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REQUIREMENTS AND STANDARDS FOR NWS CLIMATE OBSERVATIONS

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SUMMARY OF REVISIONS: This directive supersedes NWSI 10-1302, Requirements and Standards for NWS Climate Observations, dated, Nov 14, 2014. Changes made reflect the NWS Headquarters reorganization effective April 1, 2015.

Changed all references to "National Climatic Data Center" to "National Centers for Environmental Information" and "NCDC" to "NCEI" to reflect the new name.

Joseph A. Pica Date
Director, Office of
Observations

Requirements and Standards for NWS Climate Observations

Table of Contents: Page

List of Tables: Page

1 Introduction

This instruction describes the requirements and standards for National Weather Service (NWS) meteorological climate observations. The standards are for instrument siting, exposure, performance, and output data for temperature, precipitation, soil temperature, and evaporation. If standards cannot be met by the equipment in place, then the standards should be achieved when stations are changed, equipment is installed, programs are modified, or new stations are established.

The standards for instrument performance, exposure, and data output in this instruction will support the recommendations of the World Meteorological Organization (WMO) for a climate observing program. As new instruments are introduced, studies to determine adjustment factors to account for differences between old and new instruments, gauges, and shelters are made. For further information, see *Intercomparison of Hydrometeorological Instruments and Algorithms*, http://www.nws.noaa.gov/directives/sym/pd01021curr.pdf which is the NWS Policy Directive NWSPD 10-21. The goal is to preserve the temporal continuity of station databases and make the change as seamless as possible in terms of the official climate record. The initiator of the change will be responsible for managing the studies. The results of the study will be documented and changes included in the station history file.

2 Cooperative Observing Program Observations

This section outlines the types of instruments in use by the Cooperative Observing Program (COOP). The NWS COOP station equipment can be the property of the NWS, the observer, a company, or any other government agency. New equipment installed at a COOP site is required to meet the site exposure requirements defined in Section 3 of this instruction, as well as in National Weather Service Manual (NWSM) 10-1315, *Cooperative Station Observations and Maintenance*. Photos and descriptions of observing equipment are found in NWSM 10-1315, Appendices A and B. Access the manual from the NWS directives website: http://www.nws.noaa.gov/directives/sym/pd01013015curr.pdf.

Climate observing programs may meet their data requirements with these or other instruments.

1. Maximum / Minimum Air Temperature Instruments
2. Standard Rain Gauges (Non-recording)
3. Recording Rain Gauges
4. Snow Sticks, Snow Measurement Boards, and Snow Stakes
5. Maximum / Minimum Soil Temperature Instruments
6. Pan Evaporation Instruments
7. Wind Run Anemometers
8. Maximum / Minimum Water Temperature Instruments

The minimum standards for producing the required observations in the Aviation Observing Program are described in NWS Instruction (NWSI) 10-1301, *Aviation and Synoptic Observations*, located at: http://www.nws.noaa.gov/directives/sym/pd01013001curr.pdf.

3 Site and Exposure Standards

This section provides instrument siting and exposure standards for the Cooperative Observing Program. Policies for how to establish cooperative sites, collect and distribute observations, conduct site visits and manage the stations are outlined in NWSI 10-1307, *Cooperative Program Management and Operations*, found at: http://www.nws.noaa.gov/directives/sym/pd01013007curr.pdf.

Standards in document will be followed as closely as possible to ensure uniformity of observations to meet national and international climatic observation requirements. Site and exposure standards define and establish specifications and guidelines. The implementation of these should be flexible to achieve a balance between meteorological representativeness, space availability, and cost effectiveness. Site and exposure standards differ between the aviation and climate programs. The Office of Federal Coordinator for Meteorology (OFCM) details the site and exposure standards as they apply to federal and non-federal observers. See FCM-S4-1994, Federal Standard for Siting Meteorological Sensors at Airports (Washington, DC, 1994), accessible on: https://www.ofcm.gov/publications/siting/fcm-s4-1994(Siting).pdf

Instruments are **not** to be sited on rooftops. Relocation of instruments will be accomplished as funds permit and after coordination with Regional Headquarters. In a small number of cases, it is desirable to maintain the rooftop sitting in order to maintain the historical climate record. The National Centers for Environmental Information (NCEI) will provide a waiver for the continued maintenance of existing rooftop stations.

3.1 Air Temperature Measurement

Install the temperature instrument according to the following standards:

1. Over level terrain (earth or sod) typical of the area around the station, and, at least 100 feet from any extensive concrete or paved surface.

2. All attempts will be made to avoid:

    1) areas where rough terrain or air drainage are proven to result in non-representative temperature data;

    2) Areas where water tends to collect; and

    3) areas where drifting snow collects.

3. If the instrument is within a Cotton Region Shelter, or equivalent, position the shelter so it opens to the north, in the northern hemisphere (to protect the instruments from direct sun exposure) with the floor 4 to 6 feet above the surface. Shelters should be located no closer to an obstruction than four times the height of the obstruction.

4. In the case of remote instruments not enclosed in shelters, the instrument (and display, if configured) will be mounted 4 to 6 feet above the surface and shielded by an integral thermoscreen. Remote instruments should be located no closer to an obstruction than four times the height of the obstruction.

5. An object will be considered an obstruction if the object is greater than ten degrees in horizontal width as measured from the instrument and within 200 feet of the instrument. The instrument should be no closer than four times the estimated height of any nearby building, tree, fence, or similar obstruction.

3.2 Precipitation Gauges

The exposure of precipitation gauges is of primary importance in the accuracy of precipitation measurements. An ideal exposure would eliminate all turbulence and eddy currents near the gauge that tend to carry away the precipitation. The loss of precipitation in this manner tends to increase with wind speed and orifice height.

1. The orifice of the gauge will be horizontal and located approximately 3 feet above the ground for standard rain gauges (i.e., daily observation) and approximately 6 feet above the ground for recording gauges (i.e., monthly observation). Exceptions are granted by the regional headquarters in writing and described in the station information documentation.

2. If possible, the gauge should be protected in all directions by objects of uniform height. If they are not of uniform height, then use the rain gauge as a baseline to estimate the average height of the obstructions and the average distance of the obstructions from the rain gauge. The gauge should be sited no closer to the nearest obstruction than a distance that is twice the height of the obstruction. In other words, the top of obstruction should not subtend more than a 30-degree angle when sighted from the orifice of the rain gauge.

3. In open areas, the height of an obstruction above the orifice should not exceed one half its distance from the gauge.

4 Air temperature

Air temperature is temperature of the free air conditions surrounding the station at a height between 4 and 6 feet above ground level. The air should be freely exposed to sunshine and wind and not close to or shielded by trees, buildings, or other obstructions.

4.1 Air Temperature Measurement Performance

The following temperature instruments are used in the NWS cooperative observer program:

1. maximum / Minimum Temperature System (i.e., MMTS)
2. liquid-in-glass maximum and minimum thermometers

Temperature instruments will be shielded from the following elements:

1. precipitation
2. direct and reflected sunshine
3. direct and reflected thermal energy (i.e., Infrared)

Air Temperature Measurement Performance Standards					
Observed Element	**Range - Fahrenheit**	**Reference Temperature**	**Time Constant**	**Accuracy At Reference Temperature (F)**	
Air Temperature, Maximum	−40º to −20º	- 30º	25 sec	± 2.0º	90% confidence
	-20º to +115º	+ 50°	25 sec	± 1.0º	95% confidence
	+115º to +140º	+ 120º	25 sec	± 2.0º	90% confidence
Air Temperature, Minimum	−80º to −20º	- 30º	25 sec	± 2.0º	90% confidence
	−20º to +110º	+ 50º	25 sec	± 1.0º	95% confidence
Air Temperature, Current Reading	−80º to −20º	- 30º	25 sec	± 2.0º	90% confidence
	−20º to +115º	+ 50º	25 sec	± 1.0º	95% confidence
	+115º to +140º	+ 120º	25 sec	± 2.0º	90% confidence

Table 4.1. Performance Standards – Air Temperature Measurements.

All thermometers should be shielded with a thermoscreen or radiation shelter just large enough to protect against the elements stated, and slotted sufficiently to allow air to advect naturally into and out of the thermoscreen during calm air conditions. Powered aspirators are not required for these instruments.

All temperature measuring instruments should be issued with a certificate confirming compliance with the appropriate performance specification and accuracy; or be issued with a calibration certificate which gives the corrections that are applied to meet the required accuracy. This initial testing should be performed by an accredited calibration laboratory or a national testing institution.

4.1.1 Test and Evaluation

The NWS, Office of Observations (OBS), requires traceability of the performance of temperature measuring instruments which are immersed in temperature bath and evaluated in parallel with precision reference thermometers (i.e., Rosemont Model 162CE SPRT) in accordance with the National Institute of Standards and Technology (NIST) guidelines. The bath enables testing from -80ºC to +55ºC.

These tests are followed by whole system testing (for electronic instruments) inside a walk-in environment chamber. The final phase of testing requires instruments to be evaluated outdoors alongside reference thermometers for a minimum of six months. The uncertainty (i.e., accuracy) in the readings of the NWS reference instruments is estimated in accordance with the National Conference of Standards Laboratory Report RISP-5, to be ±0.01ºC at 95% confidence level, k=2.

4.1.2 Time Constant

This is the time required by the thermometer to register 63% of a step change in air temperature. Instruments possess time constant values that produce step change of 1.0ºF and afford valid measurement of air temperature with 1.0 minute temporal resolution. The WMO *Guide to Meteorological Instruments and Methods of Observation* advises that the time constant be between 30 and 60 seconds with winds of 10 miles per hour.

4.1.3 General Instruments

The WMO suggests ordinary thermometers be able to measure with high certainty in the range of -20ºF to 115ºF, with maximum error less than 0.4ºF. In practice it may not be economical to provide thermometers that meet this performance goal. Less expensive thermometers, calibrated against a laboratory standard, may be used for NWS climate purposes provided they comply with the performance requirement identified in Table 4.1 above.

4.1.4 Hardened Instruments

General purpose, current day technology, thermometers may not have the ability to directly measure the temperature extremes identified in Table 4.1. In addition to the general climate instruments, an additional set of instruments to measure extreme air temperature is required for sites where air temperature falls below -20ºF, or rises above 115ºF at least one day per year in the 30-year climate record. A separate instrument is used, or a separate calibration factor is applied to the same instrument, for any observing site that meets this definition of a site that requires hardened instruments.

4.2 Air Temperature Data

Table 4.2 gives the minimum requirements for the calculation, storage, and display of air temperature data for instruments with ability to log data. This instruction requires at least manual retrieval of the observed elements from the instrument display (outdoors) or system console (indoors), but encourages electronic reporting of the data where practical and when in an approved data format.

The observer reads and takes note of the instrument readings (indoors) and enters the observed values to an NWS reporting system as instructed by the NWS Representative.

Air Temperature Data Requirements					
Observed Element	**Data Output Resolution**	**Data Average**	**Calculation Update**	**Time Stamped**	**Memory Recall**
Air Temperature - Maximum Daily	0.1 degree F	15 seconds	1 minute	Yes	33 days
				No *	1 day
Air Temperature - Minimum Daily	0.1 degree F	15 seconds	1 minute	Yes	33 days
				No *	1 day
Air Temperature - Current Reading	0.1 degree F	15 seconds	1 minute	No	1 minute

Table 4.2. Data Requirements for Air Temperature.

* *Thermometers without an internal clock, that provide data for one time period, or require manual reset for a single time period, are not required to time segregate or time stamp their Max/Min values.*

For outdoor instrument displays, the observer walks out to the shelter (i.e., cotton region shelter) and opens the shelter and visually inspects the liquid in glass thermometers and notes the readings of daily maximum temperature, daily minimum temperature, and current temperature. The observer resets the liquid in glass thermometers. The observer then uses an NWS reporting system as instructed by the NWS Representative (NWSREP).

Air Temperature - Weather Forecast Office(WFO) Products			
Observed Element	**Observer's Reporting Method**	**Reporting Frequency**	**WFO Generated Products**
Air Temperature - Maximum Daily	WxCoderIII (web); or IV-ROCS (phone); or WS Form B-91 (paper)	Daily to WFO	RTP, RWR, PNS, AGO
Air Temperature - Minimum Daily	WxCoder (web); or IV-ROCS (phone); or WS Form B-91 (paper)	Daily to WFO	RTP, RWR, PNS, AGO
Air Temperature - Current Reading	WxCoder (web); or IV-ROCS (phone); or WS Form B-91 (paper)	Daily to WFO	RTP, RWR, PNS, AGO

Table 4.3. WFO Products Containing Air Temperature Data.

The observer will round the entered data to whole units Fahrenheit by rounding up all positively signed values between T.5ºF and T.9ºF inclusive, (i.e., + 66.5ºF to 67ºF), and rounding down positively signed values between T.1ºF and T.4ºF, inclusive. For sub-zero temperatures, special attention is given to –T.5ºF values, to round it down. This method is known as 'round half up asymmetric.' For all negatively signed values between -T.5ºF and –T.1ºF, inclusive you round down (i.e., -3.5ºF to -3ºF) to nearest integer. For negatively signed values between –T.6ºF and–T.9ºF, inclusive, the data is rounded up (i.e., -10.6ºF to -11ºF) to higher absolute value.

4.3 WFO Generated Products

Temperature observations from COOP observers that are received daily by the Weather Forecast Office (WFO) are run through a minimal level of quality assurance before they are transmitted as text products such as the Max/Min Temperature and Precipitation Table (RTP), State Weather Roundup (RWR), and Public Information Statement (PNS). Some offices also produce the agricultural summary (AGO) product, which includes air temperature as well as soil temperature and pan evaporation. Table 4.3 identifies those products and their frequency.

Note: Some observers are not required to report their air temperatures on a daily basis to the WFO, and their observations will not appear in those WFO products that are generated daily.

Air Temperature – Web Based National Oceanic Atmospheric Administration (NOAA) Datasets			
Observed Element	**NWS Reporting Method**	**Name of Dataset in Climate Data Online (CDO)**	**Name of NCEI Electronic Publication**
Air Temperature - Maximum Daily	WxCoder III	*Daily Summaries* in the Global Historical Climatology Network - Daily	*Climatological Data*
Air Temperature - Minimum Daily	WxCoder III	*Daily Summaries* in the Global Historical Climatology Network - Daily	*Climatological Data*
Air Temperature - Current Daily	WxCoder III	*Daily Summaries* in the Global Historical Climatology Network - Daily	*Climatological Data*

Table 4.4. NOAA Datasets Containing Air Temperature Data.

5 Precipitation

Precipitation data is collected from two principal types of rain gauges. The first type is a daily observation taken by observers with a manual rain gauge. These observers will report their precipitation measurements to the NWS forecast office as instructed by their NWSREP, either once per month, daily, or with each precipitation event during flooding conditions. The second type uses a recording rain gauge. It provides a recorded measurement of accumulated precipitation in coded format once per month. The primary equipment for the precipitation observations are the 8-inch standard rain gauge (SRG) for manual observations, and the Fischer Porter Rebuild (FPR) gauges for the monthly recorded observations.

5.1 Daily Precipitation Observation

Nearly all cooperative observation sites are equipped with the SRG or the four-inch plastic rain gauge. These are manual gauges that allow measurement of captured rain to the hundredth of an inch.

They do this by employing a measurement tube that is one tenth the size of the funnel aperture. The SRG measuring tube holds up to two inches of precipitation and the gauge can capture up to 20 inches of rain at one time, making it useful for almost all climate sites.

Manual Daily Precipitation – Gauge Standard					
Parameter	**Requires**	**Seasonal**	**Range**	**Resolution**	**Measurement Accuracy**
Precipitation, Rain	Eight-Inch Diameter Collection Vessel with Tube and Measuring Stick	Funnel (All year except for snow or frozen precip events)	0 to 20 inches	0.01 inches	±0.02 inches
	Four-Inch Diameter Collection Vessel with Tube	Funnel (All year except for snow or frozen precip events.)	0 to 10 inches	0.01 inches	±0.02 inches
Precipitation, Frozen (Liquid Equivalent)	Eight-Inch Diameter Collection Vessel	Open Aperture (snow or frozen precip events)	0 to 24 inches of snow	0.01 inches melted	±0.04 inches melted
	Four-Inch Diameter Collection Vessel	Open Aperture (snow or frozen precip events)	0 to 12 inches of snow	0.01 inches melted	±0.04 inches melted

Table 5.1. Gauge Standard for Manually Observed Precipitation.

The four-inch plastic rain gauge is a suitable substitute for the eight-inch standard rain gauge because it meets the accuracy requirements. The four-inch rain gauge measuring tube holds up to one-inch of precipitation and the gauge can capture up to 10 inches at one time. Observers follow the procedures for taking a daily precipitation measurement as described in NWSM 10-1315, *Cooperative Station Observations and Maintenance*, found at: http://www.nws.noaa.gov/directives/sym/pd01013015curr.pdf.

5.1.1 Daily Data and Reporting Standard

Once per day, the COOP observer places the rain stick into the SRG tube to visually inspect it for a wet mark. The height of the wet mark indicates the amount of collected precipitation. If the wet mark is less than 0.01 inch, the observer reports "T" for a trace of precipitation. If there is no wet mark on the rainstick, the observer reports '0" for the observation. The observer empties the collection tube immediately after the observation is recorded.

For observers with the four-inch gauge, the height of the collected water is read directly from an index scale imprinted on the side of the tube. If less than 0.01 inch is present, a "T" is reported for a trace of precipitation. If the bottom of the tube appears dry, then "0" is reported. The tube is emptied immediately after the observation is recorded.

Manual Daily Precipitation - Data Standard					
Observed Element	**Observation Method**	**Observation Period**	**Observation Time**	**Data Resolution**	**Null Precipitation**
Precipitation, Rain	Rain stick, into SRG tube. For Plastic Gauge read the numerals on the measuring tube.	24-Hours	Daily at a Set Time (i.e., 7am)	0.01 inch	'0' for dry. 'T' trace if < 0.01 inch
Precipitation, Accumulated Frozen	Melt indoors then pour into tube. Use rain stick into SRG to measure amount. For Plastic Gauge use numerals printed on tube.	24-Hours	Daily at a Set Time (i.e., 7am)	0.01 inch	'0' for dry. 'T" trace of < 0.01 inch

Table 5.2. Data Standard for Manually Observed Daily Precipitation.

5.1.2 Snow Measurement

COOP observers and contract observers are provided NWS-owned equipment to take snowfall and snow depth measurements. There are two sizes of snow measuring sticks, one for most snowfall events and/or snow depths and the other for heavier snowfall events and/or deeper snow depths. For sites that measure snow depth up to 60 inches, there is a snow stake. A snow board is used to measure the depth of the newly fallen snow (i.e., snowfall) and it is cleared of all snow and frozen precipitation once per day, immediately after the observation is taken.

Snowfall / Snow Depth - Equipment Standard				
Parameter	**Equipment**	**Range**	**Resolution**	**Accuracy**
Snowfall / Snow Depth: 0.1 inch to 20 inches	Snow stick (marked) and Snowboard	0 to 20 inches	0.1 inch	±0.1 inch
Snowfall / Snow Depth: 20 to 40 inches	Snow stick (marked) and Snowboard	0 to 40 inches	0.1 inch	±0.1 inch
Snow Depth: 40 to 60 inches	Snow stake (marked)	0 to 60 inches	1 inch	± 1 inch

Table 5.3. Equipment Standard for Snow Depth.

5.1.3 Snowfall and Snow Depth Observation

COOP observers who are required to report snowfall and snow depth, report a minimum of once per day on the established hour. They report the observations to the WFO on an NWS reporting system as instructed by their NWSREP. The procedures for taking an observation are given by the NWS document, *Snow Measurement Guidelines for NWS Surface Observing Program*. The document is accessible from the NWS headquarters website: http://www.nws.noaa.gov/os/coop/reference/Snow_Measurement_Guidelines.pdf

Snow Measurement - Data Standard				
Parameter	**Observation Period**	**Observation Frequency**	**Reported Units**	**Reporting Method**
Snowfall	24-Hours	Daily at a Set Hour (i.e., 7am) or after snowfall ends	Tenths of inches	WxCoder III
Snow Depth	24-Hours	Daily at a Set Hour (i.e., 7am)	Whole inches	WxCoder III

Table 5.4. Data Standard for Snow Measurement.

Recorded Precipitation – Measurement Requirements				
Parameter	**Requires**	**Range**	**Resolution**	**System Accuracy**
Precipitation, Rain (Hourly)	Oil and funnel in warm season	0 to 20 inches	0.1 inches	±0.1 inches, from 0 to 20 inches
Precipitation, Frozen (Hourly) Liquid Equivalent	Propylene Glycol (food grade) and oil, and open aperture – snow season	0 to 20 inches	0.1 inches	±0.1 inches, from 0 to 20 inches

Table 5.5. Measurement Requirements for Recorded Precipitation.

Recorded Precipitation – Data Requirements					
Observed Element	**Calculation Update**	**Data Store Rate**	**Memory, Minimum***	**Data Retrieval**	**Data Quality Control**
Precipitation, Accumulated Rain	5 minute	15 minutes	90 days*	Monthly	None
Precipitation, Accumulated Frozen	5 minute	15 minutes	90 days*	Monthly	None

Table 5.6. Data Requirements for Recorded Precipitation. * *This is minimum data storage, not the minimum amount of data to be retrieved monthly.*

5.2 Hourly Precipitation Data Observation

Nearly 2,000 cooperative observer sites possess the FPR recording precipitation gauge. The FPR gauges use an electronic weighing sensor and a data logger that records observations every fifteen minutes. In addition there are approximately 300 mechanical Fischer-Porter (F&P) gauges that rely on telemetry equipment (not an observer) to report precipitation data. The measurement standards (Table 5.5) apply to both the mechanical F&P and the electronic FPR recording gauges.

5.2.1 Monthly Data and Reporting Standard

Table 5.5 gives the minimum requirements for the production of precipitation data from a recording rain gauge. The recording gauge produces 15-minute data elements that corresponds to the clock hour such that the first element contains precipitation data measured at HH:15 local standard time.

5.2.2 Electronic Logging Gauges

The gauge is able to produce a record of the stored data elements on a portable memory device for monthly collection and submission to the forecast office. These data elements are date/time stamped and stored in the gauge for a minimum of 90 days, preferably 365 days. The forecast office does not edit or process the 15-minute data elements. Metadata on the maintenance and gauge configuration that might affect quality of data are reported separately into a centralized COOP station database managed by the NWS headquarters.

Precipitation - WFO Products			
Observed Element	**Observer's Reporting Method**	**Reporting Frequency**	**Generated Products**
Manual Daily Precipitation	WxCoder III (web); or IV-ROCS (phone); or WS Form B-91 (paper)	Daily to WFO	RTP, RWR, PNS, AGO
Recorded Precipitation	Electronic file is emailed or postal mailed to WFO	Monthly to WFO	None
Snowfall and Snow Depth	WxCoder III (web); or IV-ROCS (phone); or WS Form B-91 (paper)	Daily to WFO	RTP, RWR, PNS, AGO

Table 5.7. WFO Products Containing Precipitation Data.

Precipitation – Web Based NOAA Datasets				
Observed Element	**NWS Reporting Method to NCEI**	**Reporting Frequency**	**Name of the NCEI Dataset**	**NCEI Electronic Publication**
Standard Rain Gauge (SRG)	WxCoder III	Monthly	Daily Summaries	*Climatological Data*
FPR Recording Gauge (Electronic)	File Transfer Protocol (FTP) of CSV and TXT files	Monthly	Precipitation-15-Minutes	None
F&P Recording Gauge (Paper Tape)	WS Form 79-1D, (e.g., XLS files)	Monthly	Precipitation-15-Minutes	None
Snowfall and Snow Depth	WxCoder III	Monthly	Daily Summaries	*Climatological Data*

Table 5.8. NOAA Datasets Containing Precipitation Data and Observed Snow Data.

5.3 WFO Generated Products

Manually reported precipitation and snow depth observations are received by the WFO daily, per event, and/or monthly. During floods and special weather events, observers report data in near real time and may use observations taken from manual or recording rain gauges. For this reason, all recording gauges have a display/readout to indicate the amount of precipitation in the gauge, from which the observer can calculate the daily precipitation amount.

The WFO runs the precipitation observations through a minimal level of quality assurance before they are transmitted as text products or data files as identified in Table 5.7.

6 Soil Temperature

A number of forecast offices transmit soil temperature readings to agricultural agencies either daily or weekly especially during the beginning and middle portions of the growing season. The observation site should not be subject to irrigation, overflow, or unusual ground water conditions. The site should be open to full sunshine and represent the seasonal sun and shade patterns for the growing season. Snow cover should remain natural and undisturbed.

The thermometers should be situated in the center of a plot that measures 10 feet by 10 feet and is enclosed by a chain link fence four to five feet high. The plot should include either or both types of ground cover: bare ground to represent conditions for row-crops, or sod to represent pasture land. The sod-covered plots are trimmed to maintain a uniform two or three inch grass height. For the detailed instruction on how to install the soil thermometer refer to NWSM 10-1315, Appendix A, Section 3.

6.1 Soil Temperature Measurement Performance

Soil temperature observations should be taken once a day at the same time each day. Generally, this will be between 7am and 8am or between 5pm and 8pm local time. If automated recording instruments are used, the instruments should be checked daily to assure they are operating. Instrument performance is documented through a test and evaluation process that uses a temperature reference generator as described in Section 4.1.

Soil Temperature – Measurement Standard				
Observed Element	**Range – Fahrenheit**	**Reference Temperature**	**Time Constant**	**Accuracy At Reference Temperature**
Soil Temperature, Maximum	0º to +120º	+100º F	60 sec	± 2.0º 90% confidence
Soil Temperature, Minimum	−10º to +90º	+20º F	60 sec	± 2.0º 90% confidence
Soil Temperature, Current	−10º to +120º	+50º F	60 sec	± 2.0º 90% confidence

Table 6.1. Measurement Standards for Soil Temperatures.

Soil thermometer heads or recorders are mounted above the ground and shielded from precipitation and direct sunlight by a shield that may be fully enclosed. A wooden post may serve as the mount.

6.2 Data Requirement

Soil temperatures are essential to the agricultural industry and should represent the temperature of the natural agricultural soils of the area. Soil thermometers should be located under undisturbed soil in close contact with the ambient soil, with no insulating air spaces, or pockets. Soil temperatures should be taken at a depth of 4 inches. If required for special needs, depths of 2 inches, 8 inches, 20 inches, 60 inches, and 120 inches can be reported if they meet the measurement standards described in Table 6.1.

Regardless of the type of soil temperature instrument, the observer makes a visual reading of the measurement and records the values to the nearest whole degree Fahrenheit to a reporting method as instructed by the NWSREP (i.e., WS Form B-83a). The minimum requirements for data retrieval and reporting are described in Table 6.2.

The observer reports the maximum, minimum, and current soil temperatures at one depth: four inches. The shallow soil depths experience the greatest diurnal range in temperature, and soil temperatures in the summer can exceed the air temperature. Seasonal changes are observed at 20 inches. If the observer also reports air temperature, he should take the air temperature observation at the same hour of the day as the soil temperature.

Soil Temperature - Data Requirement				
Observed Element	**Observation Period**	**Observation Frequency**	**Observation Method**	**Data Resolution**
Soil Temperature - Maximum Daily	24-Hours	Daily at a Set Hour (i.e., 7am)	Examine dial / readout	Whole Degree Fahrenheit
Soil Temperature - Minimum Daily	24-Hours	Daily at a Set Hour (i.e., 7am)	Examine dial / readout	Whole Degree Fahrenheit
Soil Temperature - Current Reading	Current	Daily at a Set Hour (i.e., 7am)	Examine dial / readout	Whole Degree Fahrenheit

Table 6.2. Data Requirements for Soil Temperature.

6.3 WFO Generated Products

Soil temperatures are reported in the Agricultural Observations Product (AGO) on a daily basis. The AGO is a text product distributed by some offices daily through the year on AWIPS. Other offices transmit the AGO during growing season only. Soil temperature observations from COOP observers are run through an established level of quality assurance before they are transmitted as text products as identified in Table 6.3. The observers report their soil temperature observations to the WFO using the method instructed by the NWSREP.

The soil temperature observations are useful for agricultural programs and the observations are reported in the *Weekly Weather and Crop Bulletin.* The United States Department of Agriculture (USDA) website, http://www.usda.gov/oce/weather/pubs/Weekly/Wwcb/ makes these publications readily available to the public.

Soil Temperature - WFO Products			
Observed Element	**Observer's Reporting Method**	**Reporting Frequency**	**WFO Generated Products**
Soil Temperature - Maximum Daily	WxCoder III; or WS Form B-83A	Daily to WFO	Agricultural Observations (AGO)
Soil Temperature - Minimum Daily	WxCoder III; or WS Form B-83A	Daily to WFO	Agricultural Observations (AGO)
Soil Temperature - Current Reading	WxCoder III; or WS Form B-83A	Daily to WFO	Agricultural Observations (AGO)

Table 6.3. WFO Products for Soil Temperature Data.

Soil Temperature – Web Based Datasets and Electronic Publications				
Observed Element	**NWS Source**	**Reporting Frequency**	**Responsible Line Office**	**Name of the CDO Dataset / Products**
Soil Temperature Max/Min (Multiple Depths)	WxCoder III	Monthly	National Centers for Environmental Information	Daily Summaries / *Climatological Data*
Soil Temperature Max/Min (4-Inch Only)	WxCoder III	Monthly	Dept. of Agriculture	*Weekly Weather and Crop Bulletin (WWCB)*

Table 6.4. Web Based Datasets and Publications Containing Soil Temperature Data.

7 Pan Evaporation

During the growing season when air temperatures are above freezing, COOP sites may take observations of the daily evaporation to the nearest hundredth of an inch.

These pan evaporation observations are useful for agricultural programs, and the observations are reported by the USDA in the *Weekly Weather and Crop Bulletin*. It is accessible on: http://www.usda.gov/oce/weather/pubs/Weekly/Wwcb/wwcb.pdf .

When the pan evaporation observation is taken, additional observations are made of water temperature, air temperature, precipitation, and air movement. The detailed instructions for conducting pan evaporation observation are located in NWSM 10-1315, *Cooperative Station Observations and Maintenance*, Appendix B, Section 4.

7.1 Evaporation Pan Standards

The pan is constructed of monel or stainless steel and is 47.5 inches in diameter and 10 inches deep. The pan is mounted on a level wooden pallet so the pan sits approximately six inches above the ground surface.

The pan should be sited in an open field if possible, in full sunlight, and enclosed by a gated chain link fence, four to five feet high. The standard size plot measures 16 feet by 20 feet, and could be smaller or larger to accommodate site conditions or additional observing equipment. To prevent possible damage to the pan from ice in the cold season, the pan is emptied and stored indoors, or secured outdoors, inverted.

Observers use a fixed point gauge and calibrated refill cylinder to measure decreases in the volume of water. The fixed point gauge equipment is described in NWSM 10-1315, *Cooperative Station Observations and Maintenance*, Appendix A, Section 3.

Pan Evaporation – Observation Requirements				
Parameter	**Frequency**	**Range**	**Resolution**	**Accuracy**
Evaporation	Daily, or as Specified	0 to 10 inches	0.01 inches	±0.02 inch

Table 7.1. Observation Requirements for Pan Evaporation.

7.2 Required Observations

Pan evaporation is an empirical observation with additional observations made on site, within 50 feet of the evaporation pan, and reported to the WFO as useful for agricultural interests.

7.2.1 Maximum and Minimum Water Temperature of Last 24 Hours

The instrument should be held in a bracket, shielded from sunlight, and submerged in the evaporation pan. The bracket should be mounted such that the sensor tip is along the south wall of the pan or set on the bottom of the pan along the south wall, depending on type. The observations are made to the nearest Fahrenheit degree on instruments described in NWSM 10-1315, *Cooperative Station Observations and Maintenance*. The values are recorded by the observer using the method instructed by the NWSREP.

7.2.2 Maximum and Minimum Air Temperature of Last 24 Hours

The air temperature observations are taken to the nearest Fahrenheit degree on instruments that comply with those described in Section 4 of this instruction. These readings are entered in WxCoder within the group for evaporation observations, if at all possible. The values are recorded by the observer using the method instructed by the NWSREP.

Water Temperature Measurement Performance Standards				
Observed Element	**Range - Fahrenheit**	**Reference Temperature**	**Time Constant**	**Accuracy At Reference (F)**
Water Temperature, Maximum	33º to 120º	80º F	25 sec	± 2.0º 90% confidence
Water Temperature, Minimum	32º to 110º	50º F	25 sec	± 2.0º 90% confidence
Water Temperature, Current Reading	32º to 120º	50º F	25 sec	± 2.0º 90% confidence

Table 7.2. Performance Standards for Water Temperature Measurements.

Note: There are no requirements to observe the wet bulb or dew point temperatures for the pan evaporation observation. Therefore, columns marked ‘dew point’ and ‘wet bulb’ in WS Form B-92, should remain blank.

7.2.3 Precipitation Accumulation of Last 24 Hours

Precipitation observations are taken on instruments that comply with the requirements described in Section 5. Readings are taken and logged to the hundredth of an inch. The values are recorded by the observer using the method instructed by the NWSREP.

7.2.4 Air Movement of Last 24 Hours

Air movement across the evaporation pan is measured by a totalizing anemometer that complies with the standards described in Table 7.3. Air movement measurements are accurate to ±33% of the actual air movement in miles at the end of 24 hours. The measurement of one mile of wind should represent ten ‘counts’ on the totalizing anemometer display. The counter values in the display are recorded by the observer using the method instructed by the NWSREP.

The totalizing anemometer should be mounted to the pan support with cups positioned between six and eight inches above the lip of the evaporation pan. The mounting position is illustrated in NWSM 10-1315, *Cooperative Station Observations and Maintenance*.

Note: If a totalizing anemometer is unavailable, and a recording anemometer is used, then multiply the average 24-hour wind speed by 24 to calculate the miles of wind.

Air Movement Measurement – Minimum Performance Standards				
Observed Element	**Equipment Display Range**	**Units Per Count**	**Display Controls**	**Accuracy For 24-Hour Total (See Note)**
24-Hr Wind Run	0 to 10,000 Counts	One Tenth of Mile	Non-Resettable	± 33% of total miles as calculated from anemometer

Table 7.3. Minimum Performance Standards for 24-Hour Air Movement Measurements.

Note: The totalizing anemometer equipment is considered accurate when it tests in a wind tunnel to within ±33% of the total number of miles calculated from a reference recording anemometer 24-hour mean wind speed (in miles per hour) multiplied by 24.

WFO Products - Pan Evaporation Reporting Requirements			
Observed Element	**Observer's Reporting Method**	**Reporting Frequency**	**Generated Products**
Evaporation, Daily	WxCoder III ; or WS Form B-92	Daily to WFO	Agricultural Observations (AGO)
Precipitation	WxCoder III; or WS Form B-92	Daily to WFO	Agricultural Observations (AGO)
Water Temperature Max/Min, Daily	WxCoder III; or WS Form B-92	Daily to WFO	Agricultural Observations (AGO)
Air Movement, Daily	WxCoder III; or WS Form B-92	Daily to WFO	Agricultural Observations (AGO)
Air Temperature Max/Min, Daily	WxCoder III; or WS Form B92	Daily to WFO	Agricultural Observations (AGO)

Table 7.4. WFO Products Containing Pan Evaporation Data.

7.3 WFO Generated Products

Pan evaporation observations are reported in the Agricultural Observations Product (AGO) during the warm season. The COOP observer reports the pan evaporation observations to the WFO through a method as instructed by the NWSREP. The daily evaporation gets reported in the AGO together with the same site's daily precipitation, air movement, and max/min air temperature observations.

Web Based Datasets and Publications – Pan Evaporation				
Observed Element	**NWS Source**	**Reporting Frequency**	**Responsible Agency**	**Name of the CDO Dataset / Electronic Publication**
Evaporation, Daily	WxCoder III	Monthly	NCEI	Daily Summaries / *Climatological Data*
Water Temperature Maximum, Daily	WxCoder III	Monthly	NCEI	Daily Summaries / *Climatological Data*
Water Temperature Minimum, Daily	WxCoder III	Monthly	NCEI	Daily Summaries / *Climatological Data*
Air Motion, Daily	WxCoder III	Monthly	NCEI	Daily Summaries *Climatological Data*
Evaporation, Daily	AGO product	Monthly	Dept. of Agriculture	*Weekly Weather and Crop Bulletin (WWCB)*

Table 7.5. Web Based Datasets and Publications Containing Pan Evaporation Data.

8 Metadata for Cooperative Observations

The NWS COOP Program requires all hydrometeorological observations to be traceable to a minimum corresponding set of metadata. The metadata describe the following information: type of observing instruments; modification of equipment; maintenance of equipment; observation character (i.e., manual or automated); method of data entry necessary to record the observation; method of reporting; name of product generated; and whether the observation is 'distributed' or 'archived' by the NCEI.

The NWSREP is responsible for entering these and other metadata into a centralized national database for real-time access to both the current metadata and the archived metadata. The NWS headquarters provides official policy and data entry procedures for how to establish and revise COOP station metadata in the national metadata management system (i.e., Cooperative Station Service Accountability).

9 NOAA Distributed Data

Each month the WFO confirms the data collected from each NWS COOP meets basic quality assurance standards for completeness and accuracy. The WFO has until the 25th day of the month following the data observation month to confirm the observations are valid and release the data to NCEI. These observations include air temperature, soil temperature, pan evaporation rate, manually observed daily precipitation, manually observed daily snowfall, and manually observed daily snow depth.

The NCEI parses and stores the climate data reported by the WFO and makes the data available to the public through the Global Historical Climatology Network–Daily dataset via the Climate Data Online (CDO) website.

Additional data, including the precipitation data from the electronic recording rain gauge and electronic data from automated platforms, are also quality assured by NCEI and stored in separate datasets which are available on the same CDO website: http://www.ncdc.noaa.gov/cdo-web/search.