The Presentation of Temperature Information in Television Broadcasts: What is Normal?

Anthony R. Lupo*[1]

Eric P. Kelsey[1,2]

Elizabeth A. McCoy[1]

Chris Halcomb[1]

Eric Aldrich[1,2]

Stacy N. Allen[1,2]

Adnan Akyuz[1,3]

Sara Skellenger [1,2]

David G. Beiger[1]

Eric Wise[1]

Dave Schmidt[2]

Mark Edwards[2]

[1]Department of Atmospheric Sciences
373 Mc Reynolds Hall
University of Missouri-Columbia
Columbia, MO 65211

[2]KOMU - TV 8
Highway 63 South
Columbia, MO 65201

[3] Missouri Climate Center
100 Gentry Hall
University of Missouri - Columbia
Columbia, MO 65211

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** Corresponding Author Address: Dr. Anthony R. Lupo, Department of Atmospheric Sciences, 389 Mc Reynolds Hall, University of Missouri - Columbia, Columbia, MO 65211, E-mail: LupoA@missouri.edu*

Abstract

In a typical weather broadcast, observed daily temperature information such as maximum and minimum temperatures are shown and compared to the daily average or “normal”. Such information, however, does not accurately describe whether or not that particular day is fairly typical for that time of year or truly an unusual occurrence. Thus it is suggested that the presentation of temperature information can be augmented with elementary statistical information in order to give a more meaningful presentation of temperature information without the need to explain the basis of such statistical information. A study of the climatological maximum and minimum temperatures over a 30-year period for Columbia, Missouri is performed in order to provide the rationale for displaying a "typical" temperature range. This information was incorporated into television weather broadcasts at KOMU TV-8, which is the campus television station and local NBC affiliate.

1. Introduction

One of the challenges in presenting weather information in a three to five minute television segment is conveying as much meaningful and relevant information as possible without overwhelming the viewing public. Most viewers are looking for information that will be useful in making decisions about their planned activities, and occasionally, how unusual is the weather they are experiencing. Also, most television weather broadcasts are centered on the information that the broadest segment of the viewing public may be most interested in on a day-to-day basis, which is mainly temperature and precipitation information and forecasts. In the last 25 or so years, there has been a dramatic increase in the attention paid to weather and climate information such as severe weather, El Nino and La Nina events, and climate change, including global warming (e.g., Changnon and Kunkel, 1999; Kunkel et al., 1999). This has resulted in a five-fold increase in the television coverage of weather related events over that time period (e.g., Ungar, 1999). As such, a broader segment of the public is interested in weather broadcasts and has become increasingly "weather-savvy" with regard to the information presented to them.

A typical weather broadcast will show maximum and minimum temperature information and how the observed values for the day relate to "normal" or the average temperature for the day. For example, many weather broadcasters would (and do) typically refer to an observed maximum of 46 ^{o}F for a given winter day as "above the average" if that particular day's average maximum is, for example, 41 ^{o}F. While this information is true in the most literal sense, the information does not completely or accurately portray whether or not such a winter day is a fairly typical occurrence or if that day's maximum is truly an exceptional occurrence since the daily mean temperature is not observed nearly as often as temperatures which represent departures from the mean.

Thus, this short paper has two simple objectives. The first objective is to perform a short statistical study by examining daily temperature data, their means, and variations for the Columbia, Missouri area. The second objective is to demonstrate how such information can be incorporated into weather broadcasts in order to provide the public with a more informative presentation.

2. Data and Methodology

a. Data

The data used in this brief study are the daily maximum and minimum temperature records for the Columbia, Missouri Regional Airport from 1 January 1971 to 31 December 2000. These data were obtained from the Missouri Climate Center. This temporal period was chosen since 1971 - 2000 period is now the base period used to compile climatologies for given locations. Also, this 30-year period provides for a continuous record of maximum and minimum temperature information, and as such there was no need to artificially fill in missing temperature data. In this study, data from the Columbia region was chosen since the results found here were incorporated into local weather broadcasts[1]. Also, temperature observations have been taken from the locale named above over the duration of the 30-year period. Only one change in the instrumentation was made in 1996, when the Automated Surface Observation Station (ASOS) instrumentation was installed. Lastly, the temperature data and the calculations used in this study carried units of degrees Fahrenheit since that is still the standard unit for surface temperatures in the United States and is still the standard unit of temperature used in weather broadcasts.

b. Methods

The initial step required that the daily temperature information for the 30 year period, 1971 – 2000, was used to generate the statistics discussed here. Based on the 30 years of daily temperature information, the average maximum and minimum temperatures were generated for each day of the year (not shown), along with 30-year monthly averages (Table 1). The monthly averages were then used as nodes and a cubic spline (e.g., Press et al., 1988) was used to generate daily climatology data (Fig. 1). Cubic splines are a method used to fit a curve to a particular set of observed data, from which new data can also be generated by interpolating between data points. Spline interpolation is used in order to ensure that the curve representing the annual variation in temperature is smooth, which would not be the case if actual 30-year means were used. Then, higher order statistics were generated for each day including daily and monthly standard deviations (σ) (daily values are shown in Fig. 2), variances, and daily anomalies. These statistical calculations can be found in any standard statistics textbook (e.g., Neter et al., 1988). The daily anomaly data was generated ([daily observation] – [30-year daily mean]), then binned using 1 ^{o}F temperature increments, and used to construct temperature distributions (Fig. 3). These distributions appeared to take the form of normally distributed data. They were tested in order to determine if they followed a standard normal distribution at a statistically significant level using the chi-square goodness-of-fit test (e.g., Neter et al., 1988).

3. Results, Discussion, and Application

a. Results and Discussion

Figure 3 shows the daily temperature anomalies for the a) maximum temperature and b) the minimum temperature, binned by using increments of 1 ^{o}F. Thus, the ordinate represents the actual number of days in the 1971 - 2000 period contained in each bin (abscissa), and each bin represents a departure from the climatological average. The climatological averages in this case are the arithmetic mean of the daily maxima or minima over the 30-year period. The frequency distribution (solid line) was compared to a normal distribution (dashed line), where the normal distribution was constructed using σ for the entire data set. A chi-square goodness-of-fit test of the PDFs derived from Fig. 3 demonstrated, as expected, that the 30-year daily anomalies are normally distributed for both of the maximum and minimum temperatures, a result that is statistically significant at the 95% confidence level. A similar procedure was carried out season-by-season and a similar conclusion was reached. This suggests that the instrumentation change noted in Section 2 has not had an adverse impact on the 30 – year climatological records.

PDFs for the entire 30-year period and for each season were tested as opposed to PDFs for individual days since each day would represent a small sample in which it might be difficult to obtain statistically meaningful results. However, the temperature anomalies of each particular day within a season over a 30-year period can be viewed as being produced by random set of synoptic-scale and/or large-scale events or flow regimes typically occurring within that season, and thus, these events are equally likely to occur at any time during that season. But summer season flow regimes may possess different kinematic and dynamic characteristics from winter season flow regimes over North America, thus necessitating the need for seasonal tests as opposed to testing the entire 30-year sample. This same assumption does not preclude the use of seasonal statistical results as a surrogate for the daily data sets within that season.

In displaying temperature information, it would be useful to show some measure that represents a typical temperature range or typical variability for a particular day. Most television broadcasts show record highs and lows, which represent in a statistical sense (and loosely in a physical sense) the absolute range of the temperatures that may be expected for a given location on a given day. Then, an ideal measure of variability would be to use σ, which represents a measure of absolute variability in a data set (in this case, the 30-year daily temperature anomalies). For data in a set that are normally distributed, σ can be used to construct an interval (range) about the mean for which approximately 68% (rounded off to 70%) of the data points in a particular set of data should reside.

As this discussion relates to the choice of a typical range for daily temperatures, a 95% interval would represent an observation (daily temperature) that is 2σ beyond the expected mean (climatology). While the choice of 2σ would represent a statistically stringent choice akin to standard confidence testing, a more practical choice for presenting observations in a television broadcast might be an interval enclosed within a range of +/- σ. In terms of the absolute number of occurrences in a 30-year period for a date (e.g., 15 April), this indicates that one should find that 4 or 5 maximum temperatures for 15 April above the given range, 21 within +/- σ range, and the remainder below the range.

b. Application

The climatological average or "normal" maximum and minimum temperatures used in KOMU – TV8's daily television broadcasts are derived using cubic splines from the 30-year monthly means as described above (Fig. 1), and which could also be obtained through the National Weather Service. Since these interpolated daily values are used as the climatological mean or expected temperatures, corresponding daily values of σ were calculated and are shown in Fig. 2. These values also show annual variability and, as expected, temperatures are more variable during the winter season than they are during the summer season. Also, the annual variability in σ for the maximum temperature was higher than that of the minimum temperature by at least 1 ^{o}F for all seasons. Since the annual range in σ is fairly small compared to the annual variation in temperature itself, it is more convenient to choose a σ that represents each season. Thus, seasonal values of σ were calculated for both the maximum and minimum temperature (Table 2). This choice of σ also facilitates incorporating such information into graphics for a television broadcast and minimizes the need for storage of information. Alternatively, an annual or monthly (Table 3) value of σ could be calculated using the same methodologies described in this study. Calculating monthly σ values can still be performed using these methodologies without violating the assumption that our sample is sufficiently large.

Additionally, when examining or displaying summary statistics, such as comparing an observed monthly average to a 30 year mean, the methods described above and their justification for use can be applied in the analysis. Using the daily temperature values to construct monthly means and 30 – year means for each month, then calculating monthly anomalies (observed monthly mean – 30 year monthly means), it was found that within a season these anomalies were normally distributed (not shown). Monthly anomalies within seasons were examined since the distribution of 30 monthly anomalies would represent a small sample. The standard deviations for months within each season are shown in Table 4.

Figure 4 presents two suggested templates (Fig. 4a is Tukey Box plot – e.g., Tukey, 1977) for including such information in a typical weather broadcast. For example if the average maximum for 4 January in Columbia, Missouri is 37 ^{o}F, and the standard deviation for the winter season is 13 ^{o}F, an interval can be created that is 2σ in width, in this case 24 ^{o}F – 50 ^{o}F (as represented by the top and bottom of the “box” in Fig. 4a). Then an observed maximum of 43 ^{o}F can be described as a warmer than normal, but still a typical January day for Columbia, Missouri.

If the maximum were 52 ^{o}F, then that day could be described as being unusually warm for this time of the year (Fig. 4b). Conversely, if the observed maxima were 31 ^{o}F or 22 ^{o}F, the day could be described as cold, but typical for January, or unusually cold, respectively. Such information could be presented as in Fig. 4a or Fig. 4b without the need to explain to the general public the concept of standard deviations and other statistical concepts. A similar display to Fig. 4 showing monthly means could be considered for the presentation of monthly average temperature information. For example, if the average temperature in Columbia, Missouri for January 2002 was 34.4 ^{o}F, and the 30 – year monthly average and winter season monthly σ for January is 28.0 ^{o}F and 5.6 ^{o}F, respectively, then January 2002 can be described as unusually warm. Daily temperature range information was incorporated into television broadcasts on KOMU TV-8 during the spring of 2002.

4. Summary and Conclusions

In this study, the statistical properties of the 30-year record (1971 - 2000) maximum and minimum temperature observations for Columbia, Missouri, are studied with the goal of providing more information about the representativeness of observed temperatures with respect to climatological mean temperatures in television weather broadcasts. The data used in this study were obtained from the Missouri Climate Center and analyzed using standard statistical techniques. A 30-year period was chosen because the record for this time period was continuous and is consistent with the time period used to provide climatological maximum and minimum temperatures.

In general it was found that maximum and minimum temperature data in the 30-year period and in each season are normally distributed with respect to the daily mean temperature values. The standard deviation, a measure of variability, was then chosen as the statistic to use in creating a daily temperature range that could be considered typical. It was also found that, as expected, the daily values of standard deviation showed annual variability, with higher variability in the winter season than in the summer season. Since the annual variation of this quantity was much smaller than the annual variation in temperatures themselves, seasonal values of standard deviation were calculated.

This information was incorporated into routine television weather broadcasts at KOMU TV-8, the NBC affiliate in Columbia, Missouri during the spring of 2002. Meteorologists and weather broadcasters created graphics that used the daily climatological values of temperature and the seasonal and monthly values of standard deviation described here in order to present not only daily climatological maximum and minimum temperatures, but expected temperature ranges for a particular time of the year. Thus, the viewer will not only see how observed temperatures compared to normal, but how representative these observations are for that particular date within a particular month or season. In an era when weather information is presented more and more often, and climate and climate change are prominent issues, information regarding the typical range for temperatures can be used to separate out unusual temperature observations from those that are more typical.

5. Acknowledgements

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Appendix

A colorized version similar to the suggested graphic in Fig. 4a has been used in the weather segment of KOMU TV8's news program by their permanent staff and student help since April 2002. In order to obtain feedback from the general public, the broadcasters appealed for commentary in May of 2002. Requests for public feedback were also made on the KOMU website (http://www.komu.com/html/bbs.html) main bulletin board during May and August of 2002. The website generated very little feedback regarding this graphic.

As a result, a brief survey was created in order to determine whether or not viewers liked the proposed method of presenting temperature information. This survey was passed out to 287 participants, which included regular viewers of KOMU news and those who don't regularly watch television news. Those who are not regular viewers were asked to watch the weather segment on at least two different occasions. The survey participants included students, staff, and faculty from the University of Missouri as well as feedback from the general public. All information about

6. References

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Figure Captions

Figure 1. The daily climatological maxima (solid) and minima (dotted) (^{o}F) derived for the 1971-2000 period for Columbia, Missouri.

Figure 2. As in Fig. 1, except for daily standard deviations.

Figure 3. The frequency distributions for a) maximum and b) minimum temperatures for Columbia, Missouri (solid lines), and a normal distribution (dotted lines) created using the 30-year standard deviation for each quantity. The abscissa represents 1 ^{o}F bins (daily observations - daily means) and the ordinate represents the number of occurrences for each category over the 30-year period.

Figure 4. Suggested templates for incorporating seasonal standard deviation information into weather graphics depicting daily temperature observations. The template in Fig. 4a is a Tukey box plot (Tukey, 1977), while 4b was adapted from a suggestion by Kenneth Smith.

Footnotes

1. The methods used in this study are generally applicable to any region in which a continuous temperature record is available. The FORTRAN code used to manipulate the data was created by some of the co-authors and can be obtained from the lead author. Alternatively, this group can provide the results calculated for a particular location by request.

Table 1. Calculated monthly average temperatures (°F) for the base period 1971 - 2000 using daily temperature data from the Columbia, Missouri Regional Airport.

Month	Average Maxima	Average Minima	Monthly Average
January	36.6	19.3	28.0
February	43.0	24.4	33.7
March	54.3	33.0	43.7
April	65.3	43.5	54.4
May	74.1	53.3	63.7
June	83.2	62.3	72.8
July	88.3	67.0	77.7
August	87.1	64.9	76.0
September	78.8	56.5	67.7
October	67.5	45.2	56.4
November	52.7	34.2	43.5
December	40.7	23.7	32.2

Table 2. Calculated standard deviations for maximum and minimum temperatures (°F) in each season for Columbia, Missouri, and the rounded values used by KOMU TV-8. The winter season was defined as the period December through February and each following season was defined as the next three months.

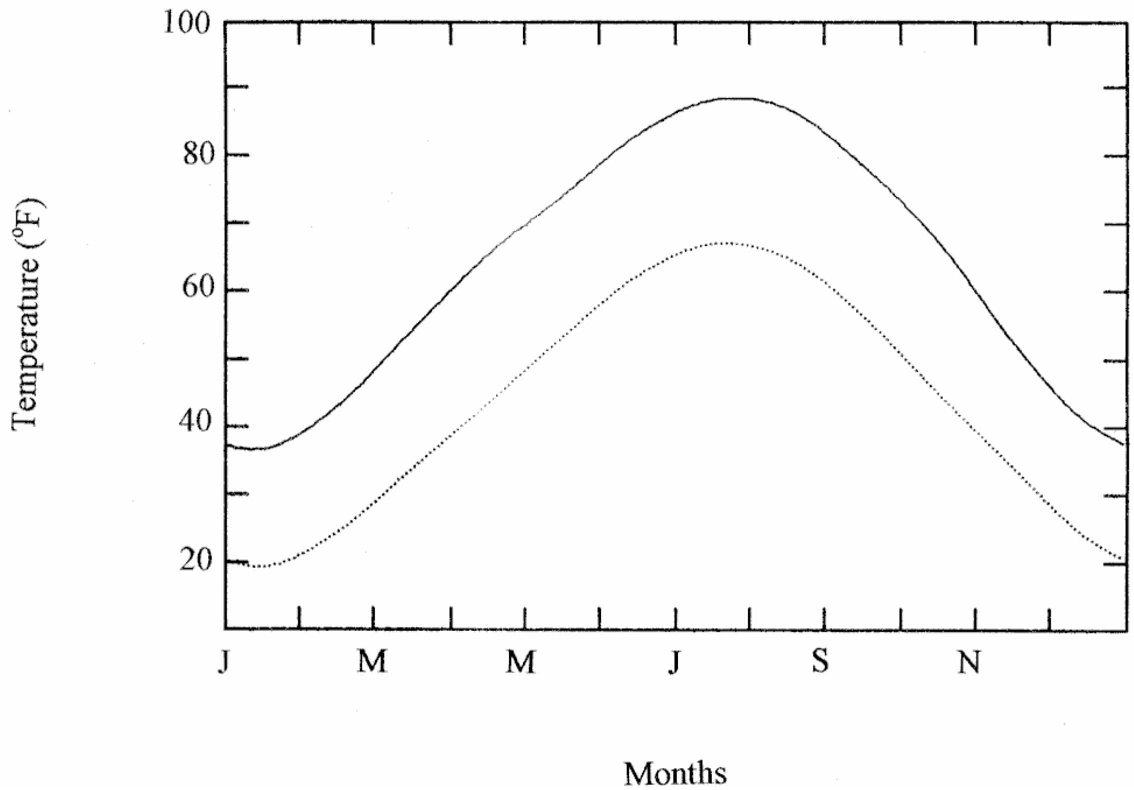
Season	σ of maxima	rounded σ - max.	σ of minima	rounded σ - min.
Winter (DJF)	12.7	13	11.6	12
Spring (MAM)	10.6	11	8.4	8
Summer (JJA)	6.6	7	5.6	6
Fall (SON)	10.0	10	8.8	9

Table 3. Calculated standard deviations for maximum and minimum temperatures (^oF) in each month for Columbia, Missouri, and the rounded values used by KOMU TV-8.

Month	σ of maxima	Rounded σ - max	σ of minima	Rounded σ - min
January	13.1	13	12.2	12
February	13.7	14	11.5	12
March	13.4	13	9.9	10
April	11.2	11	8.4	8
May	7.6	8	7.0	7
June	6.2	6	5.9	6
July	6.6	7	5.2	5
August	7.0	7	6.0	6
September	9.0	9	8.4	8
October	10.4	10	9.6	10
November	12.0	12	9.5	10
December	12.7	13	11.6	12

Table 4. Calculated standard deviations for monthly mean temperature anomalies (^oF) for each season in Columbia, MO, and the rounded values.

Season	σ of monthly anomalies	Rounded σ of monthly anomalies
Winter (DJF)	5.63	5.6
Spring (MAM)	3.23	3.2
Summer (JJA)	2.49	2.5
Fall (SON)	3.19	3.2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80
60
40
20
Temperature (°F)
J
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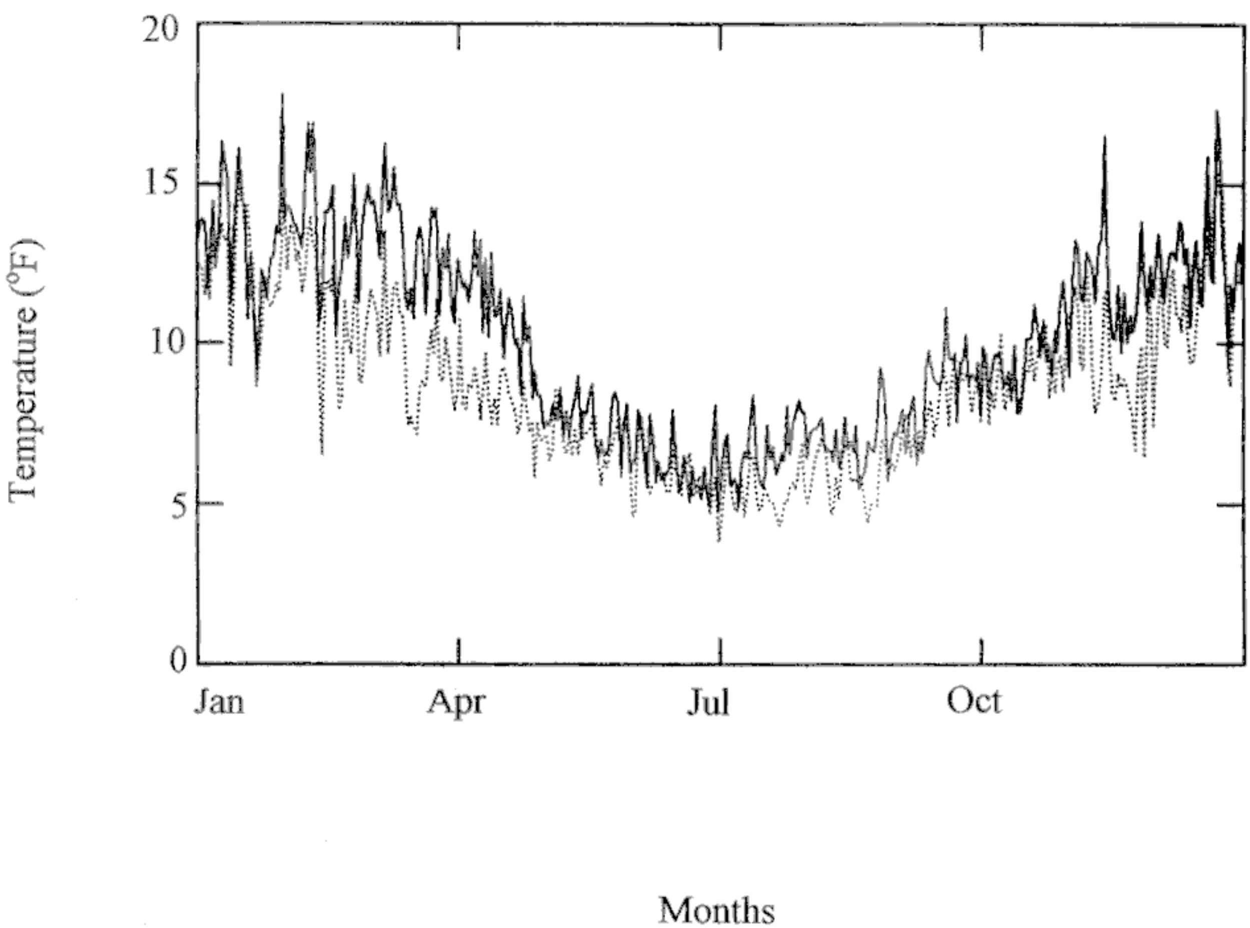
Months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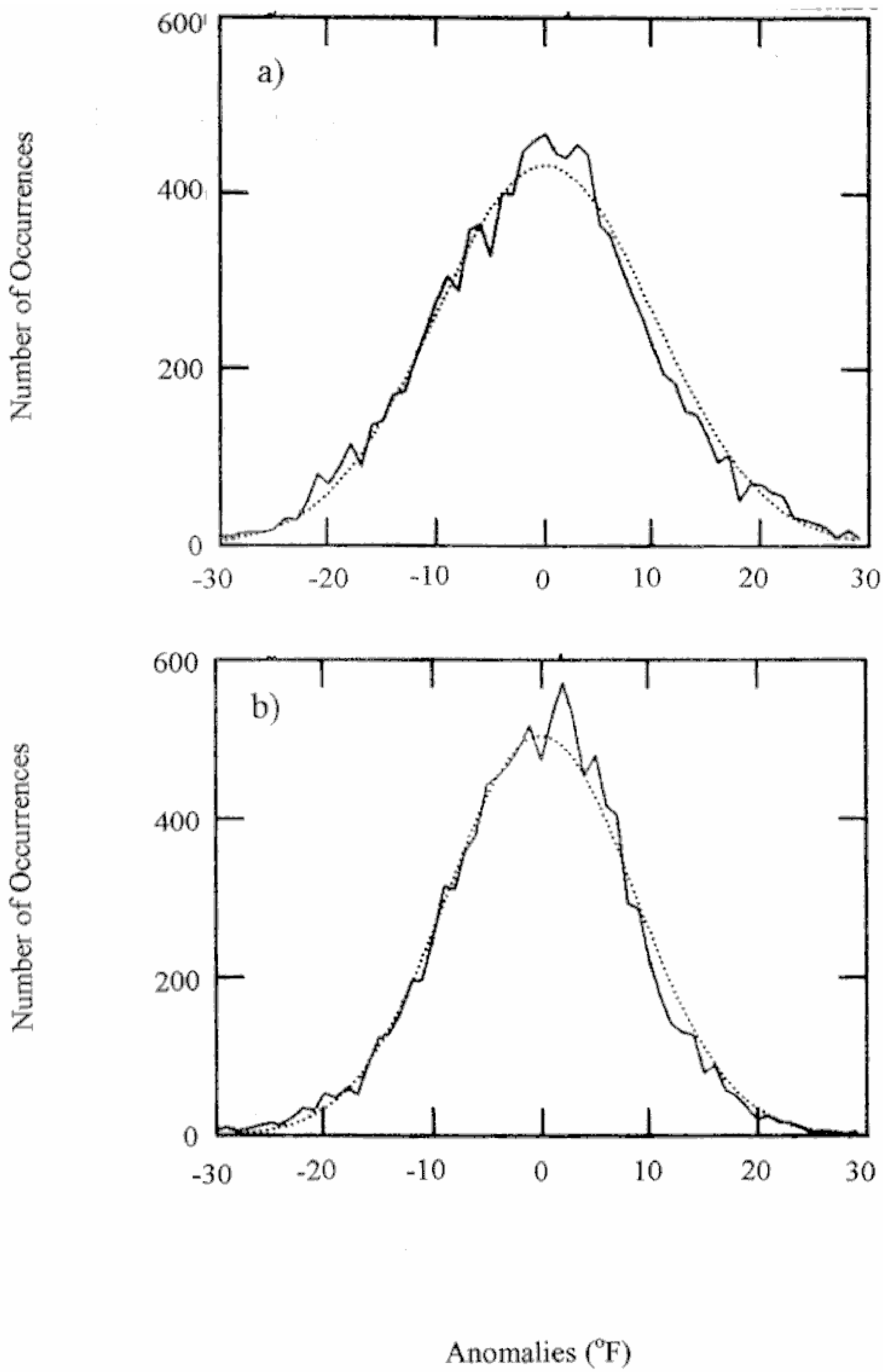
Temperature (°F)
Jan
Apr
Jul
Oct
Months


a)
b)
Number of Occurrences
Number of Occurrences
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400
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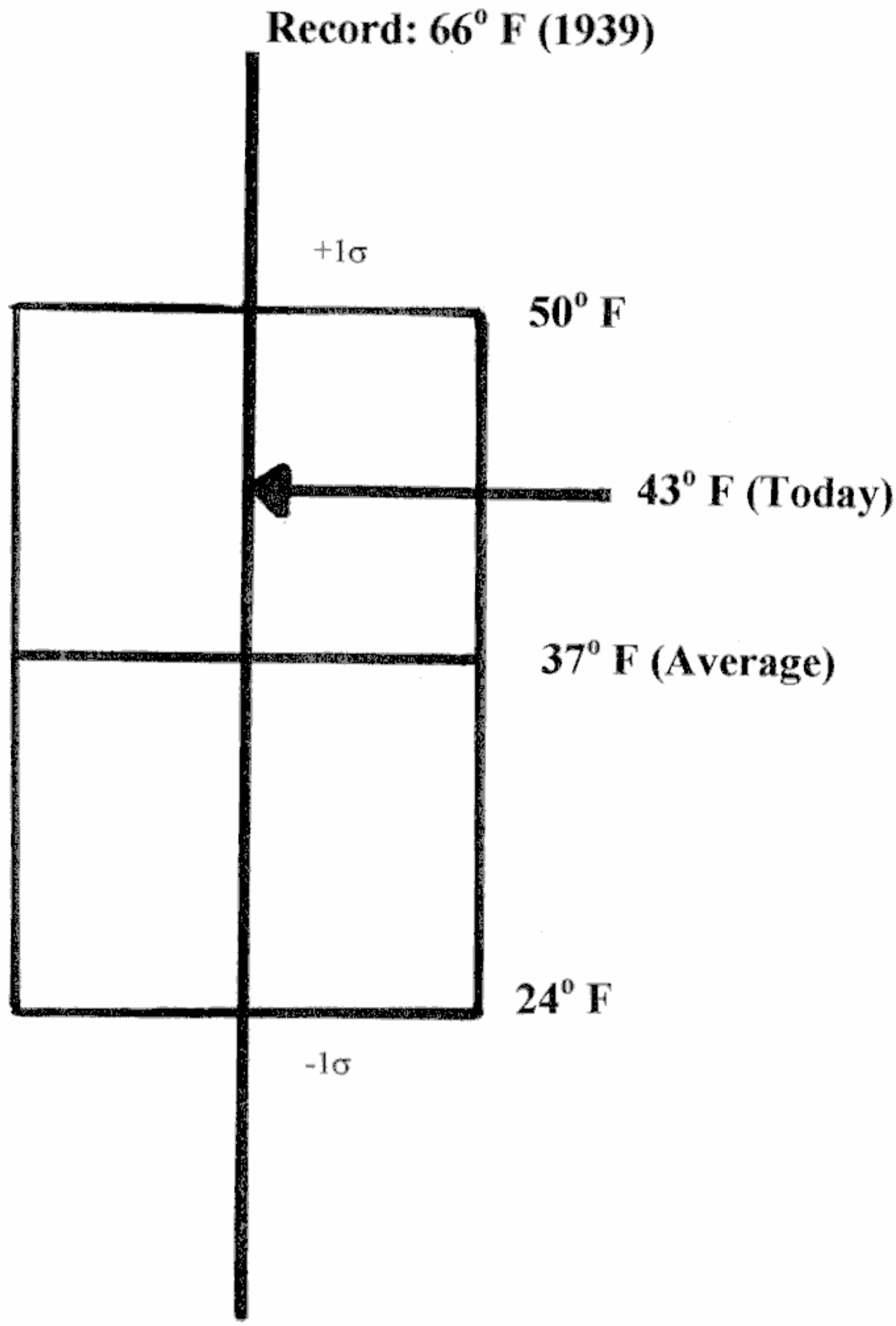
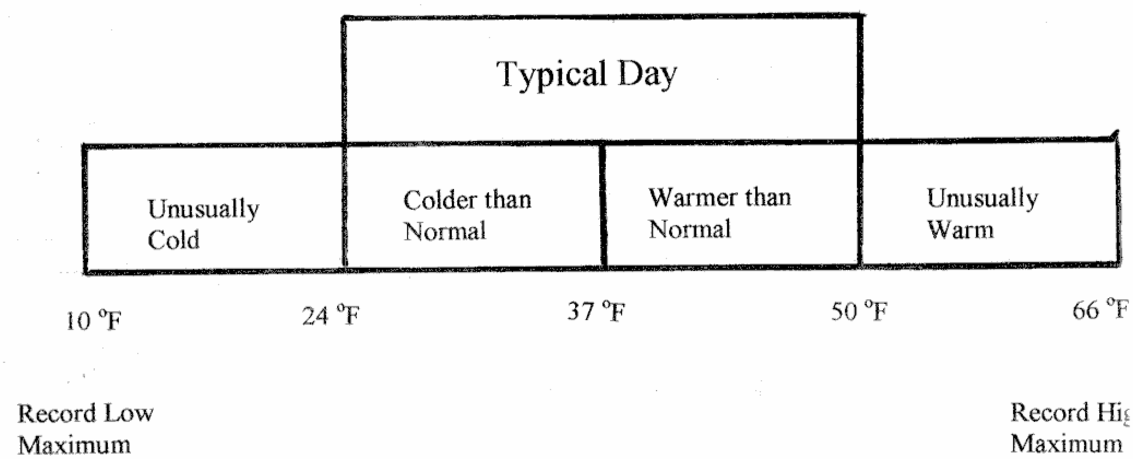
-30
-20
-10
0
10
20
30
Anomalies (°F)

High Temperature: January 4th 2002



Typical Temperature Range


Typical Day
Unusually Cold
Colder than Normal
Warmer than Normal
Unusually Warm
10 °F
24 °F
37 °F
50 °F
66 °F
Record Low Maximum
Maximum