United States Climate Reference Network (USCRN) FY 2007 Annual Report

NOAA-NESDIS

November 2007

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1. INTRODUCTION

This is the fifth annual report for the National Oceanic and Atmospheric Administration's (NOAA) United States Climate Reference Network (USCRN). The primary focus of this report is on the FY2007 USCRN development and implementation activities. Initial projections of activities planned for FY2008 are included. FY2000-FY2003 USCRN activities were reported in the USCRN FY2003 Annual Report, and FY2004, FY2005, and FY2006 activities were reported in the USCRN FY2004, FY2005, and FY2006 Annual Reports, respectively.

This report includes reviews of the USCRN Program, Performance Measures, station installations and site surveys; research progress and plans; instrument testing and forthcoming new instrumentation deployments; partnership activities at several levels; and data completeness and data availability via the Internet. Information about national and international activities including NOAA's Global Climate Observing Systems (GCOS), the forthcoming Alaskan Climate Reference Network (AKCRN), and finally, plans for completion of the deployment phase of the USCRN for the Lower-48 States or Contiguous United States (CONUS) should occur in FY2008.

2. PROGRAM BASE

The required program capability, purpose, and requirement drivers for the USCRN are stated below.

2.1 Program Capability

The NOAA Strategy of "Monitor and Observe": "We will invest in high-quality, long-term climate observations and will encourage other national and international investments to provide a comprehensive observing system in support of climate assessments and forecasts." (NOAA Strategic Plan)

2.2 Program Purpose

The USCRN Program will provide the United States with a climate monitoring and climate change network that meets national commitments to monitor and document climate change for the CONUS. The USCRN Program will complete deployment of 114 operational stations in the continental United States by the end of FY2008 to achieve the target performance measures (Section 3.3). The overall program purpose is to:

Ensure that future changes and variations in primary measurements at specific locations can be monitored without the need for unexplained adjustments and corrections to the data. Primary measurements at each site will include air temperature and precipitation supplemented with other measurements such as wind speed, solar radiation, and infrared radiation. The network will provide adequate spatial coverage to monitor the annual and decadal-to-centennial temperature and precipitation trends for the CONUS. Fundamental to this goal is the requirement to establish a network that 50 years from now will answer the specific question: How has the climate of the United States changed over the past 50 years? The program adheres as closely as possible in both spirit and scientific-technological exactness to the Climate Monitoring Principles as defined by the National Research Council (NRC) of the National Academy of Sciences (NAS), and adopted by the World Meteorological Organization (WMO) as defining principles for climate monitoring stations and long-term climate monitoring networks.

2.3 Program Requirement Drivers

2.3.1 Legislative

- Federal Data Quality Legislation (Act) (Public Law 106-554 Section 515) - Section 515 is known as the Data Quality Act "…government must assure the quality of the information disseminated…"
- 15 USC 313 "establish the climate conditions of the United States…" Global Change Research Act of 1990 -- "requires an early and continuing commitment to the establishment, maintenance, global measurements, establishing worldwide observations… and related data and information systems…"
- 44 USC 31 PL 81-754 Federal Records Act of 1950 provides for Agency Records Center and in 1951 the National Weather Records Center established an Agency for U.S. weather and climate records with the responsibilities of archiving and servicing.
- 33 USC "… authorize activities of processing and publishing data…"
- 15USC CH29 PL 95-357 National Climate Program Act authorizing "… Global data collection monitoring and analysis…;" "…management and active dissemination of climatological data…"; and "… increase international cooperation … monitoring, analysis and data dissemination…"

2.3.2 Executive/International/Programmatic

- Earth Observation Summit (and Group on Earth Observations Working Group) – The Summit Declaration reaffirmed the need for timely, quality, long-term global information as a basis for sound decision-making and called for filling data gaps. The Summit Declaration also affirmed the need for "producing calibrated data sets in useful formats from multiple sensors and venues."
- The Climate Change Science Program Strategic Plan has a goal, "complete required atmosphere and ocean

observation elements needed for a physical climate observing system" (which includes the USCRN) to provide the highest quality benchmark data for enabling the determination of transfer functions with other U.S. meteorological networks such as the Automated Surface Observing System (ASOS), the NOAA Surface Radiation Budget Network (SURFRAD), and the Cooperative Observer Program (COOP). "Data archives must include easily accessible information about the data holdings, including quality assessments, supporting ancillary data, and guidance and aid for locating and obtaining data" and "Preservation of all data needed for long-term global change research is required. For each and every global change data parameter, there should be at least one explicitly designated archive."

- The Second Report on the Adequacy of Global Climate Observing Systems addresses data accessibility and quality. There are many observations of the climate system already being taken today. The report notes many times where there are issues with respect to the limited accessibility to much of the data and problems with its quality. Resolving these issues would have an immediate and positive impact on the ability of the current global observing system for climate to meet the needs of the Parties. More pointedly, the Report states "Notwithstanding the use being made of current information and improvements made in the past few years, this report confirms the Intergovernmental Panel on Climate Change (IPCC) view that current observations are not adequate to meet the full needs of the Parties and are an increasing barrier to the full provision on advice. Without urgent action … the Parties will lack the information necessary to plan for and manage their response to climate change."
- World Climate Programme Data and Monitoring Programme Guidelines on Climate Observation Networks and Systems (WCDMP No. 52) and Guidelines on Climate Metadata and Homogenization (WCDMP No. 53) identify the "best practices" for climatological observations, data collection, metadata, and archival activities. They bring all WMO members to similar standards using the Ten Primary Climate Principles (Appendix A). These standards are a base for USCRN implementation, and are assiduously applied by NOAA to USCRN stations. Instrumentation suites are qualified as "Principal Climate Observations Stations" and "Reference Climate Stations."
- NOAA Annual Guidance Memorandum and "Taking the pulse of the planet – contributing to an Integrated Global Observing System" state that "should develop a comprehensive, NOAA-wide data collection, quality control, storage, and retrieval program." USCRN is the first step in support of the goal of an Integrated Global Observing System. Other efforts are leveraging the USCRN success and taking it to global implementation: bi-laterals, (e.g., the U.S/Canada Weather-Climate bi-lateral); the GCOS initiative, (e.g., Latin America), and eventually to other regions; and the Smithsonian International Tropical Research Center (Memorandum of Understanding).

2.4 Program Objectives and Characteristics

The USCRN Program objectives are to develop, acquire, install, and operate the premier environmental climate-monitoring network of the United States. The USCRN provides stable surface temperature and precipitation observations that are accurate and representative of environmental conditions. Station site location is particularly important as environmental conditions around each station site must not be affected by encroachment of urban expansion in the present or in the future, or by other conditions that create a changing environment. Climate representativeness and long-term maintenance at each CRN station location are essential requirements for a climate monitoring network.

As required by the climate science community and codified by the NAS-NRC, WMO, and NOAA's National Climatic Data Center (NCDC), the USCRN, as a basic if not the premier climate monitoring network, has the following attributes:

a. triple configuration sensors for temperature (see section 5.1) and precipitation;

b. a very high percentage of data ingest over various periods (e.g., minimum of 98% of all possible observations for a given year must be archived at NOAA's national archive, NCDC) to satisfy requirements for climate science;

c. stringent siting standards and an objective, quantitative assessment which is annually verified and maintained for the long term for each site as an essential part of the overall metadata pertaining to each site and station;

d. stringent and periodic maintenance and calibration program with thorough documentation which is systematically collected and archived at least annually;

e. an organized archive of complete metadata for all USCRN sensors, sites, and data characteristics which must be long-term and well-maintained at the national archive;

f. overlapping observations to develop statistical transfer functions and full metadata for systematic, periodic technology refreshes must be maintained for both intra- and inter-network comparisons;

g. strict Configuration Management (CM) for systematically documenting network change(s), maintaining standards, and ensuring requirements growth does not impinge upon

the primary purpose of the network for climate monitoring will be accomplished through thorough, updated CM documentation to ensure full implementation of sound scientific data stewardship principles;

h. maintenance of a continuous data analysis and data quality component for continuous monitoring of both network data and metadata;
i. emphasis on the network's primary purpose of satisfying the climate science community's requirements;
j. activities must be implemented to satisfy all standards, and with consistency in change management for a period of a century or more; and
k. capable of community, user, and need evolution, yet it must remain focused upon and loyal to the constancy and maintenance of the long-term Climate Principles.

When possible, USCRN stations have been co-located with or near existing meteorological observation sites such as those of the NCDC-designated Historical Climate Network (HCN), the National Weather Service's (NWS) Cooperative Observer (COOP) and Modernized COOP networks, the Canadian Reference Climate System Network (RCS), the Bureau of Land Management-Forest Service Remote Automated Weather Stations (RAWS), the NOAA SURFRAD, the University of New Hampshire's AIRMAP stations, and various State mesonet stations (e.g., Alabama, Kentucky, Oregon, and Washington).

USCRN field system technology has proven to be highly reliable, precise, robust, and maintainable, so that it collects, formats, processes, and communicates measurements of environmental parameters to NOAA's national archive at NCDC, central data management and processing facility. During FY2007, data ingest from the 96 commissioned USCRN field stations averaged 99.52% (see Appendix B). Cumulative FY2001-2007 network data ingest is slightly higher at 99.54% (see Appendix C).

USCRN field stations are designed to operate without planned, daily human obligation, and to continue operations under extreme environmental conditions. NCDC provides data ingest, quality control monitoring, data processing, archiving, and user access capabilities to both the climate research community and the general public.

After the initial four years of development and field operations, the first 40 USCRN stations deployed were verified as having sufficient spatial distribution, reliability, and stability, and science information value. Therefore, NOAA commissioned the network in January 2004. Incremental station improvements have been made and will continue to be made under strict CM control. By the end of FY2007, the network consisted of 99 homogeneous stations in 42 states.

2.4.1 Capabilities Required

The required capabilities of the USCRN are the following:

a. Provides land-based reference stations and standard land surface observing stations for tiered NOAA ground observing systems such as NOAA's COOP and ASOS networks.
b. Coverage must be of sufficient temporal and spatial resolution to monitor local-to-national spatial scales for physical phenomena and to determine with the highest confidence trends of significant socio-economic and scientific importance.
c. Measurements of key variables adhering to NRC and GCOS/WCDMP Climate Monitoring Principles. The two primary variables for USCRN are
i. very high quality and
ii. redundant measurements of temperature and precipitation, with secondary variables of solar radiation, wind velocity, and infrared radiation being used as primary variable checks.
d. Data, assimilation, archival, and product generation subsystems for observations.
e. Observing system management and information delivery infrastructure.

3. PROGRAM-LEVEL PERFORMANCE MEASURES

3.1 FY2001-2006 Achievements: Milestones & Performance Measures

The Performance Measures for these years are summarized along with those from FY2007 in Table 1 and Table 2 (in Sections 3 and 3.3 respectively).

3.2 FY2007 Achievements: Milestones & Performance Measures

In FY2007, the USCRN Program was organized and prepared for a large deployment year as well as for continuation of the testing and development program of existing, new (next-generation), and supplemental sensors. In FY2007 refinements were made to the temperature and precipitation algorithms, and a marked reduction was made in the large archival backlog of station and instrument metadata that underlies a reference-quality network

3.3 FY2007 Performance Measures: Climate Uncertainty

During FY2007, the USCRN network 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

Table 1. CRN Reduction in Climate Uncertainty

FY2004-FY2007			
End of Fiscal Year	Commisioned USCRN-Stations Fielded	Temperature Uncertainty Reduction	Precipitation Uncertainty Reduction
2004	58	96.7%	90.2%
2005	72	96.9%	91.1%
2006	77	97.0%	91.8%
2007	96	97.7%	94.0%

FY2007 increased the National Performance Measure (PM) in the CONUS for temperature from 97.0% at the end of FY2006 to >97% at the end of FY2007. Likewise the National PM for precipitation was increased from 91.8% at the end of FY2006 to >94% at the end of FY2007. The lower confidence of the precipitation PM compared to the temperature PM is to be expected because greater temporal and spatial resolution is needed to estimate the precipitation trend with confidence.

Science reviews for fitness as being climatically representative have been completed on all 114 station sites by the end of FY2007. Only four new station sites are now in their final approval process between the Site Hosts 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 FY2008 should complete the base network for the Continental United States and achieve the stated Program Goals of national uncertainty reduction for temperature to be at least 98.0% and for precipitation the confidence level should be increased to at least 95.0%. The increasing growth of the Climate Uncertainty Performance Measure over time in conjunction with the densification of the USCRN network is portrayed in Table 1:

3.4 FY2007 Performance Measures: Data Ingest

Since the USCRN Program began in FY2001 the Data Ingest Performance Measure has increased (Table 2) and is now above what the climate science community specified as an acceptable base level for support of exacting climate science studies (that is, to a minimum of 98% data set completeness). This base level first reached the 98% level in December 2002. The data ingest has remained near the 99% level since that time. The impact of the Geostationary Operational Environmental Satellite (GOES) Data Collection System (DCS) outage at the end of 2005 was temporary as individual station datalogger Storage Module (SM) downloads were delivered and entered into the NCDC archive during 2007. The current network-wide data ingest for the period of record is estimated to be above the 99.5% level. The GOES DCS outage was a satellite communications problem. Data for that period were stored at the individual station dataloggers, and then recovered during the scheduled Annual Maintenance Visits (AMV). This delay in receiving is known in advance. The data ingest figures for FY2007 are both low and incomplete because the most recent AMV datalogger downloads are not yet in the NCDC archive. The final figure will be higher.

Table 2. USCRN Observations: Network-Wide Data Ingest (in%)*, FY 2001-2007

FY	Q1 Average	Q2 Average	Q3 Average	Q4 Average	Annual
2001	86.8	96.5	70.5	97.4	87.7
2002	95.4	96.1	98.4	96.7	97.0
2003	98.5	99.4	99.8	99.5	99.4
2004	99.9	100.0	99.8	100.0	99.9
2005	98.9	99.9	100.0	100.0	100.0
2006**	99.9	100.0	99.9	97.4	99.3
2007**	99.8	99.5	98.4	98.9	99.25
Average 2000-2007	-----	-----	-----	-----	99.54

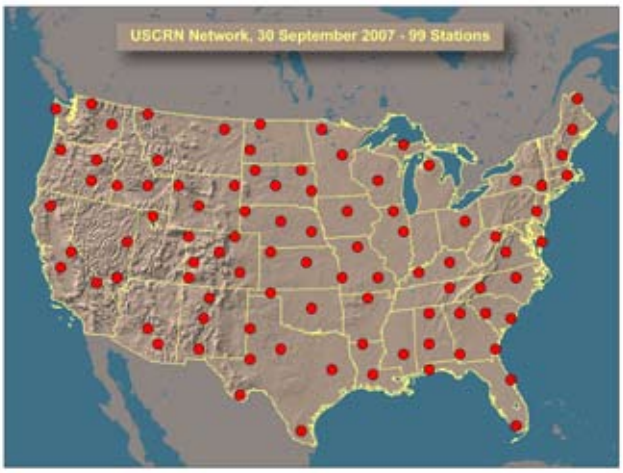


Figure 1 USCRN Field Stations - 30 September 2007

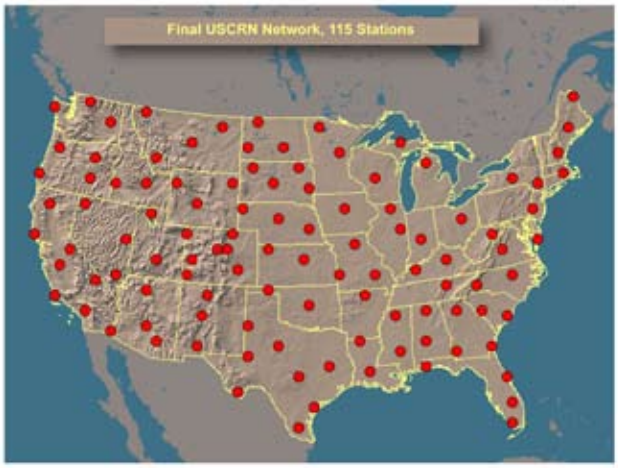


Figure 2 Completed USCRN Network Grid (FY 2008)

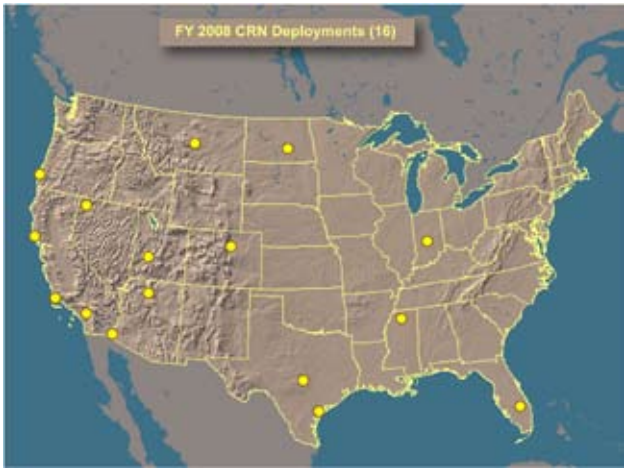


Figure 3 USCRN Field Stations to be deployed in FY 2008

4. FY2007 INSTALLATIONS AND SURVEYS

FY2007 activities included:
Site Surveys – 15 surveys done (Task finished)
Sites Approved – 18 sites approved (Task finished)
Site Licenses Signed – 14 (4 licenses remain in processing)
Stations Installed – 20 (16 stations remain to be deployed)

The map below shows the 99 USCRN field stations deployed. The network is 86% complete. The remaining 14% of stations (16 in number) will be deployed in FY2008.

At the end of the deployment phase in FY2008, the national grid of 114 USCRN stations (Figure 2) will have the most stations in Texas (eight) followed by Colorado and California (seven each). The high number of stations in Colorado as compared to geographic area of the state is due to the need to sample the heterogeneity of Colorado's climate due to its rugged terrain. States with no CRN stations are Vermont, Delaware, New Jersey, Massachusetts, and Maryland.
Grid (FY2008)

4.1 FY2008 Installations and Surveys

During FY2008, 16 additional CRN field stations will be deployed in 12 states. All site surveys required for the FY2008 deployments were identified and reviewed for climate representativity during FY2007. The 115 stations referred to in Figure 2 include a site in Colorado that was not in the original plan and is discussed in Section 4.2.

The 16 FY2008 deploys will complete the base USCRN.

These last installations will provide sufficient station density to provide the base high-quality data to monitor the variance of temperature and precipitation at the national level with high confidence. Their locations are portrayed in Figure 3 below.

4.2 Importance of Elevation Regimes in the USCRN Network

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 2500 feet,
2. a second class from 2500 feet up to 5000 feet,
3. a third smaller elevational gradient up to 9000 feet,
4. and a very small representation for those elevations above 9000 feet.

Table 3 illustrates the regional representation and their proportions in each major elevation classes by the number of CRN stations that have been located within each of these classes by both elevation and region.

Table 3. USCRN Stations by Elevation and Region

Elevation (feet)	NE	SE	C	ENC	WNC	S	SW	W	NW	Total
≤2500	11	15	10	7	11	12	1	5	5	77
≤5000	0	0	1	0	10	4	5	2	2	24
≤9000	0	0	0	0	0	1	8	2	1	12
≥9000	0	0	0	0	0	0	1	1	0	2
Total	11	15	11	7	21	17	15	10	8	114

Table 4. USCRN Site Hosts - September 2007

Site Host Sponsor/Organization	Number
Arboreta/NGO/Foundation	**14**
University-related	33
Indian Reservation	2
StatePark/Forest/Research Center	6
NOAA Facility	1
National Wildlife Refuge	11
National Park Service (NPS, NS, HM, etc.)	20
Other Federal (USDA, USGS, DOE, NASA, BLM)	12
Subtotal	**99**
The 16 FY2008 stations, not tabulated above, will be located at:	
Arboreta	2
University-related lands	8
National Wildlife Refuges	3
National Parks	1
Federal Lands (DOD and DOC, 1 each)	2
Subtotal	**16**
Grand Total	**114**

A unique example of elevation changes with the USCRN is in central Colorado. This station pair is being deployed to account for both significant elevational difference over a relatively short geographic distance and to take advantage of additional representation in a new major long-term ecological monitoring program of the National Science Foundation, the establishment of the National Ecological Observatory Network (NEON). The two stations represented on the map (Figure 3) near Boulder, Colorado have a difference of about 4350 feet in elevation, and they will anchor the two elevational extremes of the new National Science Foundation (NSF) NEON in the Rocky Mountain Front Range:

a. The western dot or station is at an altitude of 9980 feet in a mountain reserve associated with the University of Colorado, and is located on Niwot Ridge, to the northwest of Boulder, Colorado.

b. The eastern dot or station (an FY2008 deployment) identifies a much lower elevation station site that will be on a Department of Commerce Experimental Reserve about nine miles north of Boulder, Colorado, at an altitude of about 5550 feet.

4.3 Breadth of USCRN Station Partnership Net

The organizational classification of USCRN operational field stations by host agency identity gives an indicator of the breadth of the USCRN partnership of Federal and State agencies, universities, foundations, and non-governmental (not-for-profit) organizations that have been involved in hosting station sites for this network.

5. FY 2007 CRN SENSOR TESTING AND SCIENCE STUDIES

Two CRN stations, which are precipitation testbeds located in Sterling, Virginia and Johnstown, Pennsylvania, continue to provide long-term, engineering performance, and reference base data on the frequency of occurrence of false precipitation events, particularly those that provide confidence data on the performance of the CRN Geonor and its large windfence (a small double-fence intercomparison reference or SDFIR) under different environmental conditions.

5.1 Triple Redundancy for the Primary Sensors and Power-Aspiration for the Temperature Sensors

This issue of triple redundancy for the temperature and precipitation measurements has been addressed in previous annual reports. This apparent overkill in primary parameter sensing is due to the climate science need to have both accuracy and completeness in the climate record. Algorithms can identify the "most likely" temperature and the "most likely" precipitation amount given any three independent sensors. With two sensors alone, and if there is variance or discrepancies between the two sensors, it is more difficult to tell which of the two instruments might be reading correctly and which might be reading incorrectly. The third sensor added to modern long-term climate monitoring stations, assuming that it too is properly calibrated and maintained, will then identify which of the other two sensors is reading incorrectly (or correctly).

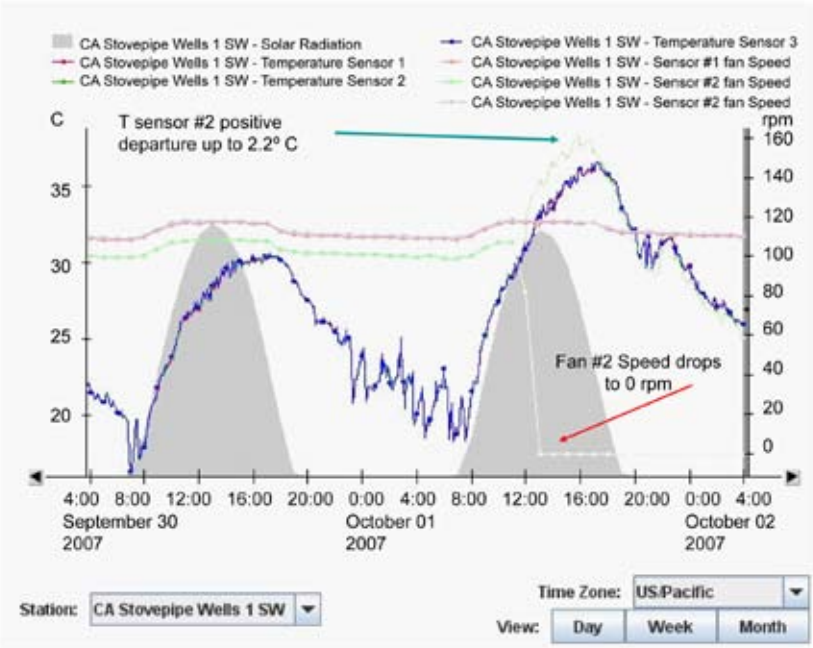


Figure 4. Fan Failure and Temperature Sensor Response

with the failed fan as compared to the measurements of temperature inside the other two temperature sensor shields with operating fans.

A failed fan and temperature deviation might not be detected without three independent measurements of temperature (e.g., Figure 4). After Fan #2 failed, the temperature readings in the #2 shield rose as much as 2.2°C higher than the ventilated readings in the other two shields. This departure occurred despite ambient wind speeds of 5 to 12 mph. Prior to sunset, the temperature readings in the #2 shield dropped to a cooler reading than the other two sensors in the working fan ventilated shields. By sunrise, the temperature readings in the shield with the failed fan were as much as 0.6°C cooler than those reported from the working fan ventilated shields. A similar incident of a single fan failure at the Newton MS CRN station on July 20, 2006, a hot and humid environment quite unlike that of Death Valley, resulted in temperature departures of the same magnitude, day and night, as those in Figure 4.

The question has been raised numerous times about why the CRN temperature radiation shields are power-aspirated instead of naturally aspirated The answer to this question is that for high-confidence climate measurements, natural aspiration is insufficient in providing measurements that are either accurate or of sufficient confidence as to provide unbiased measurements of the temperature of the free atmosphere. The atmosphere inside a non-aspirated shield or container is known to be inaccurate; the same is true of the temperature inside a traditional naturally-aspirated shield, tube, or shelter such as a Stevenson Shelter.

Even with the triple-walled radiation shield that is used on CRN stations, when a powered fan at the top of one of these shields fails and stops ingesting air from the outside atmosphere, one can see drifts or departures of the measurements inside the temperature sensor shield

5.2 Precipitation Algorithm Improvements

A fully successful version of the CRN precipitation algorithm that has been derived from this research activity has been incorporated into the routine data quality assurance/quality operations at NCDC. This same algorithm has been adopted by the Canadian Meteorological Service. In addition to the present operational CRN algorithm, two other versions are being evaluated monthly using the USCRN testbed data and the network data to see if additional improvements can be made.

5.3 Precipitation Gauge and Wind-shield Testing

The gauge and shield combination that is implemented into the CRN network is providing unprecedented accurate precipitation measurements. In side-by-side comparisons at the Sterling Test Facility with 350 liquid and solid pre-

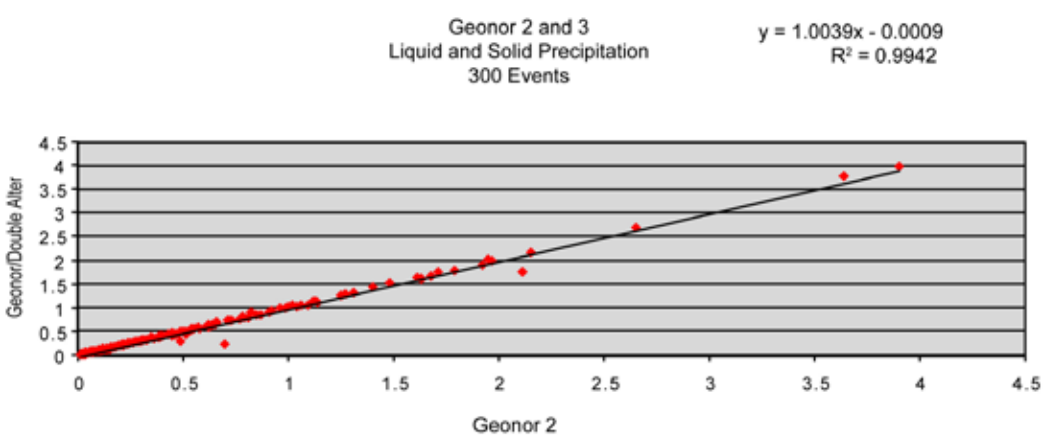


Figure 5. Comparison of Geonor Fidelity in Field Tests

cipitation events the two Geonor/SDFIRs agree within 1%. In addition, there have been 105 solid precipitation events and both systems agree within 1%. A modified windshield called a double alter is under evaluation and is showing promising results (Figure 5).

5.4 Addition of a Wetness Sensor

A sensor, earlier tested for the CRN network, has now been moved into the operational environment. This sensor addresses a critical concern that had been earlier identified by external scientists as being a potential weakness in high-precision, high-confidence precipitation measurements being taken by an automatic station where no confirming human presence was routinely available.

The solution to this problem was, in the end, both simple and elegant. It is simple in that it is a small instrument, it has no moving parts, it is unobtrusive and robust, and it does not require structural modifications to the CRN station configuration. In its simplicity, it provides the desired high level of confidence as to whether precipitation is actually occurring at this sometimes remote, unmanned station that is out of view. Without that last measure of confidence, it has been felt that the precipitation measurements, especially those at the lower end of the scale, could be interpreted as ambiguous.

After thorough testing, this wetness sensor was adopted for CRN use. Its performance has been as envisioned, and the wetness sensor has now been installed at all stations of the USCRN network. This wetness sensor has eliminated all false precipitation reports to date, particularly those amounts at the low end of the scale (0.01" of precipitation and below ["Trace"]). The network is now monitored with more confidence as to whether the precipitation amounts measured are actually the true precipitation accumulations occurring. The network is monitored daily and monthly for the presence of false precipitation reports. No false precipitation reports have been isolated or found since the wetness sensor was added to the CRN stations sensor suite.

5.5 Soil Moisture and Soil Temperature Sensor Testing and Deployment Plans

Evaluation of soil moisture (SM) and soil temperature (ST) is also under evaluation at the NOAA Atmospheric Turbulence and Diffusion Division (ATDD) in Oak Ridge, TN. A test station at the ATDD facility has been fitted with ~50 soil moisture/soil temperature sensors for fitness and parameter precision testing.

This testing has been hampered in 2007 by the extreme drought conditions that have been obtained throughout the southeastern United States. Despite this lack of natural cooperation, sufficient data has been gathered from the sensor arrays in the experimental array at Oak Ridge that there have been discussions with the Program Manager of the National Integrated Drought and Information System about beginning possible inclusion of these drought-critical sensors at USCRN stations across the United States during FY2008. It is readily apparent that there is a critical national need for SM/ST data to be incorporated into the joint NOAA/U.S. Department of Agriculture (USDA) Weekly National Drought Monitor and the Monthly North American Drought Monitor product generated by Canada, Mexico, and the United States. This deployment, when completed, will provide a national-level first look at SM/ST conditions as portrayed in Figure 5 below. Extension of this SM/ST monitoring capability to Canadian Reference Climate System stations and to proposed CRN stations in Mexico is recommended, and must await future program evolution(s).

This enhancement to the network should be useful to climate forecasting and modeling, reservoir management, irrigation scheduling, crop yield forecasting and contribute to independent verification and validation and calibration of satellite based sensors and measurements.

The proposed configuration of number and placement of soil moisture/soil

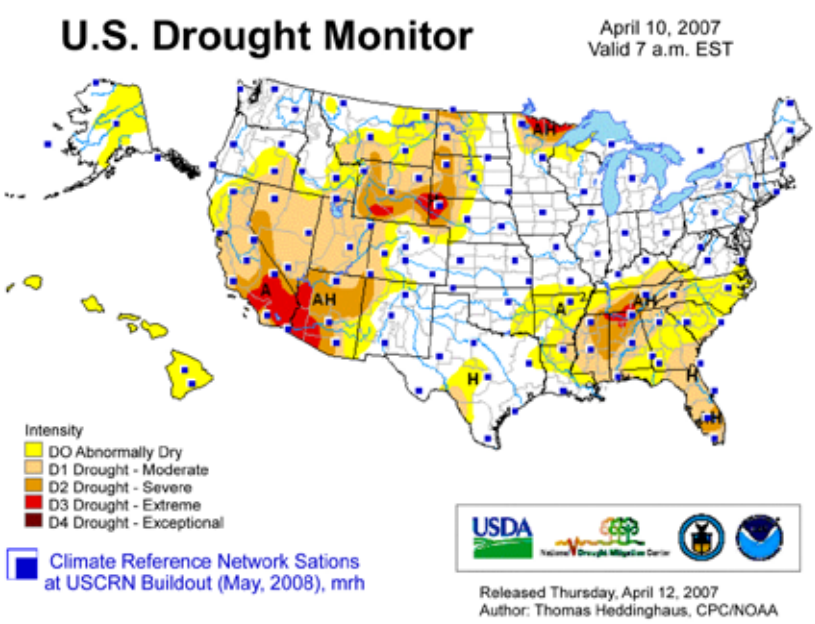


Figure 6. USCRN Soil Moisture/Soil Temperature Data Input Field Planned for Implementation in FY2008.

temperature sensors includes multiple sensors at five different soil levels. Sensor redundancy will be ensured at the critical upper levels where plant response and soil moisture conditions often change with the greatest magnitude and in the shortest amount of time.

The five levels and sensor counts at each of these five levels is as specified below:

3 sensors at 5cm depth
3 sensors at 10cm depth
2 sensors at 20 cm depth
1 sensor at 50cm depth
1 sensor at 100cm depth

Soil moisture, like many other soil measurements, is subject to an inherent natural variability that can only be assessed by replicate sampling for in situ measurement systems (in order to quantify parameter uncertainty, particularly in a soil column).

This depth configuration of the above sensors optimizes the ability to characterize and quantify the variability in the most variable upper layers.

Sensor redundancy helps to ensure continuity of measurements for a particular depth, especially if a particular sensor fails. This use of multiple sensors also potentially decreases network maintenance cost by the use of replicate measurements.

This configuration will improve our ability to calculate the water budget at these sites because the upper layers are the most variable and the uncertainty can be quantified with the replicate measurements.

This additional information of replicate measurements will be invaluable for remote sensing and modeling applications due to being able to incorporate the observed surface variability and a measure of data uncertainty.

It is planned in FY2008 to continue research on the use of replicate measurements, to start examining methods of routinely examining the matrix of the primary water budget variables of soil moisture, soil temperature, relative humidity, and precipitation; and once those relationships are better quantified, initiate the development of quality control procedures for the soil moisture and soil temperature variables.

5.6 New-Generation Sensor Testing and Testbeds

The CRN program is also evaluating a new raingauge as a possible future replacement for the Geonor precipitation gauge. This will be a multi-year comparison test.

The CRN Testbed Site currently in Sterling, Virginia will relocate in 2008 in order to retain climate representativity for the testbed. This is being done as the Dulles Airport expands into the general NOAA testing area. As a result, the Sterling, VA CRN testbed will be moved to the U.S. Geological Survey (USGS) Earth Resources Observation Systems EROS Data Center in Sioux Falls, South Dakota. The performance of precipitation measurement systems during high winds/snow conditions will be studied. The first fully-configured, automatic Canadian Reference Climate System station is also being deployed to the new testbed site selected at the EROS Data Center site in spring of 2008.

5.7 International Deployment by WMO for Testing

During 2007, the present-generation CRN all-weather precipitation gauge (Geonor) was selected as the control precipitation gauge for the new World Meteorological Organization Precipitation Intensity Test Site. This gauge was deployed by the WMO to Northern Italy in 2007. The selection of the CRN primary precipitation gauge as the primary precipitation gauge as WMO Control Gauge was based upon the field performance and evolution of the CRN gauge since it was first deployed in the CRN in 2000.

5.8 Research Papers and Abstracts in FY2007

Baker, C. B., 2007: In situ soil moisture and soil temperature networks current and future plans for the USCRN. In**:** *CGEO Workshop on Soil Moisture Monitoring, Analysis and Prediction in Agricultural Landscapes.*

Baker, C. B., 2007: U.S Climate Reference Network (USCRN) a unique national long-term climate monitoring network, In: *Workshop on Detecting the Atmospheric Response to the Changing Face of the Earth: A Focus on*

Figure 7. WMO Test Site, Northern Italy

Human-Caused Regional Climate Forcings, Land-Cover/ Land-Use Change, and Data Monitoring. Boulder, Colo. National Science Foundation, Arlington, Va.

Collins, William G. and C. B. Baker, 2007: The use of a wetness sensor in precipitation measurements for the U.S. Climate Reference Network. In: *14th Symposium on Meteorological Observations and Instrumentation*, San Antonio, Tex. American Meteorological Society, Boston, Mass.

Diamond, H. J. and M.R. Helfert, 2006: The U.S. global climate observing system (GCOS) program: plans for high elevation GCOS surface network sites based on the benchmark U.S. climate reference network (CRN) system. *Mountain views, the newsletter of the Consortium for Integrated Climate Research in Western Mountains, CIRMOUNT*, 1 (1), 16-19 (January 2007, Online at http://www.fs.fed.us/psw/cirmount/). **Mountain Views Online** ; **NCDC Online**

Diamond, H. J., 2007: The U.S. Global Climate Observing Systems (GCOS) program: plans for high elevation and high latitude GCOS surface network sites based on the benchmark U.S. Climate Reference Network. In*: 87th AMS Annual Meeting,* San Antonio, Tex. 13-18 January 2007. American Meteorological Society, Boston, Mass.

Holley, Alisa and M. E. Hall, 2007: The effects of condensation on the outside wall of a Geonor precipitation gauge. In: *14th Symposium on Meteorological Observations and Instrumentation*, San Antonio, Tex. American Meteorological Society, Boston, Mass.

Holley, Alisa, S. Gros, and M. E. Hall, 2007: Temperature deviation study of three co-located platinum resistance thermometers. In: *14th Symposium on Meteorological Observations and Instrumentation,* San Antonio, Tex. American Meteorological Society, Boston, Mass.

Holley, Alisa, S. Gros, and M. E. Hall, 2007: Noise dependencies for Geonor vibrating wire precipitation gauge. In: *14th Symposium on Meteorological Observations and Instrumentation,* San Antonio, Tex. American Meteorological Society, Boston, Mass.

Larson, Lee W., C. B. Baker, E. L. May, H. Bogin, and W. G. Collins, 2007: Continued Operational Testing of Various Precipitation Sensors and Protective Shields in Support of the United States Climate Reference Network (USCRN). In: *14th Symposium on Meteorological Observations and Instrumentation*, San Antonio, Tex. American Meteorological Society, Boston, Mass.

6. FY2007 INTERNATIONAL COOPERATION

6.1 The Canadian Climate Partnership and Technology Exchanges

The first nation to duplicate CRN technology and practices is Canada. In early spring of 2008 a Canadian RCS station will be deployed to a U.S. Test Site (Sioux Falls, South Dakota). It is anticipated that once the Canadian RCS station is installed network transfer functions will be examined between the two networks starting in late FY2008. Such transfer function determinations between these two national nets would increase the geographic spatial area of homogeneous long-term climate observations over North America by >100% (Canada is a larger country than the United States Lower-48, so more stations are required in Canada for adequate coverage).

U.S./Canada discussions have included:

a. The role played by redundant temperature and precipitation sensors;
b. Processing multiple observations into single temperature and precipitation values using standardized algorithms;
c. Field lessons learned such as experience in measuring solid precipitation;
d. Detecting, reporting, and tracking anomalous events for station maintenance;
e. Installation, maintenance, and inspection protocols;
f. Using the Web to disseminate data and documentation;
g. Quality control procedures; and
h. Currently, the Canadian RCS has deployed the triple wire configuration at ~102 sites and are in the beginning stages of implementing the CRN precipitation algorithm.

6.2 The Global Climate Observing System Program (GCOS) and CRN

In addition to United States – Canada activities, CRN stations have been selected for deployment in various environments on other continents where assistance in modernization is desired. Towards this end, two CRN-technology stations outside the CONUS were configured to be GCOS-CRN test stations (high-elevation and high precipitation environment stations). These two stations were deployed to two extreme Hawaiian environments as prototypes for future deployments in the Andes and in high-precipitation environments such as rainforest zones. This expansion of CRN technology is de rigeur as GCOS takes action to upgrade global baseline climate monitoring stations.

7. UNDERSTANDING CRN STATION DATA

Atmospheric scientists cannot accurately evaluate the true nature of climate while using inaccurate data, or by using

Table 5. CRN Period-of-Record (POR)
(10 year POR is the recommended base for Climate Purposes)

Start	Year	Stations and POR's**
2000	2	2 stations with a 7 year record
2001	6	8 stations with a 6+ year record
2002	18	26 stations with a 5+ year record
2003	18	44 stations with a 4+ year record
2004	27	71 stations with a 3+ year record
2005	10	81 stations with a 2+ year record
2006	8	89 stations with a 1+ year record
2007	20	109 stations with a 0.0-7 year record

** 4 in Alaska, 2 in Hawaii, 1 in Canada, 99 in CONUS, 3 GCOS and test sites

data with inadequate metadata concerning instrumentation or siting questions. Historical meteorological and climatological observations are often compromised by non-standard equipment, poor sensor exposure or poor siting, observer discontinuities, and other related issues. The impact of these issues concerning historical data provenance, continuity, and general quality becomes more serious over time.

It is far more scientifically rational to have a minimum of a decade of service from these high-precision stations prior to generating high-confidence climate attributions to this network. As the deployment phase of this network is now nearing completion after eight years, we are getting enticingly close to being able to derive climate meaning from this new scientific tool. It would be a mistake to attempt to derive high-confidence climate meanings too soon. A ten-year period-of-record is recommended for conservative applications of CRN to bring more precision and order to the climate data archive for the CONUS - at least at the national level.

7.1 Defining the Ranges of Parameter Records: New Tools, Serendipity, and Quantifying the Previously Unquantified

Some recorded snowfall in cold windy climates is old snow blown into the precipitation gauge. This has concerned climate scientists estimating the true snowfall. The question has been how much snow actually falls from the sky during a storm as compared to what amount of snow is from old snow that is blown to that spot from some other location (a "ground-effect blizzard"). Data from the CRN station in Glacier National Park was used to quantify wind-blown old snow by intercepting imagery from a nearby webcam during a ground-effect blizzard.

Only one of a time series of webcam photographs from Glacier National Park is shown here. The storm, which was actually a laminar-flow event of high wind, was monitored using this National Park webcam for the entire duration of the event. Only a selected photograph is used here. The photograph below was taken by a National Park Service webcam only a few hundred feet from the USCRN site at St. Mary, Montana.

Some of our ancillary instrumentation (two graphs are below) allowed us to identify that the reported snow at the St. Mary's station in Glacier National Park shown on the second graph was actually "old" wind-blown snow.

Note that the strong winds persisted from November 29 through December 1. Also, note that that the CRN station pyranometer was recording solar radiation during this period, that is, the solar radiation that would not be present or evident during a true snow event.

The composite graphs below, taken from our Network Monitoring workstation, may appear confusing at first, and indeed the first one is.

This is because all five variables being displayed at once allows one to see the full interplay of wind, false snow accumulation, solar radiation, infrared radiation, and air temperatures occurring during the full 5-day period during which this Ground-Effect Blizzard began, roared, and then died.

This one event provides us the tool to now see that we can capture this type of event. Climate scientists will require

Figure 8. Ground Effect Blizzard in Glacier National Park

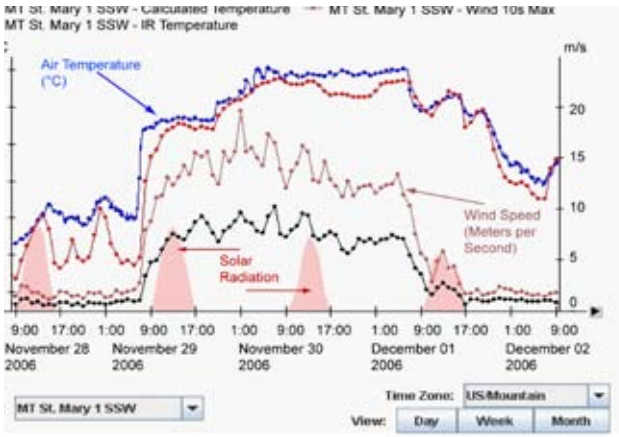


Figure 9. CRN Variables Monitored during the St. Mary's Montana Ground Effect Blizzard

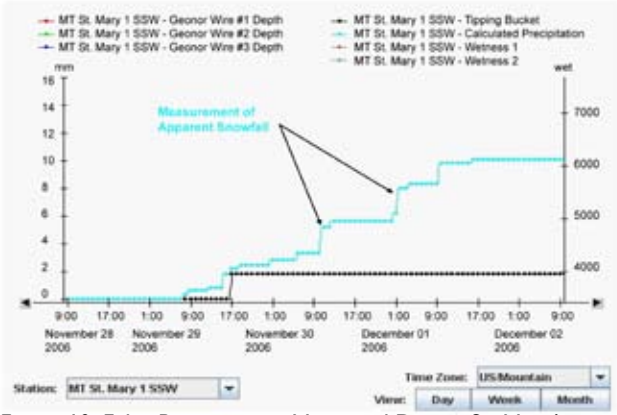


Figure 10. False Precipitation Measured During St. Mary's, Montana Ground-effect Blizzard

further quantification of ground-effect blizzards such as this one in order to be able to eventually assess what percentage of snow each year is actually the result of snowfall versus what component is wind-blown.

Table 6. CRN Temperature Records

CRN Temperature Records (F°)
Highest Air Temperature = 126° , Stovepipe Wells, California, July 5, 2007
Lowest Absolute Air Temperature = -56°, Barrow, Alaska,
Highest Ground Surface Temperature = 160°, Stovepipe Wells, California, June 24, 2006
Lowest Absolute Ground Surface Temperature = -60°, Barrow Alaska,

7.2 Defining the Ranges of Parameter Records: The Present CRN Network Records and Ranges

Despite the short period-of-record of the USCRN network, 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, and it will record other and newer and different events in the future, so this early collection of records should be considered only the first part of a dynamic tale.

Table 7. Maximum and Minimum Temperature Durations

Maximum and Minimum Temperature Durations
Maximum: Stovepipe Wells, Death Valley, California
120° F = 11 Days July 12-22, 2005
110°F = 32 Days June 13 - July 14, 2007
100°F = 82 Days June 19 - September 8, 2005
95°F = 95 Days June 8 - September 10, 2005
90°F = 132 Days May 12 - September 20, 2005
Minimum Temperature Durations, Barrow, Alaska
-50°F = 2 Days February 3-4, 2006
-30°F = 9 Days January 29 - February 6, 2006
0°F = 71 Days January 4 - March 15, 2005
< 32°F = 236 Days October 11, 2006 - June 3, 2007

Those indicated as records are records measured by stations of the USCRN network only.

7.3 Learn By Your Mistakes – Be Humble – Old "Normals" and Habits Can Mislead You

All of our USCRN stations (except the high-altitude station at 6300 feet on a windswept granite dome overlooking Yosemite National Park) are equipped with wind fences that surround the precipitation gauges.

Using existing climate information for each site, the bottom of the fences is set at a height that allows snow to blow beneath them during an average winter.

Unfortunately, during the first winter at Barrow, Alaska, the snow was deeper than the bottom of the fences. Drifting and sastrugi formation is common in Arctic and sub-Arctic environments, which have an even snow depth over a large area, and where a thaw component is not present or dominant. In these conditions, any downwind obstruction can produce a "ramp." Such a ramp formed at the Barrow

Table 8. CRN Precipitation Records (Inches)

CRN Precipitation Records in Inches			
November 2000 - September 2007			
Greatest 5 Minute	0.73 inches	Titusville, Florida	July 7, 2006
Greatest 5 Minute	0.73 inches	Lander, Wyoming	July 25, 2007
Greatest 15 Minute	1.89 inches	Titusville, Florida	July 7, 2006
Greatest 30 Minute	3.08 inches	Titusville, Florida	July 7, 2006
Greatest 60 Minute	3.77 inches	Titusville, Florida	July 7, 2006
Greatest 1 Day	11.78 inches	Quinault, Washington	November 6, 2006
Greatest 5 Day	25.12 inches	Quinault, Washington	November 2 - 6, 2006
Greatest 7 Day	27.39 inches	Quinault, Washington	November 2 - 8, 2006
Greatest 30 Day	51.35 inches	Quinault, Washington	November 1- 30. 2006
Greatest 365 day	184.90 inches	Quinault, Washington	October 1, 2006 - September 30, 2007

Note: *The Quinault 2007 Water Year (WY) Record is 52.10 inches greater than the 37-year mean WY of 132.69 inches from the Ranger Station site 1 mile to the SSW.*
The greatest WY record total for the Quinault area is 186.22 inches set during the 1972 WY
(October 1, 1971 - September 29, 1972)

station. This ramp then allowed another snow event from a different wind direction to use that ramp to completely fill the fence enclosures (see photos on the left).

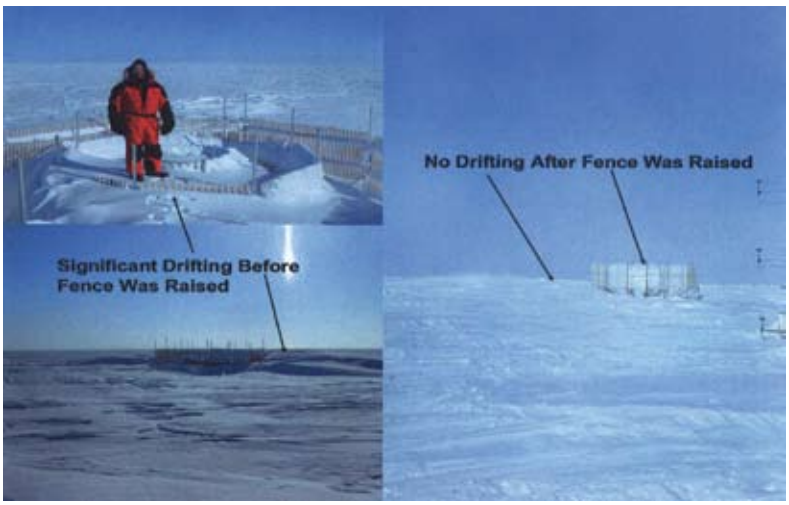
The following summer engineers raised the fence height, and as can be seen in the photo on the right, there has been no repeat of the problem (so far…), but it would be prudent to not be overly smug.

8. CRN DOCUMENTATION ACCESS: SELECTED INTERNET ADDRESSES BY TOPIC

Table 9. Number of Consecutive Days With Maximum Temperatures at Death Valley, California

Table 10. Number of Consecutive Days With Maximum Temperatures (F°) at or Above Various Thresholds at Death Valley, California	
120° = 11 Days	July 12 - 22, 2005
110° = 32 Days	June 13 - July 14, 2007
100° = 82 Days	June 19 - September 8, 2005
95° = 95 Days	June 8 - September 10, 2005
90 ° = 132 Days	May 12 - September 20, 2005

The CRN Team is aware of and sensitive to the multi-functional, multi-level composition of the climate science community that accesses and uses the CRN Web pages. As a result, the CRN Web pages will be revised in 2008 to try to conform to as many of the suggestions and needs of the user community as possible.



High Altitude station photos.

This will have to be an iterative process, that is, the CRN Team will learn continuously and attempt to satisfy the climate science community needs as they are made known, and as resources allow. This gradual improvement process should match needs with data and with resources. It is most practical to acknowledge that this process must continue and at a not fully satisfactory level for all possible users due to the climate community's strong character of conflicting heterogeneity.

The list below should be monitored for expansion and broadened with more thorough applicability in outyears. A summary of the

primary URLs (addresses) for CRN documentation on the CRN Internet site is below:

CRN Home: http://www.ncdc.noaa.gov/oa/climate/uscrn/

CRN Program Documents (in 5 Primary Document Classes):
http://www.ncdc.noaa.gov/crn/programoverview.html

CRN Performance Measures, derivation, and progress are explained in the CRN Annual Reports Series, particularly starting in FY2003/2004:
http://www.ncdc.noaa.gov/crn/programdocs.html

CRN Program Development Plan, Functional Requirements, and Configuration Management Documents are at:
http://www.ncdc.noaa.gov/crn/programdocs.html

CRN Annual Reports can be found at:
http://www.ncdc.noaa.gov/crn/programdocs.html

CRN Site Information Handbook and Station Commissioning Plan are at:
http://www.ncdc.noaa.gov/crn/programdocs.html

CRN Field Maintenance Plan (also in the Configuration Management Series):
http://www.ncdc.noaa.gov/crn/programdocs.html

CRN detailed documentation on Metadata, Data Processing, Instrument Monitoring, Data Documentation, and Station Installation/Maintenance can also be found at:
http://www.ncdc.noaa.gov/crn/docs.html

The CRN Site Data Web Site is under constant revision with new additions as new sites are added and as new metadata is received and posted. The CRN active maintenance page, which is referenced at this site, has restricted access as some information in that area involves active maintenance, housekeeping, and monitoring. Information on the other areas is, however, available here:
http://www.ncdc.noaa.gov/crn/sites.html

Detailed data and documentation about CRN Site Hardware, Sensors, and Calibration Hardware can be found at:
http://www.ncdc.noaa.gov/crn/instrdoc

The CRN Science Pages have not been vigorously developed during the Deployment Phase of the USCRN. As the period-of-record of stations is now approaching scientifically useful lengths, this page is of a priority for community inputs and exchanges, as well as for internal exchanges and postings. It can be found at:
http://www.ncdc.noaa.gov/crn/instrdoc

The most direct way to access the data from the CRN stations is to go directly to:
http://www.ncdc.noaa.gov/crn/hourly

CRN data and their metadata are also available from a number of sources:
All elements and metadata:
NCDC Customer Services (NCDC.Orders@noaa.gov)
CRN Monitoring website (www.ncdc.noaa.gov/oa/climate/uscrn/)
Hourly temperature, precipitation, solar radiation, surface temperature:
CRN ftp site (historical and near-real time)
ftp://ftp.ncdc.noaa.gov/pub/data/uscrn/products/hourly01

9. FY2000-2007 SUMMARY

The USCRN has achieved or exceeded the initial goals and performance measures that were developed at the program's inception. The FY2006 budget hiatus is viewed as an anomaly. Although the FY2006 budget situation resulted in a deployment phase that now stretches into FY2008, the integrity of the USCRN network and of its data remains at the highest level of any atmospheric monitoring network in the Nation.

Stations have been established on schedule and maintained with reliability. The USCRN is already starting to provide the United States with a first-class climate and environmental monitoring network that meets national needs, and meets international commitments to monitor and document climate change.

As of September 2006, Local Climatological Data (LCD), a baseline climatological report for the past century have been released for CRN stations. This LCD report series further enhances the usefulness and transferability of CRN data to other networks. The USCRN fills an important land-based gap in U.S. climate data. These data are needed in the proposed larger and more comprehensive Earth observation system being developed by more than 34 countries.

10. FY2008 PLANNED ACTIVITIES AND GOALS

Research and engineering development activities envisioned for FY2008 focus and resources include:

a. Transfer Function determinations inter-network. This first priority will continue to determine the transfer functions between the USCRN and NOAA's Cooperative

Network. Other networks being considered for transfer function determinations include the Automated Surface Observing System (ASOS), the Modernized NWS Co-operative Observer (COOP-M) Network, the Historical Climate Network Modernization Network (HCN-M), and insofar as possible, such non-NOAA networks including the Bureau of Land Management-Forest Service RAWS, the USDA National Resources Conservation Service (NRCS) Soil Climate Analysis Network (SCAN), the USDA/NRCS Snowpack Telemetry (SNOTEL) System, and selected state mesonets.

b. Derivation of pseudo-normals once transfer functions are established. This is being approached with great care and critical review through the first releases of CRN LCDs, noted above.

c. Exercising the capability and fitness of combinations of USCRN sensors by providing ground truth points for NOAA, National Aeronautics and Space Administration (NASA), and European Union satellite systems similar to EOS.

d. As with the now-completed deployment of Wetness Sensors to all CRN field stations in FY2005 and FY2006 (an activity completed in FY2006) and now pro forma for all new USCRN deploys, testing of candidate Relative Humidity and Soil Moisture/Soil Temperature sensor arrays for retrofitting to all CRN stations will proceed apace starting during FY2008.

e. Testing of Iridium or similar communications for harsh environs and two-way communication capabilities. The lessons of Hurricane Katrina (August 2005) strongly indicate that a two-way capability is essential for station tending when extreme weather events are present.

f. Deeper study of Health of the Network and Data Ingest Percentages in order to identify seasonal biases, component failure patterns (Mean Time Between Failures [MTBF] statistics), and identify stations that lag in their performance and/or precision of measurement.

g. Coordinate with Canada on the development of transfer functions and future common LCD product generation between the Canadian RCS and the USCRN and particularly important for snowdepth measurements.

h. Develop international ties on global standards and commonalities in the measurement of precipitation and temperature throughout the WMO community.

Table Appendix A.1. List of USCRN Stations (non-USCRN stations – in italics)
1 October 2006 - 30 September 2007

USCRN/*CRN* Station (State/City)	Initial Ops Date (yyyymmdd)	Site Host Expanded Identification
AK Barrow	*20020809*	*Barrow Arctic Observatory, NOAA-ESRL Global Monitoring Laboratory*
AK Fairbanks	*20020809*	*NOAA-NESDIS – Field Satellite Comms and Data Center*
AK Sitka	*20050817*	*US Geological Survey - Sitka Geomagnetic Observatory*
AK St. Paul	*20050807*	*NOAA-National Weather Service WFO, St Paul Island*
AL Fairhope	**20060713**	**Auburn University, Gulf Coast Research & Extension Center**
AL Gadsden	**20050414**	**Sand Mountain Research / Extension (Northwest Pasture)**
AL Selma	**20050526**	**Auburn University, Black Belt Research and Extension Center**
AR Batesville	**20061219**	**University of Arkansas, LFST Branch. Experiment. Station.,**
AZ Elgin	**20020914**	**Audubon Society Reserve Appleton-Whittell Research Ranch**
AZ Tucson	**20020918**	**Sonora Desert Museum**
CA Merced	**20040325**	**Kesterson Reservoir Reclamation Site (US Bur Reclamation)**
CA Redding	**20030325**	**Whiskeytown National Recreation Area (NPS)**
CA Stovepipe Wells	**20040505**	**Death Valley National Park (NPS)**
CO Boulder	**20030927**	**(Niwot) Mountain Research Station, University. of Colorado**
CO Cortez	**20051102**	**Mesa Verde National Park (NPS)**
CO Dinosaur	**20040721**	**Dinosaur National Monument (NPS)**
CO La Junta	**20040803**	**USDA-Ag Res Svce - Comanche National Grassland**
CO Montrose	**20040725**	**Black Canyon of the Gunnison River National Park (NPS)**
CO Nunn	**20030706**	**Colorado State Univ/USDA. Central Plains Exper. Range**
FL Everglades City	**20070210**	**Big Cypress National Biological Preserve**
FL Titusville	**20050507**	**NASA- Kennedy Space Center**
GA Brunswick	**20041216**	**Cumberland Island National Seashore (NPS)**
GA Newton-1	**20020820**	**Robert W. Woodruff Foundation Reserve**
GA Newton-2	**20020820**	**Robert W. Woodruff Foundation Reserve**
GA Watkinsville	**20040430**	**Univ of Georgia/USDA Watkinsville Experimental Farm**
HI Hilo	*20050927*	*University of Hawaii/USDA Waiakea Exper Agri Station*
HI Mauna Loa	*20050927*	*Mauna Loa Observatory, NOAA-ESRL.,Global Mon. Div.*
IA Des Moines	**20040915**	**Neal Smith National Wildlife Reserve (USFWS)**
ID Arco	**20030710**	**Craters of the Moon National Monument & Preserve (NPS)**
ID Murphy	**20030629**	**USDA- Ag Research Svc - NW Watershed Research Center**
IL Champaign	**20021220**	**University. of Illinois, Bondville Research. Station**
IL Shabbona	**20030816**	**Northern Illinois University Agronomy Research Center**
KS Manhattan	**20031001**	**Kansas State University - Konza Prairie Natl Ecological Res**
KS Oakley	**20051108**	**Nature Conservancy Reserve - Smoky Valley Ranch**

USCRN/*CRN* Station (State/City)	Initial Ops Date (yyyymmdd)	Site Host Expanded Identification
KY Bowling Green	20040519	Mammoth Cave National Park (NPS)
KY Versailles	20030612	University of Kentucky - Woodford Cty Experimental Farm
LA Lafayette	20021201	University of Louisiana-Lafayette - Cade Experiment Farm
LA Monroe	20030101	Upper Ouachita National Wildlife Refuge (USFWS)
ME Limestone	20020920	Aroostook National Wildlife Refuge (USFWS)
ME Old Town	20020913	University of Maine - Rogers Experimental Farm
MI Chatham	20041110	Michigan State Univer - Upper Peninsula Experiment Station
MI Gaylord	20070612	National Weather Service Weather Field Office (NOAA)
MN Goodridge	20030821	Agassiz National Wildlife Refuge (USFWS)
MN Sandstone	20070619	Audubon Society Reserve - Center of the North Woods
MO Chillicothe	20050611	University of Missouri - Forage Research Station
MO Joplin	20070510	Shawnee Trail State Conservation Area
MO Salem	20070510	White River Trace State Conservation Area
MS Newton	20021103	Mississippi State University - Coastal Plain Experim. Station
MT Dillon	20070711	Bannack State Park
MT St. Mary	20030925	Glacier National Park (NPS)
MT Wolf Pt-1	20011220	Fort Peck Indian Reservation
MT Wolf Pt-2	20011220	Fort Peck Indian Reservation
NC Asheville-1	20001114	NC Mountain Horticultural Crops State Research Center
NC Asheville-2	20001114	North Carolina State Arboretum
NC Durham	20070327	Duke University – Duke Experimental Forest & Reserve
ND Medora	20040918	Theodore Roosevelt National Park (NPS)
ND Northgate	20061017	Des Lacs National Wildlife Refuge (USFWS)
NE Harrison	20030827	Agate Fossil Beds National Monument (NPS)
NE Lincoln-1	20020114	Audubon Society Reserve - Spring Creek Prairie
NE Lincoln-2	20020114	University of Nebraska - Prairie Pines Station
NE Whitman	20040915	Gudmundsen Sandhills Laboratory and Reserve
NH Durham-1	20011211	University of New Hampshire - Kingman Farm
NH Durham-2	20011216	University of New Hampshire - Thompson Farm Site
NM Las Cruces	20070226	USDA/NM St Un Jornada Exper Range & Long-Term Reser.
NM Los Alamos	20040731	Valles Caldera National Preserve (NPS)
NM Socorro	20030522	Sevilleta National Wildlife Refuge & Univ New Mex LTER
NV Baker	20040509	Great Basin National Park (NPS)
NV Mercury	20040328	US Dept of Energy Desert Rock Meteorological Laboratory
NY Ithaca	20041027	Cornell University - Harford Teaching & Research Center
NY Millbrook	20041101	Institute Ecosystem Studies Reserve
OH Coshocton	20061109	USDA/NWS North Appalachian Experimental Watershed
OK Goodwell	20040227	OK Panhandle Research & Extension Center
OK Stillwater-1	20020315	Oklahoma State University Agricultural Research Farm
OK Stillwater-2	20020315	Oklahoma State University - Efaw Experimental Farm
ON Egbert	*20040715*	*Environment Canada CARE National Test Site*
OR Corvallis	20060914	Finley National Wildlife Refuge (USFWS)
OR John Day	20040316	John Day Fossil Beds National Monument (NPS)
OR Riley	20030703	USDA - Northern Great Basin Experimental Range
PA Avondale	20060602	Stroud Foundation Water Research Center
RI Kingston-1	20011216	University of Rhode Island – Plains Experimental Farm
RI Kingston-2	20011216	University of Rhode Island - Peckham Experimental Farm

USCRN/*CRN* Station (State/City)	Initial Ops Date (yyyymmdd)	Site Host Expanded Identification
SC Blackville	20020703	Clemson University Edisto Research Center and Reserve
SC McClellanville	20020808	Santee Foundation Coastal Reserve
SD Aberdeen	20070614	Nature Conservancy Reserve- Ordway Prairie
SD Buffalo	20040921	South Dakota State University - Antelope Research Station
SD Pierre	20061024	Ft Pierre National Grassland Reserve (DOI)
SD Sioux Falls	20020925	US Geological Survey – Earth Res Observ System Data Ctr
TN Crossville	20041203	University of. Tennessee Plateau Research Center
TX Bronte	20061215	Fort. Chadbourne Foundation Reserve
TX Edinburg	20040219	Lower Rio Grande Valley Nat'l Wildlife Refuge (USFWS)
TX Monahans	20030521	Sandhills State Park
TX Muleshoe	20040227	Muleshoe National Wildlife Refuge (USFWS)
TX Palestine	20030501	NASA - National Scientific High-Altitude Balloon Facility
TX Panther Junction	20070224	Big Bend National Park (NPS)
UT Brigham City	20070813	Golden Spike National Historic Site (NPS)
VA Cape Charles	20040303	Anheuser-Busch Coastal Research. Ctr., Univ. of Virginia
VA Charlottesville	20070327	Thomas Jefferson Foundation (Monticello)
WA Darrington	20030403	North Cascades National Park (NPS)
WA Quinault	20060909	Olympic National Park (NPS)
WA Spokane	20070711	Turnbull National Wildlife Reserve (USFWS)
WI Necedah	20041004	Necedah National Wildlife Refuge (USFWS)
WV Elkins	20031117	Canaan Valley Resort State Park
WY Lander	20040703	Nature Conservancy Reserve – Red Canyon Ranch
WY Moose	20040701	Grand Teton National Park (NPS)
WY Sundance	20070809	Black Hills National Forest (USFS)

Appendix B

FY2007 Data Ingest Percentages for USCRN Stations

Non-USCRN stations (those in Alaska, Hawaii, and Canada) are in blue italics below.

Time of Receipt Report October 1, 2006 - September 30, 2007

NOTE: New stations have a burn-in period of 30-90 days. During this period, initial installation problems or deficiencies are identified and repaired. The "Operational" date is the date upon which physical construction of the station was finished. In some instances, the actually service life start date (Operations Date) of some stations may be delayed for several weeks due to Site Host power hookup problems, some administrative issue, or a component failing shortly after data transmissions begin. These are normal work-up problems, and are solved routinely as a part of normal network operations and quality assurance programs.

The climate-useful period-of-record start may thus be up to 2-3 weeks after the installation date. Therefore, the "Operations Date" is, more precisely, the "Climate Period Start Date" rather than the "Installation Date."

Table Appendix B.1. FY2007 Data Ingest Percentages for USCRN Stations
Non-USCRN stations (those in Alaska, Hawaii, Canada) are in italics below.
Time of Receipt Report Oct 1, 2006 - Sept 30, 2007

State	Location	Vector	Climate Period Start Date	Max obs	Archived	% Ingested
AK	*Sitka*	*1 NE*	*08/17/2005*	*8760*	*8755*	*100*
AK	*Barrow*	*4 ENE*	*08/09/2002*	*8760*	*8760*	*100*
AK	*St. Paul*	*4 NE*	*08/07/2005*	*8760*	*8756*	*100*
AK	*Fairbanks*	*11 NE*	*08/09/2002*	*8760*	*8759*	*100*
AL	**Selma**	**13 WNW**	**05/26/2005**	**8760**	**8724**	**99.9**
AL	**Gadsden**	**19 N**	**04/14/2005**	**8760**	**8758**	**100**
AL	**Fairhope**	**3 NE**	**07/13/2006**	**8760**	**8759**	**100**
AR	**Batesville**	**8 WNW**	**12/19/2006**	**6864**	**6839**	**99.7**
AZ	**Elgin**	**5 S**	**09/14/2002**	**8760**	**8754**	**100**
AZ	**Tucson**	**11 W**	**09/18/2002**	**8760**	**8759**	**100**
CA	**Merced**	**23 WSW**	**03/25/2004**	**8760**	**8746**	**99.9**
CA	**Redding**	**12 WNW**	**03/25/2003**	**8760**	**8760**	**100**
CA	**Stovepipe Wells**	**1 SW**	**05/05/2004**	**8760**	**8748**	**99.9**
CA	**Yosemite Village**	**12 W**	**09/29/2007**	**48**	**48**	**100**
CO	**Nunn**	**7 NNE**	**07/06/2003**	**8760**	**8757**	**100**
CO	**Cortez**	**8 SE**	**11/02/2005**	**8760**	**8732**	**99.7**
CO	**Boulder**	**14 W**	**09/27/2003**	**8760**	**8686**	**99.2**
CO	**Dinosaur**	**2 E**	**07/21/2004**	**8760**	**8756**	**100**
CO	**La Junta**	**17 WSW**	**08/03/2004**	**8760**	**8760**	**100**
CO	**Montrose**	**11 ENE**	**07/25/2004**	**8760**	**8313**	**94.9**
FL	**Titusville**	**7 E**	**05/07/2005**	**8760**	**8752**	**99.9**
FL	**Everglades City**	**5 NE**	**02/11/2007**	**5568**	**5568**	**100**
GA	**Newton**	**8 W**	**08/20/2002**	**8760**	**8759**	**100**
GA	**Newton**	**11 SW**	**08/20/2002**	**8760**	**8734**	**99.7**
GA	**Brunswick**	**23 S**	**12/16/2004**	**8760**	**8431**	**96.2**
GA	**Watkinsville**	**5 SSE**	**04/30/2004**	**8760**	**8757**	**100**
HI	*Hilo*	*5 S*	*09/27/2005*	*8760*	*8730*	*99.8*
HI	*Mauna Loa*	*5 NNE*	*09/27/2005*	*8760*	*8744*	*99.9*
IA	**Des Moines**	**17 E**	**09/15/2004**	**8760**	**8760**	**100**
ID	**Arco**	**17 SW**	**07/10/2003**	**8760**	**8754**	**100**
ID	**Murphy**	**10 W**	**06/29/2003**	**8760**	**8754**	**100**
IL	**Shabbona**	**5 NNE**	**08/16/2003**	**8760**	**8715**	**99.6**
IL	**Champaign**	**9 SW**	**12/20/2002**	**8760**	**8749**	**99.9**
KS	**Oakley**	**19 SSW**	**11/08/2005**	**8760**	**8737**	**99.8**
KS	**Manhattan**	**6 SSW**	**10/01/2003**	**8760**	**8750**	**99.9**
KY	**Versailles**	**3 NNW**	**06/12/2003**	**8760**	**8675**	**99**
KY	**Bowling Green**	**21 NNE**	**05/19/2004**	**8760**	**8759**	**100**

State	Location	Vector	Climate Period Start Date	Max obs	Archived	% Ingested
LA	Monroe	26 N	01/01/2003	8760	8748	99.9
LA	Lafayette	13 SE	12/01/2002	8760	8760	100
ME	Old Town	2 W	09/13/2002	8760	8757	100
ME	Limestone	4 NNW	09/20/2002	8760	8760	100
MI	Chatham	1 SE	11/10/2004	8760	8751	99.9
MI	Gaylord	9 SSW	09/20/2007	264	264	100
MN	Goodrige	12 NNW	08/21/2003	8760	8760	100
MN	Sandstone	6 W	06/23/2007	2400	2400	100
MO	Salem	10 W	05/22/2007	3168	3168	100
MO	Joplin	24 N	05/24/2007	3120	3082	98.8
MO	Chillicothe	22 ENE	06/11/2005	8760	8759	100
MS	Newton	5 ENE	11/03/2002	8760	8754	100
MT	Dillon	18 WSW	07/28/2007	1560	1537	98.5
MT	St. Mary	1 SSW	09/25/2003	8760	8749	99.9
MT	Wolf Point	34 NE	12/20/2001	8760	8483	96.8
MT	Wolf Point	29 ENE	12/20/2001	8760	8744	99.8
NC	Durham	11 W	03/29/2007	4464	4412	98.8
NC	Asheville	13 S	11/14/2000	8760	8725	99.7
NC	Asheville	8 SSW	11/14/2000	8760	8758	100
ND	Medora	7 E	09/18/2004	8760	8750	99.9
ND	Northgate	5 ESE	10/17/2006	8376	8318	99.3
NE	Lincoln	11 SW	01/14/2002	8760	8759	100
NE	Lincoln	8 ENE	01/15/2002	8760	8759	100
NE	Whitman	5 ENE	09/15/2004	8760	8091	92.4
NE	Harrison	20 SSE	08/27/2003	8760	8755	99.9
NH	Durham	2 N	12/11/2001	8760	8759	100
NH	Durham	2 SSW	12/16/2001	8760	8759	100
NM	Socorro	20 N	05/22/2003	8760	8748	99.9
NM	Las Cruces	20 N	02/26/2007	5208	5144	98.8
NM	Los Alamos	13 W	07/31/2004	8760	8752	99.9
NV	Baker	5 W	05/09/2004	8760	8387	95.7
NV	Mercury	3 SSW	03/28/2004	8760	8757	100
NY	Ithaca	13 E	10/27/2004	8760	8755	99.9
NY	Millbrook	3 W	11/01/2004	8760	8756	100
OH	Coshocton	8 NNE	11/09/2006	7824	7793	99.6
OK	Goodwell	2 E	02/27/2004	8760	8758	100
OK	Stillwater	2 W	03/15/2002	8760	8741	99.8
OK	Stillwater	5 WNW	03/15/2002	8760	8760	100
ON	*Egbert*	*1 W*	*07/15/2004*	*8760*	*8751*	*99.9*

State	Location	Vector	Climate Period Start Date	Max obs	Archived	% Ingested
OR	Riley	10 WSW	07/03/2003	8760	8728	99.6
OR	John Day	35 WNW	03/16/2004	8760	8750	99.9
OR	Corvallis	10 SSW	09/14/2006	8760	8735	99.7
PA	Avondale	2 N	06/02/2006	8760	8755	99.9
RI	Kingston	1 W	12/16/2001	8760	8746	99.8
RI	Kingston	1 NW	12/16/2001	8760	8756	100
SC	Blackville	3 W	07/03/2002	8760	8756	100
SC	McClellanville	7 NE	08/08/2002	8760	8747	99.9
SD	Pierre	24 S	10/24/2006	8208	8164	99.5
SD	Buffalo	13 ESE	09/21/2004	8760	8753	99.9
SD	Aberdeen	35 WNW	06/26/2007	2328	2309	99.2
SD	Sioux Falls	14 NNE	09/25/2002	8760	8759	100
TN	Crossville	7 NW	12/03/2004	8760	8658	98.8
TX	Bronte	11 NNE	12/16/2006	6936	6925	99.8
TX	Edinburg	17 NNE	02/19/2004	8760	8751	99.9
TX	Monahans	6 ENE	05/21/2003	8760	8661	98.9
TX	Muleshoe	19 S	02/27/2004	8760	8559	97.7
TX	Palestine	6 WNW	05/01/2003	8760	8753	99.9
TX	Panther Junction	2 N	02/24/2007	5256	5241	99.7
UT	Brigham City	28 WNW	09/30/2007	-----	---	----
VA	Cape Charles	5 ENE	03/03/2004	8760	8753	99.9
VA	Charlottesville	2 SSE	03/28/2007	4488	4449	99.1
WA	Spokane	17 SSW	07/31/2007	1488	1462	98.3
WA	Quinault	4 NE	09/09/2006	8760	8749	99.9
WA	Darrington	21 NNE	04/03/2003	8760	8754	99.9
WI	Necedah	5 WNW	10/04/2004	8760	8751	99.9
WV	Elkins	21 ENE	11/17/2003	8760	8686	99.2
WY	Moose	1 NNE	07/01/2004	8760	8757	100
WY	Lander	11 SSE	07/03/2004	8760	8495	97
WY	Sundance	8 NNW	08/23/2007	936	936	100
-	Totals	-	-	838032	827905	99.5

Acronyms

AKCRN	Alaskan Climate Reference Network
AMV	Annual Maintenance Visit
ASOS	Automated Surface Observing System
ATDD	Atmospheric Turbulence and Diffusion Division
°C	Degrees Celsius
CM	Configuration Management
CONUS	Contiguous United States
COOP	Cooperative Observer Program
COOP-M	Modernized NWS Cooperative Observer Network
EOS	Earth Observing System
EROS	Earth Resources Observation Systems
GCOS	Global Climate Observing System
GOES DCS	Geostationary Operational Environmental Satellite Data Collection System
HCN-M	Historical Climate Network Modernization Network
IPCC	Intergovernmental Panel on Climate Change
LCD	Local Climatological Data
MTBF	Mean Time Between Failures
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NCDC	National Climatic Data Center
NEON	National Ecological Observatory Network
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NRCS	National Resources Conservation Service
NSF	National Science Foundation
NWS	National Weather Service
PM	Performance Measure
POR	Period of Record
QA	Quality Assurance
RAWS	Bureau of Land Management-Forest Service Remote Automated Weather Stations
RCS	Canadian Reference Climate System Network
SCAN	USDA/NRCS Soil Climate Analysis Network
SDFIR	Small Double Fence Intercomparison Reference
SM	Storage Module
SNOTEL	USDA/NRCS Snowpack Telemetry System
SURFRAD	NOAA Surface Radiation Budget Network
USC	United States Code
USCRN	United States Climate Reference Network
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WCDMP	World Climate Programme Data and Monitoring Programme
WMO	World Meteorological Organization