Optional Soil Moisture Sensor Protocol

Purpose

To measure the water content of the soil based on the electrical resistance of soil moisture sensors

Overview

The *Soil Moisture Sensor Protocol* consists of:

1. installing soil moisture sensors at 10, 30, 60, and 90 cm depths
2. reading the soil moisture meter
3. calibrating the sensors
4. creating a calibration curve

Time

10 minutes per day

Initial calibration requires doing the *Gravimetric Soil Moisture Protocol* for the 30 cm depth about 20 times over six to eight weeks.

Level

Advanced

Frequency

Daily

Re-installation and calibration of soil moisture sensors should be done annually.

Key Concepts

- A soil moisture sensor's electrical resistance is related to soil moisture and is a function of its wetness.
- Local conditions affect the saturation of sensors and requires us to calibrate them.
- Soil moisture increases after precipitation.
- The amount of increase in soil moisture after precipitation depends on many factors.
- Soil moisture decreases on dry, sunny days.
- The rate of soil drying depends on many factors.

Skills

Sampling soil
Using a balance
Using a soil moisture meter
Recording data

Materials and Tools

- Auger
- Meter stick
- Four soil moisture sensors
- Four 10 cm long x 7.6 cm diameter PVC tube or tin cans for wire holders at the surface
- Two 4-L soil holding/mixing buckets
- Water for making mud balls (1 L)
- One 1 m x 2 cm PVC guide tube
- Soil packing stick (e.g. an old broom handle)
- GLOBE Science Notebooks and pencils
- Soil moisture meter
- Graph paper
- Calculator
- Materials for the *Gravimetric Soil Moisture Protocol*

Preparation

Locate the soil moisture site.

Determine and report the requested soil moisture site metadata.

Collect the tools and materials.

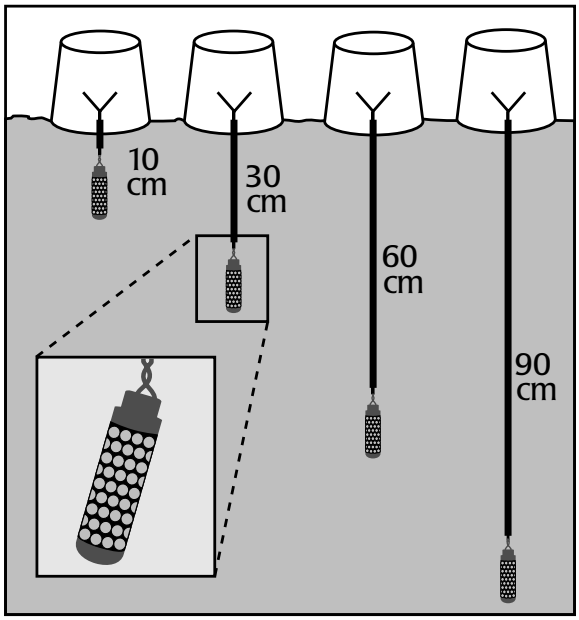
Prerequisites

It is useful to have a rain gauge nearby and to have performed the Soil Characterization protocols at your Soil Moisture Study Site.

Installation of Soil Moisture Sensors

1. Place the sensors into a container of water and soak for 5 minutes.
2. Auger a hole to the appropriate depth for each soil moisture sensor (10, 30, 60 and 90 cm). A soil auger works like a cork screw - simply lean on the handle as you turn it. It is best to remove the auger bucket from the hole after each 360° turn and clean the soil out of the bucket. If you fill it too full, it will be very difficult to remove the soil. Place the extracted soil in a large pail to keep the site clean. The four holes should be placed next to one another in sequence to reduce potential confusion while taking readings and recording data.
3. Put two large handfuls of the soil extracted from the hole into a small bucket or similar container. Add a small amount of water and stir to create a mud ball. The mud ball should stick together. Remove any rocks.
4. Drop the mud ball to the bottom of the hole. Make sure it reaches the bottom.
5. Place the wire lead from one of the sensors through the PVC guide tube.
6. Grab the end of the lead and pull the sensor up tight against the end of the pipe. Lower the sensor into the hole while holding it against the end of the pipe. Holding the wire lead tightly at the top of the pipe, gently push the pipe down to seat the sensor in the mud at the bottom of the hole. **Note:** Since it is difficult to pack soil tightly around the sensor, the purpose of the mud is to establish good contact between the sensor and the soil particles.
7. Hold the sensor in place with the pipe while you begin to backfill the hole. Add just a few handfuls of soil and gently tamp with a broom stick or similar pole. Then add a little more soil and remove the pipe as you tamp. Continue adding soil a few handfuls at a time and tamping firmly as you backfill the hole. Hold on to the wire lead as you backfill so that it will come straight to the surface.

Figure SOIL-P-13: Installed Soil Moisture Sensor Configuration



8. Place a short piece (about 10 to 20 cm long) of PVC pipe, tin can, or coffee can (with the top and bottom removed) around the wire lead at the surface to protect it and make it more visible to anyone walking in the vicinity.
   8.1. First, label the pipe or can with the appropriate sensor depth.
   8.2. Put the wire through the pipe or can and press the pipe or can 2 to 5 cm into the soil to keep it in place. Do not cut the wire, but wind up the free end extending out of the ground and place it in the pipe or can to keep it out of the way between measurements.
   8.3. A small empty can (soup, etc.) should be inverted over the end of the PVC pipe to keep the rain out.
9. Repeat the above steps for each sensor.

Do not report measurements for a week after installation. The sensors require at least one week to equilibrate to natural conditions. The wire leads are fragile, especially where they connect to the meter. If the end of the wire leads to the soil moisture sensors break, peel back the wire insulation and make new leads. It is important to leave enough wire above the ground for this.

Reading the Soil Moisture Meter

Congratulations! Your soil moisture sensors are installed. Wait at least one week before beginning to take data which you report to the GLOBE Student Data Archive. After this, monitor your sensors daily for soil moisture variations. This is the fun and easy part of this investigation. Do not monitor the sensors when the ground is frozen.

Preparation

Test the soil moisture meter to ensure it is functioning properly according to the manufacturer's instructions. Do this before each use.

How to Make a Soil Moisture Reading

1. Obtain the reading for each sensor.
   1.1. Connect the soil moisture meter to the wire leads of the sensor located at the 10 cm depth.
   1.2. Push READ button. Wait for the meter to reach a constant value - it should not be negative.
   1.3. Record the date, time, current soil conditions (CC's), and soil moisture meter reading on the *Daily Soil Moisture Sensor Data Work Sheet* in the appropriate depth column.
   1.4. Disconnect the meter and store the wire leads.
   1.5. Replace the cover over the PVC pipe.
   1.6. Repeat steps 1.1 - 1.5 for each of the remaining sensors (30, 60, 90 cm).
2. Report all four meter readings to the GLOBE Student Data Server.
3. Convert each meter reading to soil water content using the calibration chart.

How to Use the Daily Soil Moisture Sensor Data Work Sheet

There are numbers 1 to 0 in the far left column. Please keep a running count of your measurements by adding a tens digit as you accumulate more data. This allows someone reviewing your data sheets to ascertain if any pages are missing. There is also space to plot your data in the field as you collect it. You would normally expect gradual transitions except for the rapid increase in soil moisture after a rain.

Calibration of Soil Moisture Sensors

The sensors must be calibrated so that the meter reading you make can be related to soil water content (SWC). This process can take 6-8 weeks, depending upon how quickly your soil moves through its full drying cycle. Rather than calibrate your sensors at every depth, we have adopted a policy of basing each calibration on observations made from the 30 cm sensor. Technically, this assumes your soil profile is uniform and your sensors are identical. It takes about 30 minutes to complete the steps below. You may calibrate your sensors at 10, 60, and 90 cm depths using the same procedure if you wish.

What To Do and How To Do It

1. Take a soil meter reading from the 30 cm soil moisture sensor.
2. Select a random location within 5 m of the sensor hole.
3. Clear surface debris.
4. Auger to 30 cm and collect a 100 g sample centered at this depth. Place the soil sample in a container and number the container.
5. Backfill the hole and replace the surface cover.
6. Record the date, time, depth and container number.
7. Follow the instructions for *Weighing and Drying The Samples* found in the *Gravimetric Soil Moisture Protocol* and make a note of your drying method and average drying time.
8. Record on the *Annual Soil Moisture Sensor Calibration Data Work Sheet* the date and time of your measurement, the wet, dry, and container weights and the soil moisture meter reading that you obtained. There is also space to calculate soil water content (SWC).
9. Repeat steps 1 - 8 about twenty times as the soil moves through one or two complete drying cycles. Wait until your meter reading changes 5% before collecting another gravimetric sample. Re-install and recalibrate your sensors once a year.

Creating a Calibration Curve

How to plot a calibration curve

1. Complete the *Annual Soil Moisture Sensor Calibration Data Work Sheet* using the following formula to calculate the values for Soil Water Content (SWC) for each row of the Work Sheet.

$$SWC = \frac{(\text{wet weight - dry weight})}{(\text{dry weight - can weight})}$$

Remember:

wet weight = wet soil + can
dry weight = dry soil + can

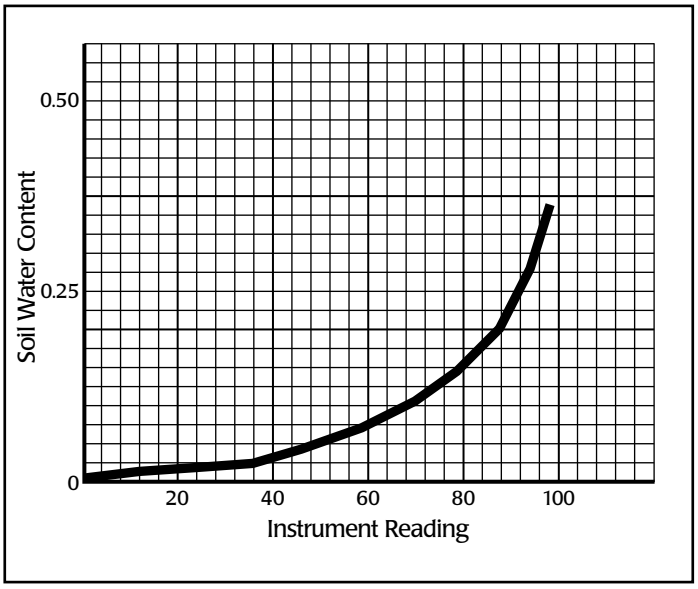
2. Create a graph in which you plot all the soil water content data collected on the Y-axis and all the corresponding soil moisture meter readings on the X-axis. Draw or calculate the *best-fit quadratic curve* through your data pairs, which should span a broad range of soil moistures. This will be your calibration curve, which you will use to convert other meter readings to soil water content.

If you have any questions about creating your calibration curve or if you need any assistance with the curve, the principal investigator for the *Soil Moisture Investigation* is glad to provide answers and assistance and can be contacted at the addresses given in the *Welcome Section*.

When you have finished determining your calibration curve, please mail or email a copy of your curve and of your corresponding *Annual Soil Moisture Sensor Calibration Data Work Sheet* to GLOBE Student Data Archive at the address given in the *Implementation Guide*.

During the year, if you get readings either higher or lower than any of the readings on your Data Work Sheet, take a gravimetric sample, and use the values you measure for this sample to extend your calibration curve. Send a copy of your revised calibration curve and extended *Annual Soil Moisture Sensor Calibration Data Work Sheet* to the GLOBE Student Data Archive.

Figure SOIL-P-14: Example of a Soil Moisture Sensor Calibration Curve



30 cm

Date	Reading	SWC
2/4/97	42	0.07
2/25/97	17	0.03
3/6/97	96	0.35
3/8/97	91	0.25
3/18/97	70	0.14