1.1 Development and Modernization of NOAA's U.S. Climate Observing Network

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ABSTRACT

A critical need for monitoring the climate in the U.S. is the development of a National to Regional Scale in-situ climate observing system. The U.S. Climate Reference Network(USCRN) is designed to provide national scale trends for temperature and precipitation and is comprised of 114 stations across the contiguous U.S. This network will be completed in 2008. Parallel to this effort is a partnership with NOAA's National Weather Service (NWS), National Environmental Satellite, Data, and Information (NESDIS), and Office of Atmospheric Research (OAR) to develop a regional scale climate observing network called the United States Historical Climatology Network (USHCN-M). This program will install 1000 modernized stations across the U.S. that will enhance the capability of the USCRN by providing additional observations of temperature and precipitation of the same quality but with more dense spatial coverage, thus enabling detection of regional climate trends with greater confidence.

1. INTRODUCTION

The USCRN is designed as a baseline climate monitoring network and has the following attributes:

a. triple configuration sensors for Temperature and Precipitation;

b. a very high percentage data ingest over various periods (e.g., a minimum of 98% of all possible observations for a given year must be received and archived at NOAA's designated National Archive – the National Climatic Data Center (NCDC) – in order to unequivocally satisfy the requirements of the climate science community;

c. a stringent Siting Standards and an objective, quantitative assessment must be made and annually verified and maintained for the long-term for each site as an

essential part of the overall metadata pertaining to each site and station;

d. a stringent and periodic maintenance and calibration program with thorough documentation must be systematically collected and archived on at least an annual basis;

e. an organized archive of complete metadata concerning all the USCRN sensors, sites, and data characteristics must be a long-term and well-maintained program investment at the National Archive;

Through the use of all data sensors it is possible to diagnose the health of the station's instrumentation at a level that was previously impossible by using only the restricted readings of only ambient temperature and precipitation, and other metadata as might be available or be able to be derived. Metadata have not been a high priority and have not had diligent standards applied in their collection in the past. The atmospheric science community is now very well aware of this shortcoming. The objective of this secondary information and sensor metadata is to provide ancillary information to identify any questionable data as soon as possible and to pass that information on to the CRN engineering team for further analysis, and if need be, to repair or replace the faulty or out-of-calibration sensor(s). The notification of any questionable data values is handled through a systematic, standardized anomaly tracking system that also provides a permanent data base of information (secondary metadata) that can be accessed through time by both scientists and engineers. Again, strict standards must be employed to do "good science".

The quality assurance process involves both the hourly oversight of automatic computer checks, as well as oversight of those flagged values by a scientist knowledgeable in meteorology and

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instrumentation. The above described suite of instrumentation has in the last few years allowed the measurement and analysis of various local and regional meteorological events. The five-minute observation period interval of the primary data has also allowed the identification of unique microclimatic behavior of each site. This is most often seen in the ambient temperature during nighttime hours. It will obviously take additional years to build a sufficient period of record to identify national trends, to seam together the meaning of a network of individual stations, each station with its own climatic profile. The primary mission of the USCRN is to determine national trends, a regional observing network is also in the process of being developed. Here, NOAA is looking to the more densely populated network of Historical Climatology Network (HCN) sites across the US (including Alaska and Hawaii). The HCN is a subset of 1221 cooperative observer sites (out of 8,000) that take daily temperature and precipitation observations. NOAA is currently working to modernize a set of 1000 sites to more fully align their monitoring capability with the Climate Monitoring Principles. The USHCN will be based on a scaled-down version of the USCRN sensor technology. The USHCN-M prototype network began in Alabama in 2005 and now has 14 stations installed. The USHCN-M leverages the USCRN infrastructure to minimize biases in the historical data record by using a common site selection process using regional teams that include NWS, NCDC, and Regional Climate Centers, common sensors and requirements for precision and calibration, ingest, QC, archive, and access systems, and metadata management systems (station history). A pilot project is planned for the southwest to include Colorado, Arizona, Utah, and New Mexico to install 141 USHCN-M stations over the next two years.

While USCRN is designed more for national climate assessments, there are plans for implementations of USCRN sites in Alaska, Hawaii, Puerto Rico, and other US affiliated states in the Atlantic and Pacific. Implementation plans for Alaska and Hawaii have not been developed as of yet, but plans are to implement such stations in those states. Planning and funding for implementing a formal USCRN program in Alaska is in place with the eventual configuration of an additional 29 stations being installed in Alaska by 2014. With some initial funding in 2008, a workshop was held in Anchorage in May 2008 in order to work with our federal and state partners in the state to plan out an eventual configuration for USCRN in Alaska. While funding is limited at this point, sufficient funding is available to install one additional station in Alaska at Sand Point. Plans call for 33 USCRN sites in Alaska to increase the certainty being able to capture Alaska-wide changes of temperature and precipitation with high accuracy. The President's budget contains adequate resources to begin execution of this plan in FY 2009.

2. DESCRIPTION OF THE NETWORK

During FY 2008, the USCRN increased to 107 commissioned field stations plus three stations in pre-commissioning (burn-in) test, and 4 additional to install for a total of 114 stations in the lower 48 states. The confidence in the contiguous United States for determining National Temperature trends are currently >97% . Likewise the confidence for Precipitation is >94% . Science reviews for site acceptability as being climatically representative have been completed on all 114 sites. Climate representativity is determined not just on the basis of temperature or precipitation classifications, but also is influenced by elevation. For the purposes of overall grid representativity of the USCRN, four broad elevational ranges were identified as being necessary in order to assure more balanced monitoring for National-level climate representativity. The four elevational classes defined are:

1. mean sea level to 2,500 feet; 96 Stations

2. a second class from 2,500 feet up to 5,000 feet; 19 Stations

3. a third smaller elevational gradient up to 9,000 feet; 15 Stations

4. a very small representation for those elevations above 9,000 feet 2 Stations

The full schedule of deployments planned for FY 2008 should completed the base network for the Continental US and the degree of confidence (in %) that the annual average National temperature and precipitation trends across the U.S.can be detected is 98.0% for temperature and 95% for Precipitation.

3. THE PRESENT USCRN RECORDS AND RANGES

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

One of the more unique measurements measured is the surface temperature. Below illustrates the extremes that have been observed at Death Valley and Barrow, AK.

CRN Temperature Records (°F)

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

The relationship between the surface temperature and air temperature at the USCRN locations will be important to Land Surface studies and remote sensing of surface temperatures from satellites.

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

4. SUMMARY

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

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

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

5. REFERENCES

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

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

3. CRN site survey manuals, checklists, procedures, instructions on survey techniques and products are available for review at: http://www.ncdc.noaa.gov/oa/climate/research/crn/crnsit esurvey.html. (United State Climate Reference Network: Site Survey Requirements, National Climatic Data Center, 10 April 2000 (updated February 2002).
NOAA Climate Reference Network Site Information Handbook, December 10, 2002; CRN Site Survey Checklist, April 26, 2002 (use Adobe Acrobat or MS Word); CRN FY02 Site Selection Task (use Adobe Acrobat or MS Word) (all are available at:
http://www.ncdc.noaa.gov/oa/climate/uscrn/siteselectgui de.html).