONV dewpoint difference has been -0.1°F. So far, among three national sites from more humid climates, the average difference has been +0.4°F. A characteristic of the dew point differences that has been observed so far is that while most differences are very small, occasional large differences (> ± 8°F) occur at most stations. These large differences may be inherent to the chilled mirror technology used in both the CONV and the ASOS hygrothermometers. Relative humidities computed from ASOS temperature and dewpoint measurements have systematically been higher by 1 to 3.5% at nearly all stations.

Table 3.
ASOS-CONV differences based on 6-hourly data for months since modified hygrothermometer installed through June 1994

		Difference		
Station	Months	Temp. (°F)	Dew Point (°F)	Relative Humidity (%)
CENTRAL U.S.				
ALS	1-6/94	-1.6	-0.8	+1.2
AMA	2-6/94	-0.5	-0.1	+0.4
COS	12/93-6/94	-0.7	+0.1	+1.5
CNK	2-6/94	-0.4	-0.0	+1.0
DDC	2-6/94	-0.8	-0.2	+1.7
GLD	3-6/94	-1.2	-0.7	+1.0
GRI	1-6/94	-1.2	-1.4	-0.3
ICT	1-6/94	-0.7	+0.7	+2.7
LNK	4-5/94	-1.4	-0.2	+2.0
OKC	11/93-5/94	-1.3	+0.3	+3.3
PUB	4-6/94	-1.0	+0.5	+1.5
TOP	1-6/94	-0.2	+0.4	+1.0
TUL	12/94-6/94	-1.7	-0.3	+3.4
NATIONAL EXPANSION SITES				
AST	5-6/94	-0.4	+0.3	+1.6
BRO	5-6/94	NA	NA	NA
BTR	3-6/94	-1.3	+0.2	+3.2
ELY	6/94	NA	NA	NA
SYR	2-6/94	-0.8	+0.7	+3.5

3.3 Precipitation

Significant differences have been observed in precipitation totals from ASOS when compared to CONV. ASOS uses a heated tipping bucket precipitation gage (HTB) while CONV observations are taken from universal weighing gages. Since commissioning, ASOS precipitation as a percent of CONV combined for the Central U.S. sites has shown a distinct seasonal pattern (Figure 3). With nearly two annual cycles completed, ASOS has measured significantly less precipitation during winter and summer. Autumn and spring totals have been much more similar. Individual station comparisons are shown in Figure 4. Since September 1993, most CDCP sites in the Central U.S. have received less ASOS precipitation than CONV. Of the national expansion sites, differences are not large for those sites that have received primarily rain. Astoria, OR (AST) systematically measures slightly more ASOS precipitation than CONV. At Syracuse, New York (SYR) large differences persist. SYR is the only CDCP national expansion site commissioned so far where significant quantities of precipitation fall as snow.

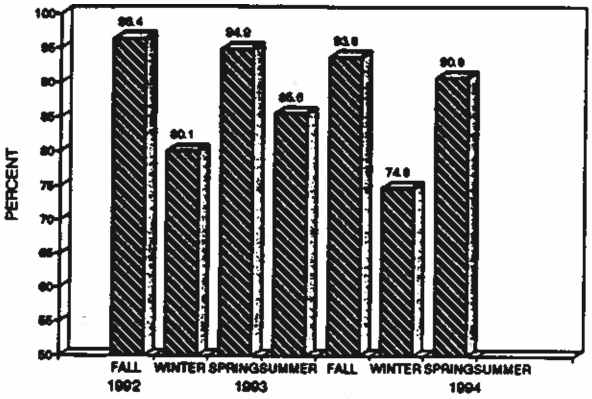

Figure 3. ASOS precipitation as a percent of CONV, by season, for each three-month period September 1992 through May 1994 based on all Central U.S. CDCP comparison data since commissioning.

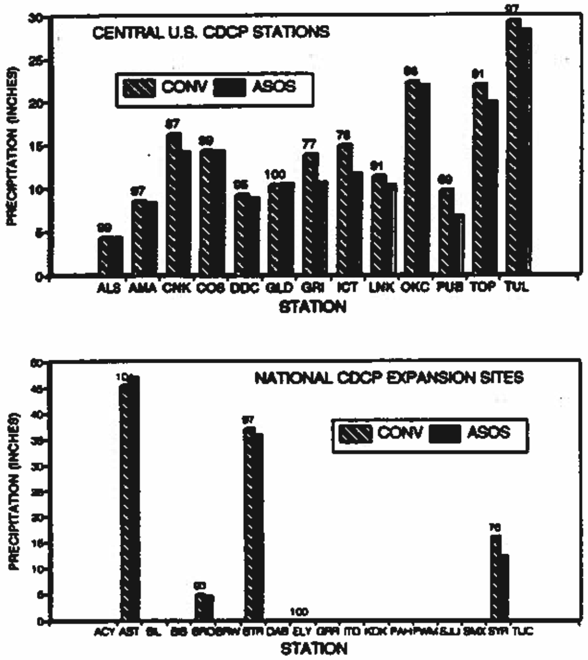

Figure 4. Comparison of total cumulative CONV and ASOS precipitation from September 1993 or date of commissioning (if after Sep. 1993) through June 1994 for each CDCP site in the Central U.S. (top) and national expansion sites (bottom). The number above the bars shows ASOS precipitation as a percent of CONV for each site.

The primary reasons for the lower precipitation measurements by ASOS have been traced to snow and heavy rain. Deficiencies in the HTB resulting in undermeasurement of intense precipitation may be overcome by a set of gage modifications which include a new switch that signals the occurrence of each tip (0.01" precipitation increment), an extension of the funnel to bring the top closer to the tipping bucket, and a redesign of mechanical stops to prevent the tipping bucket from sticking. The snow problem is more difficult. For the second winter in a row, precipitation that fell as snow, especially at temperatures below the freezing point, were significantly undermeasured by ASOS (Figure 5).

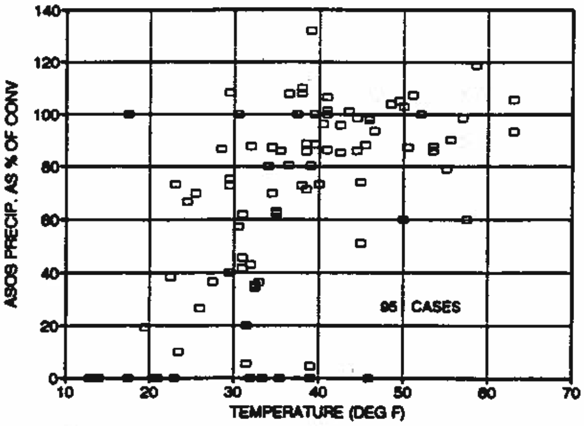

Figure 5. ASOS precipitation as a percent of CONV precipitation plotted as a function of temperature for each storm event, November 1993 through March 1994, with at least 0.10" of CONV precipitation within 36 hours for all 13 commissioned CDCP sites in the Central U.S.

4.0 PERSPECTIVE

A great deal has been learned about temperature, humidity and precipitation information from ASOS data and how it compares to CONV. This has helped justify several modifications and proposed future changes to ASOS. In the year ahead, the CDCP will focus on the 15-month comparison establishing seasonal ASOS-CONV temperature and humidity relationships. This will assist climatologists comparing current data (gathered by ASOS) with data from the past. As more data from CDCP national expansion sites becomes available, we will begin to understand if CDCP relationships can be applied nationwide or if differences vary significantly as a function of climatic conditions.

ACKNOWLEDGEMENTS

This research has been supported by NOAA, National Weather Service, Office of Meteorology under contract number NA37RJ0202-Item 9.

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Appendix B.

Climate Data Continuity of Temperature, Humidity and Precipitation with ASOS

Preprints, 12th AMS International Conference on Interactive
Information and Processing Systems (IIPS) for
Meteorology, Oceanography, and Hydrology,
28 January - 2 February 1996, Atlanta, GA

CLIMATE DATA CONTINUITY OF TEMPERATURE, HUMIDITY AND PRECIPITATION WITH ASOS

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1. INTRODUCTION

The primary goal of the Climate Data Continuity Project (CDCP) has been to compare observations from the new Automated Surface Observing System (ASOS) for temperature, dewpoint temperature, precipitation and wind with observations from the system used prior to ASOS which is defined here as the conventional (CONV) system. These comparisons are done with the recognition that two significant changes have occurred simultaneously. The instruments have changed and the location of the instruments has changed. This report will give the current status of temperature, dewpoint temperature and precipitation differences that have been observed during the transition to ASOS. Wind is the subject of a separate report. The previous report by McKee et al. (1995) focused mostly on the period prior to the final testing phase for temperature.

2. TEMPERATURE AND DEWPOINT TEMPERATURE

Initially the plan for this project was to compare observations from one group of sites relatively close to each other in the Central U.S. in order to identify instrument effects and overall system difference. Utilizing that knowledge, the plan was to expand to a larger set of sites in a wide variety of climates in the U.S. Several factors have contributed to a modified plan. A large number of National Weather Service (NWS) office relocations and regionally-determined staff reductions have made it difficult to continue CDCP data collection at the original set of stations. The modified plan now incorporates a comparison of observations from 15 sites (Table 1) for the 15 month period June 1, 1994 through August 31, 1995 with an additional set of sites from across the U.S. from September 1, 1994 through August 31, 1995 or as much of the year as is possible.

Table 1.
Climate Data Continuity Study (CDCP)
Comparison Sites

Site ID	Station Name
AMA	Amarillo, TX
AST	Astoria, OR
BRO	Brownsville, TX
BTR	Baton Rouge, LA
COS	Colorado Springs, CO
DDC	Dodge City, KS
GLD	Goodland, KS
GRI	Grand Island, NE
ICT	Wichita, KS
LNK	Lincoln, NE
OKC	Oklahoma City, OK
PWM*	Portland, ME
SYR	Syracuse, NY
TOP	Topeka, KS
TUL	Tulsa, OK

* Station commissioned in July 1994.

The temperature differences of ASOS-CONV are shown monthly for maximum and minimum temperature in Figures 1 and 2. ASOS-CONV temperature differences are summarized in Tables 2 and 3 for each season. Tables 2 and 3 show that the average value for ASOS-CONV maxima is

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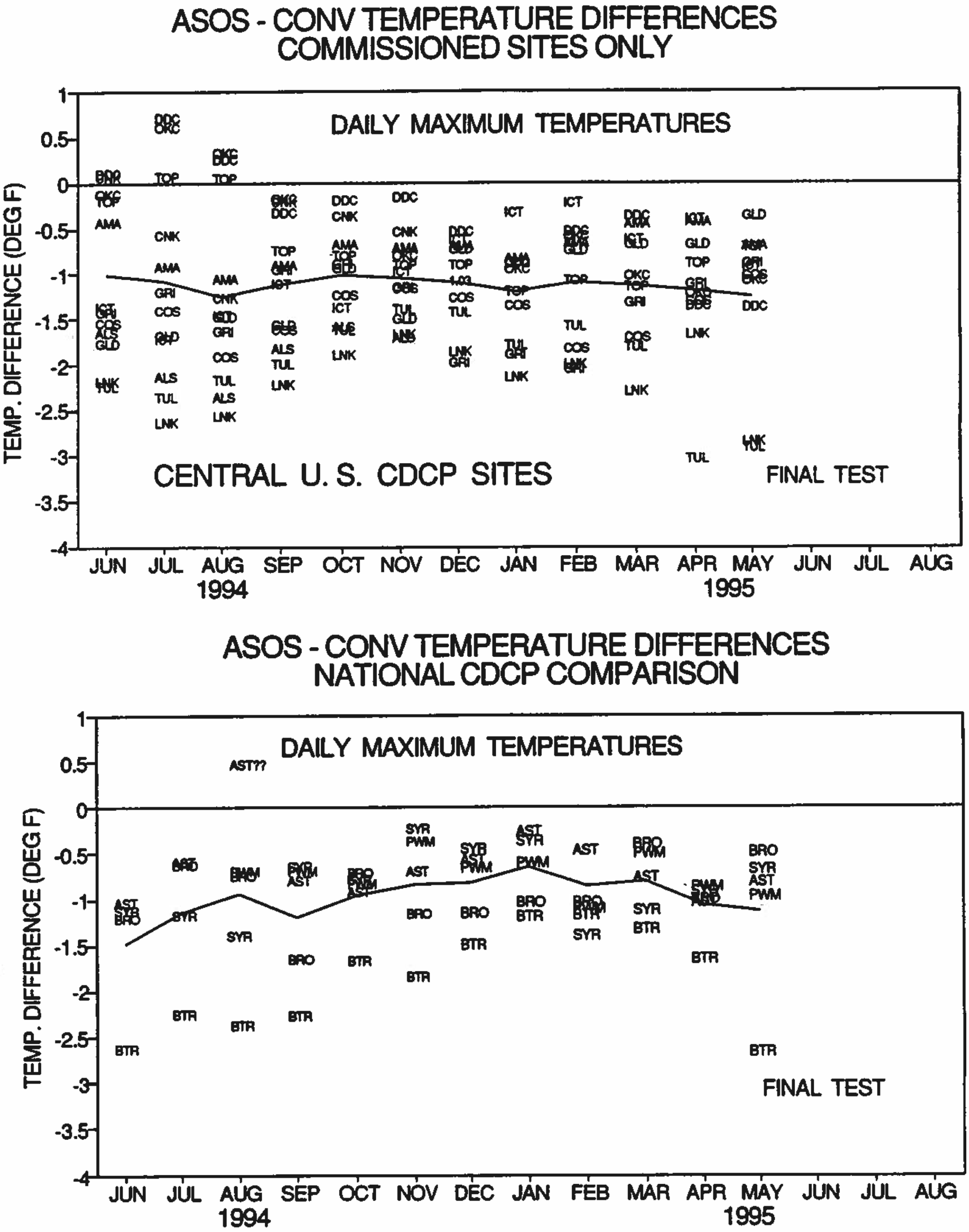

Figure 1. Mean monthly ASOS-CONV temperature difference for daily maximum temperatures for Central U.S. sites (top) and other sites (bottom).

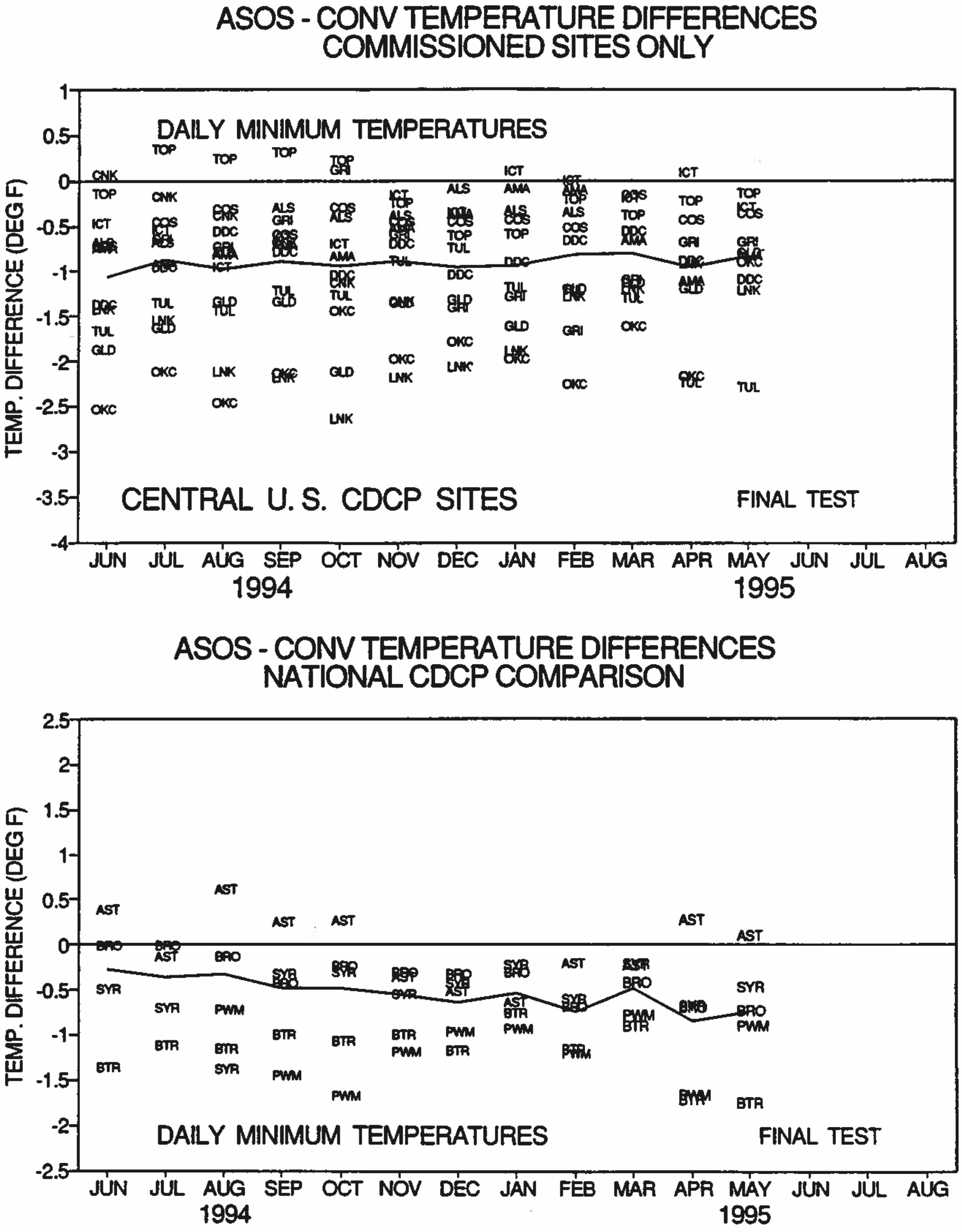

Figure 2. Mean monthly ASOS-CONV temperature difference for daily minimum temperatures for Central U.S. sites (top) and other sites (bottom).

-1.07°F and minima is -0.84°F with individual sites having a variation of at least ±1.0°F from the average value. Seasonal variations in ASOS-CONV differences have appeared at some individual sites, but the combined data show little change through the year.

Table 2.
Three month seasonal averages of the ASOS-CONV daily maximum temp difference (°F) for summer (SU), Jun-Aug 1994, autumn (FA), Sept-Nov 1994, and winter (WI), Dec 1994-Feb 1995, spring (SP), Mar-May 1995 based on midnight-midnight data.

Site	Maximum temperatures (°F)				
	SU	FA	WI	SP	AVE
AMA	-0.79	-0.75	-0.72	-0.53	-0.70
AST	-0.42	-0.80	-0.41	-0.84	-0.62
BRO	-0.82	-1.13	-1.03	-0.62	-0.90
BTR	-2.39	-1.91	-1.29	-1.85	-1.86
COS	-1.59	-1.31	-1.44	-1.32	-1.42
DDC	0.37	-0.20	-0.63	-1.01	-0.37
GLD	-1.63	-1.29	-0.76	-0.55	-1.06
GRI	-1.40	-0.97	-1.94	-1.08	-1.35
ICT	-1.50	-1.12	-0.38	-0.63	-0.91
LNK	-2.45	-1.92	-1.83	-2.26	-2.12
OKC	0.28	-0.56	-0.85	-1.09	-0.56
PWM	Inc	-0.62	-0.74	-0.75	-0.70
SYR	-1.22	-0.54	-0.70	-0.87	-0.83
TOP	0.00	-0.78	-1.07	-0.89	-0.69
TUL	-2.23	-1.64	-1.58	-2.57	-2.01
Ave	-1.13	-1.04	-1.02	-1.12	-1.07

What is the proper interpretation to give to these results? We have made a direct comparison of the ASOS temperature with a calibrated field standard at 3 sites and found ASOS does not have a systematic bias. This result is consistent with NWS testing of ASOS instruments. Two other comparisons are useful. One is that when all sites are grouped together for wind speeds greater than 14 mph the average ASOS-CONV value is near -0.5°F. This would indicate that the CONV instrument, the HO-83, has a warm bias of approximately that magnitude. The comparison at higher wind speeds minimizes the effect of solar heating on the instruments and reduces effects of local siting differences. The second special comparison concentrates on stations where ASOS and CONV instruments are very close together. Three of the sites have the ASOS hygrothermometer and the CONV HO-83 close enough together to consider them as co-located. They are COS, ICT, and SYR. The values listed in Table 3 for minimum temperatures at these co-located sites appears to confirm that the HO-83 has a warm bias with a value in the range of 0.10°F to 0.72°F including each of the four seasons. An examination of the values of the maximum temperature for these three sites indicates that the HO-83 is even warmer than the nocturnal bias. One likely interpretation for this observation, that has been found in Tucson, AZ, and in other National Weather Service comparisons, is that the CONV HO-83 reads warmer temperatures during the day due to a solar heating effect on the instrument. This effect has been observed about 1°F at COS in summer. The solar effect is somewhat lower at the other co-located sites probably as a result of more cloudiness.

Table 3.
Three month seasonal averages of the ASOS-CONV daily minimum temp difference (°F) for summer (SU), Jun-Aug 1994, autumn (FA), Sep-Nov 1994, winter (WI), Dec 1994-Feb 1995, and spring (SP), Mar-May 1995 based on midnight-midnight data.

Site	Minimum Temperatures (°F)				
	SU	FA	WI	SP	AVE
AMA	-0.79	-0.67	-0.18	-0.84	-0.62
AST	0.48	0.08	-0.42	0.08	0.06
BRO	-0.01	-0.30	-0.40	-0.57	-0.32
BTR	-1.18	-0.99	-1.01	-1.45	-1.16
COS	-0.47	-0.44	-0.46	-0.30	-0.42
DDC	-0.91	-0.82	-0.84	-0.80	-0.84
GLD	-1.58	-1.59	-1.38	-1.01	-1.39
GRI	-0.70	-0.26	-1.42	-0.79	-0.79
ICT	-0.63	-0.51	-0.10	-0.12	-0.34
LNK	-1.67	-2.35	-1.74	-1.10	-1.72
OKC	-2.38	-1.86	-1.99	-1.52	-1.94
PWM	Inc	-1.43	-1.01	-1.09	-1.18
SYR	-0.72	-0.36	-0.36	-0.40	-0.46
TOP	0.19	0.11	-0.45	-0.25	-0.10
TUL	-1.48	-1.12	-1.04	-1.92	-1.39
Ave	-0.85	-0.83	-0.85	-0.81	-0.84

The current interpretation of Figure 1 and 2 is that the HO-83 has a warm bias and a solar heating problem. In addition, the effect of changing location of the instruments at most sites results in cooler temperatures. This is consistent with the local site change being from a location near buildings and runways to the ASOS location usually at mid-field or near the end of a runway. The average of the maximum and minimum temperatures over all sites and the year in Table 2 and 3 support this interpretation.

Temperature and dewpoint temperature difference from ASOS-CONV are given in Table 4 based on observations taken four times per day at 6-hour intervals. These temperature differences behave more like the minimum than the maximum temperatures shown earlier. As an entire group the average values show no significant bias in the dewpoint temperatures for ASOS-CONV. The result is that ASOS reports a slightly higher relative humidity due to the fact that the temperature is cooler. It has been observed that both the ASOS and CONV instrument have periods of time when they report significantly erroneous dewpoint temperatures. We have labelled these periods as excursions. They seem to be inherent in these chilled-mirror hygro-thermometers.

3. PRECIPITATION

Comparison of observations between the ASOS heated-tipping bucket gage and the CONV universal gage revealed the ASOS gage was not an adequate gage for winter precipitation in cold regions and that it also recorded less precipitation than CONV in summer especially in heavy rain conditions. These results were presented earlier by McKee et al. (1995). The NWS is making modifications to the ASOS gage to improve its performance as a rain gage. CDCP comparisons will resume after modified instruments are placed in the field in the fall of 1995. The NWS is also seeking to obtain an automated precipitation gage that will be suitable for year-round operations in cold climates for frozen precipitation.

4. ACKNOWLEDGEMENTS

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Table 4.

ASOS-CONV temperature (T), dewpoint temperature (T_D), dewpoint depression ($T-T_D$) difference (°F) and relative humidity (RH) for summer (SU), Jun-Aug 1994, fall (FA), Sep-Nov 1994, winter (WI), Dec 1994-Feb 1995, spring (SP), Mar-May 1995 based on 6-hourly observations 0000, 0600, 1200 and 1800 UTC.

Site	T (°F)				T_D (°F)				$T-T_D$ (°F)				RH (%)			
	SU	FA	WI	SP	SU	FA	WI	SP	SU	FA	WI	SP	SU	FA	WI	SP
AMA	-0.5	-0.5	-0.3	-0.4	-0.1	-0.7	-0.1	0.8	-0.3	0.2	-0.2	-1.1	0.4	-0.7	-0.1	2.0
AST	-0.3	-0.3	-0.4	-0.5	0.4	0.1	-0.1	0.1	-0.7	-0.4	-0.3	-0.6	2.0	1.3	0.9	1.7
BRO	-0.4	-0.5	-0.7	-0.6	-0.4	0.4	0.1	0.1	0.0	-0.9	-0.7	-0.6	-0.1	2.3	1.9	1.5
BTR	-1.6	-1.3	-1.0	-1.4	-0.4	0.8	0.6	0.7	-1.2	-2.1	-1.6	-2.1	2.3	4.6	4.4	4.9
COS	-0.9	-0.8	-0.7	-0.6	1.1	0.4	0.2	0.0	-2.0	-1.1	-0.9	-0.5	2.6	1.4	1.4	1.0
DDC	-0.4	-0.5	-0.7	-0.9	0.5	-0.4	-0.3	0.4	-0.7	-0.1	-0.4	-1.3	1.4	0.2	0.8	2.8
GLD	-1.3	-1.2	-1.0	-0.4	-0.3	-0.4	0.0	0.4	-1.0	-0.8	-1.0	-0.9	1.7	2.0	1.9	1.2
GRI	-1.0	-0.6	-1.5	-0.8	-0.7	-1.0	-1.5	-1.2	-0.3	0.4	-0.1	0.4	0.6	-1.2	-0.1	-1.1
ICT	-1.0	-0.8	-0.2	-0.3	0.5	0.5	1.0	0.2	-1.5	-1.3	-1.1	-0.4	2.9	3.0	3.1	1.2
LNK	-1.6	-1.7	-1.5	-1.3	-1.0	-0.2	-0.8	-0.7	-0.5	-1.4	-0.7	-0.6	1.4	2.8	1.7	0.8
OKC	-1.3	-1.4	-1.6	-1.4	-0.2	0.1	0.5	0.8	-1.1	-1.6	-2.1	-2.2	2.8	3.2	3.8	4.4
PWM	Inc	-0.7	-0.7	-0.7	Inc	0.3	0.3	0.8	Inc	-1.0	-1.0	-1.4	Inc	2.3	2.7	3.2
SYR	-0.8	-0.4	-0.3	-0.4	-0.1	-0.3	-0.3	0.0	-0.7	-0.1	0.1	-0.3	1.7	-0.1	-0.2	0.6
TOP	0.2	-0.3	-0.7	-0.6	-0.3	-1.0	-0.8	-1.0	0.6	0.8	0.1	0.4	-1.1	-2.2	-0.5	-1.2
TUL	-1.5	-1.2	-1.1	-2.2	0.8	0.2	-0.1	-0.7	-2.3	-1.3	-1.0	-1.5	4.8	2.9	2.0	2.6
Ave	-0.89	-0.81	-0.83	-0.83	-0.01	-0.08	-0.09	0.05	-0.84	-0.71	-0.73	-0.91	1.67	1.45	1.58	1.71

Appendix C.

Wind Climate Data Continuity Study

Preprints, 11th AMS International Conference on
Interactive Information and Processing Systems (IIPS)
for Meteorology, Oceanography and Hydrology
15-20 January 1995, Dallas, TX

16.2

WIND CLIMATE DATA CONTINUITY STUDY

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1. INTRODUCTION

Climate generally indicates an application of data taken over long periods of time, such as 30 years or more. Perhaps the most common application of wind data in climatological time is made by the civil engineering community to design structures which will survive expected maximum wind forces. Wind data, usually speed and direction sampled separately, have been collected with a variety of instruments over the years. Distributions of average speed within a direction sector will provide return periods or probabilities of occurrence of winds at a specified speed.

The two most common wind speed averages for climatological applications are the peak 3-second average and the fastest mile wind speed (Cermak, 1970). These measurements are made with different anemometer designs and a variety of exposures. How these measurements have changed over the years, will change in the future and the impact of these changes is the main subject of this paper.

The National Weather Service (NWS) Climate Data Continuity Project (CDCP) is designed to document the impacts on climate data which may result from the implementation of the new Automated Surface Observing System (ASOS). This paper is a preliminary report for the wind measurements.

2. BACKGROUND

2.1 Fastest Mile

Distance averaging of wind speed provides the oldest wind data at the National Climatic Data Center (NCDC), starting in 1870 with the Army Signal Corps and the U. S. Weather Bureau observations (Changery, 1982). The method is simple. A cup wheel turns a shaft connected to a set of pinions and gears operating a contact switch. The gear train was designed to close the contact after a specific number of cup wheel revolutions caused by one mile of air blowing by. If a buzzer were activated by the contact switch, a wind speed observation could be made by counting the seconds between buzzes and converting time for a fixed distance (hours per mile) to speed (miles per hour). When strip charts became available, an event pen would be activated generating a permanent record of times for the passage of each mile of air. The record for a day is examined to find the two event marks which are closest together, the fastest mile. An overlay scale converts the space on the chart (time) to wind speed.

The first cup wheel had four hemispherical cups (Changery, 1982). Research in the 1920's led to a three cup design which was introduced in 1928. This design is essentially the F102 S-Type anemometer which is still in service at some stations today. The fastest mile speed is measured in knots and converted to miles per hour using a table in the FMH-1 (Lockhart, 1979).

The accuracy of this anemometer is not known precisely. Several dynamic effects will contribute to the uncertainty of the calibration. These include the inertial effect where the cups will speed up faster than they will slow down biasing the average to a higher speed. This is sometimes called dynamic overspeeding. There is also an aerodynamic effect caused by non-horizontal components of the wind vector. This may also cause a higher rate of rotation than that caused by a purely horizontal wind at the same average speed. This is sometimes called an off-axis error. The transfer function from wind speed to rate of rotation for a "wind run" sensor, such as the F102, must be simply a multiplier. A linear regression of the wind tunnel points above the threshold non-linearity may not cross the axis. The best transfer function would be a small constant plus the rate of rotation multiplied by another value. Wind run sensors must use a straight line passing through the axis which requires some compromise. It is likely that a cup design and a gear train design will not result in exactly the one mile per contact that is desired. A table of corrections is used to handle this problem. Such corrections are usually based on a limited sample size of anemometers, sometimes only one. Variations in performance from one cup wheel to another is unknown.

2.2 Peak Wind Speed

In the 1940's a new design anemometer was introduced at airport stations. This was also a three cup design, but the cups were conical and not hemispherical. They also had rolled edges rather

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than sharp edges. The anemometer had a continuous output which could drive a dial indicator or a strip chart recorder. The latest NWS version of this anemometer is the F420. The ASOS version of the F420 uses a light chopper rather than a voltage generator resulting in a lower starting threshold and an accurate 1-second average sample speed.

The F420 anemometer provides an output which can be recorded directly on a continuous strip chart called the gust recorder. It has been estimated that the time constant of the F420 - gust recorder combination is about 2-seconds, depending some on the balance of the recorder pen. The daily peak wind speed is measured and reported in knots.

Cup anemometers are devices which rotate as a consequence of the force of the wind on the asymmetrical shape. Once the wind speed is above the threshold torque requirements of the bearings and transducer, the cup wheel responds aerodynamically to the lift and drag forces of the wind. For this reason, cup anemometers require empirical calibration methods such as wind tunnels or moving platforms. The validity of the aerodynamic model can be deduced given the data showing the rate of rotation vs. wind speed transfer function is independent of fluid density, above threshold.

In a private communication, Arnold Court described the first attempt at calibrating a cup anemometer in England. Around 1870 an anemometer was mounted on the flat bed of a railroad car and checked against various known ground speeds up to the limit of railroad operation, 60 mph. Similar calibrations were run in Russia where railroad speed limits were not so restrictive.

2.3 Wind Direction

The wind direction associated with the fastest mile records with a resolution of ±22.5 degrees or the nearest point of an eight point compass.

The wind vane in the F420 system reports in 10 degree steps or a resolution of ±5 degrees. The ASOS wind vane reports to the nearest whole degree.

Accuracy of an average wind direction measurement is a combination of the ability of the sensor and transducer to divide a circle adequately and the ability to orient the sensor transducer to true north.

3. STUDY DESIGN

The question to be answered in this study is this. Will the changes in hardware, firmware and software from the F420/F102 to ASOS affect the wind climate? If the data from the study suggest that it will, the report will estimate the magnitude of the change and the cause or causes of the differences.

Since climate is some statistical manipulation of standard measurement data, the question can be directed at the measurement process in shorter periods of time, such as one year. There may be site specific differences. A representative group of stations will be selected from among the Climate Continuity sites, both the original 14 sites and the 18 expansion sites, and other sites. A total of 16 sites is planned. There will be a need to go beyond the 32 Climate Continuity sites to get a reasonable sample of stations still operating the F102 and triple register system. Only Billings, MT and Tucson, AZ currently report fastest mile among the Climate Continuity sites.

3.1 Peak Wind Speed

The peak wind speed, including time and wind direction, is reported in knots as a part of the daily summary. The observation comes from the F420 and the gust recorder. The ASOS also reports the peak wind speed, including time and wind direction, in a daily summary. The ASOS value comes from the successor to the F420 and its digital data logger. The ASOS peak wind speed is a 5-second average reported in miles per hour.

There are a variety of causes for differences in these two peak wind speed measurements. They include:

- Calibration in a wind tunnel of specific sensors,
- Averaging method - "2-second" gust recorder vs. 5-second algorithm,
- Sensor height differences (Cermak, 1979),
- Separation distance between anemometers,
- Natural turbulent differences in space (Hoehne, 1973),
- Site roughness as a function of direction,
- Gust recorder condition - pen balance - and recorder errors.

In order to generate a sample size large enough to have subsets to evaluate possible causes of differences, one hour peak wind speeds will be used. This will increase the maximum sample size for a station-year from 365 to 8,760. The F420 data will be reduced from gust recorder charts by NCDC and the ASOS data will be extracted from 1-minute data archived by NCDC.

3.2 Fastest Mile Wind Speed

While this measurement is the most significant in terms of record length, it will be the most difficult because of the scarcity of stations which operate the F102 totalizing anemometer and the triple register recorder.

In Alabama, for example, there are five stations with fastest mile data, as shown in the following table. Two stations had large moves shown by two sets of dates. One station was active for less than one year.

TABLE 1
Sample Fastest Mile Data Sets

Station	Dates	Dates	Years
Anniston	1906-1932		26
Birmingham	1903-1943	1943-1976	73
Maxwell	1936-1936		1
Mobile	1872-1963		91
Montgomery	1873-1950	1950-1976	103

It became difficult or impossible to get parts for the F102. It was decided to keep them going as long as they worked, but when they were no longer serviceable, the measurement was discontinued. The loss of this measurement was noted, with dismay, at the Workshop on Wind Climate held in Asheville, NC in November 1979. There was apparently a substitute made. The Local Climatological Data (LCD) summaries reported fastest mile where it was available and "Fastest Obs. 1 Min." where it was not available. The author was under the impression that a fastest minute had replaced a fastest mile, a simple substitute in averaging method. In fact, the fastest observation was the largest "1-minute average" taken during the day. A minimum sample size would be 24 where 24 minutes represented the 1440 minutes in the day. The "Fastest Obs. 1 Min." is not representative of extreme wind speeds and will not be used in this study.

The ASOS system will report in miles per hour the fastest 2-minute average speed in the daily summary. At 30 mph the fastest mile and the fastest 2-minute average will have the same averaging time or distance. At speeds higher than 30 mph the 2-minute time period will represent an average over more than one mile and consequently will be a smaller value than the fastest mile. Neither the fastest mile nor the fastest 2-minute speed is a running average. The fastest mile measures the speed of discreet miles, from switch closure to switch closure. A faster mile may happen using parts of two discreet miles. Similarly, the fastest 2-minute speed uses clock minutes, updated each minute. It is possible that there could be a faster 2-minute average using parts of three minutes. All of the relevant questions listed in 3.1 will be considered in 3.2, as well as the sampling differences discussed above.

It might be argued that with the decision to abandon the fastest mile measurement the continuity of wind climate measurements has already been broken. Samples stations are being used to compare measurement methods for peak wind speed and other variables. The conclusions reached from data from the sample stations will be applied to all stations. A similar logic will be applied to the fastest mile measurement. The only problem is finding enough stations to use as samples.

3.3 Wind Speed and Wind Direction

Some comparisons will be made between the SAO hourly observations made with the existing F420 system and the ASOS system. Some comparisons have been made at Billings using the MAPSO data and the daily ASOS test printout. The method, while tedious, is effective.

Wind directions will also be compared when the time of the daily fastest mile and the time of the daily ASOS fastest 2-minute wind speed are nearly the same. Differences in the direction resolution is recognized.

One additional potential cause of difference to the list in 3.1 is the observation time. For small averages, such as the "1-minute average" from the F420 and the 2-minute average from ASOS, time synchronization is important to minimize differences. The important part of this comparison will be the average difference or bias. The standard deviation of the difference is expected to be large and explainable.

3.4 Metadata

Wind speed measurement is made in a vertical speed gradient which varies with stability and roughness. In addition to the sensor height above ground, it is important to characterize the fetch for roughness estimates in each 45 degree sector of each site. A photographic method is being developed to provide this information.

The method uses a standard 35mm camera, a sighting device for finding true north by solar observation and establishing 45 degree points relative to true north, and a label sign to identify the site and the angle of the centerline of the camera. The photographs are processed to a CD-ROM for editing, analysis, and electronic communication.

3.5 Special Tests

Special tests are being conducted at Binghamton, NY and Cheyenne, WY to examine the performance of F420 sensors and ASOS sensors mounted on a common tower. Binghamton was chosen to represent extreme icing conditions and Cheyenne was chosen to represent a windy site. The F420 sensors are sampled each second which will allow a variety of characterization methods. The ASOS sensors are processed by standard ASOS algorithms.

Data from these tests will be analyzed as a baseline for the best possible agreement. The only concern will be interference from one sensor to another. Directional subsets of data will minimize this problem and any siting bias that may exist at the experiment tower locations.

4. EXAMPLES OF APPLICATIONS

4.1 Wind Engineering

The importance of joint frequency distributions of wind speed and wind direction is described by Peterka (1979). The existence of long data periods of fastest mile observations with their attendant direction makes possible the prediction of maximum wind speeds likely within certain periods of time. For example, the maximum wind speed for each 45 degree direction sector is predicted for a recurrence interval or return period of 100 years from 27 years of fastest mile record at SEA-TAC airport.

The maximum speeds are used to design the strength of the structure to withstand predicted wind forces and the direction distribution is used to design the shape and siting of the structure for pedestrian comfort.

4.2 Airport Operations

An interesting legal case discussed by Haggard (1980) puts a price tag on wind climatology. In question was whether or not the Federal Government (FAA) would fund a cross wind runway. The requirement for funding eligibility is a cross wind component of the wind equal or greater than 15 mph occurring at least 5% of the time. The first analysis of the Anchorage airport data by the State of Alaska, based on 7 years of 3-hourly observations, showed stronger components occurring 5.88% of the time.

A party whose property value would suffer if the cross wind runway were built sought a restraining order in the Federal District Court in Alaska. A certified consulting meteorologist for the plaintiff showed the cross wind component was 15 mph or greater only 4.8% of the time, based on 17 years of data. A temporary restraining order was issued and a hearing was scheduled wherein both sides were to present cross wind frequencies "utilizing all available data."

The wind equipment was set up in 1914. Records at NCDC started in 1916. The anemometer was moved 12 times during the operation at the airport. All available data resulted in 23 years of data. When the total record was used, without consideration of quality, 5.2% of the time the cross wind component was 15 mph or greater. When the analysis was enhanced by a variety of valid measurement considerations, the frequency increased to 7.73%. Presumably, Anchorage has the cross wind runway by now.

5. ACKNOWLEDGEMENTS

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Appendix D.

Wind Climate Data Continuity Study - II

Preprints, 12th AMS International Conference on
Interactive Information and Processing Systems (IIPS)
for Meteorology, Oceanography, and Hydrology,
28 January - 2 February 1996, Atlanta, GA

Annual Meeting, National Weather Association
4-8 December, 1995, Houston, TX

WIND CLIMATE DATA CONTINUITY STUDY - II

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1. INTRODUCTION

This study examines the impact of ASOS, the Automated Surface Observing System, on climatological wind data. Since applied climatology has no consensus definition, all uses of wind data will be considered. The background for the study is described in Lockhart (1995).

This paper discusses the project methodology and cites a one year data set from the Logan International Airport in Billings, Montana. The data began on September 1, 1994 and ended on August 31, 1995. It comprised the daily summary of ASOS observations printed out on site and the list of fastest mile observations read on site with a calibrated ruler.

The analysis method used exposed the fact that the ASOS anemometer and software reports speed in knots which are converted to miles per hour by a method which avoids the values of 4, 11, 19, 27, 34, 42, 50, 57, 65, 73, 80, 88 mph and more. The consequence of this bias will be considered in terms of accuracy and climatological application.

2. DATA COLLECTION

The first task was to transcribe the printed values on the daily summary sheets and the fastest mile summary sheet for each month. These were mailed to MSI by the NWS office.

Three daily characterizations of maximum wind speed were entered on a spread sheet. The fastest mile in whole miles per hour, the time of this observation, and the wind direction in 45° sectors were transcribed. These values came from an F102 totalizing cup anemometer and wind vane. The anemometer provides a switch closure for each statute mile of air that passes the sensor location. At each switch closure, an event mark is made on a strip chart recorder called a triple register. The space between event marks can be measured and expressed as an elapsed time. The conversion from time per mile to miles per hour is made in the design of the ruler.

The ASOS daily summary contains the values for the PEAK WIND SPEED (MPH), the PEAK WIND DIR (DEG), and the PEAK WIND TIME (LST). The peak speed is a "5-second" average constructed from 1-second averages sampled by the software. Each 1-second average is simply the total count from the photo-diode optical path being interrupted by the 100 window disc attached to the anemometer shaft. The count is scaled to knots by dividing by 196.4. At 10 knots the 1-second count is 1,964. The "5-second" average was originally constructed by adding 4/5 of the previous 5-second value to 1/5 of the new 1-second average. ASOS is in the process of changing this algorithm to a true 5-second average by replacing the oldest 1-second average with the newest 1-second average. The 5-second value is taken each five seconds. The peak value is the largest value found by the clock-driven program and not a running mean with the 1-second measurement resolution.

The ASOS daily FASTEST 2MIN SPEED (MPH), FASTEST 2MIN DIR (DEG), and FASTEST 2MIN TIME (LST) are the selected values from the 2-minute averages constructed each minute from the 5-second averages. This maximum value is a running mean with a one minute time resolution.

All nine values for each day were entered in the spread sheet. If any values were missing for the day, the day was called missing for this analysis. Fourteen days were missed largely because the fastest 2-minute data were missing from the summary message.

3. DATA ANALYSIS

The first calculations considered the difference between the fastest mile and the fastest 2-minute speed. Table 1 shows these results for all 351 days of complete data. Fastest mile data are labeled FM and fastest 2-minute speed data are labeled 2M.

TABLE 1

	FM	2M	2M-FM	2M-FM
	(mph)	(mph)	(mph)	(deg)
average	20.5	21.1	0.5	1
std.dev.	7.3	7.1	2.7	40
max.	44	51	16	175
min.	7	7	-9	-175
count	351	351	351	351

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At 30 mph the fastest mile and the 2-minute average are looking at the same length of flow past the anemometer., or the same "eddy size." When the ASOS speed is 51 mph, which was the largest 2-minute average in the year of data, the "eddy size" is 1.7 miles. The fastest mile speed that day was 29 mph about three hours earlier.

One would expect that the larger the averaging distance or averaging time, the smaller the speed. In this maximum case the opposite is true. When only the cases where the maximum 2-minute speed is 30 mph or greater (averaging distance is one mile or less), the 2-minute average is 5.5 mph higher than the fastest mile. Case A in Table 2 shows the statistics for the 38 cases.

After looking at an x-y plot of the differences as a function of speed, it was clear that the large differences were biasing the average toward higher 2-minute speeds. Case B considers only those days when the difference was between ± 6 mph. When the 11 days with the largest differences were removed, the average difference was reduced to 0.4 mph. There were 89% of the days with the maximum 2-minute speed representing less than a mile of flow and therefore expected to be faster than the fastest mile. At last this reasonable expectation is met.

A third case was examined. What happens if only those days when the fastest mile and the fastest 2-minute speeds occur within 60 minutes of each other? Case C shows those results. It seems that big differences occur when the event times are more than an hour apart.

TABLE 2

	Case A	Case B	Case C
	2M-FM	2M-FM	2M-FM
	(mph)	(mph)	(mph)
average	5.5	0.4	0.3
std.dev.	2.9	2.1	2.2
max.	16	6	8
min.	3	-6	-9
count	38	340	216

The difference between the peak 2-minute speed and the peak "5-second" (5S) speed were examined. Table 3 provides the statistics for these differences. The average difference was 3.4 mph over a range of 0 to 14 mph. While the average direction difference was small, the range was quite large. Limiting the direction difference to 30° made no difference in the speed difference statistics.

One would expect a reasonably strong relationship between the ASOS 5-second peak wind speed and the fastest 2-minute wind speed. To define this relationship, the linear regression of the difference between the two ASOS speeds (5S-2M) on the 2-minute speed was examined. While the graph showed a clear relationship, it was quite weak. The correlation coefficient was only 0.35. The slope predicted a difference in the two speeds by multiplying the 2-minute speed by 0.16.

TABLE 3

	5S-2M	5S-2M	5S-2M
	Speed	Direction	±30°
	(mph)	(deg)	(mph)
average	3.4	-1.2	3.4
std.dev.	2.1	25.7	2.0
max.	14	180	14
min.	0	-150	0
count	351	351	332

Another analysis technique was tried. If the difference between the fastest mile measurement and the fastest 2-minute speed measurement is strongly influenced by the sample distance or sample time, there should be a difference seen in the two frequency distributions. Lockhart (1979) considered the fastest mile data for 1977 from LAX using a histogram with a one mph resolution. The curious finding in that paper was that the peak of the distribution at 19 mph had no occurrences. The cause was the conversion from knots to miles per hour using the A10-4 table from the Federal Meteorological Handbook No. 1. Figure 1 shows the distribution.

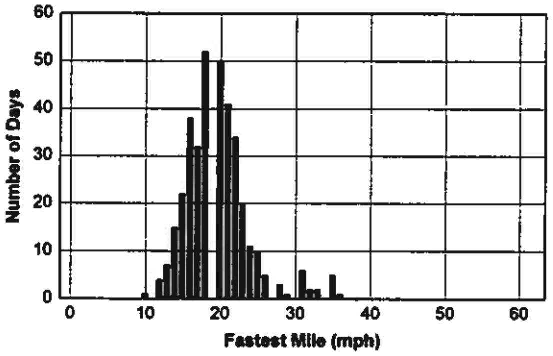

Figure 1
Fastest Mile at LAX in 1977

This distribution looks like it has a mode at 18 mph. The best estimate of the true distribution is constructed by adding 18 mph to 20 mph and dividing by three. When this is done the mode becomes 21 mph as shown in Figure 2. Where reality lies, no one knows. There is no way to reconstruct the true distribution after Table A10-4 has introduced its rounding bias.

The LAX readings were taken in knots and converted to mph with table A10-4. In the data from Billings the fastest mile was read directly in mph with the calibrated ruler. Figure 3 shows the fastest mile distribution.

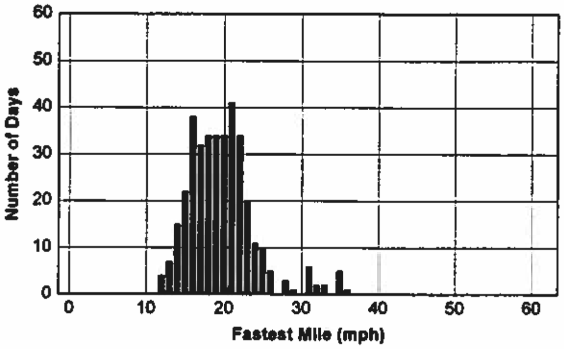

Figure 2
Adjusted Fastest Mile at LAX in 1977

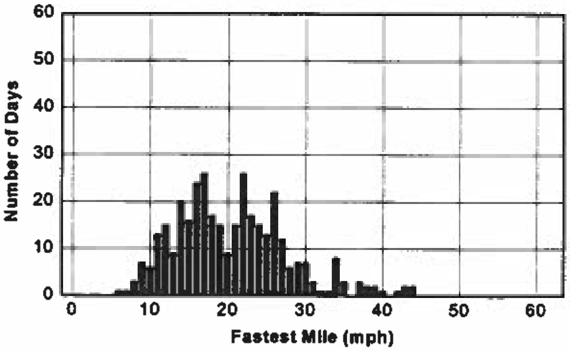

Figure 3
Fastest Mile at Billings

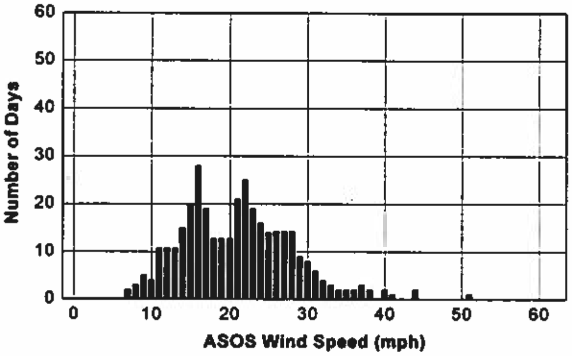

Figure 4
Adjusted Fastest 2-Minute at Billings

If it were not for the four speeds with a zero occurrence, namely 11, 19, 27 and 34 mph, Figure 4 would look smoother and more like Figure 3. The adjustment technique was the same as was done for LAX. The values on either side of the zero were added and divided by three.

Figures 5 and 6 are the raw distributions of the fastest 5-second average and the fastest 2-minute average speed for each of 351 days.

4. DISCUSSION

The automatic nature of ASOS should yield more accurate data. The fastest mile instrumentation requires a hand measurement on a chart paper. There are several opportunities for error when this kind of data reduction is required, also the paper stretches as a function of humidity. Judgment is required to select the two event marks that are closest together. There is uncertainty in both the calibration of the ruler and the reading with the ruler. Assume the F 102 cup provides a switch closure for exactly 5,280 feet of air passage and the ASOS anemometer turns at exactly 1.705 revolutions per second for each mile per hour of speed. The method for calculating a fastest 2-minute speed, except for the conversion bias, is more accurate than the manual reduction of a strip chart.

The conversion bias is the reason the comparison of peak speed distributions is imprecise. It will take more cases to tell whether or not the method is useful. While the bias must be embarrassing in this modern day of digital computers and sophisticated programs, it could cause ASOS to fail to meet the accuracy specification of 2 knots or 5%, whichever is greater. It is unlikely that those testing the accuracy specification realize that below 40 knots, where 5% is 2 knots, one half of the error budget is lost in a software conversion strategy.

5. ACKNOWLEDGMENTS

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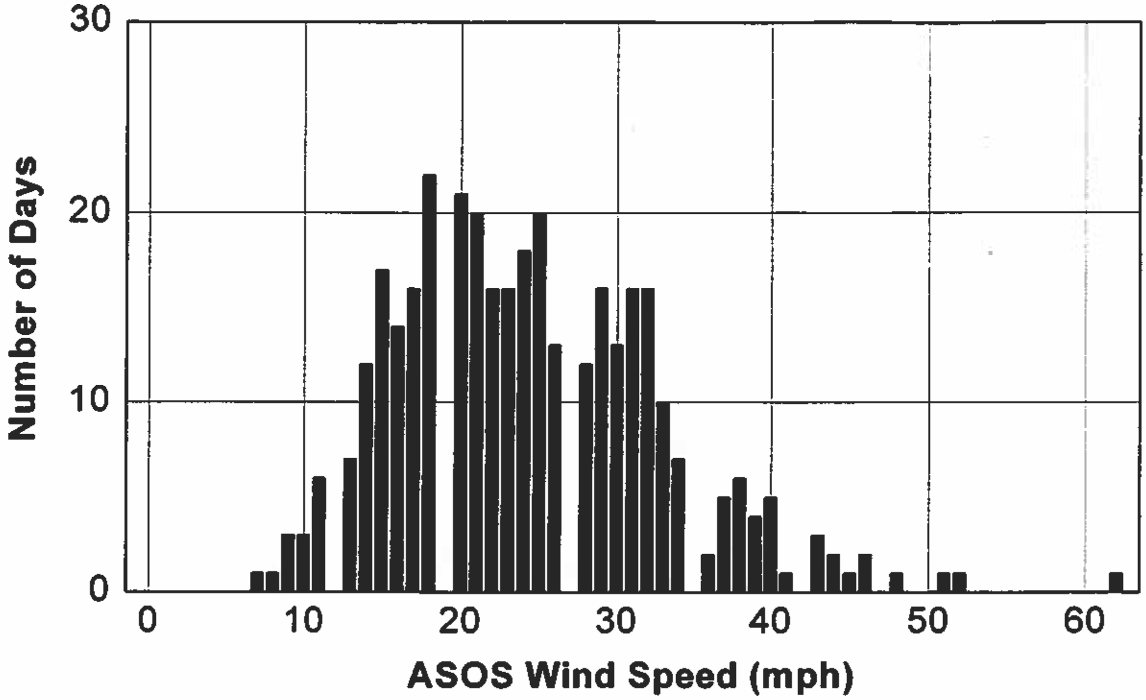

Figure 5
Maximum 5-Second Average at Billings (9/94-8/95)

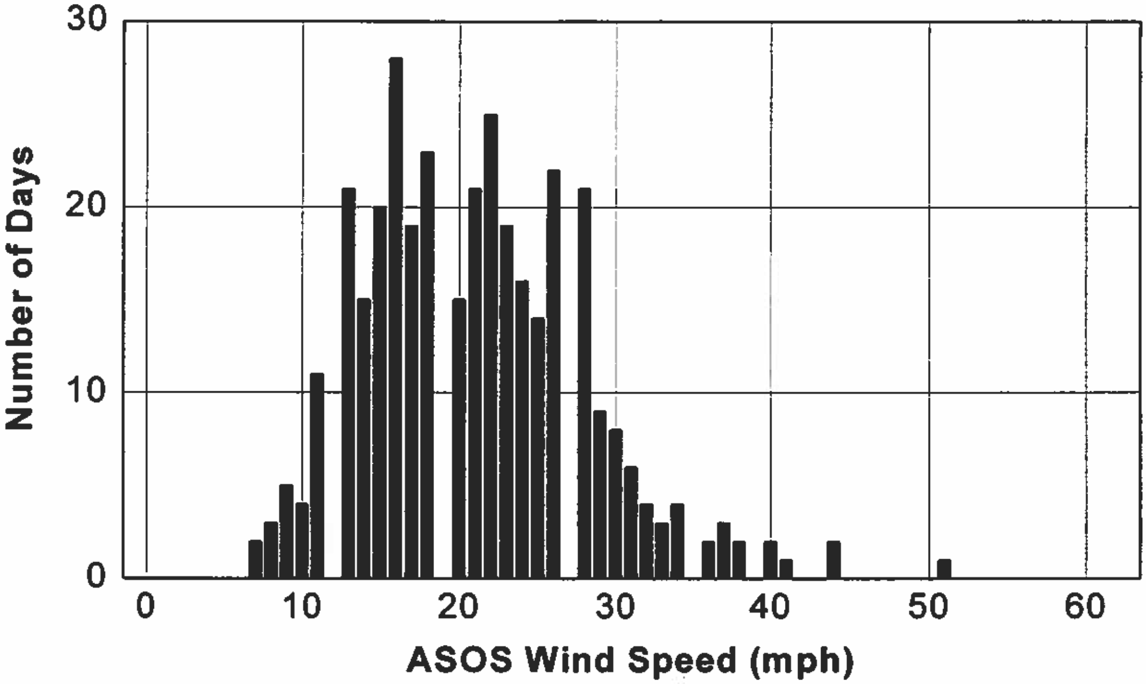

Figure 6
Maximum 2-Minute Average at Billings (9/94-8/95)