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# U.S. CLIMATE REFERENCE NETWORK (USCRN): A UNIQUE NATIONAL LONG-TERM CLIMATE MONITORING NETWORK

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**ABSTRACT**

The primary goal of the USCRN is to provide long-term (50-100 yrs) homogeneous accurate and complete observations of temperature and precipitation. Coupling these observations with existing long-term historical observations will support the detection and attribution of present and future climate change. The USCRN was officially commissioned in January 2004 and the network is scheduled to be completed in 2008 with a total of 114 stations in the Continental USA. Each USCRN site carefully records the primary measurements of climate — air temperature and precipitation — supplemented with other measurements (e.g., wind speed, solar radiation, surface temperature (infrared), wetness and several engineering variables which monitor the operating conditions of the equipment) and redundancy of critical sensors (i.e., backup instruments) to ensure the most accurate climate change monitoring. The USCRN provides improved data quality for climate purposes. For example, instead of using just one thermometer, each USCRN station uses three temperature sensing instruments. In addition, soil moisture, soil temperature and relative humidity sensors are planned after the 114 sites are installed. This paper provides an overview of the USCRN, updates its status for the meteorological and climate science communities and illustrates some of the more unique observations that have been observed by providing some examples of how the network is being used for improved climate monitoring.

## 1. INTRODUCTION

Here is some base background information concerning how the instrumentation on a CRN station works and how it interworks – why the entire assembly of sensors and metadata information onboard the station is so important for the generation of high-quality, high-confidence science – and in turn, how the network itself can be used as a single instrument.

Through the use of all data sensors it is possible to diagnose the health of the station's instrumentation at a level that was previously impossible by using only the restricted readings of only ambient temperature and precipitation, and such other metadata as might be available or be able to be derived.

Metadata have not been a high priority and have not had diligent standards applied in their collection in the past. The atmospheric science community is now very well aware of this shortcoming.

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The objective of this secondary information and sensor metadata is to provide ancillary information to identify any questionable data as soon as possible and to pass that information on to the CRN engineering team for further analysis, and if need be, to repair or replace the faulty or out-of-calibration sensor(s). The wise, focused, and experienced scientist will frame his/her sensors' data studies by examining this secondary data so as to increase his/her confidence in the data and its representation of the physical environment (atmosphere).

The notification of any questionable data values is handled through a systematic, standardized **anomaly tracking system** that also provides a permanent data base of information (secondary metadata) that can be accessed through time by both scientists and engineers. Again, strict standards must be employed to do "good science".

The quality assurance process involves both the hourly oversight of automatic computer checks, as well as oversight of those flagged values by a scientist knowledgeable in meteorology and instrumentation. The above described suite of instrumentation has in the last few years allowed the measurement and analysis of various local and regional meteorological events. The five-minute observation period interval of the primary data has also allowed the identification of unique microclimatic behavior of each site. This is most often seen in the ambient temperature during nighttime hours. It will obviously take additional years to build a sufficient period of record to identify national trends, to seam together the meaning of a network of individual stations, each station with its own climatic profile.

## 2. DESCRIPTION OF THE NETWORK

During FY 2007, the USCRN increased to 96 commissioned field stations plus three stations in pre-commissioning (burn-in) test, for a total of 99 stations in the lower 48 states. The 20 USCRN stations deployed during FY 2007 increased the confidence in the contiguous United States for Temperature from 97.0% at the end of FY 2006 to >97% at the end of FY 2007. Likewise the confidence for Precipitation was increased from 91.8% at the end of FY 2006 to >94% at the end of FY 2007. Science reviews for fitness of sites as being climatically representative have been completed on all 114 sites by the end of FY 2007. Only four new station sites are now in their final approval process between the Site Host agencies and NOAA/DOC. Final approval actions by all parties are expected on all remaining USCRN sites during Spring 2008.

The full schedule of deployments planned for FY 2008 should completed the base network for the Continental US, and achieve the state Program Goals of national uncertainty for Temperature to be at least 98.0% and for Precipitation the confidence level should be increased to at least 95.0%. The final distribution is shown in Figure 1.

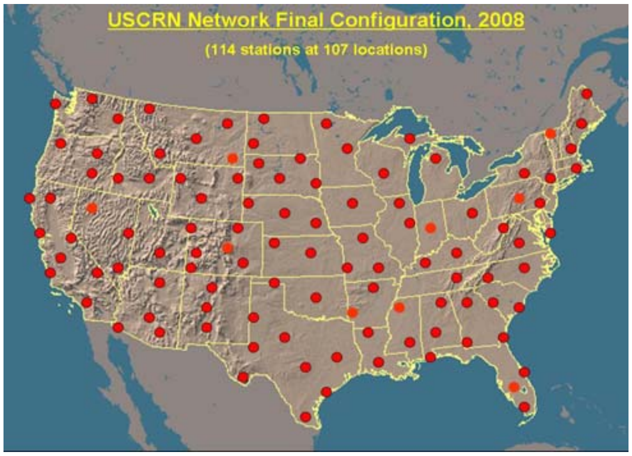


**Figure 1.** USCRN Final Configuration, 2008.

Climate representativity is determined not just on the basis of temperature or precipitation classifications, but also is influenced by elevation. For the purposes of overall grid representativity of the USCRN, four broad elevational ranges were identified as being necessary in order to assure more balanced monitoring for National-level climate representativity. The four elevational classes defined are:

1. from mean sea level to 2,500 feet;
2. a second class from 2,500 feet up to 5,000 feet;
3. a third smaller elevational gradient up to 9,000 feet; and
4. a very small representation for those elevations above 9,000 feet.

The stations depicted in Figure 1 represent both elevational classes with 77 < 2,500 ft, 24 < 5,000 ft, 12 < 9,000 ft, and 2 > 9,000 ft. This also includes eight paired stations.

## 3. THE PRESENT USCRN RECORDS AND RANGES

Despite the short period-of-record of the USCRN the records of various parameters from this network are of interest because of their high-confidence levels, the known calibrations of the sensors, and the precision measurement ranges of the various sensors. The network has already recorded some significant events – it will record other and newer and different events in the future – so these early observations should be considered only the first part of a dynamic tale.

**Table 1.** CRN Temperature Records

**CRN Temperature Records (°F)**

- Highest Air Temperature = 126°
  Stovepipe Wells, CA July 5, 2007
- Lowest Air Temperature = - 56°
  Barrow, AK
- Highest Ground Surface Temperature = 160°
  Stovepipe Wells, CA June 24, 2006
- Lowest Ground Surface Temperature = - 60°
  Barrow, AK

One of the more unique measurements measured is the surface temperature. Table 1 illustrates the extremes that have been observed at Death Valley and Barrow, AK. The relationship between the surface temperature and air temperature at the USCRN locations will be important to Land Surface studies and remote sensing of surface temperatures from satellites.

One of the new levels of knowledge that has come from having three separately housed and power-aspirated CRN thermometers is that their sensed temperatures depart from each other for minutes or sometimes a couple of hours as the relative humidity decreases from a saturated (100%) condition. This differential or separation phenomenon is caused by the unequal rate of evaporational cooling of the moisture collected on the temperature sensors during a fog condition or saturated state. The graph in Figure 2 shows the reported 5-minute temperatures from each of the three thermometers.

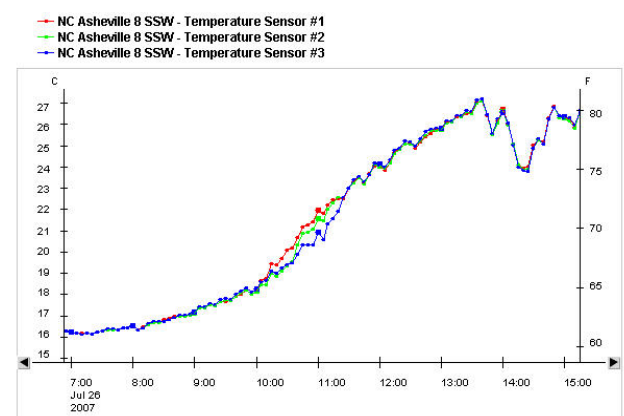


**Figure 2.** 5-minute temperatures from three different thermometers.

There have also been some interesting observed precipitation events that are shown below.

**CRN PRECIPITATION RECORDS (Inches) (November 2000 – September 2007)**

- Greatest 5 Minute = 0.73" Titusville, FL, July 7, 2006
- Greatest 15 Minute = 1.89", Titusville, FL, July 7, 2006
- Greatest 30 Minute = 3.08", Titusville, FL, July 7, 2006
- Greatest 60 Minute = 3.77", Titusville, FL, July 7, 2006
- Greatest 1 Day = 11.78", Quinault, WA, November 6, 2006
- Greatest 5 Day = 25.12", Quinault, WA, November 2-6, 2006
- Greatest 7 Day = 27.39", Quinault, WA, November 2-8, 2006
- Greatest 30 Day = 51.35", Quinault, WA, November 1-30, 2006
- Greatest 365 Day = 184.90". Quinault, WA, October 1, 2006 – September 30, 2007

## 4. SUMMARY

The USCRN has a well-defined purposed (mission), and will evolve and strengthen to answer longer-term climate science questions. The USCRN program is approaching a full operational network status with >85% of the required field stations now operational and 94% of those operational stations are now commissioned. The USCRN station deployments are founded on a robust infrastructure that includes full documentation of the metadata, timely response to unscheduled repairs, a system for monitoring of all maintenance actions, and has the highest possible quality control/quality assurance of the data.

USCRN data users include Federal agencies (BLM, EPA, USDA, NOAA, USGS, NPS, NSF, NFIC, NASA), the State Climatologists (SC), four U.S. railroads and the Canadian National railroad system, the six NOAA Regional Climate Centers, the individual SCs, and academic and private sector interests. The strong science component and its feedback into the USCRN continue to improve the precision and accuracy of the sensors, and to increase the confidence levels of data users in applying this data to their needs.

Eight years of science and technology-proofing activity has resulted in other international and national networks utilizing or replicating USCRN instrumentation and data processing algorithms.

## 5. REFERENCES

1. National Research Council (NRC), 1999. Adequacy of Climate Observing Systems, National Academy Press, Washington, D.C.

2. WMO, WMO Guide to Climatological Practices, "The Siting of Climatological Stations", Chap 4, para 2.5, pp. 45-50. Also see the 1996 WMO Document 8, Guide to Instruments and Methods of Observation, Geneva, Switzerland.

3. CRN site survey manuals, checklists, procedures, instructions on survey techniques and products are available for review at: http://www.ncdc.noaa.gov/oa/climate/research/crn/crnsitesurvey.html. (United State Climate Reference Network: Site Survey Requirements, *National Climatic Data Center, 10 April 2000 (updated February 2002)*.

NOAA Climate Reference Network Site Information Handbook, December 10, 2002; CRN Site Survey Checklist, April 26, 2002 (use Adobe Acrobat or MS Word); CRN FY02 Site Selection Task (use Adobe Acrobat or MS Word) (all are available at: http://www.ncdc.noaa.gov/oa/climate/uscrn/siteselectguide.html).