Meteorological Automatic Weather Station (MAWS) Instrument Handbook

DL Holdridge   JA Kyrouac

August 2017

DISCLAIMER

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Acronyms and Abbreviations

AC   alternating current
AMF1   first ARM Mobile Facility
AMF2   second ARM Mobile Facility
AMF3   third ARM Mobile Facility
ANL   Argonne National Laboratory
ARM   Atmospheric Radiation Measurement
BBSS   Balloon-Borne Sounding System
C   Celsius
DOE   U.S. Department of Energy
ENA   Eastern North Atlantic
F   Fahrenheit
GMT   Greenwich Mean Time
hPa   hectopascals
MAWS   Meteorological Automatic Weather Station
m/s   meters per second
NSA   North Slope of Alaska
OSS   Operations Status System
RH   relative humidity
SGP   Southern Great Plains
V   volt

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1.0   General Overview

Figure 1.   MAWS installed at the U.S. Department of Energy (DOE) Atmospheric Radiation
Measurement (ARM) Climate Research Facility Southern Great Plains (SGP) site.

The Meteorological Automatic Weather Station (MAWS) is a surface meteorological station,
manufactured by Vaisala, Inc., dedicated to the balloon-borne sounding system (BBSS), providing surface
measurements of the thermodynamic state of the atmosphere and the wind speed and direction for each
radiosonde profile. These data are automatically provided to the BBSS during the launch procedure and
included in the radiosonde profile as the surface measurements of record for the sounding. The MAWS
core set of measurements is: Barometric Pressure (hPa), Temperature (°C), Relative Humidity (%),

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Arithmetic-Averaged Wind Speed (m/s), and Vector-Averaged Wind Direction (deg). The sensors that collect the core variables are mounted at the standard heights defined for each variable:

- Temperature and relative humidity: 2 meters
- Barometric pressure: 1 meter
- Winds: 10 meters.

The sensors, all manufactured by Vaisala, Inc., include:

- Temperature and relative humidity: HMP155 in RM Young Aspirated Shield Model 43502
- Barometric pressure: Digital Barometer Model PTB330
- Winds: Ultrasonic Wind Sensor Model WMT700 (heated).

2.0   Mentor Contact Information

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3.0   Vendor/Developer Contact Information

Vaisala, Inc. (North America Support Office)
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Email: helpdesk@vaisala.com
Web: www.vaisala.com

4.0 Links to Definitions and Relevant Information

4.1 Data Object Description

Data files are named using the convention: SSSmawsXXb1.YYYYMMdd.ssssss.nc

Where:

SSS = three-letter site designation

XX = letter/digit facility designation

YYYY = four-digit year

MM = two-digit month

dd = two-digit day

ssssss = six-digit seconds

Netcdf files (*.nc) contain metadata and one-minute data averages for an entire day from 00-23 GMT

The following quantities are measured as functions of time during a free-balloon ascent:

- Pressure (hPa)   netCDF name = "atmospheric_pressure"
- Temperature (°C)   netCDF name = "atmospheric_temperature"
- Relative humidity (%RH)   netCDF name = "atmospheric_relative_humidity"
- Wind speed (m/s)   netCDF name = "wind_speed"
- Wind direction (deg)   netCDF name = "wind_direction"

Secondary (derived) quantities included in the datastream, also measured as functions of time, are:

Dew point (°C)   netCDF name = "atmospheric_dew_point_temperature"

4.2 Data Ordering

Data are available via the ARM Data Archive: http://www.archive.arm.gov/armlogin/login.jsp

4.3 Data Plots

Near-real-time data plots can be found on the Data Quality Explorer website:
http://dq.arm.gov/dq-explorer/cgi-bin/main

4.4 Data Quality

Data quality is reviewed daily by the ARM Data Quality Office (http://dq.arm.gov/).

4.5 Calibration Database

Manufacturer calibration reports are kept in the ARM Operations Status System (OSS)
https://oss.arm.gov/oss.php
Access to each report is available by searching on component by name, model, serial number, etc.

5.0 Technical Specification

The MAWS consists of the following components:

- **Temperature and relative humidity:** Vaisala T/RH Sensor, Model HMP155, installed in an R. M. Young aspirator Model 53502

- **Barometric pressure:** Vaisala Digital Barometer, Model PTB330

- **Winds:** Vaisala Ultrasonic Wind Sensor, Model WMT700 (heated)

- **Data logger:** Vaisala QML201C

- **Tower:** The instruments are mounted on a Vaisala DKP210 tiltable mast at the SGP only. At all other sites the instruments are co-located on the MET system towers.

5.1 Units

Temperature: $^\circ$C
Relative humidity: %
Pressure: hPa
Wind speed: m/s
Wind direction: degrees

5.2 Range

Temperature: -80 to +60 $^\circ$C (-112 to +140 $^\circ$F)
Relative humidity: 0 to 100 %RH
Pressure: 50 to 1100 hPa
Wind speed: 0 to 75 m/s
Wind direction: 0 to 360 degrees

5.3 Accuracy

Temperature:
Accuracy with voltage output at:

-80 ... +20 °C	±(0.226 - 0.0028 x temperature) °C
+20 ... +60 °C	±(0.055 + 0.0057 x temperature) °C
passive (resistive) output according to IEC 751 1/3 Class B	±(0.1 + 0.00167 x |temperature|)°C

RS485 output
-80 ... +20 °C   ±(0.176 - 0.0028 x temperature) °C
+20 ... +60 °C   ±(0.07 + 0.0025 x temperature) °C

Relative humidity:
+15 to +25 °C (+59 to +77 °F)   ±1 %RH (0 to 90 %RH)
                                                              ±1.7 %RH (90 to 100 %RH)
-20 to +40 °C (-4 to 104 °F)   ±(1.0 + 0.008 x reading) %RH
-40 to -20 °C (-40 to -4 °F)   ±(1.2 + 0.012 x reading) %RH
+40 to +60 °C (+104 to +140 °F)   ±(1.2 + 0.012 x reading) %RH
-60 to -40 °C (-76 to -40 °F)   ±(1.4 + 0.032 x reading) %RH

Pressure:
Accuracy at +20 °C   ±0.20 hPa

    Total accuracy -40 to +60 °C (-40 to +140 °F)
    500 to 1100 hPa   ±0.25 hPa
    50 to 1100 hPa   ±0.45 hPa

Wind speed:
±0.1 m/s or 2% of reading, whichever is greater

Wind direction:
±2 degrees

5.4 Uncertainty

- Temperature and relative humidity: ±1.0 %RH (40 to 97 %RH) for +20 °C

- Barometric pressure: Calibration uncertainty: ±0.07 hPa

- Winds: Ultrasonic Wind Sensor Model: N/A

- QML201 Data Logger: Voltage measurement:
  For temperature range -50 to +60 °C
      ±5.0 V range   <0.06 % of reading ±100 µV
      ±2.5 V range   <0.04 % of reading ±50 µV
      ±250 mV range   <0.06 % of reading ±6 µV
      ±25 mV range   <0.06 % of reading ±5 µV

5.5 Input Voltage

110VAC

5.6 Output Values

Time, temperature, relative humidity, pressure, wind speed, wind direction.

6.0   Instrument System Functional Diagram

Vaisala proprietary information.

7.0   Instrument/Measurement Theory

Temperature measurement is based on resistive platinum sensors (Pt100).

Humidity measurement is based on the capacitive thin-film HUMICAP® polymer sensor.

Pressure measurement is based on a BAROCAP® silicon capacitive absolute pressure sensor.

Wind speed and direction is measured using ultrasound to determine horizontal wind speed and direction based on transit time of the ultrasound from one transducer to another. The transit time is measured in both directions for a pair of transducer heads. Measurements are calculated using two measurements for each of the three ultrasonic paths at 60º angles to each other.

More details are available from the Vaisala webpage reference materials listed in Section 15.0.

8.0   Setup and Operation of Instrument

The MAWS is configured as follows:

For the SGP site only, all of the MAWS sensors are mounted on a 10-m tiltable mast.

For all other sites, including the first ARM Mobile Facility (AMF1), second ARM Mobile Facility (AMF2) third ARM Mobile Facility (AMF3), Eastern North Atlantic (ENA), and North Slope of Alaska (NSA), sensors will be co-located with the MET instruments.

The digital barometer is mounted inside a weatherproof enclosure mounted at the base of the mast at a height of 1 m. The PTB330 uses a BAROCAP® silicon capacitive absolute pressure sensor developed by Vaisala. It has excellent hysteresis and repeatability characteristics, low temperature dependence, and a very good long-term stability. It is robust and resistant to mechanical and thermal shocks.

The T/RH probe is mounted inside an aspirated radiation shield that is mounted above the electronics enclosure at 2 m. The Vaisala HMP155 probe provides reliable humidity and temperature measurement. Humidity measurement is based on the capacitive thin-film polymer sensor. Temperature measurement is based on resistive platinum sensors. Both sensors are located at the tip of the probe, protected by a removable filter.

The ultrasonic wind sensor is mounted at the top of the 10-m mast. The Vaisala WMT700 wind sensor has an array of three equally spaced ultrasonic transducers on a horizontal plane. Wind speed and wind direction are determined by measuring the time it takes the ultrasound to travel from each transducer to the other two. The sensor has an onboard microcontroller that captures and processes data and communicates over serial interfaces.

The data logger, communications equipment, and backup battery as also housed inside the enclosure.

The mast has a lightning rod and grounding system installed.

The data-logging configuration is as follows.

Data are collected via the Vaisala QML201C data logger and Vaisala MetCast Observation Console software. The logger configuration file is created using Vaisala Lizard software. The name of the Lizard file used to create the uploadable logger file is US313v29.dtg. The MAWS setup file uploaded to the logger is called US313v29.adc and is uploaded using the Vaisala AWS Client software.

The data are collected in one-minute averages of 10-second samples (as set in the logger configuration file US313v29.dtg created with Vaisala Lizard software) and collected daily (daily file created by Vaisala MetCast Observation Console software).

The log files, which are collected daily, are created using the Vaisala MetCast Observation Console software. The configuration is created by clicking on the View → Settings menu. A "Settings" window will open.

1. Data acquisition: Select the radio box next to Serial Port. Input the appropriate COM port as set by the Moxa port-mapping software. Select Speed = 9600, Data bits = 8, Parity = None, Stop bits = 1.

2. Message format: Select SMSAWS from the pull-down menu.

3. PC data logging: In the Log groups box, check "Enable", Interval = All, Span of log file = Day. Columns = Aligned by header. Log group directory should be set to C:\ftphome. Data delimiter = Tab. Highlight the Log group LOG1 in the top middle of the window and choose "Select…" under the "Items" column. A secondary window will open; check the following variables: DPAVG1M, PAAVG1M, RHAVG1M, TAAVG1M, WDAVG1M, WSAVG1M. Click "OK".

9.0 Software

Vaisala Lizard Software: used to create the uploadable data logger setup file.

Vaisala AWS Client Software: used to access the data logger and upload setup file.

Vaisala MetCast Observation Console: used to display and collect data files.

10.0 Calibration

- Temperature and relative humidity: HMP155 is field calibrated annually.
- Barometric pressure: Digital Barometer Model PTB330 is field calibrated annually.
- Winds: Ultrasonic Wind Sensor Model WMT700 maybe be field checked if needed at any time.

11.0 Maintenance

Daily, bi-weekly, and annual preventive maintenance is performed on each component in the MAWS.

12.0 Safety

The MAWS is powered by 110VAC. Power should be turned off and locked out before any work is done inside the control panel enclosure.

13.0 Citable References

Vaisala WINDCAP® Ultrasonic Wind Sensor Series WMT700 User's Guide
http://www.vaisala.com/Vaisala Documents/User Guides and Quick Ref Guides/WMT700 User's Guide in English.pdf

Vaisala BAROCAP® Digital Barometer PTB330 User's Guide
http://www.vaisala.com/Vaisala Documents/User Guides and Quick Ref Guides/PTB330_User_Guide_in_English.pdf

Vaisala HUMICAP® Humidity and Temperature Probe HMP155 User's Guide
http://www.vaisala.com/Vaisala Documents/User Guides and Quick Ref Guides/HMP155_User_Guide_in_English.pdf

Vaisala HydroMet™ Data Collection Platform (Volume 1-3) User's Guide
Volume 1: http://www.vaisala.com/Vaisala Documents/User Guides and Quick Ref Guides/Hydromet Data Collection Platform Users Guide Vol 1 M210784EN-E.pdf
Volume 2: http://www.vaisala.com/Vaisala Documents/User Guides and Quick Ref Guides/Hydromet Data Collection Platform Users Guide Vol 2 M210785EN-E.pdf
Volume 3: http://www.vaisala.com/Vaisala Documents/User Guides and Quick Ref Guides/Hydromet Data Collection Platform Users Guide Vol 3 M210933EN-C.pdf

Vaisala Observation Display for AWS330 User's Guide
http://www.vaisala.com/Vaisala Documents/User Guides and Quick Ref Guides/Observation_Display_User_Guide_in_English.pdf