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Deploying Weather Stations: A Best Practice Guide



Introduction

From the tropics to the poles, climate, agriculture and other types of researchers rely on unattended research-grade, data logging weather stations. For example, the US Department of Agriculture uses weather stations to study anything from molecular plant pathology to forest management. Non-government groups, such as universities, use weather stations to study a wide array of subjects including how glacial activity affects air temperature. Additionally, commercial companies depend on weather stations to conduct businesses. Paul Sloan, owner of Small Vines Vineyard, uses a research-grade weather station to determine placement of protective windscreens. He says, "Since data loggers are so portable, we can take temperature readings at different points up a hill during the course of the year and find where the frost line ends."

Weather stations monitor environmental parameters such as temperature, wind speed, wind direction, rainfall, soil moisture, barometric pressure and photosynthetically-active radiation (PAR). Researchers using weather stations typically require highly accurate and reliable measurements over long periods of time. Moreover, their deployments are often located in harsh environments. Since weather stations monitor conditions 24/7 at a specific site, researchers can obtain precise measurements instead of making estimates based on regional weather data.

Weather Station Components

A typical weather station consists of a data logger and sensors mounted on a metal tripod. The system typically runs on battery power or a combination of solar power and a rechargeable battery. Key components of a weather station include:

- Data logger
- Sensors
- Cables
- Tripod or other mounting system
- Grounding
- Securing equipment such as guy wires

The data logger is the central unit within the weather station. Its primary components are a microprocessor, data input channels, battery, and a weatherproof enclosure. Researchers should consider the number of data input channels a data logger provides before purchasing. This number determines how many sensors can be added to the weather station. Next, researchers should consider how weatherproof the housing is. Good weatherproofing ensures electronic components stay dry and function properly in wet or otherwise harsh outdoor environmental conditions.

Data loggers record and store data collected from sensors at preset intervals. Researchers retrieve this data by offloading it to a PC or Macintosh computer, or a data "shuttle" transfer device, or by accessing it remotely via cellular, Wi-Fi, or other types of remote communications.

Site Locations and Sensor Placement

A weather station's site location, and how its sensors are placed, play key roles in gaining accurate measurements.

Weather Station Positioning

Some researchers need data on general weather conditions for an area. In these applications, researchers should place their weather stations in open, unobstructed locations. Buildings and trees can affect temperature, relative humidity, rainfall, wind speed, and wind direction. For this reason, weather stations should also be at a distance of at least ten times the height of nearby trees and buildings away from these obstructions.

In many cases, researchers use weather stations to measure microclimates. For instance, a researcher might measure microclimates to learn how elevation affects temperature in a given area, while another may study how the absence of a tree canopy affects a microclimate. Although meteorological guidelines are helpful for setting up weather stations that measure general weather conditions, these guidelines may not apply for measuring microclimates. In these cases, researchers choose sites specific to their study and usually use multiple stations on various sites or move individual weather stations during the course of their research.

Weather Station Deployment Tips

Researchers typically use a tripod when deploying their weather stations. They mount their sensors either on the tripod or run cables to nearby locations. If using a tripod, it must be secured so that it will withstand the maximum possible winds for the site.

When assembling the tripod, stay organized and build as much of the weather station indoors as possible. This cuts down on losing important small parts. At the site, lay down a tarp and place all tools and components on top.

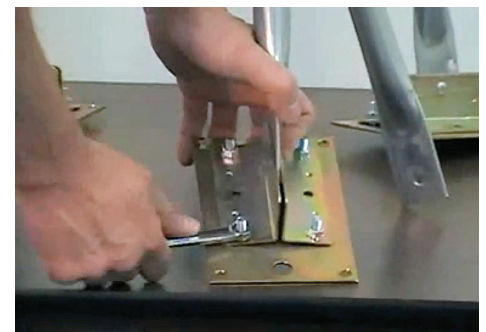
Some researchers mount sensors on the upper mast of the tripod before it is attached to the lower mast. This makes it easier to attach the sensors. To do this, stand the upper mast upright and use zip ties to attach it to one leg brace and one leg of the tripod. Once the cross arm and sensors are installed, remove the zip ties and place the upper mast on top of the lower mast. Then make final sensor height adjustments and leveling.

To help prevent corrosion of sensors and sensor ports, it is good practice to spray WD40 or a similar lubricant on sensor ports prior to plugging in the sensors.

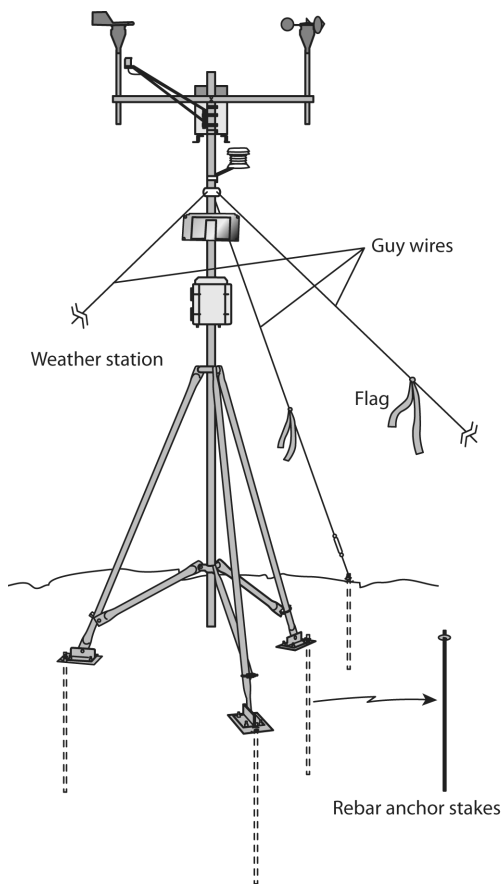
The data logger should be mounted on the mast so that the cables come out the bottom of the logger. This enables cables to hang down, which prevents water drops on the cables from entering. If the logger has a vent, be sure the vent is oriented per the vendor's recommendation to properly ventilate. For example, a Gore® vent must be on a vertical side of the logger.

Anchor legs with rebar stakes through the feet of the tripod. Then add guy wires. Finally, flag guy wires so people and animals do not run into them.

Weather stations should be located at least ten times the height of nearby trees and buildings away from these obstructions.



Partial assembly of a weather station indoors can help reduce the loss of small parts in the field.



Sensor Placement

Once the weather station is suitably placed, sensors need to be properly positioned to gather accurate measurements. The following table shows recommendations for positioning certain types of sensors:

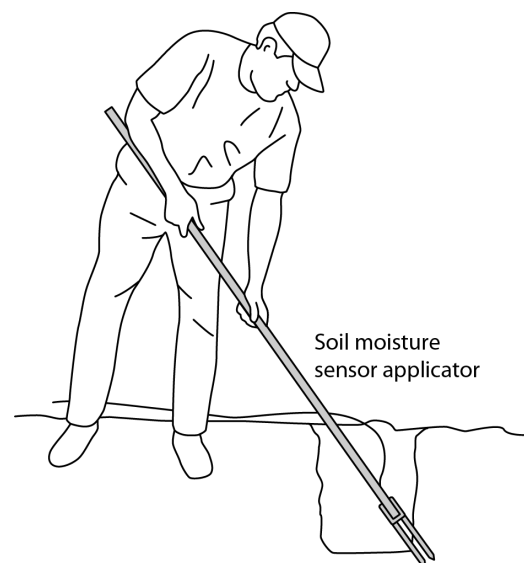
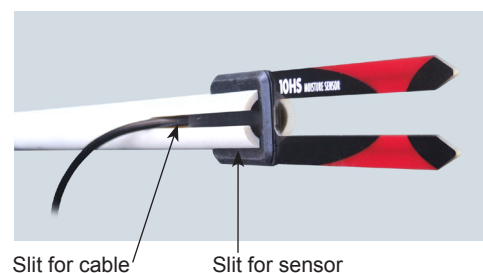
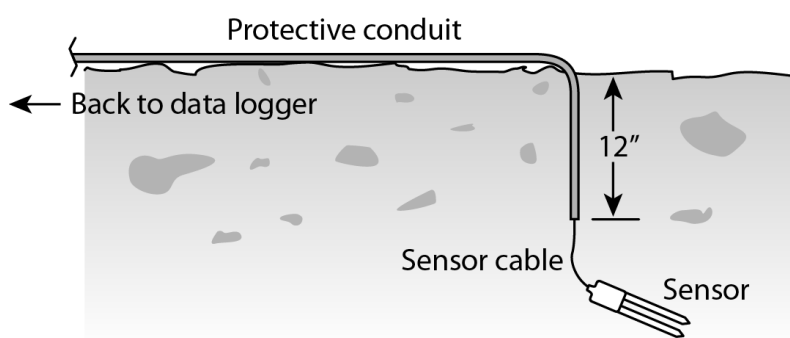
Sensor	Positioning
Solar radiation, PAR	Mount on a mounting arm or bracket on the south side of the mast if in the northern hemisphere so that it will not fall into the shade of the mast or other sensors. Point sensor up and properly leveled.
Wind speed and wind direction	Attach to the top of the upper mast and set the wind direction sensor to read 0 or 360 degrees when pointing north. Whenever possible, position sensors at the same height for all stations. If one sensor is placed lower or higher than another, the wind data can not be directly compared. Wind speeds are typically lower closer to the ground.
Soil moisture	Place in an area of the soil with only a few rocks and pebbles. If probes touch rocks or pebbles, measurements can be inaccurate. Set soil sensors far enough away from the tripod to avoid being in the shadow of the tripod.
Rainfall	Place sensor so the top is one meter above the ground, on a separate mast at a distance away of at least twice the height of the weather station.
Leaf wetness	Mount as close to plant canopy as possible. However, position far enough away from trees so plant leaves do not touch the sensor. This will also help sensors avoid coming in contact with chemical plant sprays.
Barometric pressure	Use weatherproof barometric pressure sensors and mount outside of logger enclosure, since enclosure seals and vents can cause pressure inside housing to differ. The height of the barometric sensor is not a factor.

Installing soil moisture sensors:

Accurate soil moisture measurement probes need to have good contact with surrounding soil. Here are some tips to help with installation:

- Install the sensor probes into undisturbed pebble-free soil.
- For deeper soil moisture measurements, use a soil auger to dig a hole. Ideally this should be angled, so that the soil above the sensor is undisturbed. Then push probes into undisturbed soil at the bottom of the hole.
- Use a PVC pipe with three slits made at 90-degree angles at the end of the pipe: two slits for the sensor and a longer slit for the cable.

After installing the sensor into the soil, partially backfill the hole, allowing soil to settle around the sensor. Pack the soil to the same density as the undisturbed soil. Then thoroughly water the soil around the sensor to cause the soil to fully settle around the sensor.



Here are some general tips for positioning sensors:

- To better account for spatial variability, for parameters such as rainfall, attach two or more identical sensors on the same weather station. Place one on the tripod and the other several feet away.
- In general, avoid placing sensors near radio, television, or microwave towers and equipment. Strong electromagnetic interference may cause sensor reading errors.
- To avoid fatal shock, do not set up weather stations near power lines.

After positioning sensors correctly on the tripod or at other locations, attach the sensor cables to the logger.

Relative humidity, barometric pressure, wind direction and wind speed, and PAR sensors should be checked or calibrated annually.

Weather Station Configuration

While some data logging weather stations can be difficult to configure and often require the services of a professional system integrator for setup, today's most advanced systems do not require programming or complex wiring. Instead, these systems leverage Smart Sensor technology, that provides the user with plug-and-play performance: once a sensor is plugged into the data logger, it is automatically recognized and can begin taking measurements. This type of system architecture can significantly reduce setup and deployment time, and reduce or eliminate the need for specialized integrator assistance.

In some cases, sensors will require calibrating before the deployment is started, and periodically during deployment. For example, silicon pyranometers are calibrated for use under open sky conditions. To recalibrate for microclimates, such as under tree canopies, some researchers use an additional thermopile pyranometer to calibrate readings for the conditions.

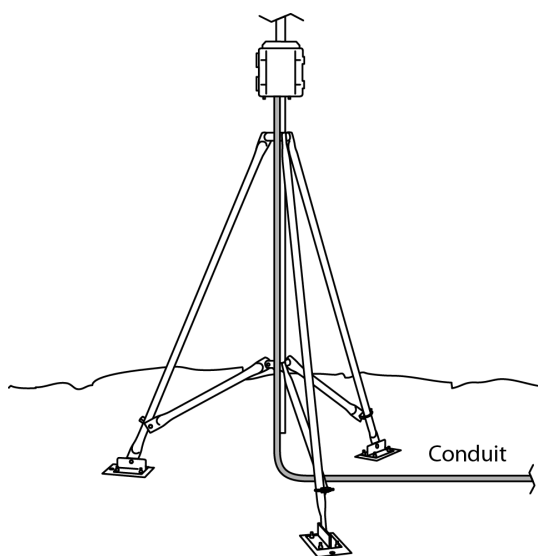
Rain gauges may also need calibrating. This should be performed in the field by pouring water into the gauge at a controlled rate and checking that the correct amount of this simulated rainfall is recorded. Adjust rain gauge screws until it provides the correct reading.

Relative humidity, barometric pressure, wind direction and wind speed, and PAR sensors should be checked or calibrated annually. Some researchers switch out sensors that need calibrating with backup sensors.

Multiple sensors or multiple weather stations can be checked against one another. Before deploying groups of sensors or weather stations, run them all in one location. Check data for inconsistencies. Then use this data to determine if any sensors should be calibrated or replaced.

Sensor Cable Protection

Lawn mowers, tractors, and chemicals can damage sensor cables. Moreover, rodents, birds, cattle, and other animals can bite, peck, or trample on sensor cables. For this reason, researchers often cover cables with conduit. Protect cables buried in the ground as well. Use a plumber's snake to pull wire and cables through conduit. Rain gauges also need protection. Birds like to build nests inside these inviting resting spots. Attach spikes around the rain gauge to deter birds.



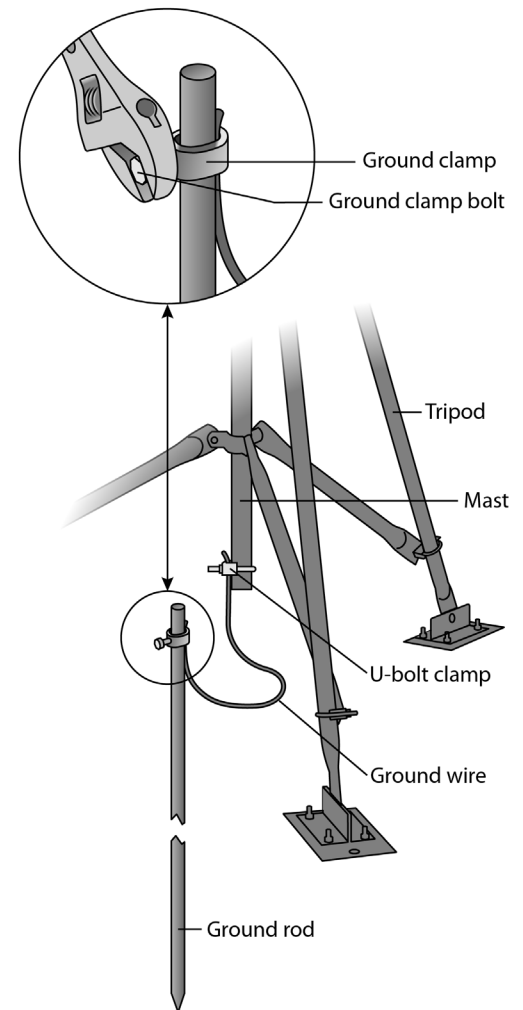
Proper Grounding

Proper grounding of a weather station is advisable, as it provides protection from electrical interference and thus can help minimize the chance of system failures in the field. An 8-foot ground rod is recommended, but a 4-foot ground rod is often sufficient. In most instances, driving the grounding rod directly into the ground is straightforward; however, sometimes site factors require creative thinking. If a weather station is on an industrial roof top, you can connect the ground wire to an AC unit chassis that is properly grounded.

Battery Maintenance

Weather station data loggers are typically powered by either regular batteries or rechargeable batteries. Rechargeable batteries are recharged with power from a solar panel. If the weather station is sited near the equator (i.e. Southern US), a 1-watt solar panel may generate enough power to sufficiently charge batteries. However, if the same weather station is farther away from the equator (i.e. Northern US), then a 6-watt solar panel may be necessary due to fewer daylight hours at certain times of the year. In some climates, even a high-wattage solar panel is not enough to keep a rechargeable battery going in the winter, especially in fog. In this case, you will need additional batteries for backup. (See manufacturer for specific recommendations.) In these extreme cases, you need to do a power-budget analysis to be sure your system has enough power.

As a general rule, replace rechargeable batteries every 3 to 5 years and regular batteries once a year. However, battery life depends on logging intervals. For example, with certain weather stations, if the logging interval is set at 1 second, the batteries last 30 to 50 days. If the interval is set at 1 minute, the batteries should last one year. Furthermore, make sure the batteries' Use Before dates are at least two years from the current date.



About Onset

Onset is a leading supplier of data logger and monitoring solutions used to measure, record and manage data for improving the environment and preserving the quality of temperature-sensitive products. Based on Cape Cod, Massachusetts, Onset has been designing and manufacturing its products on site since the company's founding in 1981.

Visit Onset on the web at www.onsetcomp.com.



About the Author

Paul H. Stiller is the Director of Energy Management at Summit Energy Services. A professional engineer and certified energy manager, Stiller has 34 years of energy management experience and has assisted hundreds of facilities in North America and Europe in becoming more energy efficient.

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Data Logger Basics

In today's data-driven world of satellite uplinks, wireless networks, and the Internet, it is common to hear the terms "data logging" and "data loggers" and not really have a firm grasp of what they are.

Most people have a vague idea that data logging involves electronically collecting information about the status of something in the environment, such as temperature, relative humidity, or energy use. They're right, but that's just a small view of what data logging is.

Choosing a Conductivity Logger

Whether you are selecting a conductivity logger for the first time or have experience measuring conductivity, this paper can help you determine the type of logger that best suits your needs. It highlights the five most important considerations in selecting and deploying a conductivity logger: measurement range and accuracy, other factors that affect accuracy, ease of deployment and offload, software capabilities, and cost of ownership.

Choosing a Temperature Data Logger

This guide details features to consider when choosing a temperature data logger, including accuracy requirements, data access needs, software packages, and power requirements. Explore real-world application examples that illustrate how users have incorporated portable data loggers into their temperature monitoring projects.

Whether you are an experienced data logger user or just getting started, this guide can help you choose the ideal temperature logger for your application.

Monitoring Green Roof Performance with Weather Stations

A data logging weather station is the ideal tool for documenting green roof performance, as it can measure weather parameters such as rainfall, stormwater runoff, temperature, relative humidity, wind speed, solar radiation, and a host of non-weather parameters, such as soil moisture. And it measures these parameters on a continuous basis (say every five minutes, hourly, or at some other interval appropriate to the situation).

The information a weather station collects can help you make wise choices about designing, tuning, and maintaining a green roof. This guide explains how a weather station can be a valuable component of a green roof project, and shares information particular to this type of application.

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Deploying Weather Stations: A Best Practices Guide

From the tropics to the poles, climate, agriculture and other researchers rely on unattended research-grade, data logging weather stations. For example, the US Department of Agriculture uses weather stations to study anything from molecular plant pathology to forest management. Non-government groups, such as universities, use weather stations to study a wide array of subjects including how glacial activity affects air temperature. Additionally, commercial companies depend on weather stations to conduct businesses.

Our best practices guide, *Deploying Weather Stations*, shares field-proven tips and techniques for installing research-grade weather stations in the field. A range of topics are discussed, including weather station site location, sensor placement, system configuration, and cable protection.

Monitoring Wetlands with Data Loggers: A Best Practices Guide

Wetlands act as a natural filter for polluted water and thus play an essential role in water quality protection. They serve as floodwater storage to help minimize erosion, and create a habitat for many fish and wildlife.

While a variety of factors have decreased the number of wetlands in the U.S. by half since 1950, many organizations are restoring wetlands back to their original flourishing ecosystems. To ensure success, it is necessary to monitor wetland factors such as water level, temperature, and rainfall.

HOBO[®]
Data Loggers
Australia

HOBO Data Loggers Australia

Ph: 1300 186 107

E: sales@hobodataloggers.com.au

www.hobodataloggers.com.au

ONSET[®]

Onset Computer
Corporation

470 MacArthur Blvd.
Bourne, MA 02532

Fax: 508-759-9100
1-800-LOGGERS
(1-800-564-4377)

www.onsetcomp.com