Temperature Trends at Topeka, Kansas

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Official weather observations have been taken in Topeka, Kansas, since June, 1887. This continuous data set is almost 125 years in length and provides an opportunity to examine long-term temperature trends for this location. The purpose of this enote is to examine these temperature trends by employing time series analysis techniques to the data series.

Data Series and Analysis Issues

Monthly average temperature data were obtained from the National Weather Service office in Topeka. Before examining this time series, two issues need to be addressed. First, the observing site has changed location on several occasions during the 120+ year history of the data set. All sites were within 3 miles of downtown Topeka. From a board perspective, these moves may not seem important, but microclimate considerations say that these changes should be addressed. Secondly, the annual temperature cycle must be taken into account.

Observation sites can be grouped into three general locations: Washburn University (2 miles southwest of downtown Topeka); 4 locations within downtown Topeka (all within 0.5 miles of each other); and Billard Airport (2.5 miles east northeast of downtown). The dates of observations for these three groups are shown in the table below:

Observation Site	Dates of Data
Washburn University	6/1887 – 3/1892
Downtown Topeka (4 locations)	4/1892 – 7/1948
Billard Airport	8/1948 – 6/2011

These three time periods will be used to divide the data series into three subseries or data groups. This will help reduce the influence of location change.

Methodology

Wilks (2006) describes a statistical measure called *standardized anomaly*; it is also known as normalization. This value is calculated by subtracting the sample average from individual values within the sample, and then dividing the result by the

standard deviation of the sample. Applying standardized anomalies to each data group defined above will help remove the influence of the location change. Positive standardized anomalies indicate warmer than average temperature values while negative standardized anomalies indicate cooler values.

Analysis of Annual Temperature Data

Annual average temperature values were calculated based on the monthly averages from 1888 through 2010. Standardized anomalies were then calculated for each subseries and these anomalies were plotted as a time series. The results are shown in Figure 1.

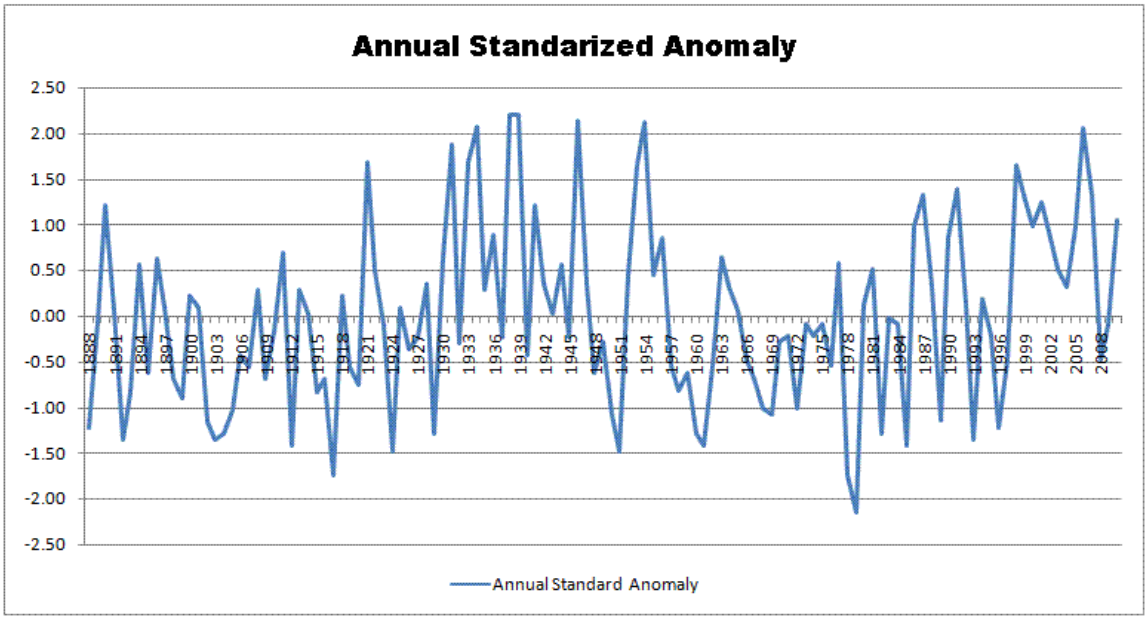

Figure 1: Annual Standardized Anomalies for Topeka, KS from 1888 through 2010.

There is considerable annual variation in the standardized anomaly values through the period. There appears to be a short-term periodicity that varies from 3 to 5 years while a longer term trend can be seen with peaks in the 1930s and around 2000.

In order to see the longer term variation and in order to minimize the effect of any solar variation associated with the sunspot cycle, an 11-year running mean was applied to the data values used in Figure 1. These results are shown in Figure 2.

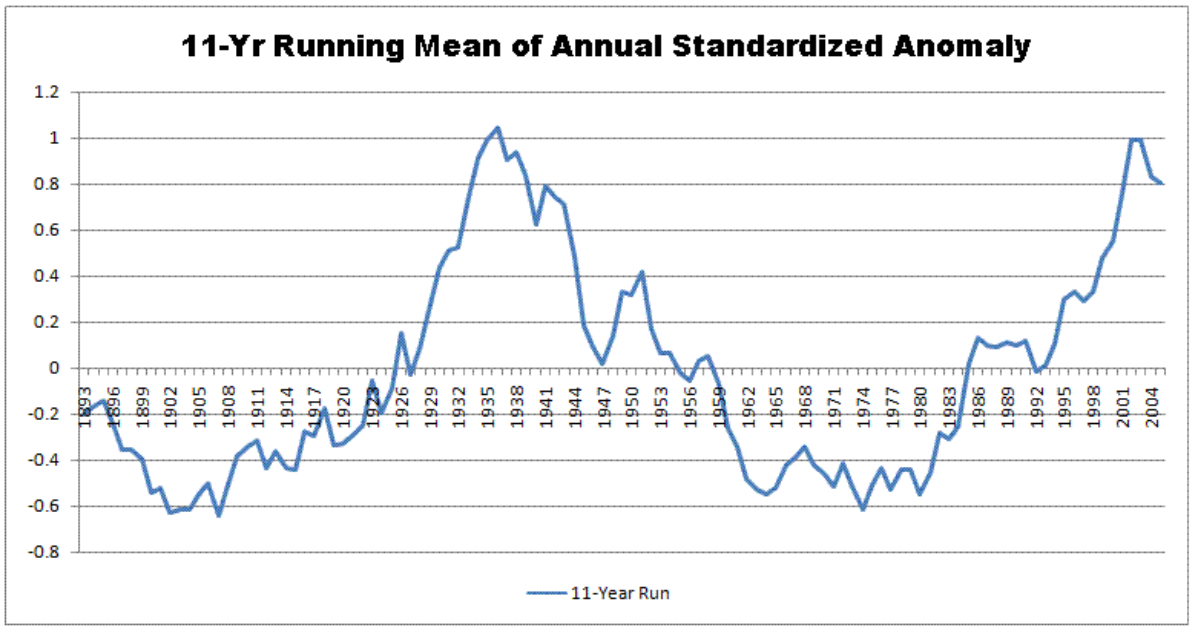

Figure 2: 11-year running mean of the Annual Standardized Anomaly for Topeka, Kansas, from 1888 through 2010.

The 11-year running mean suppresses the short-term variations and highlights the longer term trend. A well-defined peak occurs in the 1930s and another just after 2000. This latter peak needs to await more data for better definition. This series implies a period around 70 years between warmer and cooler periods. If you use a standardized anomaly value of +0.4 to define the warm period in the 1930s, it lasts approximately 15 years. Using a similar threshold value, the current warm period started around 1999 and should show cooling by 2014. This raises the question: Is the current global warming trend truly an upward trend that will continue for decades to come or is it just a short period of warmer temperatures associated with an atmospheric cycle? Come back in 10 years and find out the answer.

Analysis of Monthly Temperature Data

If the monthly data are used to conduct the analysis, data are further subdivided by month and standardized anomalies are calculated for each month for each subseries. This approach reduces the influence of the location change as well as the annual temperature cycle. Figure 3 shows these results with a 59-month (approximately 5 year) running mean applied to the time series.

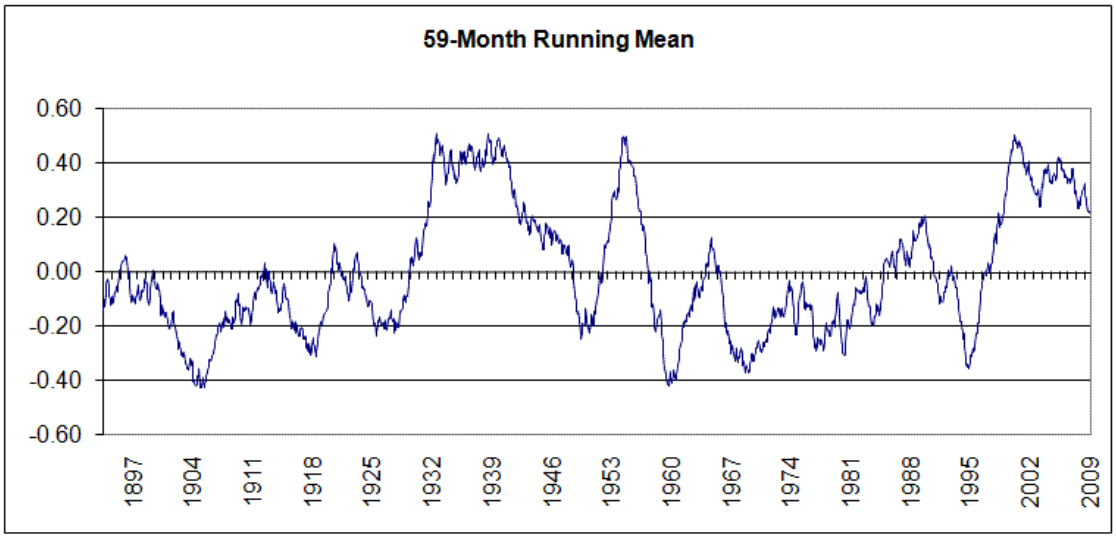

Figure 3: A 59-month running mean of Standardized Anomaly for monthly data from June 1887 through June 2011 for Topeka, KS.

The general trends shown in Figures 1 and 2 are also found in Figure 3. The warm periods in the 1930s and around 2000 are evident. There is also a shorter warm period in the early 1950s and, at times, the plot shows a warm-cool periodicity of around 11 years, on average.

Concluding Remarks

This enote has examined temperature data from Topeka, KS using standardized anomalies and running means. Both the annual data and the monthly means show a period of warmer temperature in the 1930s and currently. The period in the 1930s lasted approximately 15 years. This prompted the question: If the atmosphere is truly cyclic, will the current warm period show cooling by the year 2015?

These data are for only one location with a long series of temperature observations. It would be interesting to see a similar analysis for other locations at various points around the globe.

References

Wilks, D.S., 2006: **Statistical Methods in the Atmospheric Sciences**, 2nd edition. Academic Press (Elsevier), 627 pp.