# J2.3 U.S. CLIMATE REFERENCE NETWORK TEMPERATURE RECORD: AN INITIAL EXAMINATION

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## 1. INTRODUCTION

In recent years, NOAA's National Climatic Data Center (NCDC) has pursued two tracks to preserve the temperature record of the United States: 1) closely monitoring the health of existing observation networks and climate time series, including pursuing a strong program of data quality control and homogenization; 2) building a new U.S. climate observing network adhering to the Global Climate Observing System Climate Monitoring Principles. The U.S. Climate Reference Network (USCRN) is the outcome of the second track. The conterminous U.S. network of 114 stations was completed in 2008, and expansion of the network in Alaska commenced in 2009.

Sufficient time series length has accrued since network commissioning in 2004 to be useful in confirming that the temperature record derived operationally from the long existing stations is being corrected accurately and matches well with the USCRN record. This presentation will extend the annual comparison, and for the first time examine the monthly U.S temperature record from USCRN. Both departures from estimated normals and first difference approaches will be utilized.

## 2. USCRN QUALITY ASSURANCE

Triplicate measurements of temperature with well shielded and aspirated platinum resistance thermometers calibrated using National Institute of Standards and Technology traceable standards yield extremely accurate temperature observations in pristine environments (Figure 1). This approach

Figure 1. Three radiation shields housing and fan aspirating three independent platinum resistance thermometers at the WY Moose 1 NNE USCRN station in Grand Teton National Park.

allows the independent temperature readings to be compared in a pairwise fashion in order to detect a sensor that is malfunctioning. If only two sensors are available, it is sometimes difficult to tell which one is defective without bringing a calibration standard to the site. However, with three sensors, if one fails, two will agree closely within tolerance (0.3°C for USCRN temperature), with the pairwise differences being much larger for the pairings including the defective sensor. For example, in Figure 2, sensor 3 becomes defective, maintaining a temperature 1.5°C above that of the other two sensors. With the triplicate configuration, this problem can

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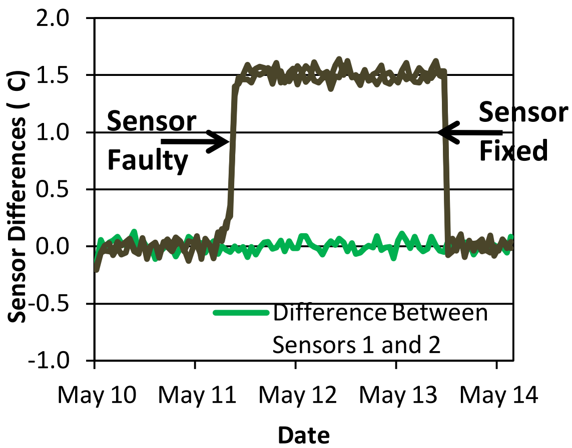


Figure 2. Example of a defective sensor (#3) subject to a pairwise comparison in a triplicate configuration. The two good sensors comparison yields near zero differences (green), while the comparisons to the defective sensor are far from zero (brown).

be determined almost in real time, and repairs ordered promptly. Detecting a subtle 1.5°C shift by comparing values from stations miles apart could require years, if it is ever detected at all.

The USCRN temperature algorithm uses information from all three PRTs and a measure of their shield aspiration fan speeds to calculate individual 5-minute temperature values for a station. An annual maintenance visit each year replaces one of the PRTs so that there is also assurance against all three instruments drifting simultaneously from calibration. Given the intrinsic instrumental accuracy of ±0.25°C, and the continuously measured pairwise accuracy of ±0.3°C, the USCRN measurement approach is a significant improvement over the Automated Surface Observing System (ASOS), which is specified to have a maximum error of ±1.0°C and a root mean square of ±0.5°C (NOAA, 1998).

## 3. NATIONAL TEMPERATURE RECORD

One of the most important applications of USCRN temperature data to date has been its use in examining the reliability of the U.S. temperature record (Menne et al. 2010). Using a segment from 2004 to 2008 of USCRN station temperatures from which an estimated normal had been removed, a national temperature departure from normal was calculated. These departures from normal were then compared to national departures for the standard United States temperature data set, the U.S. Historical Climatology Network (USHCN) Version 2. USHCN Version 2 consists of more than 1200 historical climate stations with varying levels of consistency that have been quality controlled and homogenized for the express purpose of looking at climate trends (Menne et al. 2009). The comparison showed a nearly one-to-one correspondence between the USCRN and USHCN annual temperature departures from 2004 to 2008. This confirms that the statistical methods used to correct and homogenize the USHCN did a great job in the modern era, lending credibility to the performance of these methods during the pre-USCRN period, too.

A potential criticism of the Menne et al. (2010) comparison is that the method of deriving estimated temperature normals for the short duration USCRN stations relied on station data from the same source as the USHCN, the U.S. Cooperative Observer Program (COOP) Network (Sun and Peterson 1985). To avoid this difficulty and generate a completely independent comparison of USCRN national temperature departures and those from the USHCN, a first difference approach is used here (Peterson et al. 1998), where the changes of temperature year-by-year are compared between the two observing networks, rather than the departures themselves. In both the maximum and minimum cases (Figure 3), the first differences time series are extremely close to each other during the period 2005-2010, with an adjusted r-square of 0.995 and 0.986 for maximum and minimum temperature, respectively.

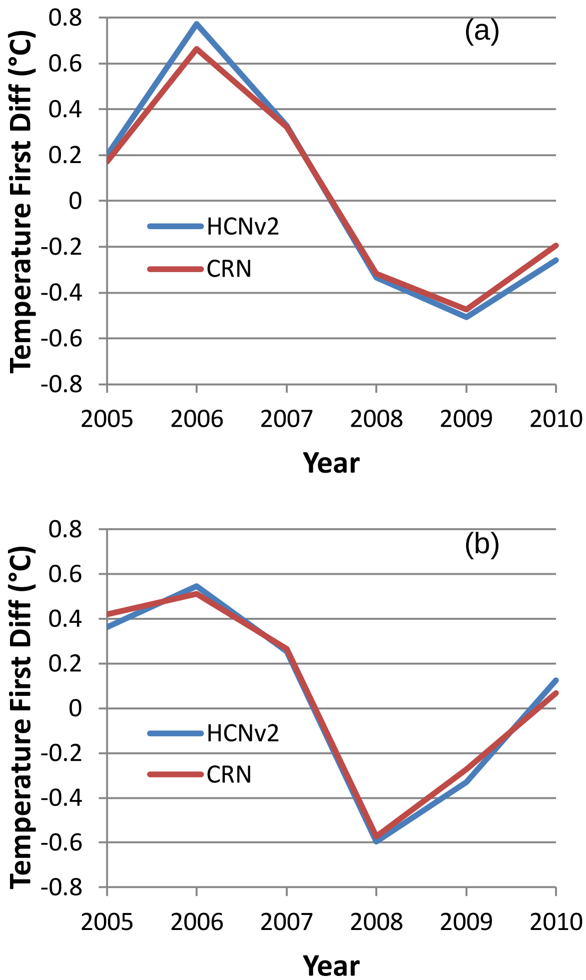


Figure 3. (a) Maximum and (b) minimum national temperature first differences over time, for USCRN (red) and USCRN Version 2 (blue).

At this point, there is no substantial uncertainty regarding the observation of modern year-to-year changes in conterminous United States air temperature. Moreover, the statistical adjustments made to the USHCN stations with less than ideal continuity of location, land use, and observing time continue to appear robust in comparison to the well situated and well maintained USCRN.

As USCRN stations increased from 40 at the time of network commissioning in early 2004 to 114 at the end of 2008, the coverage of the U.S. by 5° latitude/longitude grids that contained a USCRN station went from 43% to 99%. Examination of the monthly national maximum temperature departure difference between USCRN and USHCN shows a distinct drop off over time of the magnitude and variance of these differences as coverage improved (Figure 4). It is expected that differences will perhaps diminish further as USCRN estimated normals become better defined as more years of data become available.

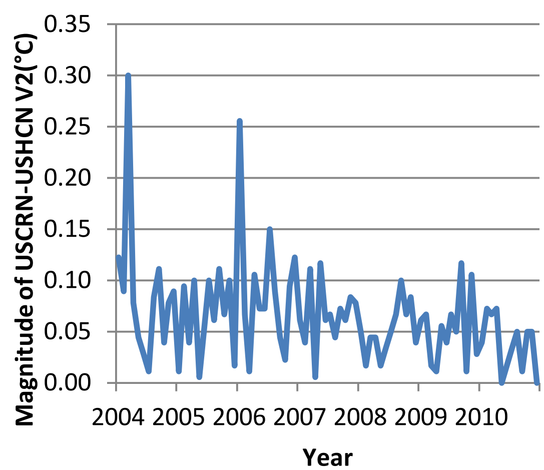


Figure 4. The magnitude of the monthly difference between USCRN and USHCN Version 2 national maximum temperature departures.

## 4. USCRN TEMPERATURE APPLICATIONS

While generating the definitive national temperature record is the most important mission of the USCRN, these data are available for other applications, and have some unique properties. For example, the stability of measurements with aspirated thermometers may make the USCRN an ideal source for information on changes in diurnal temperature range. This stability can be illustrated by examining the time series of temperature range at one of the locations with paired USCRN stations, such as near Lincoln, NE. Figure 5 displays the diurnal temperature range smoothed with an 11-month running mean at the two paired stations about 30 km apart. Variations in range over time are in synchrony, while one station on average (8 ENE) has a daily range approximately 1°C larger than the other station (11 SW). The trends of the monthly range values are not significant at this point, but are slightly negative (-0.3°C/ 100 years).

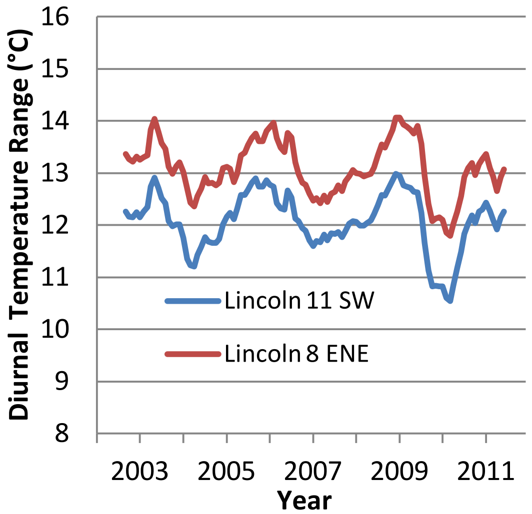


Figure 5. Diurnal temperature range for the Lincoln, NE, region smoothed with an 11-month running mean.

USCRN temperature records should also be very useful for monitoring changes in extreme temperature events over time, especially those that are very sensitive to local land use changes, such as all-time records and threshold events. Heat waves and cold waves will be of great interest as the statistical richness of the USCRN grows over time. The operational range of temperatures successfully recorded by USCRN exceeds 100°C, from -49.2°C at Barrow, AK, to 52.2°C at Stovepipe Wells, CA. These systems function well in extreme hot or extreme cold conditions if power is adequate (Palecki and Groisman 2011), insuring the observation of the full range of extremes at a location. In summary, the USCRN temperature data set is of high quality, is growing every day, and has enough observations to be used for many climate science applications, in addition to assuring the U.S. temperature record. The combination of these temperature records with high quality USCRN observations of precipitation, soil moisture, soil temperature, humidity, infrared surface temperature, solar radiation, and low level wind yields still more possibilities for using these data to solve climate-related problems of agriculture, commerce, energy, and industry.

## 5. REFERENCES


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