

# Atmospheric Radiation Measurement Program Surface Meteorological Measurements

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## Introduction

The surface meteorological measurement packages use a base set of instruments to measure wind speed and direction, temperature, relative humidity, precipitation and atmospheric pressure. Differences between the surface meteorological systems exist.

These differences are due to data collection methods and sensors required for different climate regimes. Programmatic measurement needs may also require that systems and some sub-systems measure different parameters or use different sensors.

## Sites

### Southern Great Plains (SGP)

The Surface Meteorological Observation System (SMOS) uses conventional in situ sensors to obtain 1-minute, 30-minute, and 1440-minute (daily) averages of surface wind speed, wind direction, air temperature, relative humidity, barometric pressure, and precipitation at the Central Facility and many of the extended facilities of the SGP climate research site. SMOSs have not been installed at extended facilities located within about 10 km of existing surface meteorological stations, such as those of the Oklahoma Mesonet. The SMOS is used to create climatology for each particular location, and to verify the output of numerical weather forecast and other model output. They are also used to “ground-truth” other remote sensing equipment.

For more information see: <http://www.arm.gov/instruments/instrument.php?id=smos>

### Tropical Western Pacific (TWP)

The TWP Surface Meteorology station (SMET) uses conventional in situ sensors to obtain 1-minute statistics of surface wind speed, wind direction, air temperature, relative humidity, barometric pressure,

and rain-rate. The SMET systems are located at each of the TWP sites of Darwin, Australia, Los Negros Island in Manus, Papua New Guinea and Nauru Island, Republic of Nauru. The SMET is used to create climatology for each particular location, and to verify the output of numerical weather forecast and other model output. They are also used to “ground-truth” other remote sensing equipment.

For more information see: <http://www.arm.gov/instruments/instrument.php?id=smet>

## **North Slope of Alaska (NSA)**

### *Barrow*

The Barrow meteorology station uses conventional in situ sensors mounted at four different heights (2 m, 10 m, 20 m, and 40 m) on a 40 m tower to obtain profiles of wind speed, wind direction, air temperature, dew point and humidity. It also obtains barometric pressure, visibility and precipitation data from sensors at the base of the tower. Additionally, a Chilled Mirror Hygrometer and an Ultrasonic wind speed sensor are located near the 2 m level for comparison purposes.

### *Atkasuk*

The Atkasuk meteorology station uses conventional in situ sensors to measure wind speed, wind direction, air temperature, dew point and humidity mounted on a 10 m tower. It also obtains barometric pressure, visibility and precipitation data from sensors at or near the base of the tower. Additionally, a Chilled Mirror Hygrometer is located at 1 m for comparison purposes. Temperature and relative humidity probes are mounted at 2 m and 5 m on the tower.

For more information see: <http://www.arm.gov/instruments/instrument.php?id=mettwr>

## **Atmospheric Radiation Measurement (ARM) Program Mobile Facility (AMFMET)**

The ARM Mobile Facility Surface Meteorology station uses conventional in situ sensors to obtain 1-minute statistics of surface wind speed, wind direction, air temperature, relative humidity, barometric pressure, and rain-rate. Additional sensors may be added to or removed from the base set of sensors depending upon the deployment location, climate regime or programmatic needs. Additionally, sensor types may change depending upon the climate regime of the deployment

## **Reference Systems**

### **Temperature Humidity Wind and Pressure System (THWAPS)**

The temperature, humidity, wind, and pressure systems provide surface reference values of these measurements for balloon-borne sounding system (BBSS) launches. THWAPS are located adjacent to

BBSS launch sites at the SGP Central Facility and its four boundary facilities. The THWAPS is a combination of calibration-quality instruments intended to provide accurate measurements of meteorological conditions near the surface. Although the primary use of the system is to provide accurate surface reference values of temperature, pressure, relative humidity, and wind velocity for comparison with radiosonde readings, the system includes a data logger to record time series of the measured variables. The THWAPS is not generally used as a surface meteorological measurement system. Many of the variables measured do not conform to WMO standards for surface meteorological measurements. Instead, the THWAPS is used to gather reference values for the BBSS at the SGP ARM Climate Research Facility sites.

For more information see: <http://www.arm.gov/instruments/instrument.php?id=thwaps>

### Surface Temperature and Relative Humidity Reference (SURTHREF)

The Surface Temperature and Relative Humidity system is intended to provide accurate reference values of ambient temperature and relative humidity for comparison with radiosonde prelaunch values. Six temperature and relative humidity probes (three Vaisala HMP-45Ds and three Rotronic MP-100H) are mounted in a polypropylene box inside a standard Stevenson Screen enclosure. The SURTHREF system is located at the SGP Central Facility near the BBSS launch site. Before each sonde launch, the radiosonde is placed into the SURTHREF for comparison with the six probes.

For more information see: <http://www.arm.gov/instruments/instrument.php?id=surthref>

### Variables

All variables, including unit, accuracy, measurement interval and level, are detailed in Table 1.

SGP Quantity	Unit	Accuracy	Measurement Interval	Level
Wind Speed Arithmetic Average	m/s	+/- 1%	1 min & 30 min	10 m
Wind Speed Vector Average	m/s	+/- 1%	1 min & 30 min	10 m
Wind Direction Vector Average	deg	+/- 5 deg	1 min & 30 min	10 m
Temperature Mean	C	+/- 2-3%	1 min & 30 min	1.25 m
Relative Humidity Mean	%	+/- 2% for 0 to 90% +/- 3% for 91 to 100%	1 min & 30 min	1.25 m
Vapor Pressure Mean	kPa		1 min & 30 min	1.25 m
Barometric Pressure Mean	kPa	+/- 0.15 hPa	1 min & 30 min	1 m
Snow Depth	mm	" +/- 10mm	1 min & 30 min	2 m
Precipitation Total	mm	" +/- .254 mm	1 min & 30 min	sfc

**Table 1. (contd)**

<b>TWP Quantity</b>	<b>Unit</b>	<b>Accuracy</b>	<b>Measurement Interval</b>	<b>Level</b>
Precipitation Mean, Max., Min.	mm/hr	+/- 5%	1 min	1 m
Temperature Mean	C	+/- 0.41C	1 min	1.25 m
Relative Humidity Mean	%	+/- 2% for 0 to 90% +/- 3% for 91 to 100%	1 min	1.25 m
Vapor Pressure Mean	kPa		1 min	1.25 m
Upper, Lower Wind Speed Arithmetic Avg.	m/s	+/- 1%	1 min	10 m
Upper, Lower Wind Speed Vector Avg.	m/s	+/- 1%	1 min	10 m
Upper, Lower Wind Direction Vector Avg.	deg	+/- 5 deg	1 min	10 m
Upper, Lower Wind Speed Maximum	m/s	+/- 1%	1 min	10 m
Upper, Lower Wind Speed Minimum	m/s	+/- 1%	1 min	10 m
Atmospheric Pressure	hPa	+/- 0.15 hPa	1 min	1 m
<b>AMF Quantity</b>	<b>Unit</b>	<b>Accuracy</b>	<b>Measurement Interval</b>	<b>Level</b>
Precipitation Mean, Max., Min.	mm/hr	+/- 5%	1 min	1 m
Temperature Mean	C	+/- 0.41C	1 min	1.25 m
Relative Humidity Mean	%	+/- 2% for 0 to 90% +/- 3% for 91 to 100%	1 min	1.25 m
Vapor Pressure Mean	kPa		1 min	1.25 m
Wind Speed Arithmetic Average	m/s	+/- 1%	1 min	3 m
Wind Speed Vector Average	m/s	+/- 1%	1 min	3 m
Wind Direction Vector Average	deg	+/- 5 deg	1 min	3 m
Wind Speed Max., Min.	m/s	+/- 1%	1 min	3 m
Atmospheric Pressure	hPa	+/- 0.15 hPa	1 min	1 m
<b>NSA Quantity</b>	<b>Unit</b>	<b>Accuracy</b>	<b>Measurement Interval</b>	<b>Level Barrow/Atqasuk</b>
Arithmetic Mean Wind Speed	m/s	+/- 3%	1 min	2, 10, 20, 40 m / 10 m
Vector Averaged Wind Speed	m/s	+/- 3%	1 min	2, 10, 20, 40 m / 10 m
Vector Averaged Wind Direction	deg	+/- 5 deg	1 min	2, 10, 20, 40 m / 10 m
Sonic Arithmetic Mean Wind Speed	m/s	+/- 3%	1 min	2 m / N/A
Sonic Vector Averaged Wind Speed	m/s	+/- 3%	1 min	2 m / N/A
Sonic Vector Averaged Wind Direction	deg	+/- 2 deg	1 min	2 m / N/A
Average Temperature	C	+/- 0.41C	1 min	2, 10, 20, 40 m / 2, 5 m
Average Relative Humidity	%	+/- 2% for 0 - 90 % +/- 3% for 91 - 100 %	1 min	2, 10, 20, 40 m / 2, 5 m
Average Calculated Dew Point	C		1 min	2, 10, 20, 40 m / 2, 5 m

**Table 1.** (contd)

Average Calculated Vapor Pressure	kPa		1 min	2, 10, 20, 40 m / 2, 5 m
Atmospheric Pressure	hPa	+/- 0.15 hPa	1 min	1 m / 1 m
1 minute Average Visibility	m	+/- 20%	1 min	2 m / 2 m
10 minute Average Visibility	m	+/- 20%	1 min	2 m / 2 m
Instant Present Weather Code	N/A	N/A	1 min	2 m / 2 m
15 minute Present Weather Code	N/A	N/A	1 min	2 m / 2 m
1 hour Present Weather Code	N/A	N/A	1 min	2 m / 2 m
Precipitation Rate	mm/hr	+/- 30%	1 min	2 m / 2 m
Cumulative Water Sum	mm/hr	+/- 30%	1 min	2 m / 2 m
Cumulative Snow Sum	mm/hr	+/- 30%	1 min	2m / 2 m
Chilled Mirror Temperature	C	+/- 1 deg F	1 min	2 m / 1 m
Chilled Mirror Dew Point	C	+/- 2 deg F for 30 - 86 F +/- 3 deg F for -10 to 30 F +/- 4 deg F for -30 to - 10 F	1 min	2 m / 1 m
Chilled Mirror Calc. Saturation Vapor Pressure	kPa		1 min	2 m / 1 m
Chilled Mirror Calc. Vapor Pressure	kPa		1 min	2 m / 1 m
Chilled Mirror Calc. Relative Humidity	%		1 min	2 m / 1 m
<b>THWAPS Quantity</b>	<b>Unit</b>	<b>Accuracy</b>	<b>Measurement Interval</b>	<b>Level</b>
Atmospheric Pressure	hPa	+/- 0.15 hPa	5 min	1 m
Temperature Mean	C	+/- 0.41C	5 min	1 m
Relative Humidity Mean	%	+/- 2% for 0 to 90% +/- 3% for 91 to 100%	5 min	1 m
Vapor Pressure Mean	kPa		5 min	1 m
Wind Speed Arithmetic Mean	m/s	+/- 1%	5 min	5 m
Unit Vector Wind Direction	deg	+/- 5 deg	5 min	5 m
<b>SurTHRef Quantity</b>	<b>Unit</b>	<b>Accuracy</b>	<b>Measurement Interval</b>	<b>Level</b>
Temperature V1, V2, V3 Avg., Max., Min.	C	+/- 1%	1 min	1 m
Temperature R1, R2, R3 Avg., Max., Min.	C	+/- 0.2 C	1 min	1 m
Rel. Humidity V1, V2, V3 Avg., Max., Min.	%	+/- 2% for 0 to 90% +/- 3% for 91 to 100%	1 min	1 m
Rel. Humidity R1, R2, R3 Avg., Max., Min.	%	" +/- 1.5% "	1 min	1 m
Sonde Present Bit Flag	N/A		1 min	1 m



**Figure 1.** SMOS tower at the SGP site.



**Figure 2.** Surface meteorology system at the TWP site in Darwin, NT, Australia.



**Figure 3.** Met system tower at the NSA site in Barrow, Alaska.





**Figure 4.** Met system tower at the NSA site in Atkasuk, Alaska.



**Figure 5.** ARM Mobile Facility Surface Meteorology station set-up.



**Figure 6.** THWAPS at the SGP site.



**Figure 7.** SURTHREF system used at the SGP site.