METER
ENVIRONMENT

SOIL MOISTURE SENSORS—WHICH INSTALLATION METHOD IS BEST?

Contributors

Patterns of water replenishment and use give rise to large spatial variations in soil moisture over the depth of the soil profile. Accurate measurements of profile water content are therefore the basis of any water budget study. When monitored accurately, profile measurements show the rates of water use, amounts of deep percolation, and amounts of water stored for plant use.

HOW TO AVOID MEASUREMENT ERRORS

Three common challenges to making high-quality volumetric water content measurements are:

1. Making sure the soil moisture sensor is installed in undisturbed soil

2. Minimizing disturbance to roots and biopores in the measurement volume

3. Eliminating preferential water flow to, and around, the probe

All dielectric probes are most sensitive at the surface of the probe. Any loss of contact between the probe and the soil or compaction of soil at the probe surface can result in large measurement errors. Water ponding on the surface and running in preferential paths down probe installation holes can also cause large measurement errors.

Installing soil moisture sensors will always involve some digging. How does one accurately sample the profile while disturbing the soil as little as possible? Consider the pros and cons of five different profile sampling strategies.

PREFERENTIAL FLOW IS A COMMON ISSUE WITH COMMERCIAL PROFILE PROBES

Profile probes are a one-stop solution for profile water content measurements. One probe installed in a single hole can give readings at many depths. Profile probes can work well, but proper installation can be tricky, and the tolerances are tight. It's hard to drill a single, deep hole precisely enough to ensure contact along the entire surface of the probe. Backfilling to improve contact results in repacking and measurement errors. The profile probe is also especially susceptible to preferential flow problems down the long surface of the access tube. (NOTE: The new TEROS Borehole Installation Tool eliminates preferential flow and reduces site disturbance while allowing you to install sensors at depths you choose.)

TRENCH INSTALLATION IS ARDUOUS

Installing sensors at different depths through the side wall of a trench is an easy and precise method, but the actual digging of the trench is a lot of work. This method puts the probes in undisturbed soil without packing or preferential water flow problems. But because it involves excavation, it's typically only used when the trench is dug for other reasons or when the soil is so stony or full of gravel that no other method will work. The excavated area should be filled and repacked to about the same density as the original soil to avoid undue edge effects.

AUGER SIDEWALL INSTALLATION IS LESS WORK

Installing probes through the side wall of a single auger hole has many of the advantages of the trench method without the heavy equipment. This method was used by Bogena et al. with EC-5 probes. They made an apparatus to install probes at several depths simultaneously. As with trench installation, the hole should be filled and repacked to approximately the pre-sampling density to avoid edge effects.

An augered borehole disturbs the soil layers, but the relative size of the impact to the site is a fraction of what it would be with a trench installation. A trench may be about 60 to 90 cm long by 40 cm wide. A borehole installation performed using a small hand auger and the TEROS Borehole Installation Tool creates a hole only 10 cm in diameter—just 2-3% of the area of a trench. Because the scale of the site disturbance is minimized, fewer macropores, roots, and plants are disturbed, and the site can return to its natural state much faster. Additionally, when the installation tool is used inside a small borehole, good soil-to-sensor contact is ensured, and it is much easier to separate the horizon layers and repack to the correct soil density because there is less soil to separate. Watch the video to see how it works.

MULTIPLE-HOLE INSTALLATION PROTECTS AGAINST FAILURES

Digging a separate access hole for each depth ensures that each probe is installed into undisturbed soil at the bottom of its own hole. As with all methods, take care to assure that there is no preferential water flow into the refilled auger holes, but a failure on a single hole doesn't jeopardize all the data, as it would if all the measurements were made in a single hole.

The main drawback to this method is that a hole must be dug for each depth in the profile. The holes are small, however, so they are usually easy to dig.

SINGLE-HOLE INSTALLATION IS LEAST DESIRABLE

It is possible to measure profile moisture by augering a single hole, installing one sensor at the bottom, then repacking the hole, while installing sensors into the repacked soil at the desired depths as you go. However, because the repacked soil can have a different bulk density than it had in its undisturbed state and because the profile has been completely altered as the soil is excavated, mixed, and repacked, this is the least desirable of the methods discussed. Still, a single-hole installation may be entirely satisfactory for some purposes. If the installation is allowed to equilibrate with the surrounding soil and roots are allowed to grow into the soil, relative changes in the disturbed soil should mirror those in the surroundings.

REFERENCE

Bogena, H. R., A. Weuthen, U. Rosenbaum, J. A. Huisman, and H. Vereecken. "SoilNet-A Zigbee-based soil moisture sensor network." In *AGU Fall Meeting Abstracts*. 2007. Article link.

GET EXPERT ADVICE

Want to know more about measuring soil moisture in your unique application? METER scientists have over 100 years combined experience measuring soil hydraulic and physical properties. Contact us, or watch the video here. Sensor installation expert, Chris Chambers, explains why you need a smarter soil moisture sensor installation and how to achieve it. Learn:

- What good soil moisture data look like

- How various installation issues show up in your data (i.e, air gaps, a loose sensor,

soil type change, depths crossing)

- How to ensure an accurate installation

- How the new TEROS Borehole Installation Tool reduces air gaps and site disturbance while improving consistency

- What other scientists are doing to ensure a correct installation

GET THE COMPLETE PICTURE

Learn everything you need to know about measuring soil moisture—all in one place: why you need it, how to measure it, method/sensor comparisons, how many measurements, where you should measure, best practices, data troubleshooting, and more.

Download the “Researcher’s complete guide to soil moisture”

TAKE OUR SOIL MOISTURE MASTER CLASS

Six short videos teach you everything you need to know about soil water content and soil water potential—and why you should measure them together. Plus, master the basics of soil hydraulic conductivity.

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