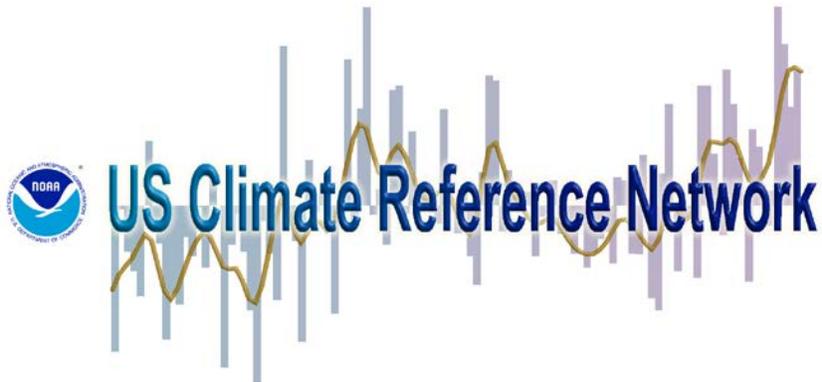


US Climate Reference Network (USCRN)

Handbook for Manual Quality Monitoring



June 11, 2003

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Introduction

The U.S. Climate Reference Network (USCRN) is a network of climate stations whose primary goal is to provide future long-term homogeneous observations of temperature and precipitation that can be coupled to long-term historical observations for the detection and attribution of present and future climate change.

USCRN's data are automatically quality controlled but a human analyst is used to bridge the gap between the current automated process and what that process will become as knowledge and resources effect more sophisticated algorithms. And, as experience with networks from ASOS to the Oklahoma Mesonet has affirmed, there is always a requirement for human assessment. Analysis involving the use of satellite and radar images, retrospective analysis of incidents detected after automated processing is completed, and the detection of previously undefined drift patterns and biases all require the skills of a meteorologist experienced in quality assurance and control.

This document is a set of evolving guidelines - it will change over time as automation is increased, algorithms are added and updated, and new uses for the data are identified.

Section 1.0 Background Analysis

1. Do a quick review of the “Missing Obs” report to get an overall feel for the general network availability. This report is available two ways: by automated email once daily for the previous day and via the [USCRN web reports](#) where it is updated on an hourly basis. The web also provides a “Reported Obs” report that gives a percent reported for each site selected.

On occasion, all sites reporting through a single satellite have been missing. For example, seventeen out of thirty sites reporting through GOES West (GOES 10) disappeared when the satellite ground system experienced some problems. If all sites for a given satellite fail to report for more than 2 consecutive hours, notify the Network Monitoring Team lead and enter the incident into the ATS with a severity of 2.

2. Review the hourly email flag messages received since the last monitoring review. There are two types: “missing observation by station” message and QA/QC flag messages. A flag message indicating an open Datalogger door should result in an ATS entry with a severity of 3.
3. Review the emailed Flag Summary report(s). There is a daily summary, one produced each Monday for the previous week, and one produced on the first of the month for the previous month. The historical weekly and monthly summaries are currently also kept available in a directory on the [USCRN download site](#):
 - a. Use the “Station” section to do a quick overview of individual sites’ availability and health.
 - b. Use the “Flag” section to do a quick overview of individual elements’ availability and health across the network.
4. Review and note by site and date any exceedance/error message and the time of occurrence.
5. Review the report “Daily Checklist” found under the [Data -> Reports](#) option on the web. It provides a summary of some of the values used when analyzing an element and provides quick access to an hourly updated count of the number of observations received during a day. *Note: The number of hours received will decrease with each time zone to the west.*

Section 2.0 Analysis by Site

1. Use the hourly display, graphs, listings and reports found on the [USCRN web site](#) to place the flagged parameter in context.
2. Identify reportable incidents by applying the element analysis for each element as described in Section 4 of these Guidelines.
3. If there is a reportable incident, assess whether it indicates data loss or compromise (the credibility of the data may be suspect).
 - a. A rating of 1 indicates that data loss/compromise has occurred
 - b. A rating of 2 indicates that data loss/compromise is imminent
 - c. A rating of 3 or 4 indicates that data loss/compromise is possible
 - d. If the incident doesn't have an impact on the data, note it as an interesting event and rate it a 5.
4. Provide a meaningful and useful description of the problem.
 - a. The description of the incident should be detailed enough to aid in resolving the incident.
 - b. The scope of the description should provide enough ancillary and background information to aid in resolving the incident.

Tips:

- Upon returning to work on a Monday morning, start with Monday and work backwards.
- It is possible to receive an automated hourly notification of missing observations. You may or may not want to make use of this option since it can result in high volume of e-mail.

Section 3.0 Reporting Incidents

Use the Anomaly Tracking System (ATS) to report incidents. The ATS allows us to log entries that describe incidents, which could lead to data loss. These entries are known as incident reports or IRs and can be updated if additional information becomes available.

1. Log on to the [ATS](#) using your ATS user name and password.
2. There are several required fields. You will need to be ready to enter
 - the date of the incident
 - a descriptive title such as:

“No data received 15:00 Z for any of the sites transmitting through GOES West.”
“Exceedance of IR Temp SD 3.0 degree C”

- the site name (state, location and vector)
- whether or not the incident is site specific
- a severity rating from Section 2.3 of 1-5
- the originating organization (NCDC)
- your name as the originator
- which site component is affected
- a description such as:

“Data have not been received for the last 5 hours from any of the 17 sites that transmit through GOES West.”

“The transmitted readings of the IR sensor showed a SD of 21.34 degrees C during the 1200 LST hour and slightly larger for the 1300 LST at Stillwater 2 W., and by the 1400 LST hour indicated a SD of zero. Again as in yesterday's IR #66 on the same subject there was no commensurate effect shown in the ambient temperature data. There was an episode (April 1, 2003 IR #47) that was similar to today's episode but was only one hour duration and occurred at 2100 LST. The paired site at Stillwater 5 WNW, as yesterday, showed no similar "wild" swings in the IR values.

Today's satellite and radar imagery show some 40 to 55 dbz returns within 25 miles of the site so lightning induction surge could be possible, although doubtful as the cause given that the events of April 22 and April 1 occurred without any thunderstorms.”

3. Incidents rating a 1 or 2 should be brought to the attention of the Network Monitoring Team lead as soon possible, preferably by email.
4. Incidents may be edited or updated by selecting the “Approve/Edit” link for each IR.
5. **Important!** New IRs and IR updates will not be logged into the ATS unless you click on the “Submit IR” button at the bottom of the page.

Section 4.0 Element Analysis

4.1 Overview

The element analysis is performed after the error messages have been collated (See section 1.3). Each element analysis follows these guidelines:

1. **Verify and quantify the error.** Use the web's [hourly observation page](#) to see the element in the context of the rest of the observation.
2. **Place the error in temporal context.** Use the [graphs](#) and the [listing reports](#) to see the element in the context of preceding and following observations.
3. **Use auxiliary information to attempt to prove or disprove your hypothesis.**

Incidents not detected by the automated QA/QC and communicated by the reports and summaries but identified during manual analysis should also be analyzed using these guidelines.

4.2 Ambient Temperature

4.2.1 Primary

Inter-comparison of the 3 temperature sensors: Sensors should be within 0.3° C of one another. An hourly flag message is generated for any departure greater than 0.30° C (i.e., 0.301° C and greater).

4.2.2 Secondary

1. Comparison with the IR temperature sensor. A basic sanity check is for the ambient max temp not to be higher/greater than the IR and the ambient min not to be less than the IR. *Note: When the ground is covered by snow, sleet, or hail, the IR temperature will not rise above 0° C even when the ambient temperatures rise to levels above 0° C.*
2. Comparison of relative humidity temperature sensor for incidents at the Asheville sites.

4.2.3 Emailed error message example

“Station Report for: Kingston 1W, University of Rhode Island (Peck 0362DC on 05 10 2003 at 0800 LST

Temp2avg +12.06 Bad Value Flag: 2”

4.2.4 Explanation

This message lists the hourly average for a suspect temperature sensor. In this case sensor #2 reported +12.06 and the QA/QC process is indicating a departure from the other co-located temperature sensors exceeding 0.30° Celsius (0.301° C or greater). It is possible for all three temperature sensors to exceed the 0.30° C flag limit.

4.2.5 Analysis

This site's paired site had a near exceedance at 0700 LST so this was probably a real event and doesn't indicate an instrument or equipment problem.

1. **Verify and quantify** the indicated incident. In this case, .30 and above will display in red on the hourly ob display, and the relevant line segment will appear in gray on the graphs.
2. **Put the incident into temporal context** by reviewing the temperature graph. Look for persistence. The third consecutive occurrence means a possible instrument issue and requires an ATS entry. Check the fan speed for a normal change of up to 10%. Check the battery voltage levels for abnormal voltages less than 10 volts. *See Note under Battery Voltage in this Section.*
3. **Use auxiliary information**, in this case other elements and a sister site, to explain the incident. Since the paired site experienced a similar event near the same time, other elements were not needed in describing the incident, but they are often useful in validating a temperature exceedance.

Winds

Expect low wind speeds during exceedance periods, usually 0-2 m/s.

Infrared Radiation

Expect a rapid change in IR during exceedance periods. The most frequent occurrences are during the first couple hours after sunrise or with thunderstorm outflow cooling.

Solar Radiation

Expect a rapid change in solar radiation during exceedance periods. This may even occur during the winter when a dry slot or other break in cloudiness allows a rapid increase or decrease in solar input.

Precipitation

Some exceedances occur during or near periods of precipitation.

4.2.6 Ambient Temperature Standard Deviation

Threshold: 3 standard deviations

Method is the same as for ambient temperature.

4.3 Infrared Temperature

4.3.1 Primary

Reverse test to the ambient temperature stated above. That is, the IR max should exceed the ambient temperature, and IR min should be less than ambient temperature.

Note: When the ground is covered by snow, sleet, or hail, the IR temperature will not rise above 0° C even when the ambient temperatures rise to levels above 0° C.

4.3.2 Secondary

1. Diurnal IR temperature trend should closely follow solar radiation trend.
2. Method is the same as for ambient temperature.

4.3.3 Emailed error message example

“Station Report for: Asheville 13 S, NC Mtn. Horticultural Crops Re 0255BC on 05 09 2003 at 0800 LST

sfctmpsd +09.51 Bad Value Flag: 2”

4.3.4 Same situation one day later

“Station Report for: Asheville 13 S, NC Mtn. Horticultural Crops Re 0255BC on 05 10 2003 at 1000 LST

sfctmpsd +07.32 Bad Value Flag: 2”

4.3.5 Explanation

This shows the standard deviations of the three co-located temperature sensors exceeding 6.

4.3.6 Analysis

There were missing values that were used in the calculation of the standard deviation.

4.3.7 Infrared Temperature Standard Deviation

Threshold: 6 standard deviations

Method is the same as for ambient temperature.

4.4 Solar Radiation

4.4.1 Primary

It must be greater than zero but less than 1500 watts/m² between sunrise and sunset. Note: Except for Alaskan sites near or north of the Arctic Circle during the winter when no measurable solar radiation is received.

4.4.2 Secondary

Trend should follow overall diurnal pattern of IR temperature.

4.5 Precipitation

Flagged precipitation measurements from the Geonor precipitation gauge are rare because the QA/QC is based on global limits. On occasion, the gauge depth is missing and accurately presents a code of -6999. Because of a bug in the datalogger program, this results in a +6999 in the following 15 minute's precipitation total field and in the hourly total field. As of 05/13/2003, the datalogger program inaccurately uses the -6999 as a gauge depth when calculating the precipitation totals. No ATS entry is required unless a missing gauge depth (-6999) occurs more than 3 times a day for a given site.

But a general daily review of precipitation is required. This review makes use of the current radar (http://www.nws.noaa.gov/radar_tab.html) storm total precipitation map and therefore should be performed as early as possible in the day before the map becomes unavailable. Satellite images are also useful (<http://www.ghcc.msfc.nasa.gov/GOES/>).

1. Check the gauge depth at every site using the [“Daily Checklist”](#) for easy reference. Enter an IR (severity 3) in the ATS for each site whose depth is greater than 400mm which is 67% of the bucket's capacity. Gauge depths are not flagged unless they fall below -2.0mm. Until automated notification is available, notify Mark Hall (cc Lynne Satterfield) weekly by email of gauge depths in excess of 50%. Notification may be more often if indicated by impending precipitation events. Note gauge emptying into crnsites.

Sample ATS title: *“GA, Newton 8 W: Geonor approaching dump volume”*

If a significant precipitation event is imminent, the IR severity should be a 2, and the Network Monitoring Team lead notified.

2. Review the previous day's precipitation graphs for about half the sites each during each day's QA/QC. Use the “Plot Precip” button on the “Hourly Data” observation page to display the graphs. Vary the sites reviewed from day to day.

Tips:

- Each bar on the “Hourly” graph displays the total precipitation for the hour preceding each hash mark.
- The “15 Min” graph displays the precipitation for the 15 minute period preceding each hash mark. For resolution reasons, this graph only displays an 8 hour period at one time; to change the period from 0000-0800, select the next start time and click on “Plot Precip”. Note: The 15 minute graph will plot the data across LST midnight if hour 17 or greater is selected.
- Precipitation at paired sites should compare reasonably during synoptic precipitation events, but may not during small scale convective events. The storm total precipitation from the nearest neighboring NWS radar will show the spatial distribution of events and can assist in assessing the reported precipitation from paired sites.

4.5.1 Primary – Inter-comparison of the three Geonor transducers

1. A reported/derived value greater than 0.5 mm on one wire (in 15 minutes) with no increase on the other 2 wires indicates the reported value from the first wire is likely to be noise. The vibrating wires tend to be more noisy when precipitation is not occurring. You may expect noise values in the range of 0.3mm to 0.7mm per hour. Satellite and radar images can provide assistance in determining whether the reported precipitation is real.
2. A broken wire can not be detected by comparing its precipitation total values to those for the other two wires. A broken wire’s reported gauge depth will remain the same from the time of the break until it is repaired despite any real precipitation or evaporation. The indicated gauge depths for the unbroken wires will almost always show a decrease because the bucket tilts and its liquid contents shift toward the broken wire. An IR (severity 1) should be entered and the Network Monitoring Team lead notified.
3. Vibration of transducer wires should be between 0000 and 3000hz.

4.5.2 Secondary

1. An increase in any one 15 minute period should not exceed 100 year return period extreme.
2. Large/intense rainfall events should be accompanied by a significant decrease in solar radiation and IR.
3. During times when ambient temperature is less than –2 degrees centigrade, reported rate of fall greater than .3 mm should not increase by more than 4 times the current rate in any 15 minute period. (This is a test for melt through or slippage accumulated snow/freezing rain into the bucket).

4. Any reported 15 minute total greater than 25 mm should be flagged suspect if no precipitation was reported in the 15 minute period prior to or following the period in question.
5. For those sites which are equipped with tipping bucket gauges, compare the 15 minute values from the tipping bucket to the 15 minute values from the Geonor. If the tipping bucket doesn't report precipitation in the presence of precipitation reported credibly by the Geonor, and if the tipping bucket then reports at a later time when the Geonor does not report precipitation, an ATS entry for delayed precipitation report should be logged.

4.6 Wind Speed

1. Reported wind speed should be greater than zero some time during the day.
2. Reported wind run (found on the ["Daily Checklist"](#) t) must be greater than zero for a day.

4.7 Fan Speed

1. Must be greater than zero.
2. Should be between 90 and 125rps.
3. Fan speeds may vary as much as 10% without a corresponding change in battery voltage. This variation is usually diurnal and is due to the reduction in air density during the warmer hours of the day. Speeds increase when the temperature warms and the density of the air decreases.
4. Sites such as AZ Tucson 11W, and CA Redding 12 WNW which are powered by solar panels may have even larger diurnal changes in fan speed. If this occurs, the change in fan speed is primarily due to the change in voltage.

4.8 Battery Voltage

GOES transmitter battery	12 - 14.5 volts
GOES transmitter battery under full load	11 - 14.5 volts
Datalogger battery	10 - 14.5 volts

Appendix A GOES Coverage



GOES WEST



GOES EAST

Appendix B Ingest & Processing Branch’s “USCRN Limits and Ranges”

[Link to QAQCRanges.xls](#)

Appendix C Web URL List

US Climate Reference Network home page (data and station listings, missing/reported reports)

<http://www.ncdc.noaa.gov/oa/climate/uscrn/>

National Weather Service (radar)

http://www.nws.noaa.gov/radar_tab.html

Global Hydrology and Climate Center (satellite)

<http://www.ghcc.msfc.nasa.gov/GOES/>

Anomaly Tracking System

<http://nsi5.osd.noaa.gov/ats/CRN/>

ASOS URLs

USCRN site	Nearest ASOS
AK, Barrow 4 ENE	http://weather.noaa.gov/weather/current/PABR.html
AK, Fairbanks 11 NE	http://weather.noaa.gov/weather/current/PAFA.html
AZ, Elgin 5 S	http://weather.noaa.gov/weather/current/KFHU.html
AZ, Tucson 11 W	http://weather.noaa.gov/weather/current/KDMA.html
	http://weather.noaa.gov/weather/current/KTUS.html
CA, Whiskeytown 12 WNW	http://weather.noaa.gov/weather/current/KRDD.html
GA, Newton 8 W	http://weather.noaa.gov/weather/current/KBGE.html
GA, Newton 11 SW	http://weather.noaa.gov/weather/current/KABY.html
IL, Champaign 9 SW	http://weather.noaa.gov/weather/current/KCMI.html
LA, Monroe 26 N	http://weather.noaa.gov/weather/current/KMLU.html
LA, Lafayette 13 SE	http://weather.noaa.gov/weather/current/KLFT.html

USCRN site	Nearest ASOS
ME, Old Town 2 W	http://weather.noaa.gov/weather/current/KBGR.html
ME, Limestone 4 NNW	http://weather.noaa.gov/weather/current/KCAR.html
MS, Newton 5 ENE	http://weather.noaa.gov/weather/current/KMEI.html
	http://weather.noaa.gov/weather/current/KNMM.html
MT, Wolf Point 29 ENE	http://weather.noaa.gov/weather/current/KOLF.html
MT, Wolf Point 34 NE	http://weather.noaa.gov/weather/current/KOLF.html
NC, Asheville 8 SSW	http://weather.noaa.gov/weather/current/KAVL.html
NC, Asheville 13 S	http://weather.noaa.gov/weather/current/KAVL.html
NE, Lincoln 11 SW	http://weather.noaa.gov/weather/current/KLNK.html
NE, Lincoln 8 ENE	http://weather.noaa.gov/weather/current/KLNK.html
NH, Durham 2 SSW	http://weather.noaa.gov/weather/current/KPSM.html
NH, Durham 2 N	http://weather.noaa.gov/weather/current/KPSM.html
OK, Stillwater 2 W	http://weather.noaa.gov/weather/current/KSWO.html
OK, Stillwater 5 WNW	http://weather.noaa.gov/weather/current/KSWO.html
OR, John Day 35 WNW	http://weather.noaa.gov/weather/current/K5J0.html
	http://weather.noaa.gov/weather/current/KRDM.html
RI, Kingston 1NW	http://weather.noaa.gov/weather/current/KOQU.html
RI, Kingston 1W	http://weather.noaa.gov/weather/current/KPVD.html
SC, Blackville 3W	http://weather.noaa.gov/weather/current/KCAE.html
SC, McClellanville 7 NE	http://weather.noaa.gov/weather/current/KCHS.html
SD, Sioux Falls 14 NNE	http://weather.noaa.gov/weather/current/KFSD.html
WA, Darrington 21 NNE	None

Appendix D Anomaly Tracking System Users Guide

