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Operations and Services

Surface Observing Program (Land), NDSPD 10-13

REQUIREMENTS AND STANDARDS FOR NWS CLIMATE OBSERVATIONS

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SUMMARY OF REVISIONS:

Revised Section 3, to state NCDC will provide a policy waiver to allow a qualified site to continue rooftop observations.

Revised Table 4.1, to clarify the standards for the Maximum Temperature and to change the reference temperatures for the Minimum Temperature.

Revised Section 4.1, to recognize current methods in the test and evaluation of thermometers.

Revised Section 4.2, to clarify how temperature measurements are rounded when readings are below zero.

Revised Section 5.1, to recognize the four-inch plastic rain gauge as meeting NWS requirements.

Revised Section 5.1.3, to recognize snowfall is reported in tenths of inches and snow depth in whole inches. Added a web link to the NWS publication, *Snow Measurement Guidelines*.

Revised Section 6, to give detail for the required site exposure for soil temperature observations.

Corrected Section 7.2.d, for the required measurement accuracy for the totalizing anemometer.

Removed the requirement for the 'sunshine duration,' in Section 8.

Signed September 11, 2012

David B. Caldwell Date

Director, Office of Climate,

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Requirements and Standards for NWS Climate Observations

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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 and precipitation. If standards can not be met by equipment in place, the standards should be achieved as 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 NWS Policy Directive NWSPD 10-21, *Intercomparison of Hydro-meteorological Instruments and Algorithms*. (http://www.nws.noaa.gov/directives/ sym/ pd01021curr.pdf). 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 to 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*. Photos and descriptions of observing equipment are found in NWSM 10-1315, Appendices A, B, C, D, and E. (http://www.nws.noaa.gov/directives/sym/pd01013015curr.pdf).

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

a. Maximum / Minimum Air Temperature Instruments

b. Standard Rain Gauges (Non-recording)

c. Recording Rain Gauges

d. Snow Sticks, Snow Boards, and Snow Stakes

e. Soil Temperature Maximum / Minimum Instruments

f. Pan Evaporation Gauges

g. Wind Run Anemometers

h. Water Temperature Maximum / Minimum Instruments

For some COOP sites, data collection platforms (DCP) integrate and disseminate observational data. Any data provided by DCPs are required to meet the most stringent standards set for all observing programs the system supports (i.e., Aviation Observing Program, Synoptic Observing Program, Climate Observing Program, and Supplementary Observing Program).

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

The procedures for NWS forecast offices and contractors to provide supplemental observations in support of the climate observing program are detailed in the NWSI 10-1311, *Supplementary Observations and Complementary Data Sources and Networks*. (http://www.nws.noaa.gov/directives/sym/pd01013011curr.pdf).

3. Site and Exposure Standards. This section provides instrument siting and exposure standards for the Climate Observing Program. Policies for how to establish cooperative sites, collection and distribution of observations, site visitation and management, are outlined in NWSI 10-1307, *Cooperative Program Management and Operations*. (http://www.nws.noaa.gov/directives/sym/pd01013007curr.pdf).

Standards in this 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: http://www.ofcm.gov/siting/text/a-cover.htm .

Instruments are **not** to be sited on rooftops. Relocation of existing rooftop instruments will be accomplished as funds permit and after coordination with the Regional Headquarters. In a small number of cases when it is possible to maintain continuity with the historical rooftop climate record, NCDC 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:

a. over level terrain (earth or sod) typical of the area around the station, and;

b. at least 100 feet from any extensive concrete or paved surface.

c. 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.

d. 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.

e. 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.

f. 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.

a. 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.

b. The gauge site should have protection in all directions by objects of uniform height. Where the heights of the objects are uniform and the height of these objects and the distance from the gauge is generally uniform, their height above the gauge orifice should not exceed twice their distance from the gauge.

c. In open areas, the heights of obstructions above the orifice should not exceed twice their distance from the gauge.

4. Air Temperature. Air temperature is temperature of the free air conditions surrounding the station at a height between 4 feet to 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 observing program:

a. Maximum / Minimum Temperature System (i.e., Nimbus), and

b. Liquid-in-glass maximum and minimum thermometers.

Temperature instruments will be **shielded** from the following elements:

a. Precipitation,

b. Direct and reflected sunshine, and

c. Direct and reflected thermal energy (i.e., Infrared).

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 convect 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.

Table 4.1 Air Temperature Measurement Performance Standards

Observed Element	Range - Fahrenheit	Reference Temperature	Time Constant	Accuracy At Reference (F)
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
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

Test and Evaluation: The NWS, Office of Operational Systems, requires traceability of the performance of temperature measuring instruments which are immersed in temperature bath (i.e., Hart Scientific, Model 7081) 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 uses liquid silicone, electric resistance heaters, and a two-stage heat exchanger to enable testing from -80°C to +55°C. These tests are followed by whole system testing (for electronic instruments) inside a walk-in environmental 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 ±0.01º C at 95% confidence level, k=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 a 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 the time constant be between 30 and 60 seconds with winds of 10 miles per hour.

General Instruments: The WMO suggests ordinary thermometers be able to measure with high certainty in the range -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.

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 (below) 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 retrieval of the data where practical and when in an approved data format.

Table 4.2 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

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

The observer notes the instrument readings and enters the observed values to an NWS reporting system according to instructions given him by the NWS Representative. This may include the

WxCoderIII website, the IV-ROCS voice recognition system, other electronic transfer, or a paper form.

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

Less than 25% of all air temperature observation sites use liquid in glass thermometers. For these sites, on a daily basis, the observer walks out to the shelter (i.e., cotton region shelter), opens the shelter and visually inspects the liquid in glass thermometers to observe the readings of daily maximum temperature, daily minimum temperature, and current temperature. The observer notes the instrument readings and enters the observed values to an NWS reporting system according to instructions given by the NWS Representative. This may include the WxCoderIII website, the IV-ROCS voice recognition system, other electronic transfer, or a paper form.

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.

The reporting forms, reporting methods, reporting frequency by which cooperative data is received into the WFO, are identified in Table 4.3. Some observers still use a reporting method of United States Postal Service only, and for these sites the WFO does not generate any of the products identified in Table 4.3.

Table 4.3 Air Temperature - WFO Products

Observed Element	Observation Form	Reporting Time	Reporting Method	Generated Products
Air Temperature - Maximum Daily	WxCoderIII, or WS B-91	Daily to WFO	WxCoderIII; IV-ROCS (phone)	RTP, RWR, PNS, AGO
Air Temperature - Minimum Daily	WxCoderIII, or WS B-91	Daily to WFO	WxCoderIII; IV-ROCS (phone)	RTP, RWR, PNS, AGO
Air Temperature - Current Reading	WxCoderIII, or WS B-91	Daily to WFO	WxCoderIII; IV-ROCS (phone)	RTP, RWR, PNS, AGO

Table 4.4 Air Temperature - NOAA Publications				
Observed Element	**NWS Source**	**Reporting Date**	**Agency / Users Who Publish**	**Name of the Publication**
Air Temperature - Maximum Daily	WxCoderIII, or WS B-91	Monthly to NCDC	National Climatic Data Center	*Climatological Data (CD)*
Air Temperature - Minimum Daily	WxCoderIII, or WS B-91	Monthly to NCDC	National Climatic Data Center	*Climatological Data(CD)*
Air Temperature - Current Daily	WxCoderIII, or WS B-91	Monthly to NCDC	National Climatic Data Center	*Climatological Data (CD)*

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 daily measurements to the NWS forecast office either daily, or by precipitation event, or at least once per month. The second type uses a recording rain gauge, it provides a recorded measurement of accumulated precipitation in coded format. These are the primary equipment for the precipitation observation:

a. Manual Rain Gauge (i.e., Standard Rain Gauge), and

b. Recording Rain Gauge (i.e., Fischer-Porter Recording Gauge)

5.1 Daily Precipitation Observation. Nearly all cooperative observation sites are equipped with the Standard Rain Gauge (SRG) or the Four-Inch plastic 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 1/10 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.

The Four-Inch plastic gauge is a suitable substitute for the Eight-Inch standard rain gauge because it meets the accuracy requirements. The Four-Inch gauge's 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 the NWSM 10-1315, *Cooperative Observations*, see http://www.nws.noaa.gov/directives/sym/pd01013015curr.pdf.

Table 5.1 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

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 mark on the rain stick, 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 gage, 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.

Table 5.2 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 is < 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 is < 0.01 inch

5.1.2 Snow Measurement. COOP observers and contract observers are given NWS owned equipment to take snow depth measurements. There are two sizes of snow measuring sticks, one to measure up to 20 inches, the other up to 40 inches, and there is a snow stake to measure snow depths up to 60 inches. 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.

Table 5.3 Snow Depth - Equipment Standard				
Parameter	**Equipment**	**Range**	**Resolution**	**Accuracy**
Snow Depth: 0.1 inch to 20 inches	Snow stick (20") and Snow board	0 to 20 inches	0.1 inch	±0.1 inch
Snow Depth: 20 to 40 inches	Snow stick (40") and Snow board	0 to 40 inches	0.1 inch	±0.1 inch
Snow Depth: 40 to 60 inches	Snow stake (60")	0 to 60 inches	1 inch	± 1 inch

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 into an NWS reporting system. This may include the WxCoderIII web site, the IV-ROCS voice recognition system, other electronic transfer, or a paper form if instructed by the NWS Representative. The procedures for taking an observation are given by an NWS document: http://www.nws.noaa.gov/os/coop/reference/Snow_Measurement_Guidelines_05-1997.pdf, *Snow Measurement Guidelines for NWS COOP Observers*.

Table 5.4 Snow Measurement - Data Standard

Parameter	Observation Period	Observation Time	Reported Depth	Observation Form
Snowfall	24-Hours	Daily at a Set Hour (i.e., 7am)	Tenths of inches	WxCoderIII, or WS B-91
Snow Depth	24-Hours	Daily at a Set Hour (i.e., 7am)	Whole inches	WxCoderIII, or WS B-91

5.2 Hourly Precipitation Data Observation. Approximately 2,300 cooperative observation sites are equipped with the Fischer-Porter (F&P) recording precipitation gauge. The majority of the mechanical gauges have been retrofit with electronic measuring and recording equipment. The following data standards apply to both the mechanical and the electronic recording gauges.

Table 5.5 Recorded Precipitation – Data 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

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 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 ninety days, preferably 365 days. The forecast office does not edit nor process, the 15-minute data elements. Metadata on the maintenance and gauge configuration that might affect quality of data is reported separately into CSSA until further instruction is given in the course of the modernization program.

Table 5.6 Recorded Precipitation - Data Requirements (Electronic)

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

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.

Table 5.7 Precipitation - WFO Products

Observed Element	Observation Form	Reporting Time	Reporting Method	Generated Products
Manual Daily Precipitation	WxCoderIII, or WS B-91	Daily to WFO	WxCoderIII; IV-ROCS (phone)	RTP, RWR, PNS, AGO
Recorded Precipitation	CSV file (electronic)	Monthly to WFO	Mail to NCDC, or FTP to NCDC web	None
Snowfall and Snow Depth	WxCoderIII, or WS B-91	Daily to WFO	WxCoderIII; IV-ROCS	RTP, RWR, PNS, AGO

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

Table 5. 8 Precipitation - NOAA Publications

Observed Element	NWS Source	Reporting Date	Agency / Users Who Publish	Name of the Publication
Standard Rain Gauge (SRG)	WxCoderIII, or WS B-91	Monthly to NCDC	National Climatic Data Center	*Climatological Data (CD)*
F&P Recording Gauge (Paper Tape)	WS Form B-18 (e.g., Punched Tape)	Monthly to NCDC	National Climatic Data Center	*Hourly Precipitation Data (HPD)*
F&P Recording Gauge (Electronic)	File Transfer Protocol (i.e., CSV files)	Monthly to NCDC	National Climatic Data Center	*Hourly Precipitation Data (HPD)*
Snowfall and Snow Depth	WxCoderIII, or WS B-91	Monthly to NCDC	National Climatic Data Center	*Climatological Data(CD)*

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 at least 10 feet by 10 feet and is enclosed by by a chain fence 4 or 5 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 2 or 3 inch grass height. For the detailed instruction on how to install the soil thermometer refer to NWSM 10-1315, Appendix E.

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. This instruction does not require soil temperatures to be recorded on electronic thermometer. 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 generators as described in Section 4.1.

Table 6.1 Soil Temperature – Measurement Standard				
Observed Element	**Range – Fahrenheit**	**Reference Temperature**	**Time Constant**	**Accuracy At Reference (F)**
Soil Temperature, Current	−10º to +120º	+50º F	60 sec	± 2.0º 90% confidence
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 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. Electronic thermometers that measure soil temperatures will have their display read-out mounted in an enclosed shelter.

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 in and 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 notes the values to WS Form B-83A, Supplementary Record of Climatological Observations. The form can be updated and transmitted daily to the local WFO via WeatherCoderIII. Otherwise the Form B-83A is completed for all days of the month, and mailed to the WFO after the end of the month.

The minimum requirements for data retrieval and reporting are described in Table 6.2.

The observer reports the maximum, minimum, and current soil temperature at one depth: 4 inches. The shallow soil depth experiences 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.

Table 6.2 Soil Temperature - Data Requirement				
Observed Element	**Observation Period**	**Observation Time**	**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

6.3 WFO Generated Products. Soil temperatures are reported in the Agricultural Weather Summary 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 observer uses an observation form and a specific reporting method to deliver soil observations to the WFO.

Table 6.3 Soil Temperature - WFO Products				
Observed Element	**Observation Form**	**Reporting Time**	**Reporting Method**	**WFO Generated Products**
Soil Temperature - Current Reading	WxCoderIII, or WS B-83A	Daily to WFO	WxCoderIII; IV-ROCS(phone)	AGO
Soil Temperature - Maximum Daily	WxCoderIII, or WS B-83A	Daily to WFO	WxCoderIII; IV-ROCS(phone)	AGO
Soil Temperature - Minimum Daily	WxCoderIII, or WS B-83A	Daily to WFO	WxCoderIII; IV-ROCS(phone)	AGO

Table 6.4 Soil Temperature - NOAA Publication				
Observed Element	**NWS Source**	**Reporting Date**	**Agency / Users Who Publish**	**Name of the Publication**
Soil Temperature Max/Min, Daily (Multiple Depths)	WxCoderIII, or WS B-83A	Monthly to NCDC	National Climatic Data Center	*Climatological Data (CD)*
Soil Temperature Max/Min, Weekly (4-Inch Only)	WxCoderIII, or WS B-83A	Monthly to NCDC	Dept of Agriculture	*Weekly Weather and Crop Bulletin (WWCB)*

7. Pan Evaporation. During the growing season, when air temperatures are above freezing, Cooperative Sites may take observations of the daily evaporation to the nearest hundredth of an inch. The daily observations are useful for agricultural programs and are published monthly in the *Climatological Data*.

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 an evaporation observation are located in NWSM, 10-1315, *Cooperative Station Observations*, Appendix D.

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 ground surface.

The pan should be sited in an open field if possible, in full sunlight, and enclosed by a gated chain link fence, 4 or 5 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. During months when freezing temperatures are expected, empty the pan and either store the pan indoors, or secure it 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, Appendix D.

Table 7.1 Pan Evaporation – Observation Requirements				
Parameter	**Frequency**	**Range**	**Resolution**	**Accuracy**
Evaporation	Daily, or as Specified	0 to 10 inches	0.01 inches	±0.02 inch

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.

a. Maximum and Minimum Water Temperature in the last 24 hours are recorded to WS Form B-92 at time of observation. The instrument should be held in a bracket, shielded from sunlight, and submerged in the evaporation pan. The bracket may be mounted to the south wall of pan or set on the bottom of the pan, depending on type.

b. Maximum and Minimum Air Temperature in the last 24 hours are recorded to WS Form B-92 at time of observation. The air temperature observations comply with standards described in section 4 of this instruction.

c. Precipitation Accumulation in the last 24-hours is recorded to hundredth of an inch. This is recorded to B-92 at time of observation. Precipitation observations comply with standards described in section 5 of this instruction.

d. Air Movement as measured by a totalizing anemometer or by an anemometer with logger with ability to produce a 24-hour average wind speed. The anemometer should be mounted to the pan support with the cups positioned between 6 to 8 inches above the lip of the pan. 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 one 'count' unit as appears on the totalizing anemometer's display. If a recording anemometer is used, then multiply the average 24-hour wind speed by 24 to calculate the miles of wind. Air movement is recorded to Form B-92 at time of observation.

Table 7.2 Water Temperature Measurement Performance Standards				
Observed Element	**Range - Fahrenheit**	**Reference Temperature**	**Time Constant**	**Accuracy At Reference (F)**
Water Temperature, Current Reading	32º to 120º	50º F	25 sec	± 2.0º 90% confidence
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

The WS Form B-92 mentions dew point temperature and wet bulb temperature, however these observations are not required for the pan evaporation observation.

Table 7.3 WFO Products - Pan Evaporation Reporting Requirements				
Observed Element	**Observation Form**	**Reporting Time**	**Reporting Method**	**Generated Products**
Evaporation, Daily	WxCoderIII WS B-92	Daily to WFO	WxCoderIII; IV-ROCS (phone)	AGO
Precipitation	WxCoderIII WS B-92	Daily to WFO	WxCoderIII; IV-ROCS (phone)	AGO
Water Temperature Max/Min, Daily	WxCoderIII WS B-92	Daily to WFO	WxCoderIII; IV-ROCS (phone)	None
Air Movement, Daily	WxCoderIII WS B-92	Daily to WFO	WxCoderIII; IV-ROCS (phone)	AGO
Air Temperature Max/Min, Daily	WxCoderIII WS B-92	Daily to WFO	WxCoderIII; IV-ROCS (phone)	AGO

7.3 WFO Generated Products. Pan evaporation observations are reported in the Agricultural Weather Summary product (AGO) during the warm season. The COOP observer uses an observation form and a specific reporting method to deliver pan evaporation observations to the WFO. The daily evaporation gets reported in the AGO together with the same site's daily precipitation, air movement, and max/min air temperature observations.

Table 7.4 NOAA Publications – Pan Evaporation				
Observed Element	**NWS Source**	**Reporting Date**	**Agency / Users Who Publish**	**Name of the Publication**
Evaporation, Daily	WxCoderIII, WS Form B-92	Monthly to NCDC	NCDC	*Climatological Data (CD)*
Water Temperature Maximum, Daily	WxCoderIII, WS Form B-92	Monthly to NCDC	NCDC	*Climatological Data (CD)*
Water Temperature Minimum, Daily	WxCoderIII, WS Form B-92	Monthly to NCDC	NCDC	*Climatological Data (CD)*
Air Motion, Daily	WxCoderIII, WS Form B-92	Monthly to NCDC	NCDC	*Climatological Data (CD)*

8. Metadata for Cooperative Observations. Observations made by the NWS Cooperative Observing Program, have a minimum corresponding set of metadata to describe the observing instruments, the observation character, the data entry form necessary to record the observation, method of reporting, name of product generated by forecast office, and name of publication in which the observation is published.

The metadata are recorded to the NWS Cooperative Station Service Accountability (CSSA) system for real time access and archive access. The required metadata and instructions for recording this information into the CSSA are found in NWSM 10-1313, *Cooperative Station Service Accountability* (Appendix C, The Data Entry).
http://www.nws.noaa.gov/directives/sym/pd01013013curr.pdf

9. NOAA Published Data. Most observations are now sent to the WFO by electronic methods and a small percentage of observations are mailed into the WFO in printed form at the end of the month.

The WFO then submits detailed observation records, in electronic form to the National Climatic Data Center (NCDC). The NCDC collects and processes all electronic and paper submissions, providing a receipt log for WFO feedback. The NCDC quality control process will flag precipitation data that are spatially inconsistent, exceed climatological limits, or are inconsistent with prevailing weather patterns. Summary results of data quality are generated and reported online, on a web site, titled, *Health of the Networks*, see:
http://www.ncdc.noaa.gov/oa/hofn/coop/coop-home.html.

Once quality issues have been resolved, NCDC publishes the observations in three monthly periodicals: *Climatological Data (CD)*; *Hourly Precipitation Data (HPD), and the Local*

Climatological Data (LCD). The LCD contains a subset of COOP sites, observations made by the ASOS instruments.

In addition to these NOAA periodicals, the Department of Agriculture, publishes the *Weekly Weather and Crop Bulletin*, in which soil temperature data is reported for the nation.