

Procedure to Establish a Meteorological Sensor Reference Mark and to Measure Meteorological Sensor Heights

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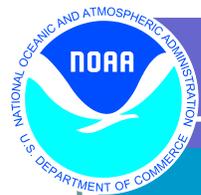
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1. **Title** Procedure to Establish a Meteorological Sensor Reference Mark and to Measure Meteorological Sensor Heights
2. **Purpose**
This SOP explains the procedure to establish a Meteorological Sensor Reference Mark (Met SRM), and to measure meteorological sensor elevations referenced to the Met SRM. It also includes guidance on choosing a Met SRM at different types of stations, as well as documentation requirements. Compliance with these procedures ensures complete documentation of meteorological elevations and allows CO-OPS to provide users with sensor and site elevations at CO-OPS-owned stations. Partners are also required to provide these metadata as part of the documentation requirements.
3. **Background/History**
Historically, all meteorological sensor heights had been referenced to station datum (SD), consistent with oceanographic metadata collection methods; however, the National Weather Service (NWS) and other meteorological data users require heights above ground, rather than above station datum for modeling, research, and other purposes. Therefore, CO-OPS now uses a Met SRM that is established on the surface where the station is installed (typically the ground) and measures the wind, air temperature, relative humidity, and visibility sensor elevations above the Met SRM to meet these user requirements. The barometer, conductivity, and water temperature sensors shall continue to be reported above SD to obtain a tie to Mean Sea Level (MSL) or Mean Lower Low Water (MLLW). Users also require a site elevation to ascertain whether a station is located on a large hill or at the shoreline. The Met SRM elevation is used to define the site elevation at the location of the meteorological sensors.

There are three main categories of stations for which measurement procedures and documentation requirements may vary: Coastal, Stand-alone Met and Remote Met.

- Coastal stations are primarily water level stations (including the Great Lakes) in the vicinity of a BM network. *e.g. 8413320 Bar Harbor, ME*
- A Stand-alone Met station consists solely of meteorological sensors and therefore may not be accompanied by a suite of tidal BMs. *e.g. 8574729 Francis Scott Key Bridge, MD*



- A Remote Met station is associated with a nearby water level station but may not be located in the immediate physical vicinity of the water level station or the BM network. *e.g. 1612480 Mokuoloe, HI*

4. **Scope/Applicability**

This SOP applies to FOD field crews and contractors conducting an installation or annual maintenance at a station with at least one meteorological or physical oceanographic sensor installed (winds, air temperature, water temperature, barometric pressure, relative humidity, and conductivity). Procedures shall also be conveyed to any partner-owned stations to ensure complete metadata records.

5. **Main Processes**

All elevations shall be measured and documented when a station is upgraded with a new meteorological sensor, when a sensor or station has been relocated, or a new Met SRM has been established. Methods to obtain the Met SRM and sensor elevations will depend upon the type of station that the sensors are located at (a coastal station versus a stand-alone or remote met station).

A Met SRM is used to mark a point on the ground (and thus define “ground” location) that provides a reference for measuring certain meteorological sensor elevations.

1. Establish a Met SRM location if it is not already established, or identify a nearby BM that can be used as a Met SRM.
2. Level to the Met SRM to obtain an elevation
3. Provide Met SRM photographs
4. Measure meteorological and physical oceanographic sensor elevations:
 - a. Above Met SRM for winds, air temperature, relative humidity, and visibility.
 - b. Above SD for barometer, water temperature, conductivity.
5. Document in the site report the Met SRM elevation, a Met SRM description, met sensor elevations, and any comments.

Rainfall, Solar Radiation and Dew Point sensors are not declared operational at present or displayed on CO-OPS webpages even though they may be used at OSTEP test stations or by partners; however, if these sensors become part of the CO-OPS meteorological suite, then elevations shall be reported above Met SRM.

6. Detailed Sub-Processes/Checklists

1) **Establish or identify a Met SRM:**

The Met SRM will typically be at the base of the met tower for standard installations where the tower is next to the station.

Exception: Sentinels

Sentinels are single-pile platforms surrounded by water, thus we consider Met SRM to be the water surface and the elevation to be 0 m above MSL. A Met SRM does not need to be established at these locations. Met sensor elevations are still required (see section 4a for detail).

- a) If there is a nearby BM that can be identified as a Met SRM (**Figure 1**), it must be:
 - Within a 3 m (10 ft) radius of the met tower, AND
 - On a flat surface (less than +/- 15 cm (0.5 ft) elevation change between the tower/pole and BM).
- b) A bolt used to anchor the met tower can be used as the Met SRM. This bolt shall be marked in such a manner so that it can be described and recovered by others in the future.

Appendix A (Choosing a Met SRM Location) provides further guidance on establishing a Met SRM at a variety of different stations.

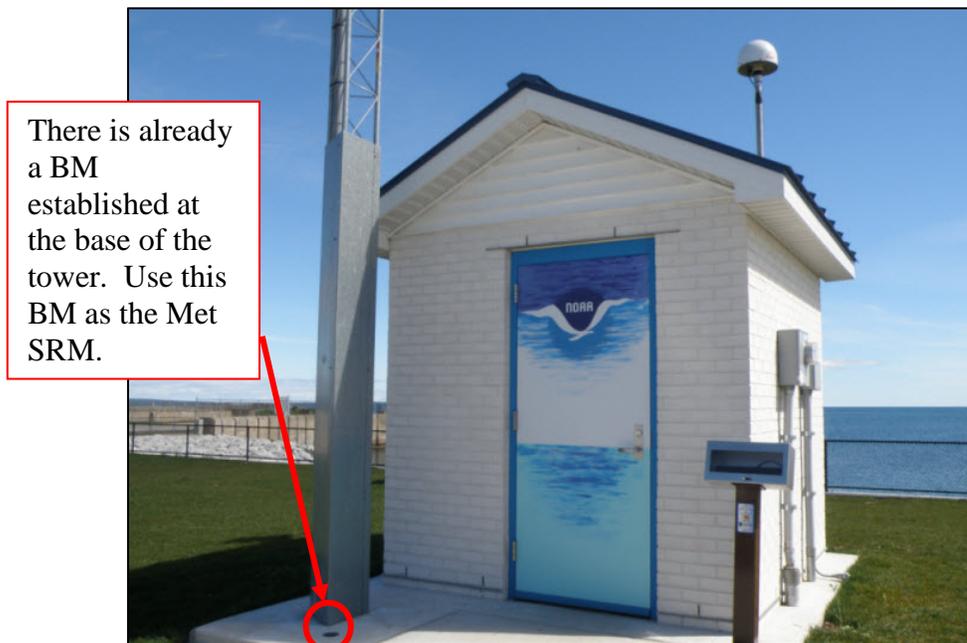
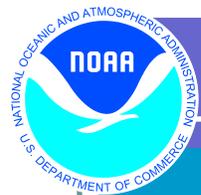


Figure 1. 9075080 Mackinaw City, MI. Example of a station with a nearby BM that can be used as the Met SRM.



2) Measure the Met SRM elevation (aka “site elevation”):

Elevations will be referenced to one of three possible datums, depending on the type of installation:

- ❖ Coastal stations: Report value above SD.
- ❖ Great Lakes stations: Report value above IGLD.
- ❖ Stand-alone and Remote Met stations: Report value above the water surface or above MSL. The value above the water surface must contain a date/time so that it can be converted by the COET into an elevation above MSL.

The Met SRM elevation per station will be manually entered in DPAS by COET (5.x *Procedure to Enter Met SRM Elevations in DPAS*).

Coastal/Great Lakes Water Level Stations with a nearby BM network:

- a) The Met SRM shall be connected via line leveling to at least one BM at a water level station so that the Met SRM elevation and the meteorological sensor elevation above SD or IGLD can be determined.
- b) If a nearby BM is substituted for the Met SRM, it must be included in the leveling run only if the elevation has not been documented (or as COET requires). Specify the BM in the comments section of the site report.
- c) If the station is at a high elevation or in an area that poses safety issues making it impossible to level in the Met SRM, then see the section below on **stations or sensors that pose safety issues**.

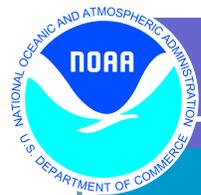
Stand-alone and Remote Met stations:

There is no single best fit method to obtain a tie to MSL without the presence of BMs since every stand-alone/remote met station will present unique situations. The following guidelines will provide the field crew with various methods to obtain a Met SRM height relative to MSL. It will be up to the judgment and discretion of the crew chief to choose the method that best fits the situation facing him/her at a particular station.

- In certain situations there may be a published BM sheet or a data sheet available (NGS or USGS BMs that would give a site elevation) in the area of a stand-alone met station. If the BM has a published elevation, then the field crew can level to the mark from the Met SRM to obtain a tie from the Met SRM to MSL. Provide the specific BM sheet or resource used in the comments section of the site report.
- In the absence of a published BM elevation, level from the Met SRM to the vicinity of the water surface. **Provide the date and time of measurement in GMT. COET will use this information to estimate the relationship of the measurement to MSL using nearby observations or predictions.**

From this point there are several methods that may be used to obtain a height of the average water level:

- a) If there is a bulkhead present use a steel tape to measure from the Met SRM down to the water surface.



- b) A level rod may be held as close to the water surface as possible. This method may be difficult to obtain a steady elevation but still remains viable.
- c) A spike may be set and leveled to the shoreline at a height that best represents the average water level based on the judgment of the crew chief.
- d) A "staff" may be driven into the sea/lake floor and leveled to the top of the staff. The instantaneous water level may then be read off the staff.

Exception: Stations with two or more Met SRMs

Note that this situation should be rare. Identify all Met SRMs in the comments section of the site report.

➤ **Met sensors at a single station that are NOT co-located:**

Example: an anemometer that is installed one mile from the water level station, yet the air temperature is installed at the water level station.

- Identify an air temperature Met SRM and a wind Met SRM.
 - The wind Met SRM would be located at the base of the wind tower, and elevation measurement requirements would follow those for a remote met or stand-alone met station.
 - The air temperature Met SRM would be a nearby BM or located at the base of the air temperature tower, and the air temperature Met SRM would be leveled in, due to its close proximity to the parent water level station's BM network.
- Naming convention: 'SRM xxx xxxx MET AT' and 'SRM xxx xxxx MET WD,' for the air temperature SRM and the wind SRM, respectively.

➤ **Redundant water level stations:**

Example: A water level station that has an entire redundant water level station, both complete with meteorological sensors.

- Identify a primary station Met SRM and a redundant Met SRM, if the met sensors are all co-located with their respective water level stations,
 - Each would be located at the base of the meteorological tower.
- Naming convention: SRM xxx xxxx MET 1 and SRM xxx xxxx MET 2 to denote the primary and redundant station, respectively.
- If the winds and air temperature sensors are not co-located, then there could be four possible Met SRMS, for each sensor at each station: 'SRM xxx xxxx Met AT1,' 'SRM xxx xxxx MET AT2', 'SRM xxx xxxx MET WD1' and 'SRM xxx xxxx MET WD2.'

3) Take a photograph of the Met SRM.

Ensure that the Met SRM is clearly marked in the photograph. Figure 2 provides an example.

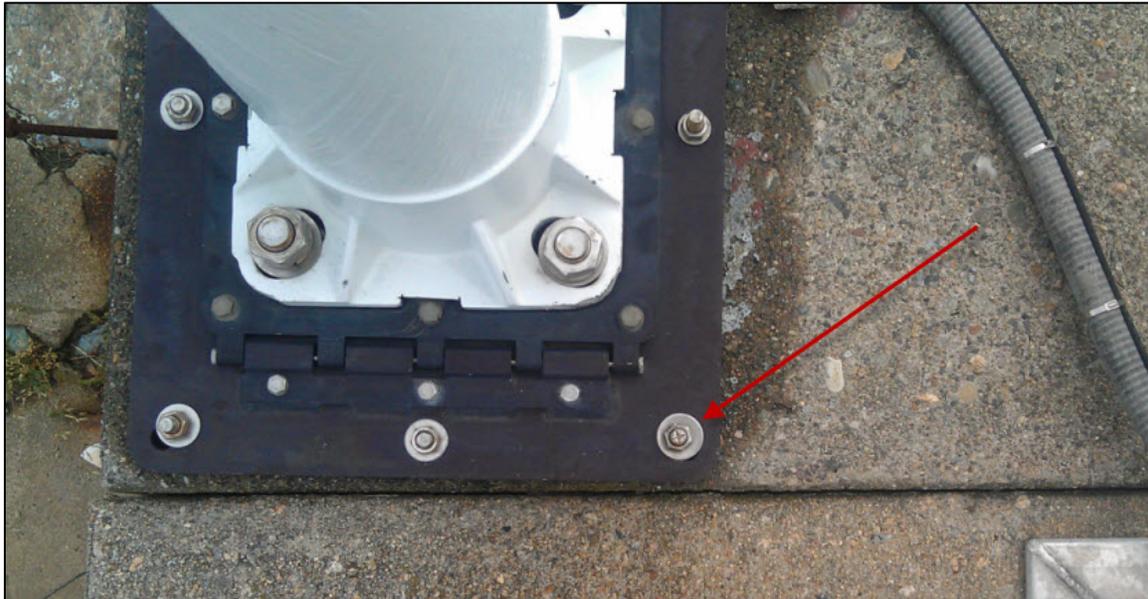


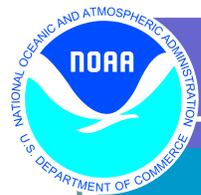
Figure 2. Example of a Met SRM photograph (8452660 Newport, RI). Note the Met SRM is marked by a cross-hatch in the tower bolt.

- a) One photograph must show the Met SRM at close range.
- b) Two photographs in perpendicular directions must show the Met SRM location relative to the met tower.

4) Measure all sensor elevations:

Sensor heights **must be measured to the nearest 30 cm (1 ft)**. Measurements are to be made to the middle of the sensor for winds, air temperature, relative humidity and barometric pressure. For visibility sensors, measure to the inward facing bottom edge of the transmitter or receiver unit.

- a) Measure wind, air temperature, relative humidity and visibility sensors above the identified Met SRM (bolt or nearby BM) in order to establish the height of the sensor above “ground.”
 - Sentinels: If the sensors are installed at a sentinel, then the Met SRM is considered the water surface and, as mentioned in section 1 above, is simply 0 m above MSL. Obtain a measurement of these sensors above the water surface and document in the field labeled “Height above Met SRM (m)” in the eSite.



- b) Measure conductivity, water temperature and barometric pressure sensors relative to SD. These requirements have not changed.
- c) For sensors mounted in an area that is dangerous, obtain an elevation above MSL.
- d) IF there is a barometer at a stand-alone or remote met station, measure the elevation above the Met SRM. From there, COET can calculate the elevation above MSL.

➤ **Stations or sensors that pose safety issues:**

Some stations are located on a high bridge or atop a lighthouse. In these instances, obtaining a Met SRM or a sensor elevation might be too difficult or dangerous to adhere to the routine procedures. In these particular cases, the following procedures shall be used:

- Met SRM elevation: A handheld GPS unit referenced to MSL may be used to obtain an elevation above MSL. (e.g. from the surface of a bridge to the water level).
- Met sensor elevation: If the elevation above Met SRM cannot be determined, use the GPS unit to obtain the sensor elevation(s) above MSL.
- Document the safety issue and alternate measurement methods used in the comments section of the site report, complete with the manufacturer/model of the instrument used to determine the elevation. This information will be taken into account for the following year's Project Instructions input, and also informs the accuracy of the measurement, which must be conveyed to the public.

Also see *Appendix A* for procedures for high-elevation installations.

5) Document Met SRM and Sensor Elevations and Comments

All values must be submitted in meters.

- a) Enter the winds, air temperature, relative humidity or visibility sensor elevations in the eSite report in the fields labeled "Height above MET SRM."
 - Sensor elevations that are obtained above MSL must be included in the comments section of the site report, and NOT in the field labeled "Height above Met SRM."
- b) Enter the barometer, water temperature and conductivity elevations in the appropriate field labeled "Height above Station Datum."
 - A barometer elevation obtained above MSL must be included in the comments section of the site report, and NOT in the field labeled "Height above Station Datum."
- c) **Always identify what is used as the Met SRM.** Enter this information in the comments section for the wind and/or air temp sensors. e.g. "Met SRM is the northwest bolt at the base of the wind tower." See **Figure 3**.

- If a nearby BM is identified as the Met SRM, then document the name of the BM. *e.g.* Met SRM is BM 975 5371 A. **See Figure 4.**
- d) IF NOT using a nearby BM as a Met SRM, then enter the leveled Met SRM elevation above SD in the eSite “Bench Mark Elevations” tab with a designation of “SRM [Station ID] MET.” *e.g.* SRM 863 8863 MET. **See Figure 5.**
 - If using a nearby BM, then that BM elevation will already be captured in the leveling run and eSite report as part of standard leveling requirements.
- e) Add a standard description of the Met SRM to the BM description file. If the Met SRM has been identified as a nearby BM, then it is only necessary to state the BM name as the Met SRM description.
- f) Other information to include in the comments section of the site report:
 - The date/time of the measurement of the Met SRM height above the water surface, if applicable.
 - If a GPS unit or laser range finder was used to obtain an elevation above MSL, then this must be documented in the site report so that the COET can convey to users the level of accuracy associated with this measurement.
 - If a site is too precarious for a height measurement within the 30-cm accuracy, note this circumstance in the site report so that the following year’s project instructions will document this fact.
 - If a stand-alone or remote met station has a barometer, measure the barometer height above the Met SRM. COET will determine the barometer elevation above MSL by using the Met SRM elevation.

Ancillary Equipment Information					
WIND SENSOR					
Station ID	9449419	DCP #	1	Date Installed	12/04/2007 01:00
Type	RM Young Wind	Serial #	80412	Date Removed	
Height Above MET SRM (m)	7.000	Cable		Model	
Manufacture	R. M. Young	Cable Length (m)	9.1400		
Latitude	48° 51' 36" N	Longitude	122° 45' 25.2" W		
Elevation		Elev Ref		Sensor ID	C1
Sensor Comments					
2012: Replaced nose cones, checked directions. Measured height above SRM (7.000m) SRM is bolt at base of wind mast. Measurement from Met SRM to water at 17:58 UTC on 4/18/2012 was 5.570m.					

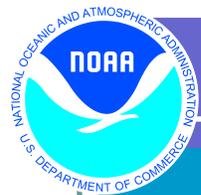
Figure 3. 9449419 Cherry Point South Dock, WA Stand-alone Met Station. eSite documentation for the anemometer elevation above Met SRM, and a comment that provides the Met SRM elevation above the water surface.

AIR TEMP SENSOR							
Station ID	1611400	DCP #	3	Date Installed	01/13/2009 00:00	Date Removed	
Type	YSI Air Thermistor		Serial #	*174		Model	
Height Above MET SRM (m)	1.9348		Cable			Cable Length (m)	
Manufacture	Yellow Springs Instrument Company						
Latitude	21° 57' 12.9" N		Longitude	159° 21' 11" W			
Elevation			Elev Ref			Sensor ID	D1
Sensor Comments							
Note 2012: SRM is bench mark 161 1400 J							

Figure 4. eSite documentation for air temperature elevation above Met SRM, and a comment that identifies a nearby BM used as a Met SRM.

Leveling Equipment						
ITEM	TYPE		SERIAL#			
Zeiss Ni2	Level Instrument	Compensator Level	101641			
Nedo (cm)	Level Rod	Checkerboard	NOSERIAL#			
Designation	Condition	Most Recent Elevation (m)	Most Recent Date	Present Elevation(m)	Difference (m)	L
182 0000 TIDAL 8		2.8530	10/18/2010	2.853	.	8° 43' 5
182 0000 TIDAL 5		2.8476	10/18/2010	2.8483	.0007	8° 43' 5
182 0000 TIDAL 6		3.6723	10/18/2010	3.6723	.	8° 43' 5
182 0000 TIDAL 9		3.3551	10/18/2010		.	8° 43' 5
182 0000 TIDAL 11		3.1622	03/17/2010	3.1628	.0006	8° 44' 9
182 0000 TIDAL 12		2.8240	10/18/2010	2.8277	.0037	8° 43' 5
182 0000 M		3.2628	10/18/2010	3.2659	.0031	8° 43' 5
TBM 182 0000 AQUATRAK		4.6156	10/18/2010	4.6199	.0043	8° 43' 5
182 0000 N		3.4448	10/18/2010	3.4445	.0003	8° 43' 5
182 0000 R		4.0861	10/18/2010		.	8° 43' 5
182 0000 S		3.2396	03/17/2010	3.2403	.0007	8° 44' 3
SRM 182 0000 Met				3.2084		8° 43' 5

Figure 5. eSite documentation of the Met SRM that was tied to SD and reported in the leveling run. Note the syntax of the Met SRM (SRM xxx xxxx Met).



Checklist:

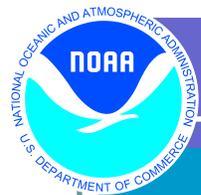
- All elevations are provided in meters.

Met SRM:

- If the station is a Sentinel, then the Met SRM is NOT identified (skip to **Sensors**).
- The Met SRM(s) is/are identified in the comments section, whether it is a nearby BM or a bolt.
 - If a nearby BM is used, it is within a 3-m (10-ft) radius and on a flat surface (+/- 15 cm (0.5 ft) elevation change).
- A standard description is included in the BM description file.
- Met SRM photographs were taken.
- The Met SRM is marked (e.g. a cross stamped in a bolt) for future reference, unless a nearby BM is used.
- The Met SRM is included in the leveling run.
- The Met SRM elevation is documented in the site report (comment section).
 - If more than one Met SRM has been identified, then all Met SRM elevations are documented in the site report comments section (per sensor or station), following the correct naming conventions.
 - If the elevation is provided above MSL, this is noted in the comments section.
 - If the elevation was measured to the water surface, the date/time of the measurement is included in the comments section.
 - If the elevation was obtained via a handheld GPS unit or a laser range finder, this is documented in the comments section.

Sensors:

- The barometer was included in the leveling run to obtain an elevation above SD (unless there is no nearby BM network).
 - The barometer elevation is obtained above MSL in the absence of a BM network.
- Water temperature, barometric pressure and conductivity sensor elevations are provided in the field labeled “Height above Station Datum.”
- Winds, air temperature, relative humidity, and visibility sensor elevations are provided in the field labeled “Height above MET SRM.” Includes measurements obtained at Sentinels.
 - If a sensor elevation is provided above MSL, it is submitted in the comments section and NOT in the field labeled “Height above Met SRM” or “Height above station datum.”
 - If the 30-cm accuracy is not feasible, a note is included in the comments section.



7. **Management/Responsibility** The ED Branch Chief manages field and metadata requirements. Specific meteorological measurement requirements are supplied by the COET and approved by ED management. COET is responsible for maintaining this SOP.

8. **Quality Assurance/Control** COET reviews all incoming site reports and will determine if any errors were made. COET will provide any additional guidance as necessary. Any questions about a Met SRM location should be directed to COET.

9. **Change History**
11/12/2014, Kathleen Bailey: Removed Met Team, updated OET to COET, removed the requirement to update the SRM elevation and sensor heights every 5 years unless a sensor was relocated.

Appendix A: Guidelines for Met SRM Locations

Given the variety of installation types, it is not always clear where the Met SRM should be located. The rule of thumb is to locate the Met SRM on the ground surface, however there are certain exceptions. Met SRM is used to determine a site elevation; therefore, it is important to note the location of the station itself, usually defined by where the DCP housing is located. Several examples are provided below for guidance on Met SRM locations:

Pier: Ground is considered the base of the met tower/pier surface. The Met SRM will be the base of the met tower or a nearby BM will substitute as the Met SRM.

DCP housing for 8727520 Cedar Key, FL in **Figure A.1.** is installed on an elevated platform; therefore, the Met SRM (red arrow) shall be established on the surface of this platform so that the site elevation accurately represents the station elevation. The DCP housing for 8536110 Cape May, NJ (right) is installed at the base of the tower. Therefore, the Met SRM shall be located at the base of the structure where the winds are mounted.

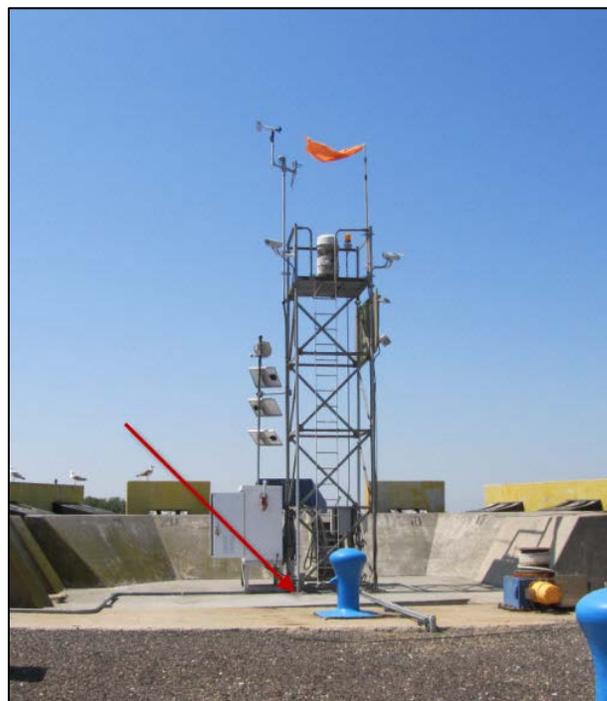
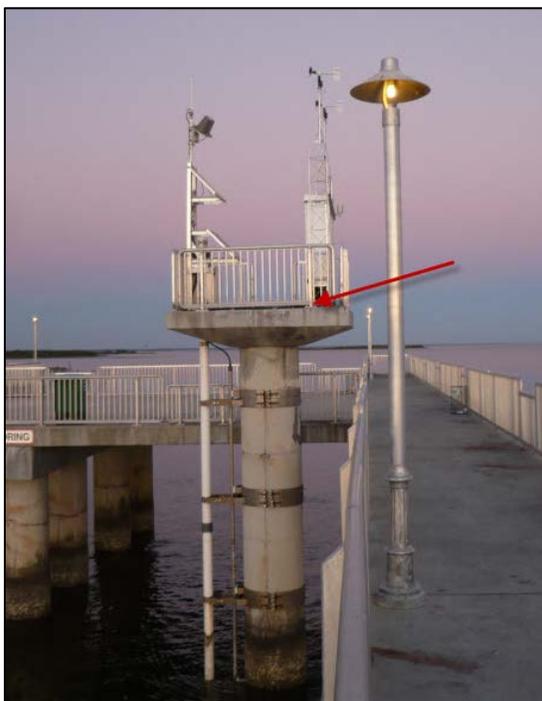


Figure A.1. 8727520 Cedar Key, FL (left) and 8536110 Cape May, NJ (right). The red arrow points to the location of the Met SRM. Note the location of the DCP housing.

Rooftop: Ground is considered the base of the building. Establish a Met SRM on the ground at the base of the building. Sensor elevations shall be measured from the sensor to the base of the building or to a nearby BM. If the rooftop is high enough to pose safety issues, see the section below on elevation procedures for **high-elevation installations**. Note that the Met SRM should still be the ground, and not the base of the met tower.



Rooftop



Sentinel

Sentinel: Sentinels are unique because they are single-pile platforms surrounded by water. The Met SRM would technically be at the base of the tower, but this is the water surface. Therefore, the Met SRM for sentinels is always known to be 0 m above MSL, and does not need to be identified, measured or documented. Winds, air temperature, relative humidity and visibility elevations shall be measured to the water surface.

Lighthouse: Ground is considered the base of the lighthouse or at the location where the DCP is installed. In general, the Met SRM should be located at the base of a lighthouse. Sensor elevations will be measured from sensor to an established Met SRM located at the base of the lighthouse, or to a BM nearby the base of the lighthouse. If it is a shore-based lighthouse, then the Met SRM should be located as close to the ground as possible (**Figure A.2**).



Figure A.2. Two lighthouses with winds installed at the top, one shore-based (9014098 Fort Gratiot, MI, left) and one surrounded by water (8537121 Ship John Shoal, NJ, right). The Met SRM location is denoted by the red arrow.

High-elevation installations: A ship or bridge installation poses safety issues due to the high elevation, and typically requires fall protection gear. Therefore, obtaining Met SRM and sensor elevations may prove to be too difficult, depending on the installation. In these cases where steel tape measurements may not be possible, a handheld GPS referenced to MSL or a laser range finder to obtain an elevation above the water or mounting surface may be used. Document which device was used in the site report.

For a bridge or ship installation:

- 1) Establish a Met SRM on the bridge surface (e.g. roadway) or ship deck surface that supports the structure that the met sensors are installed on.
- 2) Obtain a Met SRM elevation above the water, deck, or referenced to MSL. Note the date/time of the measurement.
- 3) Obtain the met sensor elevations referenced to the Met SRM or to MSL.
- 4) Document all values (even sensor elevations) **in the comments section of the site report and NOT in the field labeled “Met SRM.”**

Once the documentation is submitted, COET can review the elevations to calculate a sensor height above Met SRM with the information provided. Furthermore, COET may consult a nautical chart to determine the bridge elevation as well. Values conveyed to users will thus contain information about uncertainty associated with the measurements.



Figure A.3. 9410172 USS Midway, CA. The winds are located at the top of the ship tower. The Met SRM (red arrow) should be at the base of this tower on the deck surface (if possible).



Figure A.4. 9415118 Union Pacific Railroad Bridge, CA. The winds are mounted at the top of the bridge, but the bridge surface presents the best Met SRM (red arrow).