

United States Climate Reference Network (USCRN)

FY 2006 Annual Report

NOAA–NESDIS
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FY2006 Annual Report
United States Climate Reference Network (USCRN)
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1.0 Introduction

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

This report includes reviews of the USCRN, Performance Measures, stations installed, research progress, instrument testing, partnership activities at several levels, data quality, data availability, and relationship with other programs.

2.0 Program Base

The required program capability and requirement drivers for the USCRN are derived from U.S. legislation, executive programs, international agreements, and NOAA programmatic directives.

2.1 Program Capability

The NOAA Strategy of "Monitor and Observe" states that "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 FY02).

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. The USCRN Program expects to deploy, by the end of FY08, about 100 operational stations in the continental United States (CONUS, which excludes Alaska, Hawaii, and the various Territories) to achieve this goal. The program purpose is to:

Ensure that future changes and variations in primary measurements at specific locations can be monitored without the need for uncertain 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 at the National Scale for the United States.

Fundamental to this goal is the requirement to establish a network that 50 years from now, (~2060) will answer the question: How has the climate of the United States changed over the past 50 years?

To accomplish this goal the program will adhere to the Ten Climate Monitoring Principles¹ as defined by National Research Council of the National Academy of Sciences contained in Appendix A.

The program requirement drivers and program objective and characteristics are given below.

2.3 Program Requirement Drivers

2.3.1 Legislative

- a. 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.
- b. 15 USC 313 “establish and record 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”.
- c. 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 responsibilities of archiving and servicing.
- d. 33 USC “... authorize activities of processing and publishing data...”
- e. 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

- a. Earth Observation Summit July 2003 – Summit Declaration called for “timely, quality, long-term global information as a basis for sound decision-making” and affirmed need for filling data gaps, and producing calibrated data sets in useful formats from multiple sensors and venues.
- b. Climate Change Science Program Strategic Plan July 2003 – has a number of goals articulated including completing the required atmosphere and ocean observation elements needed for a physical climate observing system. Specifically, “the CCSP will complete the U.S. Climate Reference Network... nationwide to provide long-term

homogeneous observations of temperature and precipitation that can be coupled to past long-term observations for the detection and attribution of present and future climate change (CCSP Strategic Plan July 2003 Ch12).

- c. The Group on Earth Observation (GEO) Working Group November 2004 - states that the modernized Coop, of which Historical Climatological Network Modernization (USHCN-M) is a part, will be a network that can serve the nation as the backbone of an Integrated Surface Observing System...and it will be the sustaining factor around which all surface environmental monitoring networks are integrated. It further identifies includes the US Climate Reference Network as an underpinning for providing the highest quality benchmark data for enabling the determination of transfer functions with other U.S. meteorological networks such as ASOS, SURFRAD, and COOP. (Understanding Climate Variability and Change Technical Reference Document 10, Understand, Assess, Predict, Mitigate, and Adapt to Climate Variability and Change, November, 2004, pp 6-10)
- d. The NRC report Climate Change Science: An Analysis of Some Key Questions June 2001 – stated that “an effective strategy for advancing the understanding of climate change also will require a global observing system in support of long-term climate monitoring and prediction.”
- e. Our Changing Planet FY1997 - Data Management for Global Change Research Policy Statements; “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.”
- f. Global Change Observing Systems Second Adequacy Report April 2003 -concerning data accessibility and quality, stated “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. Addressing 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 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”.
- g. World Climate Programme Data and Monitoring (WCDMP) Guidelines on Climate Observation Networks and Systems (WCDMP No. 52) and Guidelines on Climate Metadata and Homogenization (WCDMP No. 53) 2003 - These WMO documents were written to identify the “best practices” for climatological observations, data collection, metadata, and archival activities. The intent of the documents is to bring all WMO members up to similar standards using the Ten Primary Climate Principles

(see Appendix A) as a base. Using these standards for USCRN implementation, the USCRN stations and instrumentation are qualified as “Principal Climate Observations Stations” and “Reference Climate Stations.”

- h. Annual Guidance Memorandum FY2006 – “Taking the pulse of the planet... contributing to an Integrated Global Observing System” and that “we should develop a comprehensive, NOAA-wide data collection, quality control, storage, and retrieval program.”
- i. Several bi-laterals, particularly, U.S/Canada Weather/Climate, and the Global Climate Observing Systems (GCOS) initiative to stimulate CRN-like initiatives in Latin America, and eventually to other regions.
- j. U.S. Climate Change Research Initiative June 2001 – work to improve global observing systems, including involving those of and/or being built by developing countries; work to improve access to global observations.
- k. The Administration position is outlined in a speech by President George W. Bush in June 2001 enjoining the climate community to provide decision-makers with the most precise, least controversial climate data and trend analyses than any previously possible in order that public policy decisions of great gravity could be made with the highest confidence.

2.4 Program Objectives and Characteristics

The USCRN program objectives are to develop, acquire, field, operate and maintain the premier environmental climate-monitoring network of the United States. The USCRN provides stable surface temperature and precipitation observations that are accurately representative of environmental conditions. Site location is particularly important as environmental conditions must not be affected by encroachment of urban expansion or other conditions that create a changing environment. The program also provides for end-to-end management of the data, metadata and ancillary information.

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 climate monitoring network, must have the following attributes: (derived from the Climate Monitoring Principles as initially formulated² with, and reviewed by, the government and academic climate communities in 1999². See Appendix A for general attributes and the USCRN Functional Requirements Documents for specific climate monitoring requirement implementations).

- a. redundant sensors for Temperature and Precipitation;
- b. a very high data ingest over various periodicities (e.g., ≥98% of all possible observations for a given year must be received and archived at the NCDC);

- c. stringent siting rules and an objective, quantitative assessment must be made of each site;
- d. a stringent and periodic maintenance and calibration program with thorough documentation;
- e. an organized archive of complete metadata concerning all the USCRN sensors, sites, and data characteristics;
- f. overlapping observations with transfer functions and full metadata for systematic, periodic technology refreshes and for both intra- and inter-network comparisons;
- g. a Configuration Management program for systematizing and documenting network change(s), maintaining standards, ensuring requirements growth does not impinge upon the primary purpose of the network as being a climate monitoring tool; through thorough documentation and full implementation of sound scientific data stewardship principles;
- h. a continuous Data Analysis and Data Quality component maintained for continuous monitoring of network data and metadata;
- i. an emphasis on the network's primary purposes of satisfying the climate science community's requirements;
- j. an implementation of network activities' goal of satisfying all standards with consistency in change management for a period of a century or more.

As the premier reference network for the Nation, USCRN site locations must remain stable for a period of 50 to 100 years.

USCRN field system technology is designed to be highly reliable, precise, robust and maintainable so that it collects, formats, processes and communicates measurements of environmental parameters to NCDC's central data management and processing facility in Asheville, N.C.

The equipment at USCRN field stations is designed to operate without human intervention under a wide variety of environmental conditions. The 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 six years of development and implementation, the USCRN stations thus far deployed were verified as having sufficient spatial distribution, reliability and stability, and science information value that NOAA formally commissioned the network in January 2004. The desired outcome, capabilities required, and program-level performance measures of USCRN are discussed below.

2.4.1 Desired Outcome

The USCRN is a sustained, cost-effective science-driven national and climate monitoring, climate data and benchmark system complementary to older and less rigorous or less precise NOAA in-situ (surface) networks. USCRN provides highly verified, calibrated, documented, and reliable information related to the state and changing state of the climate system. This climate monitoring system thus enables more reliable and higher-confidence climate-related predictions and projections to be made by both national decision-makers.

2.4.2 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. Provides coverage of sufficient temporal and spatial resolution to monitor national spatial scales for physical phenomena and to determine trends with the highest confidence of socio-economic and scientific significance.
- c. Measures key variables adhering to NRC and GCOS/WCDMP Climate Monitoring Principles. The two primary variables for USCRN are very high-quality, redundant measurements of temperature and precipitation, with secondary variables of solar radiation, wind velocity, and infrared radiation being used as primary variable checks.
- d. Provides data, assimilation, archival, and product generation subsystems for the observations.
- e. Observing system management and information delivery infrastructure.

2.5 Program-Level Performance Measures

The programmatic level Performance Measures for the USCRN are built upon the simplest, cleanest, most basic purpose of the network:

To reduce the uncertainty in the quality of the data and minimize the error in the measurements in order to produce the most accurate in-situ temperature and precipitation records possible, and to do it with the fewest possible stations located in areas of minimal human disturbance and with the least likelihood of human development over the coming 50-100 years.

Therefore, the highest level, single goal of USCRN is to *reduce Climate Uncertainty at the National Level* to a statistically insignificant level.

End goals for development of this primary USCRN Performance Measure are for Temperature Climate Uncertainty at the national level to be reduced by at least 98%, and for Precipitation Climate Uncertainty to be reduced by at least 95%.

By the end of FY2006 station deployments in the CONUS reduced National-level Climate Uncertainty for temperature by about 97%; the precipitation Climate Uncertainty was reduced by over 91%. This lag of the precipitation PM behind the temperature PM is normal due to the greater temporal and spatial resolution needed to estimate with confidence either the normal and abnormal behavior of precipitation.

FY2006 reductions of Climate Uncertainty were, as was the case in FY2005, hampered by a lack of funding. This resulted in a virtual hiatus in field station deployments. The network now consists of 77 commissioned field stations. Of those 77 field stations, two are still in their normal 90-day pre-commissioning test period. Thus, at the end of FY2006 there are 77 commissioned field stations towards the end goal of about 100 commissioned USCRN field stations in the CONUS. Funding limitations during FY2006 resulted in only 6 USCRN stations being deployed in the CONUS during the Fiscal Year. *(For a fuller discussion of the apparent discrepancy between the total number of USCRN stations versus the number of commissioned field stations in the CONUS, and the negative impacts that this has upon estimation of the USCRN Performance Measures, please see Section 4.6)*

Reductions in Climate Uncertainty were most pronounced and even dramatic in the first part of the program, FY2000-2004. Progress in reducing the climate uncertainty to the required national level comes in smaller increments and is approached asymptotically as the USCRN moves into the end phase of the station deployment campaign during FY2006-2008. About 30-35 additional USCRN stations deployed in a specific geographic pattern are required in the FY2007-2008 period to meet the minimum acceptable program goals of satisfying national decision-maker needs for high-confidence science support.

Stations installed through additional grants and supplemental funding, (USHCN-M prototype stations) may not necessarily decrease National Climate Uncertainty levels – although they may be used to decrease Regional Climate Uncertainty levels which are goals of the USHCN-M program. In the case of the three FY2005 Alabama stations, their deployment did not impact the National Climate Uncertainty figures.

A spacing of about 2.5° geographic degrees constitutes an optimal national grid for the estimation of the National-level Performance Measures for Temperature and Precipitation.

Tables 1a and 1b show the relationship between USCRN station numbers and growth of National Performance Measure of Reduction of Climate Uncertainty:

Table 1a
US Climate Reference Network Performance Measures, FY2002-2008,
Temperature

U.S. Climate Reference Network (USCRN)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
PM: Reduce climate uncertainty concerning variability of temperature trends to required levels for monitoring climate variability and change.								
National Goal – % of Climate Uncertainty	26	<20	<5	<4	<3.1	<2.9	<2.3	<2.1
# of Sites to reach National Goals ¹	23	40	67	72	77	105	104*	114

*Commissioned field stations.

Table 1b
US Climate Reference Network Performance Measures,
FY2002-2008,
Precipitation

U.S. Climate Reference Network (USCRN)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
PM: Reduce climate uncertainty concerning variability of precipitation trends to required levels for monitoring climate variability and change.								
National Goal -% of Climate Uncertainty	26	<20	<15	< 8	<8.7	<7.5	<5.7	<5.0
# of Sites to reach National Goals ¹	23	40	65	72	77	86	104*	114

*Commissioned field stations.

¹ For the Lower 48 States of the continental United States, about 100 commissioned field stations are needed to meet the primary, composite (T & P) National Performance Goal of Reduction of Climate Uncertainty to required levels. Test, engineering, and other sites are not included in the commissioned field station future total number. Supplementally funded, off-grid and other unplanned station additions may or may not count against the station total depending upon their geographic placement. Thus two of the present three Alabama stations are

commissioned field sites, but they do not result in PM augmentation because of their off-grid locations.

3.0 FY 2001-2005 Achievements

The USCRN achievements, Milestones, and Performance Measures were presented in detail in the USCRN FY2003 (covering FY2001-2003), FY2004, and FY2005 Annual Reports, previously submitted.

4.0 FY 2006 Achievements

In FY2006 the USCRN Program was organized and prepared for a large number of deployments as well as for continued testing and development of existing, new (next-generation), and supplemental sensors. The program brought to maturity both the temperature and precipitation algorithms, converting, formatting, and standardizing a large backlog of station and instrument metadata to be posted on our Internet site. Additionally, USCRN was encouraged to assist the startup processes involved in the NOAA NERON and USHCN Modernization programs.

The USCRN program is one of NOAA's best examples of research-to-operations. Overall the USCRN program has become a model for NOAA in terms of in-situ observing systems. In FY2005 and FY2006 the HCN-M prototypes deployed to Alabama, and the GCOS stations both adopted the same instrumentation, sampling period, and algorithms for the measurement of precipitation for their networks. Additionally, CRN technology, data handling characteristics, communications, and QA/QC algorithms were adopted by the Canadian National Reference Climate Stations (RCS) as the basis for their forthcoming deployment of 300+ long-term climate monitoring stations for that nation. CRN technology is also being considered as a minimum standard for long-term climate monitoring stations overseas that may be acquired through World Bank and European Union assistance grants.

The USCRN program is approaching a full operational network status with ~75% of the estimated field stations thus far deployed. The station deployments are underlain by a robust infrastructure that includes full documentation of the metadata, timely response to unscheduled repairs, summary and monitoring of all maintenance reports, an action item notification chain and check, and quality control/quality assurance of the data.

The customers for the data include BLM, EPA, USDA, NOAA, USGS, NPS, NSF, NFIC, four U.S. railroads and the Canadian National railroad system, the six NOAA Regional Climate Centers, the individual State Climatologists, and many others. The continued emphasis upon a strong science component for the USCRN continues 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. Six years of science and technology activity is resulting in other international and national networks utilizing USCRN instrumentation and data processing algorithms.

In summary, for FY2006 the USCRN undertook normalization and infrastructure activities that mark a mature and healthy network that has both a well-defined purpose (mission), but which still has the youth and energy to evolve, experiment, and strengthen data meaning and applicability.

4.1 FY2006 Corporate Climate Goal Performance Measures

The USCRN program's performance is measured against the Climate Goal corporate Performance Measures for the Climate Observations and Analysis Program (COA). The USCRN program is also measured as part of the Government Performance and Results Act of 1993. Performance Measures for COA are discussed in the next two sections.

4.1.1 FY2006 Performance Measures: Climate Uncertainty

During FY2005, the USCRN network increased in number to 77 commissioned field stations plus eleven pre-commissioning off-grid and selected engineering/test sites, for a total of 88 stations (not all of which have been funded by Climate Goal USCRN, see Section 4.6).

The full schedule of deployments planned for FY2006 did not materialize as the USCRN deployment budget was effectively zeroed late in FY06Q1. Two stations were deployed in early November prior to funding limitations being imposed. Although funding was provided to preserve operations and maintenance for commissioned stations, all other Climate Goal funded FY2006 station deploys that had been planned were cancelled and no new-start research or engineering tests and programs were undertaken for the last three quarters of the year. Late supplementary (non-USCRN) funding allowed the deployment of two USCRN stations into the Pacific Northwest in September 2006. These two stations are now in normal pre-commissioning testing at the end of FY2006. The second successive year of funding shortfalls (FY2005 and FY2006) has had two principal impacts on the USCRN primary Performance Measures during FY2006:

The fewer-than-planned FY2006 station deployments left the National Climate Uncertainty targets unmet from what was planned the previous year. By September 30, 2006, the PM for temperature was 97.0% (100 minus uncertainty in table 1.a). Likewise the precipitation PM was 91.8% (100 minus uncertainty in table 1.b)

4.1.2 FY2006 Performance Measures: Data Ingest

A secondary Performance Measure, Data Ingest, is not tracked by the Climate Goal but gives a measure of how many of all possible field station measurements were successfully transmitted and then received in NOAA's National Archive (NOAA's National Climatic Data Center). The higher the percentage, the more effective is a near-real time man-machine data delivery and quality assurance program which in turn validate the USCRN layered communications system, and strengthen station

maintenance while making the scientific community's interpretation of the dataset more confident.

Network data ingest during the course of FY2006 averaged 99.3% (see Appendix C, Table A) from the 77 commissioned field stations of the network. The cumulative FY2001-2006 network data ingest is slightly higher at 99.6% (see Appendix C, Table B).

The slight decrease in FY2006 data ingest percentages is due to the impact of two new stations coming on-line in early September, 2006, as well as a separate GOES-West Data Collection System (DCS) outage during late September. Both of these activities occurred in September. Corrective station datalogger recovery actions will not be finished until late October or early November 2006. Therefore, selected station reporting percentages and the overall network data ingest statistics are biased slightly downward as a result. Full data recovery is expected using the layered USCRN communications systems as well as by routine USCRN maintenance program interventions developed for precisely such circumstances.

This Performance Measure is a quantitative measure of how robust the network technology and communications are, and also is a measure of how effective are both the annual maintenance and the emergency maintenance programs. The pre-deployment target at the program outset was to attain a Data Ingest into the NCDC Archive of 98% of all possible station observations within 30 days. This Performance Measure was felt to be so high, based on data ingest percentages from previous networks, that it was initially felt that CRN was planning for failure rather than success.

As reported in the FY2005 report, the USCRN network integrity was severely tested in the Southern CONUS during the passage of Hurricane Katrina across the (then) three CRN stations in Mississippi and Alabama. Although the primary electrical grids at two of the stations went down during the storm – no sensors or other station components were lost and backup station battery packs worked as planned. As a result 100% of all possible 5-minute interval storm observations were ingested at NCDC from all USCRN stations in Katrina's broad path.

Since the USCRN program began in FY2001 this Data Ingest Performance Measure has been gradually increasing to a level equal to and then above what the climate science community has specified is 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 the 1st quarter of FY2002. The Data Ingest has now sustained itself above the 99% level since the 1st quarter of FY2003 with the exception of the *temporary* impact of the GOES DCS outage that occurred during FY06Q4. Tracking of this Performance Measure is portrayed in Table 2 below:

Table 2 USCRN Observations: Network-Wide Data Ingest (%)*, FY2001-2006

FY	Q1	Q2	Q3	Q4	Annual

2001	86.8	96.5	70.5	97.4	87.8
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
Average	96.9	98.6	94.7	98.0	97.3

** Percentage of all possible measurements received in the National Archive NCDC and made available via the Internet. Cumulative data received into the NOAA Archive for the entire POR (11-14-2000 through 09-30-2006) is 1,841,279 observations of a possible 1,845,816 observations (99.8% of all possible observations)*

The data and progression of data ingest figures at a high plateau level of ~99% for thirteen of the past sixteen quarters indicates that USCRN technologies, redundancies, and communications layering have produced a highly reliable, multi-layered, and robust climate monitoring network. USCRN meets or exceeds the most stringent climate science criteria (98% data ingest rate) developed by National Academy of Science – National Research Council (NAS-NRC) and the World Meteorological Organization (WMO). Indeed, the network technology has demonstrated during FY2006Q4 DCS downage that it seems to be more robust than the GOES-DCS technology.

The very low FY01Q3 70.5% Data Ingest is due to major upgrading of the two field prototypes (the Asheville NC stations) during that quarter. These were the only two stations in the network at that time. This reconfiguration downtime resulted in data gaps while the upgrades were being made. Field station deployments did not take place in large numbers until FY2002, thus an argument can be poised that FY2001 was a prototyping, experimental year and, perhaps, should be excluded from network-wide statistical summaries and studies. It is nevertheless included in this data ingest summary in the interest of historical accuracy.

A solid improvement from the FY2002 Q1 of 95+% data ingest level has now reach its plateau with high data ingests (99±%) in October 2002 through FY2006. During this period the network has increased from two prototypes to 77 commissioned field stations. CRN technology is behaving at a mature level; maintenance programs are both proactive and reactive -- and they are effective. Layered communications have made the difference between good performance and outstanding performance. Seasonal differences in data ingest, with a late winter/early spring minimum and a late summer/early fall maximum now appear to be parts of a normal, even a forecastable cycle.

USCRN FY01-05 and some FY2006 data has been recovered from station dataloggers using PDA's (Personal Digital Assistants) and the newer, more robust Storage Modules (SM's) which have then been downloaded to the NCDC archives (see Appendix C Tables).

4.2 FY2006 Installations and Surveys

FY2006 installations and surveys included the following activities:

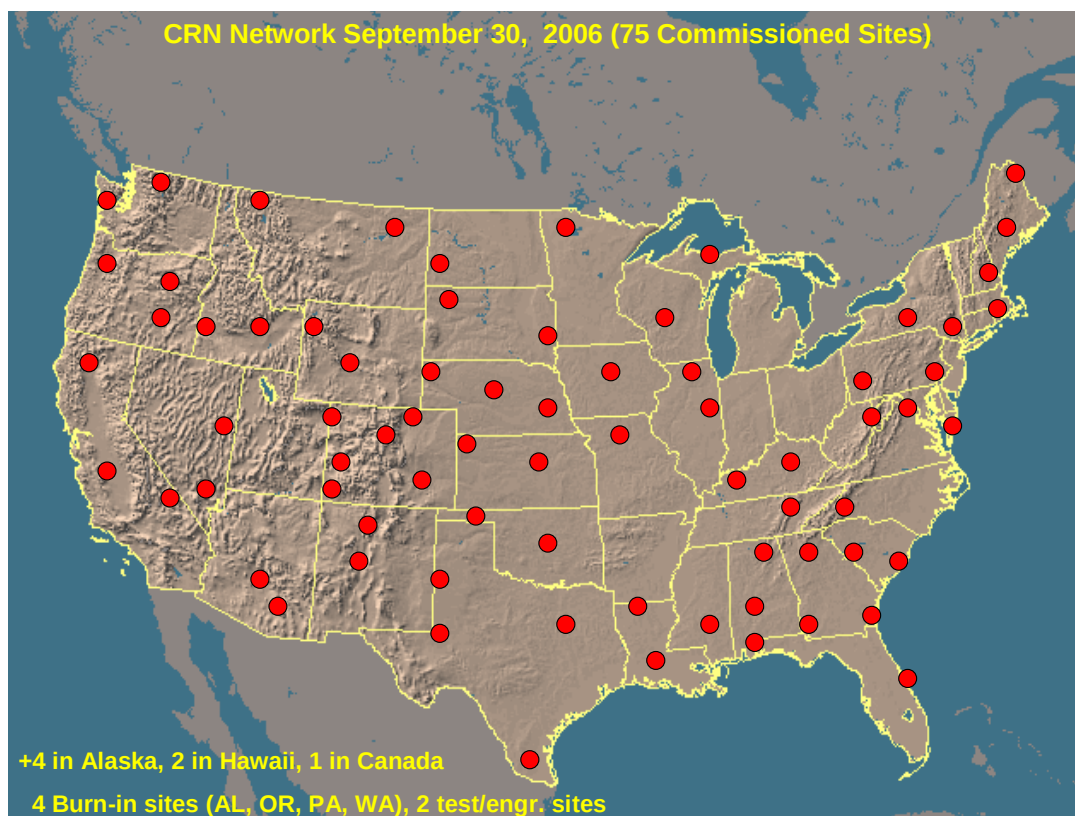
Site Surveys	19
Sites Approved	7
Site Licenses Signed	6
Stations Installed	6

The new CRN field stations installed in FY2006 by month:

October 2005	Oakley, KS	(USCRN funding)
November 2005	Cortez, CO	(USCRN funding)
December 2005	N/A	No deploys
January 2006	N/A	No deploys
February 2006	N/A	No deploys
March 2006	N/A	No deploys
April 2006	N/A	No deploys
May 2006	Fairhope, AL	(External funding)
June 2006	Avondale, PA	(External funding)
July 2006	N/A	No deploys
August 2006	N/A	No deploys
September 2006	Quinalt, WA	(NOAA supplementary)
	Corvallis, OR	(NOAA supplementary)

The following map portrays the USCRN CONUS commissioned field station network configuration at the end of FY2006:

Figure 1 Map of Current CONUS Commissioned Field Stations



NOTE: The locations of the two test sites and the two stations in burn-in (test or pre-commissioning) phase are also plotted on the map above.

4.3 FY 2006 Sensor Testing and Science Studies

Due to FY2006 budgetary constraints and the reduced funding to the USCRN all research accomplished was performed only by the use of external funding.

WMO intercomparison of rain gauges is being guided by the results from the USCRN precipitation testbeds and a formal proposal to adopt the triple configuration for temperature will be put forth to the WMO for inclusion in the forthcoming updated WMO guide on Instrumentation and measurements.

The USCRN has also completed the relative humidity study begun in FY2004. this study completion provided the baseline accuracy and reliability statistics which have allowed confident identification of the Relative Humidity (RH) sensors which may be incorporated into the entire CRN network. Inclusion of the RH sensors will probably be scheduled for FY2007 and FY2008 - subject to funding and program needs.

Results from two years of rigorous measurements at two USCRN testbed stations have encouraged the Canadian Reference Climate Network (RCN) to use the USCRN precipitation gauge and to adopt the USCRN triple-temperature sensor configuration. It

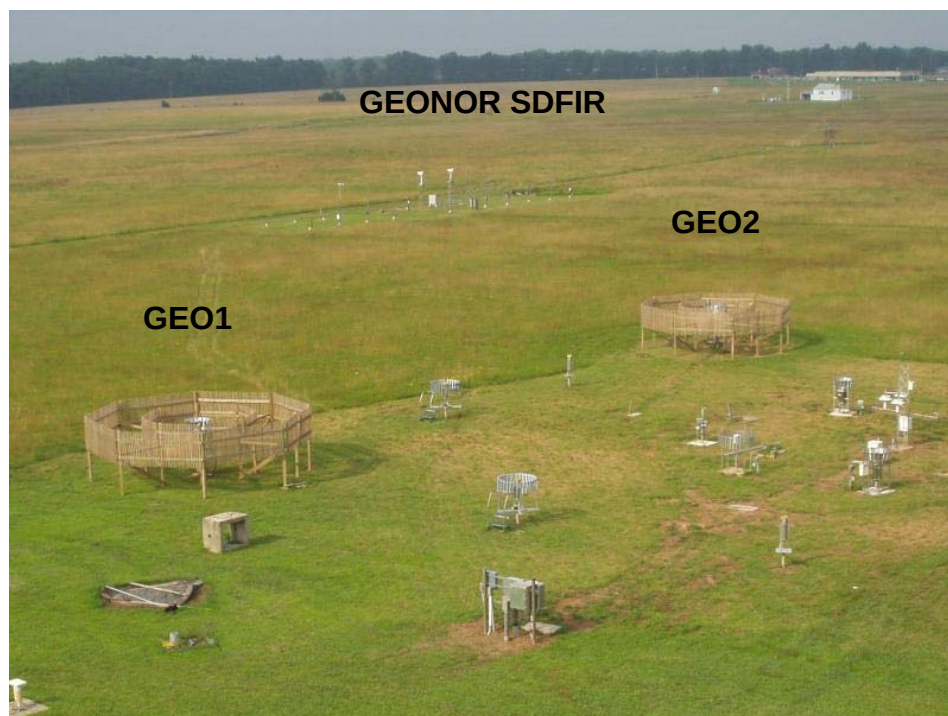
is likely that the full Canadian RCN station, sensors, communications, and data processing configurations will be virtually identical to that of the USCRN.

Six early HCN-M prototype stations deployed to Alabama under supplemental funding in FY2005-06 are also using the CRN precipitation gauge and temperature sensors and station configurations. Future evolutions of HCN-M await decisions on this opportunity to achieve significant procurement, calibration, logistical, and maintenance cost-savings commonalities between the two networks.

4.3.1 FY2006 Precipitation Testing Results

Continued testing of the double alter wind fence configuration with Geonor and Vaisala gauges in FY 2006 resulted in the SDFIR vs. double alter and Geonor vs. Vaisala gauge evaluations (Figure 2).

Figure 2 Configuration of the Precipitation Test Site and Equipment



Two USCRN precipitation testbeds are located at Sterling, VA and Johnstown, PA. Most of the new development engineering and testing undertaken by the USCRN program uses these two NOAA facilities. The facilities allow sufficient room and controlled monitoring to test numerous precipitation gauges (weighing bucket, weighing spot, tipping bucket, etc.), other sensors, and large and small wind fences from a variety of NOAA networks.

Using controlled multiple sensor data, focused transfer functions are being developed separately for liquid and frozen precipitation measurements and control. These transfer functions are being developed for three non-CRN sensors of importance: the current ASOS precipitation gauge, the new ASOS precipitation gauge, and the new modernized rain gauge in FY2006. Additionally, during FY2006, testing continued on a new wind fence design for the USCRN rain gauge.

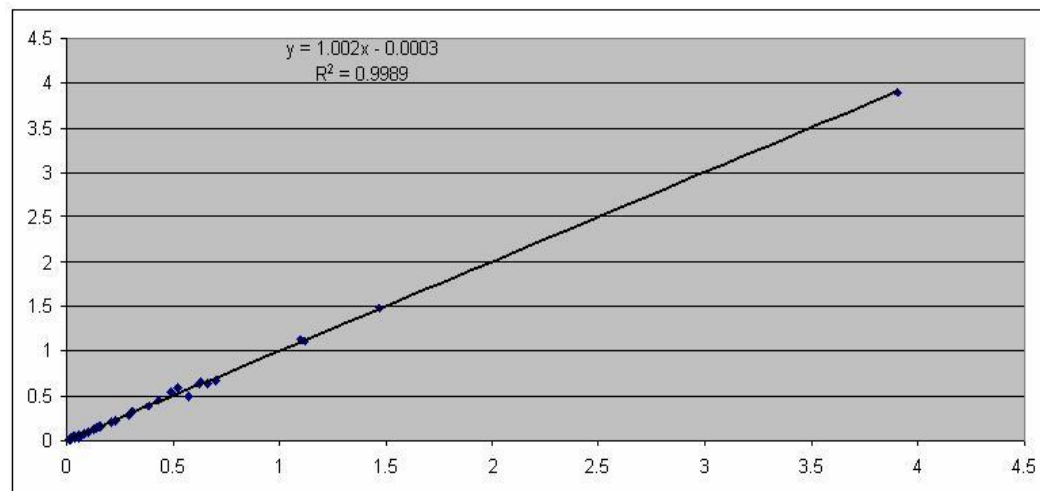
Some of the experiments underway at the CRN testbed sites include (d):

- Installation of Double Alter shields to define operating characteristics with the DFIR and the SDFIR. The Double Alter shields are proving to be an acceptable alternative to the SDFIR. In FY 2006-2007 there will be approximately 15 automated stations in Alabama that will be using the double-alter shield.

The USCRN Precipitation Algorithm has been fully tested and has been fully implemented into the ingest process at NCDC. This includes the use of the wetness sensor as a QC check for false precipitation values. The network is checked on a monthly basis as to the performance of the algorithm in removing false precipitation values and thus far has done so 100% of the time.

The statistical comparison of the two Geonors used in this baseline study showed that the two precipitation gauges were in almost perfect alignment with one another (Figure 3 below).

Figure 3 Baseline Comparison of Geonor-1 and Geonor-2



The Vaisala Precipitation gauge was provided with the double-alter wind fence (Figure 4 below). In previous multi-year, all-season, all wind-regime comparative studies of the double-alter windfence against the SDFIR, the differences between the two wind fence configurations has been found to be $\leq 1\%$.

Figure 4 Vaisala Precipitation Gauge with Double Alter Shield



Two Geonor precipitation gauges configured with the SDFIR were compared to the Vaisala precipitation gauge to assess which gauge was the most efficient at catching precipitation. The differences were found to be nominal (see Figures 5a and 5b below):

Figure 5a Comparison of Geonor 1 with SDFIR plotted against the Vaisala with Double Alter

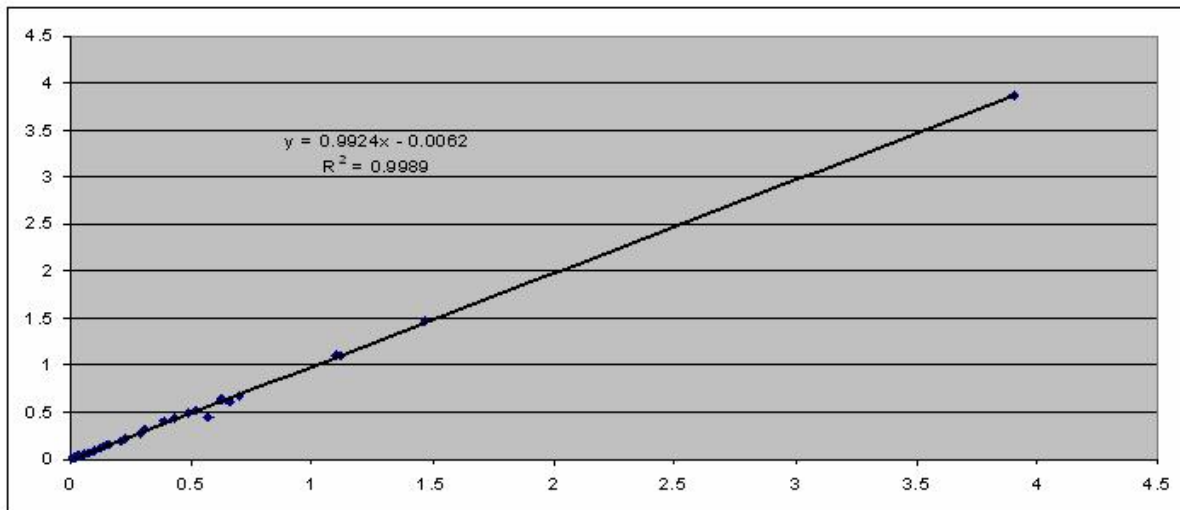
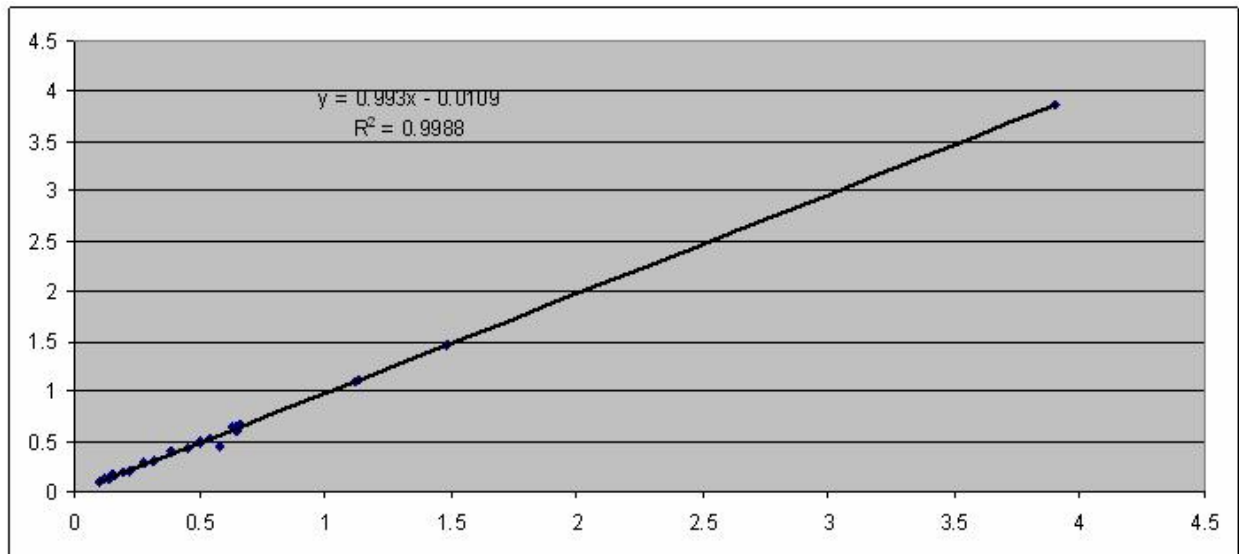


Figure 5b Comparison of Geonor 2 with SDFIR plotted against the Vaisala with Double Alter



It is apparent that the Vaisala/double alter combination compares quite well with the Geonor/SDFIR. The control is to find all events that were commonly measured by the Geonor/SDFIR and Vaisala/Double Alter. Secondly, compare the two Geonors systems for those common events to ascertain the variability between the two systems and/or spatial variability of the events within the plot.

Given the 36 common precipitation events there is no statistical difference between the two systems. We will need a larger sample of solid precipitation events to determine if this relationship will remain the same in that environment. The significant finding is the ability to develop a relatively simple transfer function due to the linearity in the comparison.

Liquid precipitation events are fairly well understood with regard to gauge/shield functioning. Solid precipitation events need further refinement. Unfortunately, the Johnstown test site and, especially, the Sterling test site have relatively few solid events. Installation of test gauges in higher-latitude, more severe climates in terms of temperature and wind is required.

Locations for higher-latitude locations with higher incidence of solid precipitation events are being censused. Candidate locations have been identified in the upper Midwest, Canada, and Alaska. These options will be explored in FY 2007 due to the recent unrelated decision to expand the Dulles Airport which will require moving the Sterling Testbed in the autumn of 2007 to accommodate the Dulles Airport expansion. It is fortunate that the initial liquid precipitation testing has been largely completed prior to this move taking place, and it is likewise fortunate that the solid precipitation study phase has not yet begun.

After its repositioning to an edge area of the airport, the Sterling Testbed will have limited future usefulness and lowered test result confidence due to high-density residential housing and the uncertain impact of what has now a very large airport

complex immediately adjacent to the site. Although such a site may be adequate for exposure and testing of meteorological instrumentation, it is not felt that such an area will allow for high-confidence climate monitoring or long-period testing.

Continued collection of data from current gauges and test sites will increase the number of precipitation events so that the resulting statistics will be more robust.

FY2006 sensor testing and science studies included refinements to existing instrumentation such as testing of all rain gauge sensing devices and completion of the installation of wetness sensors at all USCRN sites.

4.3.2 FY2006 Temperature Testing Results

Temperature testing studies were conducted in FY2006 by the NOAA OAR offices in Oak Ridge, Tennessee. Please see on-line publications at <http://www.ncdc.noaa.gov/crn/technotes.html>.

Two of the largest sources of uncertainty in the USCRN air temperature measurement are the datalogger measurement error and error caused by the bridge resistor temperature coefficient. Tests were conducted to quantify these errors, and summarized in a technical note *USCRN Technical Note 07-01, Temperature Measurement Improvement*, by D.L. Senn.

The USCRN stations use a custom platinum resistance thermometer (PRT) sensor in a 3-wire half bridge circuit. This circuit is wired to a Campbell Scientific, Inc. CR23X datalogger. The CR23X measures the resistance of the PRT from which the temperature reading is computed. There are several sources of error in this air temperature. Among these errors are calibration errors, aspirated shield errors, PRT self-heating, and datalogger measurement errors. The calibration error is likely on the order of a few thousandths of a °C, and at most a few one hundredths of a °C. Aspirated shield errors are difficult to measure but they are considered to be no more than 0.05°C. The largest portion of the error in the overall temperature measurement is the resistance measurement of the PRT sensor. The maximum (worst-case) error is the sum of these errors. The worst-case error can be decreased from $\pm 0.457^{\circ}\text{C}$ to $\pm 0.168^{\circ}\text{C}$ by changing the bridge resistor and measurement range used in the measurement.

4.4 Relationship of USCRN with other Station Network Programs

Where possible, USCRN stations are being co-located with or near existing meteorological observation sites such as those of the Historical Climate Network (HCN), the National Weather Service's Cooperative Observer (COOP) and Modernized COOP networks, the Canadian RCS, the NWS Automated Surface Observing System (ASOS), the Bureau of Land Management/Forest Service Remote Automated Weather Stations (RAWS), the NOAA Surface Radiation Network (SURFRAD), the University of New Hampshire's AIRMAP stations, and various State mesonet stations.

Co-locations of USCRN sites near existing networks also provide new elements of data, primary data continuity, and station survivability. Increased emphasis upon these factors came into sharp focus since the passage of Hurricane Katrina across Louisiana, Mississippi and Alabama in August 29-30, 2005. Missing data ingests from some networks in those three States during this hurricane indicate that non-CRN station/sensor destruction and/or data outages occurred in some operational networks. The complete data is critical for extreme hurricane analysis. USCRN stations in the area survived and have provided 100.0% of all observations to the data archive (NCDC) before, during, and after the event.

The organizational classification of USCRN operational field stations by Host Agency identity gives an indicator of the breadth of the USCRN partnership involved in the building of this network.

Table 3 CRN Hosts September 2006

Arboretum/Audubon/Foundation	11
University	31
Indian Reservation	2
State Park/Forest	3
NOAA	4
National Wildlife Refuge	9
National Park Service	16
Other Fed (Ag, NASA, USGS, DOE, BLM, Can)	10
Test Sites	2

As the USCRN is intended to serve as a model environmental monitoring network for the United States and the international community, the program will develop data transfer functions relating observations between these networks and the USCRN to thereby leverage primary and specialized climate observations over broader coverage areas.

During FY2006, exchanges with the NERON program continued. In June 2006 the NOAA Executive Council modified the scope and breadth of NERON and defined it as "a project to integrate a network of observing systems to sustain the Nation's climate record of land surface measurements essential to monitor and assess the surface climate". The modernization of the USHCN was designated to be the first phase of NERON. For reduction of Climate Uncertainty for the individual nine U.S. Standard Climate Regions of the CONUS to similar values as at the national level, the USHCN spatial density would have to be much greater than that of the USCRN.

Additional grants and supplemental funding was used for installing stations off the USCRN grid as prototype USHCN-M stations. These stations may decrease Regional Climate Uncertainty levels, an important goal of the USHCN-M.

Adding USHCN-M stations under the USCRN program raises the question of cost – how does the USCRN pay for the annual maintenance and re-calibration of USHCN-M stations? The USCRN Operations & Maintenance (O&M) budget is very tightly estimated and does not include expansion capacity for USHCN-M station additions, unless the O&M outyear line is proportionally increased. Conceivably, further USHCN-M station additions may erode the overall network data quality over time as maintenance and re-calibration, etc., may have to be spread too thin to maintain required specifications at all stations.

These issues need to be carefully documented to see what the long-term impact might be of what are apparent front-end improvements of the network. Outyear O&M budget for USCRN may be impacted by USHCN-M installs – O&M that is critical for long-term network science confidence and credibility. Based on the past five years of Annual Maintenance Visits (AMV), the average annual cost for each station's maintenance/re-calibration and equipment upgrades is about \$3.6K/year, so there are only slight but measurable impacts thus far from USHCN-M prototype installs. It should also be noted that there are geographical differences in the cost of AMV's depending upon station location. Fortunately these Alabama stations are in close proximity to the USCRN maintenance and calibration facility (NOAA-ATDD, Oak Ridge, TN).

The initial suite of equipment deployed in USCRN and USHCN-M meets the climate requirements for measuring and recording surface air temperature and precipitation. The design is flexible, extensible and scalable to provide for later deployments of additional sensors such as soil moisture and temperature, necessary for meeting added requirements, such as drought monitoring within the NIDIS program.

Work continued in FY2006 on developing relationships between USCRN and other national and international climate networks. CRN presentations at national and international conferences continue to result in inquiries from abroad in linking or exchanging technology, developing common observing, archiving, operating, and siting standards worldwide.

4.5 FY 2006 International Cooperation

International interest in the USCRN and its technology continues to grow. USCRN high-quality environmental measurements have been proven in rigorous field tests and six years of field operations. International interest is now being more finely focused upon adopting and adapting USCRN technologies, station siting evaluations, surveys and standards, data processing, and archival procedures.

The first nation to duplicate USCRN practices and technology is Canada. The USCRN was invited to have a U.S Representative on the Canadian Atmospheric Environment Service (AES) National Monitoring Change Management Board (NCMB) This invitation was accepted. This exchange is ongoing and included participation in NCMB meetings in FY2006 and participation in a Snowfall workshop held in July 2006 by the USCRN Chief Scientist. As a result of the "The Snowfall Workshop" the NWS will conduct a

study the winter of 2007 using the triple-configuration snowdepth sensor at ~20 WFO's and in addition the same configuration will be installed in the Sterling testbed. Further collaboration will take place in the spring of 2007 to discuss a common algorithm to be utilized to measure snow depth and snowfall.

Canada, the only nation, thus far, with a formal relationship with USCRN, is in the process of co-locating a Canadian RCS with a USCRN station at a test site in Sioux Falls, SD in Q1 of FY2007. It is anticipated that once the Canadian RCS station is installed network transfer functions will be examined between the two networks starting in late FY2007. 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

In addition to U.S. – Canada activities, USCRN stations have been selected for deployment in various environments on other continents where assistance in modernization is desired, especially through the GCOS program, as it takes action to upgrade global baseline climate monitoring stations.

Two CRN-technology stations outside the CONUS were configured to be GCOS test stations for 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.

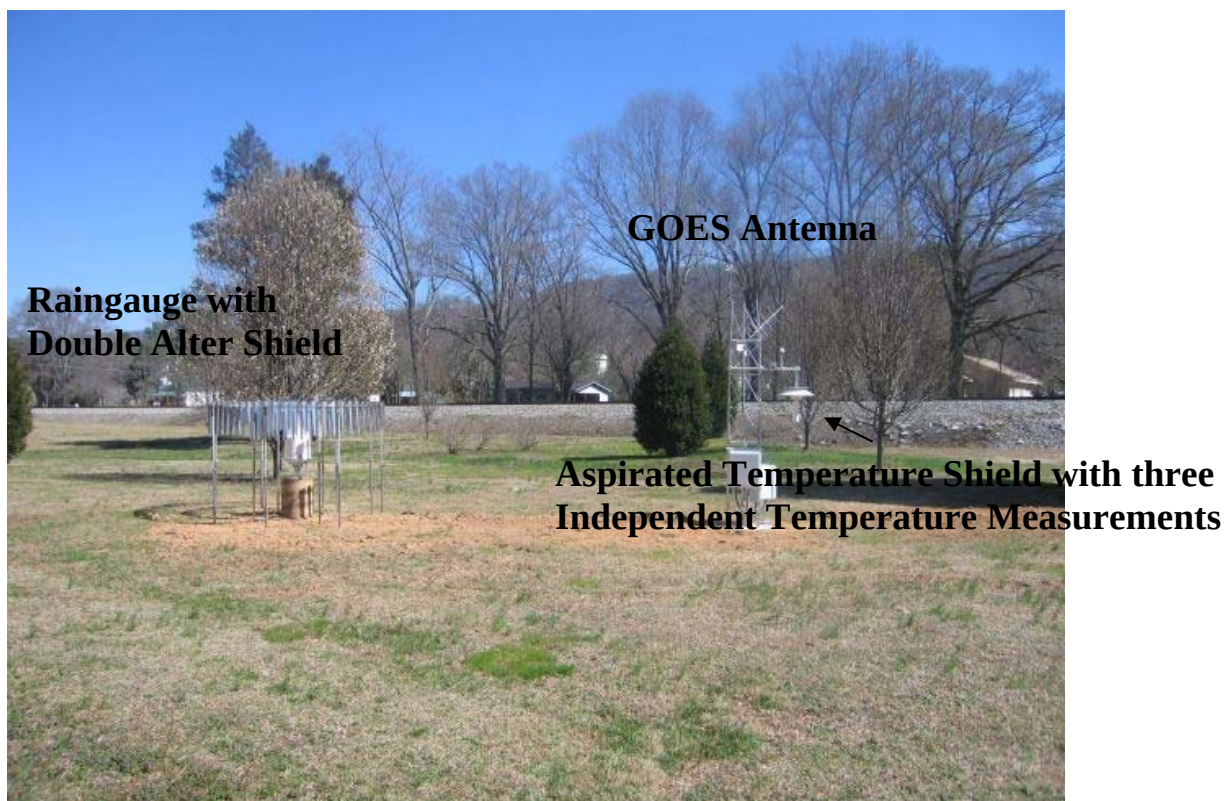
Negotiations are underway at the close of the FY on the GCOS program's use of the CRN technology in deployments in the Pacific, specifically in the lesser Pacific islands starting with American Samoa, and with Latin America. Current GCOS USCRN application plans through the NOAA International Polar Year Office include deployment

of a CRN stations configured for GCOS use into Northern Siberia (Tiksi area at the mouth of the Lena River) in Q3 or Q4 of FY2007. Access and logistical difficulties at these locations make those tentative station deployments problematic.

At the close of the FY, interest was also building for a World Bank proposal to deploy the GCOS configuration of CRN stations for monitoring rapid climate change that is occurring at the snouts of several important Andean glaciers. Melting of these glaciers is a critical problem in the Andean nations as the capital cities of these nations are almost all 100%-dependent upon glacial meltwater as their only input of freshwater. It is possible that CRN will be called upon to establish GCOS-level (HCN-M) stations (see Figure 6) in and about 6-10 of these Andean glaciers during the period FY2007-2010. Andean glacier diminution is becoming very marked, particularly in Venezuela, Colombia, Ecuador, and Northern Peru. Glacier wasting in higher latitudes (Southern Peru, Chile, Bolivia, and Argentina) is less critical, but is also severe. In all of these countries, glacial meltwater is a critical source of water. Meltwater comprises 30-50% of the national energy needs (hydropower), and is also the primary source of agricultural water, especially in the Altiplano of Peru and Northern Bolivia, and in southeastern fore ranges of the Andes in Bolivia and Argentina.

Candidate initial glacier monitoring sites in the Northern Andean nations have been tentatively identified for 10 locations. If this project is developed and funded, it will be implemented starting in FY2007 for technology development (beefing up of CRN station technology and logistical preparations), with formal site surveys occurring in FY2008 and station deploys in FY2009-2010. The first suite of glaciers to be monitored is tentative, but includes five glaciers in Peru, four in Colombia, and one in Ecuador (see Figure 6 below for the configuration of the base GCOS CRN station).

Figure 6 GCOS Configuration of CRN station for deployment overseas



The GCOS stations to be deployed are similar to the USCRN configuration but have been downsized to only measure temperature and precipitation. The temperature incorporates the same shield but has all three temperature sensors in one shield and the system utilizes the double alter instead of the SDFR. Above is an illustration of the system.

Discussions began in August-September 2005 and have continued throughout 2006 to satisfy an interest in modernization and climate monitoring in Latin American countries by identifying with the National Meteorological Service of Mexico and various Andean countries specific station sites for possible future deployments of CRN stations at various high-elevation locations. If this activity comes to fruition it will be via FY2007 funding stimulated by the World Bank and coordinated via the NOAA International Affairs Office and NOAA-GCOS.

Other possible CRN station offshoots that have been discussed include future lowland sites in Mexico. Such stations in Mexico can be particularly important for allowing transfer functions to be established between the U.S. Southwestern CRN stations and those Mexican CRN stations that may be co-located with longer-period stations of the Mexican NMS. This low-elevation Mexican station effort would be particularly useful in supporting the joint NOAA-Mexico-Canada integrated drought analysis product, the North American Drought Monitor.

Additionally this proposed activity in Mexico would fill in geographically critical information gaps adjacent to the U.S. Southwest which are vital for support of the

National Integrated Drought Information System NIDIS. If successful, this would be a multi-year effort. Thus this complementary initiative would extend the areal coverage and increase the confidence level of older Mexican data for use in the North American Drought Monitor, an operational NCDC product that portrays drought conditions in all three countries of North America.

Additionally, during FY2006 the USCRN will be involved with the WMO and have a representative to the Expert Team on Surface-based Instrument Inter-comparisons and Calibration Methods (ET/SBII&CM). This will include participating in international intercomparisons of other nation's precipitation gauges underway at evolving European Union meteorological testbeds in Italy and France.

4.6 FY 2006 and FY2007 Station Deployments & Commissionings: Plans and Definitions

At the end of FY2006, 88 CRN stations were operating; 77 of those 88 stations were commissioned field sites. The remaining 11 (non-commissioned) stations were in burn-in phase (90 days of post-deployment site testing), or were set aside solely as engineering test sites (and were off-line - not on GOES DCS as the primary communication mode), or were deployments outside of the USCRN Performance Measure spatial grid (e.g., in Alaska, Hawaii, and Canada). As a general rule, station commissioning usually follows station deployment after a burn-in (test) period of no fewer than 30, but more usually about 90 days.

The amalgamation of all CRN station into one apparent statistical class prior to FY2005 led to unintended confusion of the relationship between the base Performance Measures for USCRN and the number of USCRN stations. Therefore, in an effort to achieve greater clarity it should be understood that the USCRN PM is based ONLY upon the number of and the proper geographic location of those USCRN stations that are commissioned field stations. A list of those stations is attached as Appendix C.

To clarify this possible misunderstanding, during mid-2005 CRN personnel developed a more accurate station figure (using only "commissioned field stations in the CONUS") as the most accurate representation of the National PM for Climate Uncertainty.

For FY2006 end-of-the-year reporting, we have a total of 88 CRN stations deployed. Only 77 of those are classified as USCRN operational (commissioned) stations. Those non-commissioned stations are these:

- a. two stations funded by State of Alabama supplemental funds in FY2005 and FY2006 (unfortunately these stations were deployed in specific, designated counties, and are not located on the USCRN PM grid);
- b. two stations were deployed to Alaska using FY2005 GCOS funding for densification of high-latitude data inputs to assist in satisfying a NOAA support element for the forthcoming International Polar Year;

- c. two other stations were deployed in Hawaii as FY2005 GCOS extreme environment test sites (high-altitude and tropical closed forest ecotones). These Hawaiian test sites provide readily accessible U.S.-controlled locations prior to the probability of CRN stations being adopted by other nations for deployments in their mountain ranges and heavy precipitation areas. If there are problems in these stations' functionality in these extreme environments, these problems can be addressed prior to being installed internationally.
- d. four other stations are also not included in the PM calculation due to restricted functionality or geographic fitness as fully commissionable USCRN field stations in the CONUS. These four sites are:
 - . two Alaskan stations deployed in FY2001 as early CRN test sites for Alaskan extreme environmental conditions – neither of those stations should be used in calculation of the CONUS PM, but they may be integrated into any forthcoming Alaskan CRN network as supplementary sites for that area, and
 - . two U.S. CONUS primary engineering test sites at Johnstown, PA and Sterling, VA. Data from neither of these two sites is presently available via GOES-DCS. Likewise neither of these two sites has had a site survey, a site panel review, nor a Site License Agreement (not technically necessary as they are located at NOAA-owned or leased engineering facilities).
- e. One station is deployed to the Canadian National Engineering Testbed Site in Egbert, Ontario. This station functions as a transfer function site as well as an engineering demonstration and control station for the Canadian RCS – a network under construction in Canada of 320-340 Canadian long-term climate monitoring stations which are virtual clones to the smaller U.S. Climate Reference Network. In turn during FY2007, the Canadians will deploy one of their RCS stations to be co-located with one of the CRN operational field stations in the northern tier (at EROS Data Center in Sioux Falls, S.D.).
- f. New CRN field stations were deployed to a National Wildlife Reserve in Western Oregon and the Olympic peninsula of Washington State in September 2006. Assuming that all goes well during their burn-in periods, these two stations will most likely be commissioned in late December or early January, 2007.

Thus, only 77 USCRN stations are presently used in calculating the end-of-the year FY2006 Performance Measures. Yet it is true that there are, at this time, 88 CRN stations. Input calculation of the USCRN CONUS PM's from the stations identified above is not statistically precise or proper as the data from each of those other fourteen stations is either off the USCRN CONUS grid or it is reserved as emanating from experimental/test sites whose configuration is not static.

There are 26 USCRN sites scheduled for deployment in the CONUS in FY2007, assuming that full funding is received. 10 of those stations are from a NOAA Supplemental received late in FY2006; the other 16 are those stations that will be deployed under the normal budgetary allocation received by the CRN program.

There are no USCRN-funded sites scheduled for deployment outside the CONUS in FY2007, nor are any further special purpose stations (e.g., test sites) currently scheduled or funded for deployment during FY2007. There may well be additional stations deployed during FY2007 from unplanned external funds, so the potential for end-of-year FY2007 confusion may once again exist. If this occurs, proper care will be taken in the FY2007 EOY Annual report to explain whatever circumstances might have developed that might cause any confusion.

5.0 FY2007 Planned Activities and other Future Activities and Expected Results

Research and engineering development activities envisioned for FY2007 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 ASOS, COOP-M or HCN-M, and insofar as possible – such non-NOAA networks include h RAWS, SCAN, SNOTEL, 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 LCD's, noted above.
- c. Exercising the capability and fitness of combinations of USCRN sensors by providing ground truth points for NOAA, NASA, and EU satellite systems such as EOS. Exploration of Calibration/Validation studies with integration of in-situ and satellite data will continue.
- 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 future retrofitting to all CRN stations will proceed apace starting during FY2007. Sensors for Moisture/Soil Temperature are important for the collaboration with the NIDIS program.
- 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 (MTBF statistics), and individual stations that lag in their performance and/or precision of measurement.
- g. Coordinate with Canada on development of transfer functions and future common LCD product generation between the Canadian RCS and the USCRN and snowdepth measurements.
- h. Develop international ties on global standards and commonalities in the measurement of precipitation and temperature throughout the WMO community.

6.0 Summary

The Climate Reference network 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 has a stretch-out 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's), 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 Climate Reference Network fills an important land-based gap in U.S. climate data. These data are needed in a larger and more comprehensive Earth observation system being developed by more than 34 countries.

Appendix A Ten Climate Principles

1. Management of Network Change: Assess how and the extent to which a proposed change could influence the existing and future climatology obtainable from the system, particularly with respect to climate variability and change. Changes in observing times will adversely affect time series. Without adequate transfer functions, spatial changes and spatially dependent changes will adversely affect the mapping of climate elements.

2. Parallel Testing: Operate the old system simultaneously with the replacement system over a sufficiently long time period to observe the behavior of the two systems over the full range of variation of the climate variable observed. This testing should allow the derivation of a transfer function to convert between climatic data taken before and after the change. When the observing system is of sufficient scope and importance, the results of parallel testing should be documented in peer-reviewed literature.

3. Metadata: Fully document each observing system and its operating procedures. This is particularly important immediately prior to and following any contemplated change. Relevant information includes: instruments, instrument sampling time, calibration, validation, station location, exposure, local environmental conditions, and other platform specifics that could influence the data history. The recording should be a mandatory part of the observing routine and should be archived with the original data. Algorithms used to process observations need proper documentation. Documentation of changes and improvements in the algorithms should be carried along with the data throughout the archiving process.

4. Data Quality and Continuity: Assess data quality and homogeneity as a part of routine operating procedures. This assessment should focus on the requirements for measuring climate variability and change, including routine evaluation of the long-term, high-resolution data capable of revealing and documenting important extreme weather events.

5. Integrated Environmental Assessment: Anticipate the use of the data in the development of environmental assessments, particularly those pertaining to climate variability and change, as part of a climate observing system's strategic plan. National climate assessments and international assessments, (e.g., international ozone or IPCC) are critical to evaluating and maintaining overall consistency of climate data sets. A system's participation in an integrated environmental monitoring program can also be quite beneficial for maintaining climate relevancy. Time series of data achieve value only with regular scientific analysis.

6. Historical Significance: Maintain operation of observing systems that have provided homogeneous data sets over a period of many decades to a century or more. A list of protected sites within each major observing system should be developed, based on their prioritized contribution to documenting the long-term record.

7. Complementary Data: Give the highest priority in the design and implementation of new sites or instruments within an observing system to data-poor regions, poorly observed variables, regions sensitive to change, and key measurements with inadequate temporal resolution. Data sets archived in non-electronic format should be converted for efficient electronic access.

8. Climate Requirements: Give network designers, operators, and instrument engineers climate monitoring requirements, at the outset of network design. Instruments must have adequate accuracy with biases sufficiently small to resolve climate variations and changes of primary interest. Modeling and theoretical studies must identify spatial and temporal resolution requirements.

9. Continuity of Purpose: Maintain a stable, long-term commitment to these observations, and develop a clear transition plan from serving research needs to serving operational purposes.

10. Data and Metadata Access: Develop data management systems that facilitate access, use, and interpretation of the data and data products by users. Freedom of access, low cost mechanisms that facilitate use (directories, catalogs, browse capabilities, availability of metadata on station histories, algorithm accessibility and documentation, etc.), and quality control should be an integral part of data management. International cooperation is critical for successful data management.

¹ *Adequacy of Climate Observing Systems (NRC), National Academy of Sciences Press, Washington, D.C., 1999 (see pp. 17-18).*

Appendix B Relevant FY2006 Science Studies and Scientific Source Papers Relating to USCRN

Baker, B.C. 2006a. Emerging technologies and development of Automatic Weather Stations and national networks. Fourth International Conferences Experiences with Automated Weather Stations. Lisbon, Portugal, May 2006.

Baker, B.C. 2006b. Transfer Functions and efficiency of catch of various raingauge and windshield combinations for solid precipitation. Snowfall Workshop July 2006, Toronto, Ontario.

Hubbard, K. G, Baker, C.B. 2006. Sensor Averaging for the Determination of Daily Tmax and Tmin Temperature: Experiments with Model and Field Data . 86th AMS Annual Meeting, 29 January - 2 February 2006, Atlanta, Georgia, American Meteorological Society, Boston, MA, (2006 - 10IOAS)

Hubbard, K.G. Univ. of Nebraska, Lincoln, NE; and X. Lin and C. B. Baker 2006. Sensor averaging is a filtering method to determine the daily maximum and minimum surface air temperature. 86th AMS Annual Meeting, 29 January - 2 February 2006, Atlanta, Georgia, American Meteorological Society, Boston, MA, (2006 - 10IOAS)

Otkin, J.A., Anderson C., Meiikalski, J.R., Diak G.R. 2006. Validation of GOES-based Insolation estimates using data from the U.S. Climate Reference Network . Journal of Hydrometeorology. Volume 6 pp 460-475.

Sun, B., and T.C. Peterson. 2006: Estimating precipitation normals for USCRN stations , Journal of geophysical research, atmospheres/, (D09), D09101, 8 p., May 16 2006)

Sun, B., and T. Peterson. 2006: Estimating precipitation normals for USCRN stations. 86th AMS Annual Meeting, 29 January - 2 February 2006, Atlanta, Georgia, American Meteorological Society, Boston, MA, (18 PROB 9.8), 5 p. (January 2006)

Sun, B., and T.C. Peterson, 2005: Estimating temperature normals for USCRN stations. /International Journal of Climatology, 25 (14): 1809-1817

Appendix C USCRN Data Ingest Performance Measure Percentages

Discussion:

Although the USCRN network average (99.5%) for the full Period-of-Record (POR – through September 28, 2006) is outstanding, and above the minimum level recommended (98.0%) as an overall Network Performance Measure for operations, a USCRN target of 100.0% is both the operational target day-by-day as well as an unattainable, if not unrealistic, long-term target. The September 2006 GOES DCS outage has impacted the FY2006 figures, in particular. A data recovery campaign is currently underway to download all datalogger memories at all GOES-West dependent stations which were impacted by this downtime. It will take 4-8 weeks to fully recover from this downtime. So a recovery during November 2006 is envisioned that will bring the network data ingest back up to the more comfortable, more complete 99.6-99.8% level.

Therefore, the ingest of data and metadata from individual stations felt to be adequate (98-99.9%) or the underperforming data ingest (those less with a data ingest of less than 98%) are examined in detail to identify diurnal, seasonal anomalies, trends or biases (microclimatic problems) or systemic or systematic engineering problems of a higher order priority. As these biases or shortcomings are identified, engineering upgrades and fixes are applied.

These fixes are captured by the Configuration Management tool of the Configuration Change tracking. Examples of such fixes, which are largely invisible to the data users, include datalogger heaters, better moisture seals, estimation of mean time between failures (MTBF) of small but important components such as anemometer bearings and lifetimes, power issues and backups, battery lifetime extensions and layering, persistent icing conditions in high-latitude and high-elevation stations, and a host of small and incremental improvements to the precipitation gauge over the past four years.

POR statistics on data ingest are known to be biased, particularly for the early FY2001-2002 prototype stations, by early startup data gaps. Although engineering improvements may have already been applied, the data gaps in the early POR will continue to contaminate (as a decreasing proportion) the longer-term POR, while not affecting the later portions of the POR (e.g., FY2003-2006).

During FY2006, there were an increased number of GOES-DCS communication failures or gaps, such as that of mid-September 2006 on GOES-West. These failures are worrisome to the future of the USCRN network, which is 100% dependent upon the GOES DCS systems for data delivery, in that they indicate that the DCS system is perhaps aging, understaffed, and/or oversubscribed. Each DCS communications outage, *whatever its cause*, results in the CRN Project Office having to send downloadable Storage Modules (SM) to the affected Site Hosts in the network. The Site Hosts, who are largely volunteers, are then required to download the CRN station

datalogger memory to the SM and then return it to our maintenance facility for uploading to the NCDC permanent archival facility. This is an absolutely necessary requirement for maintaining a high-confidence, high-reliability, and timely benchmark or reference system of any observational type. It is also very time-consuming, very personnel-intensive, and unnecessarily expensive to conduct mop-up operations after each outage.

Thus, two tables are presented in the Appendix to demonstrate the differentiation between early (2000-2002) POR problems versus the later (2003-2006) higher performing data ingest percentages that follow the most recent engineering improvements. Critical to the increased later data ingest percentages has been the network backfitting of a 32-month memory capability to CRN station dataloggers – now a standard.

The impact of recent GOES-West DCS outages is reflected in the overall lower data ingest rates for FY2006. This is particularly marked in the data ingest percentages of the 28 CRN stations currently dependent upon that system. One example of the impact of this downages is the CRN station at Elgin AZ which currently has a FY2006 data ingest percentage of 95.3%, which is below the minimum acceptable floor. This low data ingest percentage is due to the late FY2006 GOES-West downage which reduced the Elgin annual total of observations in the archive. In the case of Elgin, prior to the GOES-West downage, the data ingest rate for the year was 100%, see below:

Time of Receipt Report Oct 1, 2005 - Aug 31, 2006

State	Location	Vector	Operational		max obs	archived	% ingested		% 1st hr	% 2nd hr	% 3rd hr	% delayed	% pda
AZ	Elgin	5 S	09/14/2002	-	8040	8039	100	-	92.6	2.5	0.9	4	0
-	Totals	-	-	-	8040	8039	100	-	92.6	2.5	0.9	4	0

The September 2006 DCS downage is reflected in the September data ingest:

Time of Receipt Report Sep 1, 2006 - Sep 28, 2006

State	Location	Vector	Operational		max obs	archived	% ingested		% 1st hr	% 2nd hr	% 3rd hr	% delayed	% pda
AZ	Elgin	5 S	09/14/2002	-	672	267	39.7	-	48.3	19.5	16.9	15.4	0
-	Totals	-	-	-	672	267	39.7	-	48.3	19.5	16.9	15.4	0

Table A

FY2006 USCRN Individual Station and Network Transmission and Data Ingest Percentages, For FY2006: Oct 1, 2005 - Sep 30, 2006

State	Location	Vector	Operational		max obs	archived	% ingested		% 1st hr	% 2nd hr	% 3rd hr	% delayed	% pda
AL	Fairhope	3 NE	07/13/2006	-	1920	1775	92.4	-	3.4	82.7	6.8	7	0
AL	Gadsden	19 N	04/14/2005	-	8760	8757	100	-	70.6	22.6	1.8	5	0
AL	Selma	13 WNW	05/26/2005	-	8760	8745	99.8	-	65.9	22.6	3.4	8.1	0
AZ	Elgin	5 S	09/14/2002	-	8760	8364	95.5	-	91.1	3.2	1.4	4.3	0
AZ	Tucson	11 W	09/18/2002	-	8760	8715	99.5	-	89.1	3.7	1.2	6	0
CA	Merced	23 WSW	03/25/2004	-	8760	8470	96.7	-	72.5	18.4	3.6	5.5	0
CA	Redding	12 WNW	03/25/2003	-	8760	8752	99.9	-	65.9	21	2.9	10.1	0
CA	Stovepipe Wells	1 SW	05/05/2004	-	8760	8511	97.2	-	66.8	22	4	7.2	0
CO	Boulder	14 W	09/27/2003	-	8760	8748	99.9	-	70.1	21.4	2.8	5.8	0
CO	Cortez	8 SE	11/02/2005	-	7992	7956	99.5	-	70.2	22.1	2.5	5.2	0
CO	Dinosaur	2 E	07/21/2004	-	8760	8693	99.2	-	70.9	20.6	3	5.5	0
CO	La Junta	17 WSW	08/03/2004	-	8760	8758	100	-	59.8	30.5	3.7	6	0
CO	Montrose	11 ENE	07/25/2004	-	8760	8759	100	-	70.3	21.4	3.2	5.1	0
CO	Nunn	7 NNE	07/06/2003	-	8760	8759	100	-	76.3	16.5	2.2	5	0
FL	Titusville	7 E	05/07/2005	-	8760	8583	98	-	60.8	25.2	5.8	8.2	0
GA	Brunswick	23 S	12/16/2004	-	8760	8751	99.9	-	70.1	22.2	2.7	5.1	0
GA	Newton	8 W	08/20/2002	-	8760	8752	99.9	-	92.2	2.3	0.9	4.6	0
GA	Newton	11 SW	08/20/2002	-	8760	8760	100	-	92.2	2.4	0.8	4.5	0
GA	Watkinsville	5 SSE	04/30/2004	-	8760	8759	100	-	70.8	22.4	1.8	5	0
IA	Des Moines	17 E	09/15/2004	-	8760	8754	99.9	-	68	22.1	3.1	6.8	0
ID	Arco	17 SW	07/10/2003	-	8760	8730	99.7	-	70.9	21	2.5	5.6	0
ID	Murphy	10 W	06/29/2003	-	8760	8709	99.4	-	71.8	20.2	2.9	5.1	0
IL	Champaign	9 SW	12/20/2002	-	8760	8407	96	-	87.2	4.7	1.9	6.1	0
IL	Shabbona	5 NNE	08/16/2003	-	8760	8754	99.9	-	85.1	5.2	3.6	6.1	0
KS	Manhattan	6 SSW	10/01/2003	-	8760	8573	97.9	-	71.9	19	3.6	5.6	0
KS	Oakley	19 SSW	11/08/2005	-	7848	7840	99.9	-	69.4	22.5	2.7	5.4	0
KY	Bowling Green	21 NNE	05/19/2004	-	8760	8758	100	-	69.9	22.5	1.7	5.9	0

KY	Versailles	3 NNW	06/12/2003	-	8760	8709	99.4	-	87.5	3.9	1.3	7.2	0
LA	Lafayette	13 SE	12/01/2002	-	8760	8320	95	-	90.6	3	1.5	4.9	0
LA	Monroe	26 N	01/01/2003	-	8760	8564	97.8	-	84.8	7.7	2.5	5	0
ME	Limestone	4 NNW	09/20/2002	-	8760	8758	100	-	91.6	2.8	0.9	4.7	0
ME	Old Town	2 W	09/13/2002	-	8760	8760	100	-	92	2.5	0.8	4.6	0
MI	Chatham	1 SE	11/10/2004	-	8760	8758	100	-	69.3	22.8	1.7	6.3	0
MN	Goodridge	12 NNW	08/21/2003	-	8760	8757	100	-	65	24.6	3.3	7.2	0
MO	Chillicothe	22 ENE	06/11/2005	-	8760	8750	99.9	-	67.4	23.4	3.7	5.4	0
MS	Newton	5 ENE	11/03/2002	-	8760	8760	100	-	88.9	4.9	1	5.3	0
MT	St. Mary	1 SSW	09/25/2003	-	8760	8705	99.4	-	71.6	20.1	3	5.3	0
MT	Wolf Point	34 NE	12/20/2001	-	8760	8756	100	-	91.4	2.8	1.4	4.4	0
MT	Wolf Point	29 ENE	12/20/2001	-	8760	8708	99.4	-	91	2.9	1.5	4.6	0
NC	Asheville	13 S	11/14/2000	-	8760	8758	100	-	92.3	2	0.8	4.8	0
NC	Asheville	8 SSW	11/14/2000	-	8760	8760	100	-	92	2.4	0.8	4.8	0
ND	Medora	7 E	09/18/2004	-	8760	8745	99.8	-	64.9	23.2	2.9	8.9	0
NE	Harrison	20 SSE	08/27/2003	-	8760	8757	100	-	70.7	21.1	3.1	5.1	0
NE	Lincoln	11 SW	01/14/2002	-	8760	8660	98.9	-	90.2	3.6	1.7	4.6	0
NE	Lincoln	8 ENE	01/15/2002	-	8760	8685	99.1	-	90.4	3.4	1.6	4.6	0
NE	Whitman	5 ENE	09/15/2004	-	8760	8758	100	-	69	21.4	2.9	6.7	0
NH	Durham	2 N	12/11/2001	-	8760	8759	100	-	64.7	23.2	3.3	8.8	0
NH	Durham	2 SSW	12/16/2001	-	8760	8637	98.6	-	73.1	20.5	1.6	4.7	0
NM	Los Alamos	13 W	07/31/2004	-	8760	8723	99.6	-	64.5	24.2	4.8	6.5	0
NM	Socorro	20 N	05/22/2003	-	8760	8690	99.2	-	72	20.7	2.2	5.1	0
NV	Baker	5 W	05/09/2004	-	8760	8756	100	-	68.2	22.2	3.3	6.3	0
NV	Mercury	3 SSW	03/28/2004	-	8760	8532	97.4	-	71.6	19.4	3.4	5.6	0
NY	Ithaca	13 E	10/27/2004	-	8760	8760	100	-	62.7	23.1	3.2	10.9	0
NY	Millbrook	3 W	11/01/2004	-	8760	8758	100	-	63.9	22.7	3	10.5	0
OK	Goodwell	2 E	02/27/2004	-	8760	8759	100	-	69.9	22.8	2	5.3	0
OK	Stillwater	2 W	03/15/2002	-	8760	8754	99.9	-	84.1	8.6	2.4	4.9	0
OK	Stillwater	5 WNW	03/15/2002	-	8760	8750	99.9	-	91.9	2.6	0.9	4.5	0
OR	Corvallis	10 SSW	09/13/2006	-	432	260	60.2	-	0	87.7	10.8	1.5	0
OR	John Day	35 WNW	03/16/2004	-	8760	8755	99.9	-	70.8	20.9	3.1	5.1	0
OR	Riley	10 WSW	07/03/2003	-	8760	8752	99.9	-	71	20.2	3.1	5.7	0

PA	Avondale	2 N	06/02/2006	-	2904	2883	99.3	-	30	59.1	5.7	5.2	0
RI	Kingston	1W	12/16/2001	-	8760	8760	100	-	71.7	21.5	1.8	4.9	0
RI	Kingston	1NW	12/16/2001	-	8760	8731	99.7	-	67.5	21.1	1.6	9.8	0
SC	Blackville	3W	07/03/2002	-	8760	8756	100	-	91	3	1	4.9	0
SC	McClellanville	7 NE	08/08/2002	-	8760	8746	99.8	-	79.6	4.3	1.3	14.7	0
SD	Buffalo	13 ESE	09/21/2004	-	8760	8720	99.5	-	68	22.7	2.7	6.7	0
SD	Sioux Falls	14 NNE	09/25/2002	-	8760	8631	98.5	-	89.6	3.7	1.7	5.1	0
TN	Crossville	7 NW	12/03/2004	-	8760	8759	100	-	69.7	22.5	1.8	6	0
TX	Edinburg	17 NNE	02/19/2004	-	8760	8614	98.3	-	71.9	20.2	2.4	5.5	0
TX	Monahans	6 ENE	05/21/2003	-	8760	8495	97	-	74.6	18.7	1.8	4.9	0
TX	Muleshoe	19 S	02/27/2004	-	8760	8758	100	-	70.6	22.7	1.8	4.8	0
TX	Palestine	6 WNW	05/01/2003	-	8760	8594	98.1	-	73.8	19.5	1.7	5.1	0
VA	Cape Charles	5 ENE	03/03/2004	-	8760	8760	100	-	71.9	22	1.2	4.9	0
WA	Darrington	21 NNE	04/03/2003	-	8760	8750	99.9	-	71.2	20.5	2.8	5.6	0
WA	Quinault	4 NE	09/09/2006	-	528	510	96.6	-	0	87.6	9	3.3	0
WI	Necedah	5 WNW	10/04/2004	-	8760	8760	100	-	68.4	22.5	1.7	7.4	0
WV	Elkins	21 ENE	11/17/2003	-	8760	8759	100	-	69.6	22.5	1.7	6.2	0
WY	Lander	11 SSE	07/03/2004	-	8760	8614	98.3	-	71.2	19.6	3.4	5.9	0
WY	Moose	1 NNE	07/01/2004	-	8760	8650	98.7	-	71.2	20	3.1	5.6	0
-	Totals	-	-	-	661104	656215	99.3	-	75	16.6	2.4	6	0

Table B**2000-2006 USCRN Individual Station and Network Transmission and Data Ingest Percentages 2000-2006 (January 1, 2000 - September 30, 2006)**

State	Location	Vector	Operational		max obs	archived	% ingested		% 1st hr	% 2nd hr	% 3rd hr	% delayed	% pda
AL	Fairhope	3 NE	07/13/2006	-	1920	1775	92.4	-	3.4	82.7	6.8	7	0
AL	Gadsden	19 N	04/14/2005	-	12840	12820	99.8	-	75.1	16.5	1.8	6.3	0.3
AL	Selma	13 WNW	05/26/2005	-	11832	11805	99.8	-	71.5	17.7	3	7.8	0
AZ	Elgin	5 S	09/14/2002	-	30024	29965	99.8	-	90.3	2.2	1	5.8	0.7
AZ	Tucson	11 W	09/18/2002	-	30024	29965	99.8	-	87.9	3.5	1.3	6.5	0.9
CA	Merced	23 WSW	03/25/2004	-	22080	22068	99.9	-	82.1	8.9	2.3	6.4	0.3
CA	Redding	12 WNW	03/25/2003	-	30024	30009	100	-	83.6	7.6	1.6	6.4	0.9
CA	Stovepipe Wells	1 SW	05/05/2004	-	21096	20879	99	-	79.4	11.4	2.5	6.5	0.2
CO	Boulder	14 W	09/27/2003	-	26400	26379	99.9	-	83.4	8.8	1.6	5.7	0.4
CO	Cortez	8 SE	11/02/2005	-	7992	7956	99.5	-	70.2	22.1	2.5	5.2	0
CO	Dinosaur	2 E	07/21/2004	-	19248	19160	99.5	-	79.5	12.2	2.2	5.8	0.3
CO	La Junta	17 WSW	08/03/2004	-	18936	18913	99.9	-	67.4	21	3.4	6.6	1.6
CO	Montrose	11 ENE	07/25/2004	-	19152	19138	99.9	-	79.4	12.6	2.3	5.6	0
CO	Nunn	7 NNE	07/06/2003	-	28392	28370	99.9	-	83.7	9.4	1.6	4.8	0.4
FL	Titusville	7 E	05/07/2005	-	12288	12109	98.5	-	62.5	22.3	6.4	8.8	0
GA	Brunswick	23 S	12/16/2004	-	15696	15657	99.8	-	76.8	15	2.5	5.6	0
GA	Newton	8 W	08/20/2002	-	30024	30007	99.9	-	89	2	1	4.5	3.5
GA	Newton	11 SW	08/20/2002	-	30024	30004	99.9	-	91.8	2	0.9	4.7	0.7
GA	Watkinsville	5 SSE	04/30/2004	-	21216	21197	99.9	-	82	11.3	1.5	5	0.2
IA	Des Moines	17 E	09/15/2004	-	17904	17879	99.9	-	78.4	12.7	2.2	6.7	0
ID	Arco	17 SW	07/10/2003	-	28296	28241	99.8	-	84.8	7.9	1.4	4.6	1.3
ID	Murphy	10 W	06/29/2003	-	28560	28490	99.8	-	83.4	7.5	1.6	6.1	1.3
IL	Champaign	9 SW	12/20/2002	-	30024	29661	98.8	-	89.8	2.8	1.1	5.2	1
IL	Shabbona	5 NNE	08/16/2003	-	27408	27378	99.9	-	89.7	2.9	1.7	5.2	0.6
KS	Manhattan	6 SSW	10/01/2003	-	26304	26298	100	-	83.6	8.1	1.8	5.7	0.7
KS	Oakley	19 SSW	11/08/2005	-	7848	7840	99.9	-	69.4	22.5	2.7	5.4	0
KY	Bowling Green	21 NNE	05/19/2004	-	20760	20735	99.9	-	81.4	11.3	1.3	5.7	0.3

KY	Versailles	3 NNW	06/12/2003	-	28968	28904	99.8	-	88.8	2.8	1.3	6	1
LA	Lafayette	13 SE	12/01/2002	-	30024	30017	100	-	89.4	2.2	1	6.1	1.3
LA	Monroe	26 N	01/01/2003	-	30024	29808	99.3	-	88.6	4.6	1.3	4.9	0.5
ME	Limestone	4 NNW	09/20/2002	-	30024	30016	100	-	91.7	2.1	0.8	4.7	0.6
ME	Old Town	2 W	09/13/2002	-	30024	30022	100	-	91.7	1.9	0.8	2.3	3.2
MI	Chatham	1 SE	11/10/2004	-	16560	16545	99.9	-	78.5	13.8	1.7	6	0
MN	Goodridge	12 NNW	08/21/2003	-	27288	27284	100	-	75.9	13.6	1.9	6.1	2.5
MO	Chillicothe	22 ENE	06/11/2005	-	11448	11420	99.8	-	71.7	19.2	3.4	5.8	0
MS	Newton	5 ENE	11/03/2002	-	30024	30011	100	-	90.1	3.4	0.9	4.8	0.8
MT	St. Mary	1 SSW	09/25/2003	-	26448	26444	100	-	83.2	8.2	1.6	5.2	1.8
MT	Wolf Point	34 NE	12/20/2001	-	30024	30017	100	-	89.5	2.1	1.2	5	2.2
MT	Wolf Point	29 ENE	12/20/2001	-	30024	30022	100	-	90.2	1.9	1.1	4.8	1.9
NC	Asheville	13 S	11/14/2000	-	30024	29950	99.8	-	91.3	2	1	5.4	0.3
NC	Asheville	8 SSW	11/14/2000	-	30024	29990	99.9	-	91	2	0.9	5.5	0.6
ND	Medora	7 E	09/18/2004	-	17832	17818	99.9	-	75.4	14.1	2.3	7.8	0.5
NE	Harrison	20 SSE	08/27/2003	-	27144	27123	99.9	-	84	8.3	1.7	5.1	0.9
NE	Lincoln	11 SW	01/14/2002	-	30024	30013	100	-	88.7	2.7	1.5	6.1	1.1
NE	Lincoln	8 ENE	01/15/2002	-	30024	30021	100	-	90.4	2.2	1.1	5.4	0.9
NE	Whitman	5 ENE	09/15/2004	-	17904	17902	100	-	76.9	13.2	2.6	6.4	0.9
NH	Durham	2 N	12/11/2001	-	30024	30003	99.9	-	79.4	9	2.1	5.8	3.7
NH	Durham	2 SSW	12/16/2001	-	30024	29898	99.6	-	84.9	8.7	1.1	4.9	0.3
NM	Los Alamos	13 W	07/31/2004	-	19008	18946	99.7	-	71.1	15.7	3.8	6.3	3.2
NM	Socorro	20 N	05/22/2003	-	29472	29404	99.8	-	85.7	7.6	1.3	5	0.5
NV	Baker	5 W	05/09/2004	-	21000	20981	99.9	-	79.7	11.8	2.3	5.9	0.3
NV	Mercury	3 SSW	03/28/2004	-	22008	21988	99.9	-	80.1	10.6	2.6	6.1	0.6
NY	Ithaca	13 E	10/27/2004	-	16896	16875	99.9	-	74.5	13.9	2.4	8.8	0.3
NY	Millbrook	3 W	11/01/2004	-	16776	16756	99.9	-	75.2	13.9	2.4	8.4	0.2
OK	Goodwell	2 E	02/27/2004	-	22728	22686	99.8	-	81.4	11.1	1.5	5.6	0.4
OK	Stillwater	2 W	03/15/2002	-	30024	30011	100	-	87.9	5.2	1.5	4.9	0.5
OK	Stillwater	5 WNW	03/15/2002	-	30024	30004	99.9	-	91.5	2.1	0.9	4.8	0.7
ON	Egbert	1 W	07/15/2004	-	19392	19368	99.9	-	79.5	12.7	1.6	6.3	0
OR	Corvallis	10 SSW	09/14/2006	-	408	260	63.7	-	0	87.7	10.8	1.5	0
OR	John Day	35 WNW	03/16/2004	-	22296	22287	100	-	81.3	10	2	4.5	2.3
OR	Riley	10	07/03/2003	-	28464	28461	100	-	83.6	7.7	1.7	4.9	2.1

		WSW											
PA	Avondale	2 N	06/02/2006	-	2904	2883	99.3	-	30	59.1	5.7	5.2	0
RI	Kingston	1W	12/16/2001	-	30024	29710	99	-	84	7.9	1.2	5	1.9
RI	Kingston	1NW	12/16/2001	-	30024	29990	99.9	-	84.4	7.6	1.1	6.2	0.6
SC	Blackville	3W	07/03/2002	-	30024	29996	99.9	-	90	2.4	1.1	5.9	0.7
SC	McClellanville	7 NE	08/08/2002	-	30024	29994	99.9	-	86.1	3.2	1.2	8.6	0.9
SD	Buffalo	13 ESE	09/21/2004	-	17760	17733	99.8	-	77.3	13.9	2.1	6.5	0.2
SD	Sioux Falls	14 NNE	09/25/2002	-	30024	29992	99.9	-	90.3	2.4	1.1	5.8	0.4
TN	Crossville	7 NW	12/03/2004	-	16008	15989	99.9	-	77.1	14.2	2	6.3	0.4
TX	Edinburg	17 NNE	02/19/2004	-	22920	22889	99.9	-	83.1	9.4	1.5	5.7	0.2
TX	Monahans	6 ENE	05/21/2003	-	29496	29347	99.5	-	86	6.8	1	5.5	0.7
TX	Muleshoe	19 S	02/27/2004	-	22728	22696	99.9	-	80.5	11.7	1.7	6	0.1
TX	Palestine	6 WNW	05/01/2003	-	29976	29295	97.7	-	86.4	7.1	1	5.2	0.3
VA	Cape Charles	5 ENE	03/03/2004	-	22608	22552	99.8	-	83.6	10.2	1.2	4.9	0.1
WA	Darrington	21 NNE	04/03/2003	-	30024	30013	100	-	83.1	7.6	1.4	5	2.8
WA	Quinault	4 NE	09/09/2006	-	528	510	96.6	-	0	87.6	9	3.3	0
WI	Necedah	5 WNW	10/04/2004	-	17448	17448	100	-	78.2	13.3	1.5	6.9	0
WV	Elkins	21 ENE	11/17/2003	-	25176	25158	99.9	-	82.8	9.3	1.3	5.2	1.4
WY	Lander	11 SSE	07/03/2004	-	19680	19513	99.2	-	80.1	11	2.2	5.5	1.2
WY	Moose	1 NNE	07/01/2004	-	19728	19618	99.4	-	80.5	11.4	2.2	5.7	0.2
-	Totals	-	-	-	1845816	1841279	99.8	-	83.8	8	1.6	5.6	0.9

Notes for Appendix C, Table A & B, above:

Only operational (commissioned) field stations in the Lower 48 States are included in this listing.

A new GOES antenna capable of transmitting through ice and snow was backfitted to the network. In 2005-2006, It was first installed at those stations characterized by extreme winter conditions. The prototype antennae were first developed and tested at Alaskan test sites. The results were remarkable - Point Barrow and Fairbanks data ingests increased in real-time from the 65-75% range to 99.9-100.0% starting from the installation date of the antenna cover. This antenna is now deployed at all stations.. 2004-2005 winter icing events affecting satellite transmissions were recorded as far south as the USCRN commissioned field station near Brownsville, Texas – it is therefore logical to assume that no place in the CONUS network is immune from these weather-related outages – in the past or in the future.

Solar panel and battery improvements have also resulted in fewer station power problems on those stations which operate using solar power.

Appendix D USCRN Commissioned Field Stations with Metadata

This listing below is a listing of all USCRN Field Stations in the CONUS that have been commissioned as of 28 September 2006. All maintenance and calibration actions taken during the year for each station are enumerated below. Appropriate geographic metadata has been included in this table.

Station Metadata for Oct 1 2005 to Sep 28 2006

AL Gadsden 19 N - Sand Mountain Research / Extension (Northwest Pasture)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Unscheduled Maintenance (replaced PrecipVW2)	2005-12-07 21:00:00.0	Gadsden 19 N, Sand Mountain Research / Extension (Northwest Pasture)	34.2851	-85.9621	1152

AL Selma 13 WNW - Auburn University, Black Belt Research and Extension Center

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Unscheduled Maintenance (replaced TempPRT2)	2005-10-24 21:00:00.0	Selma 13 WNW, Auburn University, Black Belt Research and Extension Center	32.4567	-87.2422	193
Coefficient Corrected (TempPRT2)	2005-10-25 14:01:00.0	Selma 13 WNW, Auburn University, Black Belt Research and Extension Center	32.4567	-87.2422	193
Changed Datalogger Version #	2005-10-25 14:02:00.0	Selma 13 WNW, Auburn University, Black Belt Research and Extension Center	32.4567	-87.2422	193
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger)	2006-01-30 22:00:00.0	Selma 13 WNW, Auburn University, Black Belt Research and Extension Center	32.4567	-87.2422	193

AZ Elgin 5 S - Audubon (Appleton-Whittell Research Ranch)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Unscheduled Maintenance (replaced TempPRT3)	2005-10-05 22:00:00.0	Elgin 5 S, Audubon (Appleton-Whittell Research Ranch)	31.5907	-110.5087	4811
Annual Maintenance (replaced TempPRT1, WS, SolarRad,	2006-03-10 01:00:00.0	Elgin 5 S, Audubon (Appleton-Whittell Research Ranch)	31.5907	-110.5087	4811

Annual Maintenance	2006-03-10 19:00:00.0	Elgin 5 S, Audubon (Appleton-Whittell Research Ranch)	31.5907	-110.5087	4811
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AZ Tucson 11 W - Sonora Desert Museum

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger)	2006-03-07 23:00:00.0	Tucson 11 W, Sonora Desert Museum	32.2395	-111.1696	2733

CA Merced 23 WSW - Kesterson Reservoir (US Bureau of Reclamation)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Unscheduled Maintenance (replaced AspShield2)	2005-12-17 00:00:00.0	Merced 23 WSW, Kesterson Reservoir (US Bureau of Reclamation)	37.2381	-120.8825	78
Annual Maintenance (replaced TempPRT2, WS, SolarRad, Datalogger)	2006-05-11 17:00:00.0	Merced 23 WSW, Kesterson Reservoir (US Bureau of Reclamation)	37.2381	-120.8825	78

CA Redding 12 WNW - Whiskeytown National Recreation Area (RAWS Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger)	2006-05-16 00:00:00.0	Redding 12 WNW, Whiskeytown National Recreation Area (RAWS Site)	40.6507	-122.6068	1418
Annual Maintenance	2006-05-17 00:00:00.0	Redding 12 WNW, Whiskeytown National Recreation Area (RAWS Site)	40.6507	-122.6068	1418
Annual Maintenance	2006-05-17 19:00:00.0	Redding 12 WNW, Whiskeytown National Recreation Area (RAWS Site)	40.6507	-122.6068	1418

CA Stovepipe Wells 1 SW - Death Valley National Park (Stovepipe Wells Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Unscheduled Maintenance (replaced Datalogger)	2005-10-05 02:00:00.0	Stovepipe Wells 1 SW, Death Valley National Park (Stovepipe Wells Site)	36.6020	-117.1449	84

CO Boulder 14 W - Mountain Research Station INSTAAR Univ. of CO (Hills Mill)

Unscheduled Maintenance (replaced PrecipVW2)	2005-10-09 20:00:00.0	Boulder 14 W, Mountain Research Station INSTAAR Univ. of CO (Hills Mill)	40.0354	-105.5409	9828
Changed Datalogger Version #	2005-10-09 20:00:00.0	Boulder 14 W, Mountain Research Station INSTAAR Univ. of CO (Hills Mill)	40.0354	-105.5409	9828
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger)	2006-07-16 03:00:00.0	Boulder 14 W, Mountain Research Station INSTAAR Univ. of CO (Hills Mill)	40.0354	-105.5409	9828
Annual Maintenance	2006-07-16 18:00:00.0	Boulder 14 W, Mountain Research Station INSTAAR Univ. of CO (Hills Mill)	40.0354	-105.5409	9828

CO Cortez 8 SE - Mesa Verde National Park (Far View Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Installation	2005-11-02 10:56:12.0	Cortez 8 SE, Mesa Verde National Park (Far View Site)	37.2553	-108.5033	8034
Commissioning	2006-01-06 19:32:52.0	Cortez 8 SE, Mesa Verde National Park (Far View Site)	37.2553	-108.5033	8034
Unscheduled Maintenance (replaced PrecipVW2)	2006-04-04 21:00:00.0	Cortez 8 SE, Mesa Verde National Park (Far View Site)	37.2553	-108.5033	8034
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger)	2006-07-19 19:00:00.0	Cortez 8 SE, Mesa Verde National Park (Far View Site)	37.2553	-108.5033	8034

CO Dinosaur 2 E - Dinosaur National Monument (Hdq. Maintenance Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger)	2006-07-20 23:00:00.0	Dinosaur 2 E, Dinosaur National Monument (Hdq. Maintenance Site)	40.2446	-108.9677	6062

CO La Junta 17 WSW - USDA Comanche National Grassland

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance	2005-03-06	La Junta 17 WSW,	37.8639	-103.8224	4386

(replaced TempPRT1, WS, SolarRad, Datalogger, installed Wetness)	00:00:00.0	USDA Comanche National Grassland			
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CO Montrose 11 ENE - Black Canyon of the Gunnison National Park (Vernal Mesa)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger)	2006-07-17 20:00:00.0	Montrose 11 ENE, Black Canyon of the Gunnison National Park (Vernal Mesa)	38.5440	-107.6928	8402

CO Nunn 7 NNE - Ag. Res. Svc. Central Plains Exp. Range (SGS LTER at CSU)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
PDA Data Download	2005-12-15 22:00:00.0	Nunn 7 NNE, Ag. Res. Svc. Central Plains Exp. Range (SGS LTER at CSU)	40.8066	-104.7552	5390
Unscheduled Maintenance (replaced TempPRT1)	2005-12-15 22:00:00.0	Nunn 7 NNE, Ag. Res. Svc. Central Plains Exp. Range (SGS LTER at CSU)	40.8066	-104.7552	5390
Changed Datalogger Version #	2005-12-15 22:00:00.0	Nunn 7 NNE, Ag. Res. Svc. Central Plains Exp. Range (SGS LTER at CSU)	40.8066	-104.7552	5390
Unscheduled Maintenance	2006-02-11 19:00:00.0	Nunn 7 NNE, Ag. Res. Svc. Central Plains Exp. Range (SGS LTER at CSU)	40.8066	-104.7552	5390
Unscheduled Maintenance (replaced PrecipVW2/3)	2006-03-16 00:00:00.0	Nunn 7 NNE, Ag. Res. Svc. Central Plains Exp. Range (SGS LTER at CSU)	40.8066	-104.7552	5390
PDA Data Download	2006-03-16 00:00:00.0	Nunn 7 NNE, Ag. Res. Svc. Central Plains Exp. Range (SGS LTER at CSU)	40.8066	-104.7552	5390
Annual Maintenance (replaced TempPRT3, WS, PrecipVW#, SolarRad, Datalogger, installed Wetness)	2006-07-15 01:00:00.0	Nunn 7 NNE, Ag. Res. Svc. Central Plains Exp. Range (SGS LTER at CSU)	40.8066	-104.7552	5390
PDA Data Download	2006-07-15 01:00:00.0	Nunn 7 NNE, Ag. Res. Svc. Central	40.8066	-104.7552	5390

		Plains Exp. Range (SGS LTER at CSU)			
Annual Maintenance	2006-07-15 18:00:00.0	Nunn 7 NNE, Ag. Res. Svc. Central Plains Exp. Range (SGS LTER at CSU)	40.8066	-104.7552	5390

FL Titusville 7 E - NASA Kennedy Space Center, SLF Mid-Field Site

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger)	2006-01-20 21:00:00.0	Titusville 7 E, NASA Kennedy Space Center, SLF Mid- Field Site	28.6159	-80.6929	3

GA Brunswick 23 S - Cumberland Island National Seashore (Stafford Field)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, PrecipVW2, SolarRad, Datalogger)	2006-01-23 21:00:00.0	Brunswick 23 S, Cumberland Island National Seashore (Stafford Field)	30.8078	-81.4596	25
Unscheduled Maintenance (replaced AspShield3)	2006-04-05 15:00:00.0	Brunswick 23 S, Cumberland Island National Seashore (Stafford Field)	30.8078	-81.4596	25

GA Newton 11 SW - Robert W. Woodruff Foundation (Ichauway-Dubignon Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, PrecipVW3, SolarRad, Datalogger)	2006-01-23 00:00:00.0	Newton 11 SW, Robert W. Woodruff Foundation (Ichauway-Dubignon Site)	31.1923	-84.4465	156

GA Newton 8 W - Robert W. Woodruff Foundation (Ichauway-George Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger)	2006-01-22 17:00:00.0	Newton 8 W, Robert W. Woodruff Foundation (Ichauway- George Site)	31.3127	-84.4706	176

GA Watkinsville 5 SSE - USDA/ARS Watkinsville (Colham Ferry Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, SolarRad, Datalogger)	2006-03-18 00:00:00.0	Watkinsville 5 SSE, USDA/ARS Watkinsville (Colham Ferry Site)	33.7837	-83.3896	741

IA Des Moines 17 E - Neal Smith NWR (NOAA Station Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, Wetness, SolarRad, Datalogger)	2006-05-02 20:00:00.0	Des Moines 17 E, Neal Smith NWR (NOAA Station Site)	41.5562	-93.2855	921

ID Arco 17 SW - Craters of the Moon NM & Preserve (Headquarters Area)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual maintenance (replaced TempPRT2, WS, PrecipVW1/3, SolarRad, Datalogger, installed Wetness)	2005-06-21 00:00:00.0	Arco 17 SW, Craters of the Moon NM & Preserve (Headquarters Area)	43.4621	-113.5560	5920

ID Murphy 10 W - ARS NW Watershed Research Cntr. (Reynolds Creek Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger)	2006-05-25 23:00:00.0	Murphy 10 W, ARS NW Watershed Research Cntr. (Reynolds Creek Site)	43.2044	-116.7505	3950

IL Champaign 9 SW - Univ. of Illinois (Bondville Environ. & Atmos. Resrch. Stn.)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger)	2006-05-04 22:00:00.0	Champaign 9 SW, Univ. of Illinois (Bondville Environ. & Atmos. Resrch. Stn.)	40.0528	-88.3729	700
Unscheduled Maintenance (replaced TempPRT2)	2006-06-14 21:00:00.0	Champaign 9 SW, Univ. of Illinois (Bondville Environ. & Atmos. Resrch. Stn.)	40.0528	-88.3729	700

IL Shabbona 5 NNE - Northern Illinois Agronomy Research Center

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger)	2006-05-03 20:00:00.0	Shabbona 5 NNE, Northern Illinois Agronomy Research Center	41.8430	-88.8513	861

KS Manhattan 6 SSW - Kansas State University (Konza Prairie Biological Station)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger)	2006-06-21 19:00:00.0	Manhattan 6 SSW, Kansas State University (Konza Prairie Biological Station)	39.1027	-96.6098	1137

KS Oakley 19 SSW - The Nature Conservancy Kansas (Smoky Valley Ranch)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
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Installation	2005-11-08 00:00:00.0	Oakley 19 SSW, The Nature Conservancy Kansas (Smoky Valley Ranch)	38.8701	-100.9627	2870
Commissioning	2006-01-06 19:33:18.0	Oakley 19 SSW, The Nature Conservancy Kansas (Smoky Valley Ranch)	38.8701	-100.9627	2870
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger)	2006-06-23 21:00:00.0	Oakley 19 SSW, The Nature Conservancy Kansas (Smoky Valley Ranch)	38.8701	-100.9627	2870

KY Bowling Green 21 NNE - Mammoth Cave National Park (Job Corps Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, SolarRad, Datalogger, Transmitter, installed Wetness)	2006-04-28 01:00:00.0	Bowling Green 21 NNE, Mammoth Cave National Park (Job Corps Site)	37.2504	-86.2325	790
Annual Maintenance	2006-04-28 18:00:00.0	Bowling Green 21 NNE, Mammoth Cave National Park (Job Corps Site)	37.2504	-86.2325	790

KY Versailles 3 NNW - University of Kentucky (Woodford County Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger)	2006-04-29 01:00:00.0	Versailles 3 NNW, University of Kentucky (Woodford County Site)	38.0945	-84.7465	891
Annual Maintenance	2006-04-29 16:00:00.0	Versailles 3 NNW, University of Kentucky (Woodford County Site)	38.0945	-84.7465	891
Unscheduled Maintenance	2006-05-05 22:00:00.0	Versailles 3 NNW, University of Kentucky (Woodford County Site)	38.0945	-84.7465	891
Unscheduled Maintenance (replaced Transmitter)	2006-05-10 20:00:00.0	Versailles 3 NNW, University of Kentucky (Woodford County Site)	38.0945	-84.7465	891

LA Lafayette 13 SE - University of Louisiana at Lafayette (Cade Farm)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger)	2006-01-24 22:00:00.0	Lafayette 13 SE, University of Louisiana at Lafayette (Cade Farm)	30.0918	-91.8731	35

LA Monroe 26 N - Upper Ouachita National Wildlife Refuge

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger)	2006-01-25 23:00:00.0	Monroe 26 N, Upper Ouachita National Wildlife Refuge	32.8833	-92.1165	88

ME Limestone 4 NNW - Aroostook National Wildlife Ref. (Fire Training Area)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, PrecipVW2/3, PrecipTB3, SolarRad, Datalogger)	2005-07-25 00:00:00.0	Limestone 4 NNW, Aroostook National Wildlife Ref. (Fire Training Area)	46.9601	-67.8833	737

ME Old Town 2 W - University of Maine (Rogers Farm Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced WS, SolarRad, Wetness)	2005-07-26 00:00:00.0	Old Town 2 W, University of Maine (Rogers Farm Site)	44.9281	-68.7006	127

MI Chatham 1 SE - Michigan State University (Upper Peninsula Experiment Station)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger, installed Wetness)	2005-09-20 00:00:00.0	Chatham 1 SE, Michigan State University (Upper Peninsula Experiment Station)	46.3345	-86.9200	875

MN Goodridge 12 NNW - Agassiz National Wildlife Refuge (Maintenance Shop Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, SolarRad, Datalogger, installed Wetness)	2005-09-19 00:00:00.0	Goodridge 12 NNW, Agassiz National Wildlife Refuge (Maintenance Shop Site)	48.3055	-95.8744	1150

MO Chillicothe 22 ENE - University of Missouri (Forage Systems Research Station)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Commissioning	2005-10-27 17:23:27.0	Chillicothe 22 ENE, University of Missouri (Forage Systems Research Station)	39.8668	-93.1470	833
Annual Maintenance (replaced TempPRT2, WS, SolarRad,	2006-05-01 19:00:00.0	Chillicothe 22 ENE, University of Missouri (Forage Systems	39.8668	-93.1470	833

Datalogger)		Research Station)			
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MS Newton 5 ENE - Mississippi State University (Coastal Plain Exp. Station)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Raingauge (TB3) - Emptied/Cleared	2005-10-25 00:00:00.0	Newton 5 ENE, Mississippi State University (Coastal Plain Exp. Station)	32.3378	-89.0703	374
Changed Datalogger Version #	2005-10-25 00:01:00.0	Newton 5 ENE, Mississippi State University (Coastal Plain Exp. Station)	32.3378	-89.0703	374
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger)	2006-01-26 23:00:00.0	Newton 5 ENE, Mississippi State University (Coastal Plain Exp. Station)	32.3378	-89.0703	374

MT St. Mary 1 SSW - Glacier National Park (St. Mary Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, PrecipVW3, SolarRad, Datalogger, installed Wetness)	2005-06-26 00:00:00.0	St. Mary 1 SSW, Glacier National Park (St. Mary Site)	48.7412	-113.4330	4555

MT Wolf Point 29 ENE - Fort Peck Indian Res. (Poplar River Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, PrecipVW2/3, SolarRad, Datalogger, installed Wetness)	2005-08-02 01:00:00.0	Wolf Point 29 ENE, Fort Peck Indian Res. (Poplar River Site)	48.3082	-105.1018	2085

MT Wolf Point 34 NE - Fort Peck Indian Res. (Give Out Morgan Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger, Installed PrecipTB3)	2004-09-14 00:00:00.0	Wolf Point 34 NE, Fort Peck Indian Res. (Give Out Morgan Site)	48.4887	-105.2096	2643

NC Asheville 13 S - NC Mtn. Horticultural Crops Res. Ctr. (Backlund Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, Wetness, SolarRad, Datalogger)	2005-12-12 23:00:00.0	Asheville 13 S, NC Mtn. Horticultural Crops Res. Ctr. (Backlund Site)	35.4185	-82.5567	2103

NC Asheville 8 SSW - North Carolina Arboretum (Bierbaum Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
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Annual Maintenance (replaced TempPRT1, WS, Wetness, SolarRad, Datalogger)	2005-12-13 00:00:00.0	Asheville 8 SSW, North Carolina Arboretum (Bierbaum Site)	35.4945	-82.6142	2151
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ND Medora 7 E - Theodore Roosevelt National Park (Painted Canyon Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger, installed Wetness)	2005-08-02 23:00:00.0	Medora 7 E, Theodore Roosevelt National Park (Painted Canyon Site)	46.8946	-103.3769	2771

NE Harrison 20 SSE - Agate Fossil Beds National Monument (Visitor Center Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger)	2006-06-26 22:00:00.0	Harrison 20 SSE, Agate Fossil Beds National Monument (Visitor Center Site)	42.4248	-103.7358	4406

NE Lincoln 11 SW - Audubon Society (Spring Creek Prairie Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Unscheduled Maintenance (replaced AspShield1)	2006-03-09 19:00:00.0	Lincoln 11 SW, Audubon Society (Spring Creek Prairie Site)	40.6954	-96.8541	1372
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger)	2006-06-28 23:00:00.0	Lincoln 11 SW, Audubon Society (Spring Creek Prairie Site)	40.6954	-96.8541	1372

NE Lincoln 8 ENE - University of Nebraska (Prairie Pines Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger)	2006-06-29 02:00:00.0	Lincoln 8 ENE, University of Nebraska (Prairie Pines Site)	40.8484	-96.5651	1189

NE Whitman 5 ENE - Gudmundsen Sandhills Laboratory (Site 1)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, SolarRad, Datalogger)	2006-06-27 22:00:00.0	Whitman 5 ENE, Gudmundsen Sandhills Laboratory (Site 1)	42.0680	-101.4450	3740

NH Durham 2 N - University of New Hampshire (Kingman Farm Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3,	2005-11-10 00:00:00.0	Durham 2 N, University of New	43.1716	-70.9277	119

WS, SolarRad, Datalogger, Wetness)		Hampshire (Kingman Farm Site)			
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NH Durham 2 SSW - University of New Hampshire (Thompson Farm Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger, Wetness)	2005-11-09 23:00:00.0	Durham 2 SSW, University of New Hampshire (Thompson Farm Site)	43.1092	-70.9484	63

NM Los Alamos 13 W - Valles Caldera National Preserve (Valle Grande Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, SolarRad, Datalogger)	2006-05-06 01:00:00.0	Los Alamos 13 W, Valles Caldera National Preserve (Valle Grande Site)	35.8584	-106.5214	8716

NM Socorro 20 N - Sevilleta National Wildlife Refuge (LTER Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger)	2006-03-09 02:00:00.0	Socorro 20 N, Sevilleta National Wildlife Refuge (LTER Site)	34.3557	-106.8859	4847

NV Baker 5 W - Great Basin National Park (Gravel Pit Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, SolarRad, Datalogger)	2006-05-08 01:00:00.0	Baker 5 W, Great Basin National Park (Gravel Pit Site)	39.0118	-114.2090	6617
Unscheduled Maintenance	2006-05-22 17:00:00.0	Baker 5 W, Great Basin National Park (Gravel Pit Site)	39.0118	-114.2090	6617
Unscheduled Maintenance (replaced PrecipVW3)	2006-05-26 23:00:00.0	Baker 5 W, Great Basin National Park (Gravel Pit Site)	39.0118	-114.2090	6617

NV Mercury 3 SSW - Nevada Test Site (Desert Rock Meteorological Lab)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, SolarRad, Datalogger)	2006-05-09 21:00:00.0	Mercury 3 SSW, Nevada Test Site (Desert Rock Meteorological Lab)	36.6240	-116.0225	3284
Unscheduled Maintenance	2006-06-27 21:00:00.0	Mercury 3 SSW, Nevada Test Site (Desert Rock Meteorological Lab)	36.6240	-116.0225	3284
Unscheduled Maintenance (replaced	2006-07-10 23:00:00.0	Mercury 3 SSW, Nevada Test Site (Desert	36.6240	-116.0225	3284

PrecipVW1)		Rock Meteorological Lab)			
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NY Ithaca 13 E - Cornell University (Harford Teaching & Research Center)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger, Wetness)	2005-11-14 00:00:00.0	Ithaca 13 E, Cornell University (Harford Teaching & Research Center)	42.4401	-76.2462	1228
Annual Maintenance (replaced TempPRT2, WS, SolarRad, Datalogger, Transmitter)	2006-06-04 18:00:00.0	Ithaca 13 E, Cornell University (Harford Teaching & Research Center)	42.4401	-76.2462	1228

NY Millbrook 3 W - Institute of Ecosystem Studies (Environmental Monitoring Station)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger, Wetness)	2005-11-07 00:00:00.0	Millbrook 3 W, Institute of Ecosystem Studies (Environmental Monitoring Station)	41.7857	-73.7422	413
Unscheduled Maintenance (replaced Transmitter)	2006-03-20 19:00:00.0	Millbrook 3 W, Institute of Ecosystem Studies (Environmental Monitoring Station)	41.7857	-73.7422	413
Unscheduled Maintenance	2006-03-23 21:00:00.0	Millbrook 3 W, Institute of Ecosystem Studies (Environmental Monitoring Station)	41.7857	-73.7422	413
Unscheduled Maintenance	2006-03-24 16:00:00.0	Millbrook 3 W, Institute of Ecosystem Studies (Environmental Monitoring Station)	41.7857	-73.7422	413
Annual Maintenance (replaced TempPRT2, WS, Wetness, SolarRad, Datalogger)	2006-06-05 17:00:00.0	Millbrook 3 W, Institute of Ecosystem Studies (Environmental Monitoring Station)	41.7857	-73.7422	413
Unscheduled Maintenance (replaced TempPRT2)	2006-06-13 17:00:00.0	Millbrook 3 W, Institute of Ecosystem Studies (Environmental Monitoring Station)	41.7857	-73.7422	413
Datalogger Door Open	2006-06-22 15:00:00.0	Millbrook 3 W, Institute of Ecosystem Studies (Environmental Monitoring Station)	41.7857	-73.7422	413
Unscheduled Maintenance (replaced Transmitter)	2006-06-23 14:00:00.0	Millbrook 3 W, Institute of Ecosystem Studies (Environmental Monitoring Station)	41.7857	-73.7422	413

OK Goodwell 2 E - OK Panhandle Research & Extn. Center (Native Grassland Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, PrecipVW2/3, SolarRad, Datalogger, Transmitter, installed Wetness)	2005-03-05 00:00:00.0	Goodwell 2 E, OK Panhandle Research & Extn. Center (Native Grassland Site)	36.5993	-101.5950	3266

OK Stillwater 2 W - Oklahoma State Univ. (Ag. Research Farm Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, PrecipVW2, SolarRad, Datalogger, Transmitter, installed Wetness)	2005-03-03 00:00:00.0	Stillwater 2 W, Oklahoma State Univ. (Ag. Research Farm Site)	36.1181	-97.0914	890

OK Stillwater 5 WNW - Oklahoma State University (Efaw Farm Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, PrecipTB3, SolarRad, Datalogger, Transmitter, installed Wetness)	2005-03-02 00:00:00.0	Stillwater 5 WNW, Oklahoma State University (Efaw Farm Site)	36.1346	-97.1082	888

OR John Day 35 WNW - John Day Fossil Beds Nat'l. Mon.(Sheep Rock Hdqs.)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger)	2006-05-20 22:00:00.0	John Day 35 WNW, John Day Fossil Beds Nat'l. Mon.(Sheep Rock Hdqs.)	44.5560	-119.6459	2245

OR Riley 10 WSW - Northern Great Basin Experimental Range (Rainout Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger)	2006-05-19 23:00:00.0	Riley 10 WSW, Northern Great Basin Experimental Range (Rainout Site)	43.4711	-119.6917	4583

RI Kingston 1NW - University of Rhode Island (Plains Road Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger, Wetness)	2005-11-08 21:00:00.0	Kingston 1 NW, University of Rhode Island (Plains Road Site)	41.4911	-71.5413	115

RI Kingston 1W - University of Rhode Island (Peckham Farm Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance	2005-11-08	Kingston 1 W,	41.4782	-71.5417	106

(replaced TempPRT3, WS, SolarRad, Datalogger, Wetness)	00:00:00.0	University of Rhode Island (Peckham Farm Site)			
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SC Blackville 3W - Clemson University (Edisto Research & Edu. Ctr.)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Unscheduled Maintenance (replaced TempPRT1/2/3)	2005-10-09 00:00:00.0	Blackville 3 W, Clemson University (Edisto Research & Edu. Ctr.)	33.3550	-81.3279	317
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger)	2006-02-25 01:00:00.0	Blackville 3 W, Clemson University (Edisto Research & Edu. Ctr.)	33.3550	-81.3279	317

SC McClellanville 7 NE - SCDNR (Santee Coastal Reserve)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger)	2006-02-24 01:00:00.0	McClellanville 7 NE, SCDNR (Santee Coastal Reserve)	33.1532	-79.3637	9

SD Buffalo 13 ESE - SDSU Antelope Research Station (Calving Pasture Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger, installed Wetness)	2005-08-03 22:00:00.0	Buffalo 13 ESE, SDSU Antelope Research Station (Calving Pasture Site)	45.5160	-103.3017	2883

SD Sioux Falls 14 NNE - EROS Data Center

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger)	2005-08-04 21:00:00.0	Sioux Falls 14 NNE, EROS Data Center	43.7346	-96.6222	1594

TN Crossville 7 NW - Univ. of Tennessee (Plateau Research and Education Center)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger)	2005-12-22 22:00:00.0	Crossville 7 NW, Univ. of Tennessee (Plateau Research and Education Center)	36.0138	-85.1345	1913

TX Edinburg 17 NNE - Lower Rio Grande Valley NWR (La Sal Del Rey)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, PrecipVW3, SolarRad,	2006-01-23 01:00:00.0	Edinburg 17 NNE, Lower Rio Grande Valley NWR (La Sal	26.5258	-98.0633	64

Datalogger)		Del Rey)			
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TX Monahans 6 ENE - (Sandhills State Park)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, PrecipVW1/3, SolarRad, Datalogger, Transmitter, installed Wetness)	2005-03-09 00:00:00.0	Monahans 6 ENE, (Sandhills State Park)	31.6219	-102.8071	2724

TX Muleshoe 19 S - Muleshoe National Wildlife Refuge (Headquarters Site)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger, Transmitter, installed Wetness)	2005-03-08 00:00:00.0	Muleshoe 19 S, Muleshoe National Wildlife Refuge (Headquarters Site)	33.9557	-102.7740	3742

TX Palestine 6 WNW - NASA (National Scientific Balloon Facility)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT3, WS, SolarRad, Datalogger)	2006-01-20 23:00:00.0	Palestine 6 WNW, NASA (National Scientific Balloon Facility)	31.7796	-95.7232	383

VA Cape Charles 5 ENE - Anheuser Busch Coastal Res. Ctr. Univ. of VA (Oyster)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, SolarRad, Datalogger)	2005-12-03 00:00:00.0	Cape Charles 5 ENE, Anheuser Busch Coastal Res. Ctr. Univ. of VA (Oyster)	37.2907	-75.9270	29

WA Darrington 21 NNE - North Cascades National Park (Marblemount)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance	2006-05-22 21:00:00.0	Darrington 21 NNE, North Cascades National Park (Marblemount)	48.5405	-121.4460	407
Annual Maintenance (replaced TempPRT1, WS, PrecipVW2, SolarRad, Datalogger)	2006-05-23 22:00:00.0	Darrington 21 NNE, North Cascades National Park (Marblemount)	48.5405	-121.4460	407

WI Necedah 5 WNW - Necedah National Wildlife Refuge (Rynearson Dam No. 2)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT1, WS, SolarRad, Datalogger, installed Wetness)	2005-09-16 00:00:00.0	Necedah 5 WNW, Necedah National Wildlife Refuge (Rynearson Dam No. 2)	44.0604	-90.1737	933

WV Elkins 21 ENE - Canaan Valley Resort State Park (Cabins Area)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, SolarRad, Datalogger, Wetness)	2005-11-05 00:00:00.0	Elkins 21 ENE, Canaan Valley Resort State Park (Cabins Area)	39.0130	-79.4743	3390

WY Lander 11 SSE - Nature Conservancy (Red Canyon Ranch)

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, SolarRad, Datalogger)	2006-07-22 03:00:00.0	Lander 11 SSE, Nature Conservancy (Red Canyon Ranch)	42.6754	-108.6686	5773

WY Moose 1 NNE - Grand Teton National Park

EVENT	EVENT_DATE	NAME	LATITUDE	LONGITUDE	ELEVATION
Annual Maintenance (replaced TempPRT2, WS, PrecipVW2, SolarRad, Datalogger)	2006-07-24 02:00:00.0	Moose 1 NNE, Grand Teton National Park	43.6615	-110.7120	6466