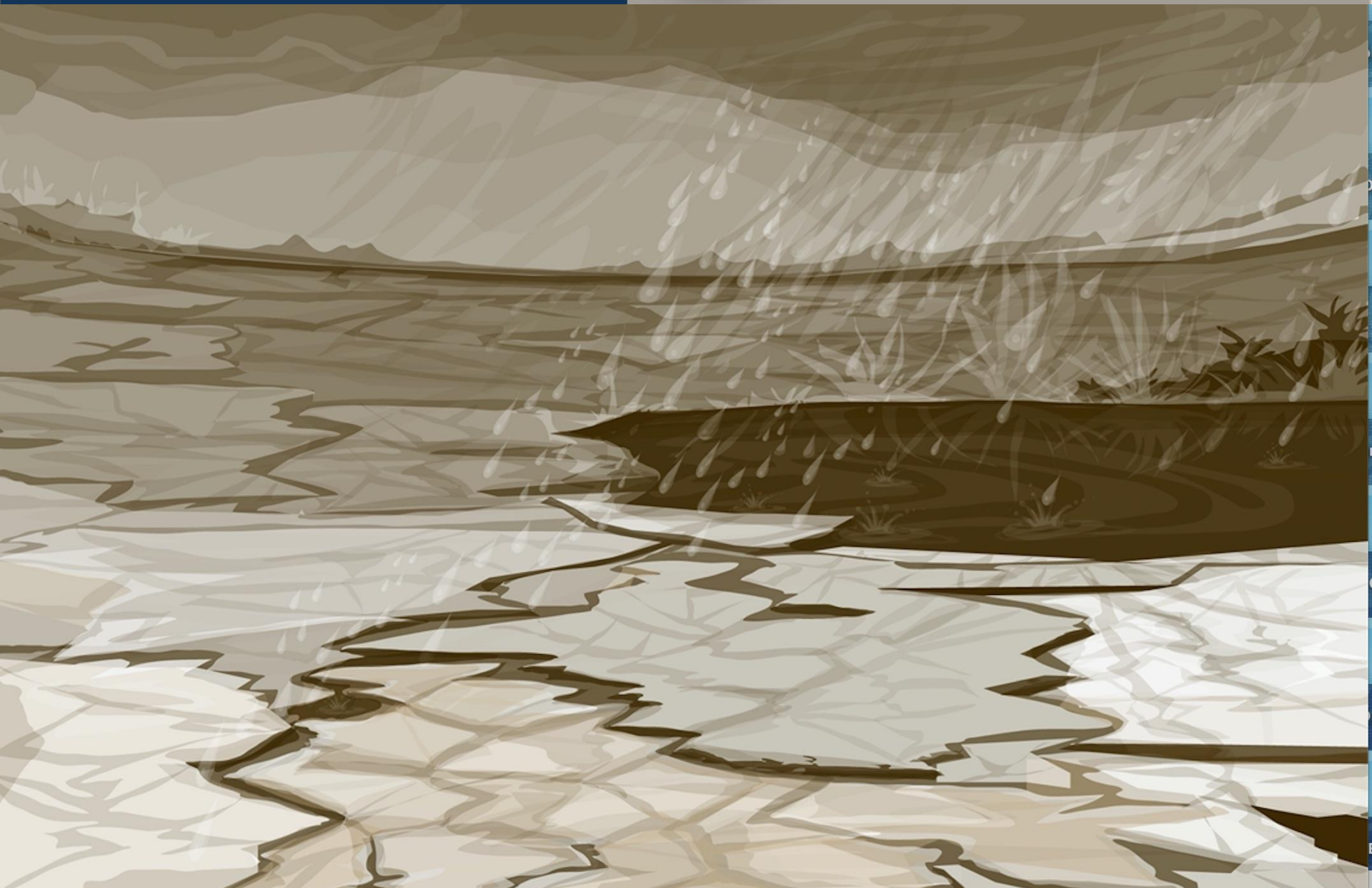
THE GLOBE PROGRAM
A Worldwide Science and Education Program

Soil (Pedosphere)
Infiltration Protocol



Overview and Learning Objectives

Soil infiltration is a measure of the rate at which soil is able to absorb rainfall or irrigation water. This module provides step-by-step instructions in how to do the Infiltration Protocol.

Learning Objectives:

After completing this module, you will be able to:

- Explain why soil moisture is worth studying
- Decide where to do an infiltration measurement
- Determine a schedule for taking this measurement
- Measure infiltration using a dual-ring infiltrometer
- Measure gravimetric soil moisture content
- Report these data to GLOBE

To complete the protocol, you will also need to learn either the Gravimetric Soil Moisture Protocol or SMAP Soil Moisture Protocol.

Estimated time needed for completion of this module: 1.5 hours

What is a Soil Infiltration Rate?

The infiltration rate is determined by measuring the time it takes for water sitting on a soil to drop a fixed distance. This rate changes with time as the soil pore spaces, filled originally with air, fill with water.

There are three flow rates:

- Unsaturated flow is the initial flow rate and is high as the dry soil pore spaces fill with water.
- Saturated flow is a steady flow rate that occurs as water moves into the soil at a rate determined by soil texture and structure.
- Ponding is the flow rate that occurs when the ground becomes totally saturated and is no longer able to conduct water through its pores.

The Role of Soil Moisture in the Environment

- Soil acts like a sponge spread across the land surface. It absorbs rain and snowmelt, slows run-off and helps to control flooding.
- The absorbed water is held on soil particle surfaces and in pore spaces between particles. This water is available for use by plants.
- Some of this water evaporates back into the air; some of this water is transpired by plants; some drains through the soil into groundwater.
- The infiltration rate of water into soil changes depending upon the level of soil saturation. Water that is not stored in the ground evaporates or becomes runoff and may pool on the surface for a time. It is possible to determine how flood-prone an area is based on the infiltration rate of the soil.

The Importance of Infiltration

The rate at which water flows through the soil affects how much water is available for plant use; how nutrients and other particles move through the soil; the amount of water available for use by animals; and the length of time the water will remain in the soil.

Soil Infiltration Is Important Because It Affects:

Water For Plant Use

Flooding

Evaporation Rates

Water Storage

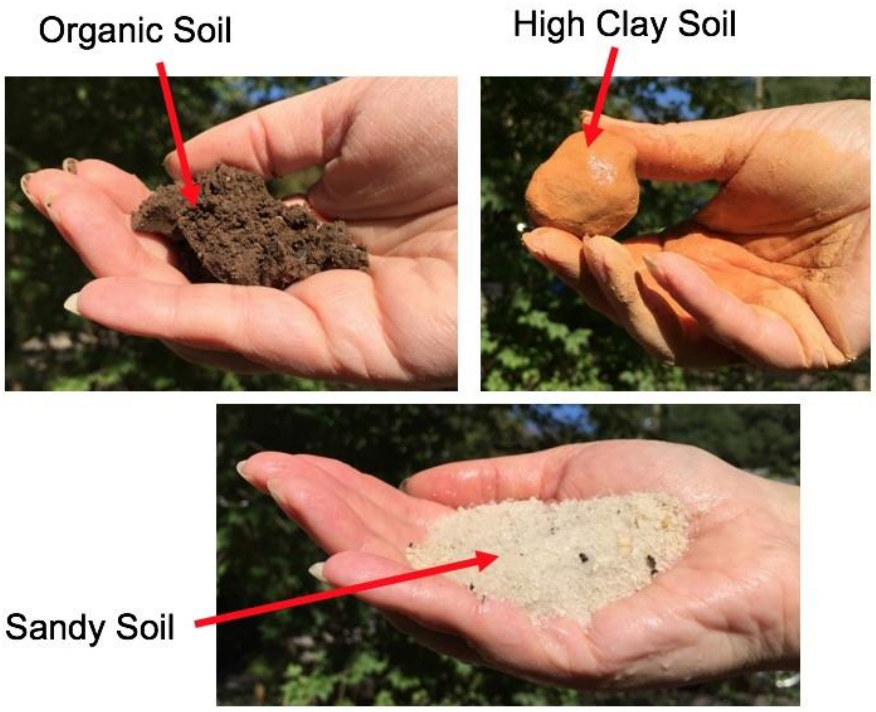
Weathering and Erosion

Soil Properties Affect Infiltration Rates

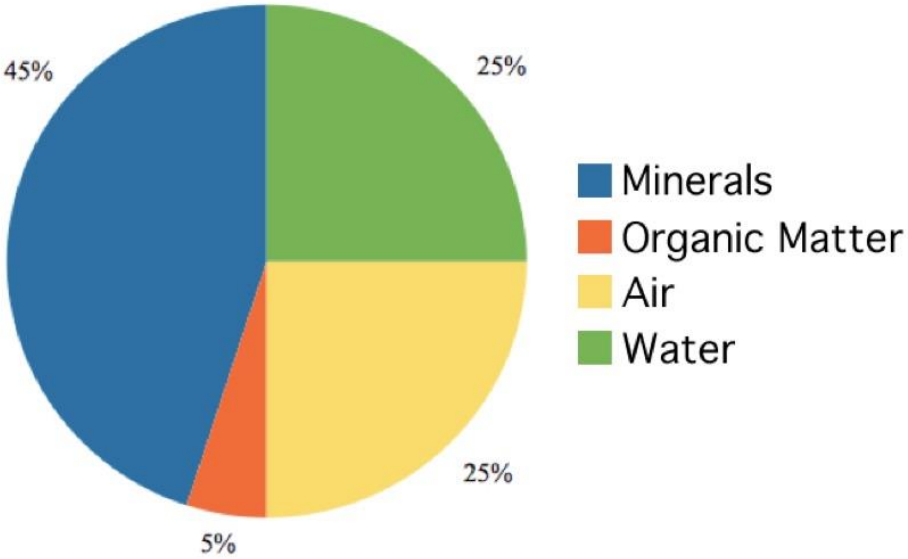
A soil's structure, texture, density, and relative amount of organic material affect the speed at which water flows through soil.

If the soil is dense and/or compacted, water will likely move through it more slowly.

If the soil has relatively little pore space or is already saturated, flooding or run off will occur.



Ideal Soil Composition

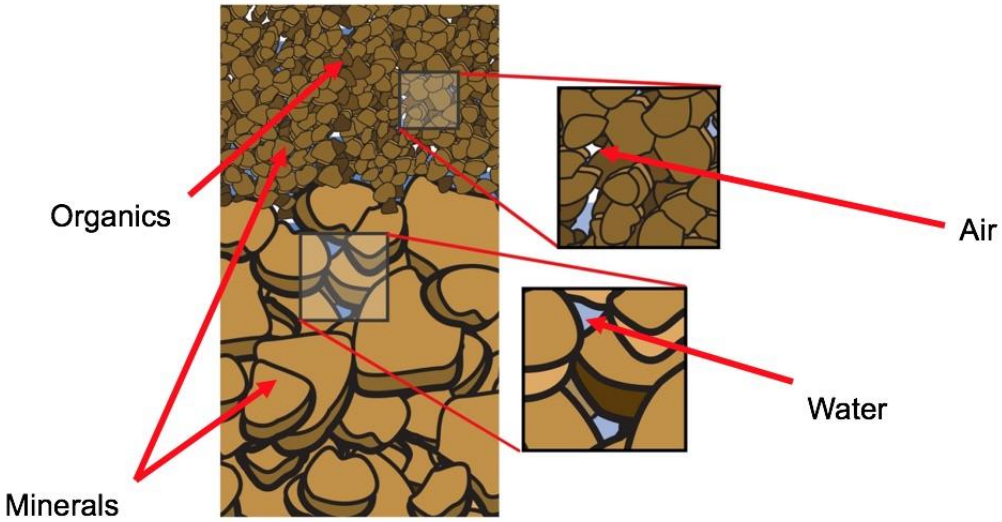


Approximate Total Soil Volume

The air and water in soil represent the soil's pore space. Volumetrically, they should comprise approximately 50% of the soil's volume.

The pore spaces allows for movement of air, water, and organisms through the soil.

Sample Soil Components



Sample Soil Components in Horizons

If soil pore space increases and density decreases, water moves through soil more quickly. If the pore space decreases and soil's density increases, water moves through the soil more slowly.

A high infiltration rate keeps water and nutrients available to plants for growth. A too-high rate might lead to unwanted chemicals and nutrients in the groundwater or other subsurface water.

A low infiltration rate might lead to increased run-off, which also lead to flooding and erosion.

Overview of Protocol

Where	Conduct this protocol at your soil moisture study site and your soil characterization sample site, within 5 m of your sample site
Key Equipment	Infiltrometer, can be built using 2 different sized coffee cans
Time	One class period to build and test the double-rig infiltrometer; 45 minutes to make the measurement
Frequency	3-4 times a year at Soil Moisture Study Site 1 time at Soil Characterization Sample Site
Documents needed	Soil Infiltration Protocol and Field Guide Soil Infiltration Data Sheet

Required Materials

- Metal ring with a diameter of 10 - 20 cm (Coffee cans work!)
- Metal ring with a diameter 15 - 25 cm (Coffee cans work!)
- Buckets or other containers to transport at least 8 L of water to the site
- Ruler
- Waterproof marker
- Stop watch or watch with a second hand
- Block of wood
- Hammer
- Three soil sample containers suitable for soil moisture measurement
- Grass clippers
- Funnel

Constructing a Dual-Ring Infiltrometer

- Cut out the bottom of your cans

- Place one inside the other and be sure that the distance between the walls of the cans is between 2-5 cm.

Caution students when cutting the bottom of the cans, and when handling the cans when doing the infiltration protocol- the raw edges are sharp.

Measuring your Dual-Ring Infiltrometer

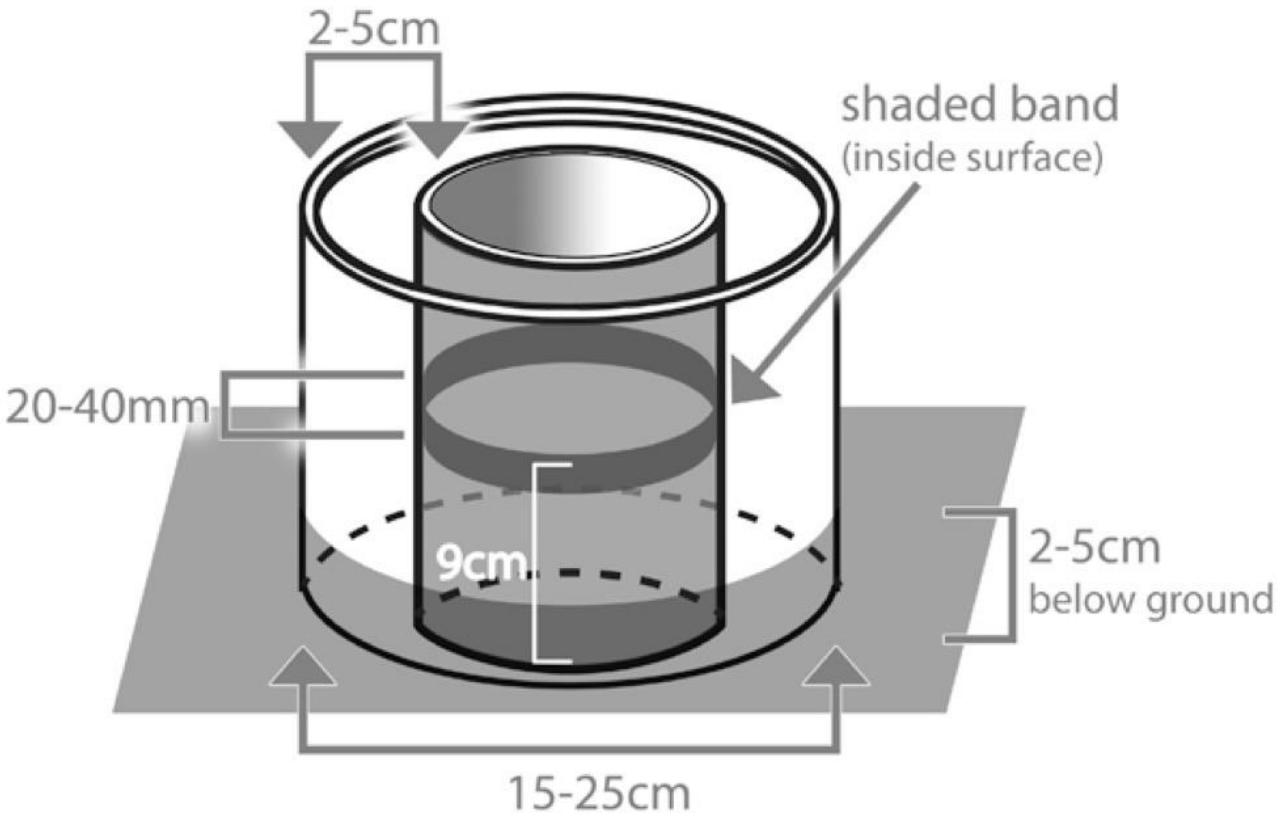
- Measure and record the width of your reference band (in mm).
- Measure and record the widths of your inner and outer rings (in cm- see below).

Marking the Outside of the Dual-Ring Infiltrometer

Mark 2 cm and 5 cm from the bottom of each can as a reference for when you will push the can into the soil at least 2 cm but not deeper than 5 cm.

Diagram of the Finished Dual-Ring Infiltrometer

This illustration shows a fully constructed Dual Ring Infiltrometer in the soil.



Measuring Infiltration Rates: Clear Vegetation

Clip any vegetation (grass) to the ground surface and remove all loose organic cover over an area just larger than your largest can. Try not to disturb the soil.

Push Cans into the Soil

- Starting with the smaller can, twist the cans 2 - 5 cm into the soil.

- Use the reference points you marked earlier as guides.

Instilling Cans in Hard Soil

You may use a hammer to pound the can into the surface. If you do, place a block of wood between the hammer and the top of the can to distribute the force of the hammering.

Do not hammer so hard that the can crumples, but a little bending at the top is okay.

Overview of Measuring Soil Infiltration

- Once the rings are in the soil, if you are using a stop watch, start it.
- Pour water into both rings
- When you pour water into the rings, the outer ring should not be leaking water to the surface around its rim. If it is, start over in another location, push the outer ring deeper into the soil, or pack mud around its base.
- Prepare to record your data with the Data Entry app or on the Data Entry Sheet

Pouring Water into the Rings

In the inner ring, pour water to just above the upper reference band and maintain the same water level of the outer ring.

Topping up the Outer Ring

The level of the water in the outer ring tends to drop faster than the inner ring as water spreads outward and not just downward.

To keep the water in the inner ring flowing only downward it is important to keep the water level in the outer ring at the same level as the inner ring by adding water to the gap between the rings.

Begin Timing Infiltration Rate

- As the water level in the inner ring reaches the upper reference mark of the band, read the stop watch or note the time to the second.
- This is your start time.
- Record this time in the Data Entry app. or on the Data Entry Sheet.

Maintain the Water Level in the Outer Ring Equal to the Water Level in the Inner Ring

During the timing interval, keep the water level in the outer ring approximately equal to the level in the inner ring.

Record the End Time

As the water level in the inner can reaches the lower reference mark, note the time on the stop watch. This is your end time.

Be careful not to pour water into the inner ring (using a funnel can help).

Troubleshooting: Soils Impervious to Water Infiltration

At times, some clays and compacted soils will be impervious to water infiltration and your water level will not drop to the bottom of the marked band in a 45-minute time period.

In this case:

- Record the time at which you stopped your observations as the end time.
- Record the level to which the water fell and report it as the:
- “Height Above Ground (Lower Mark)”.
- Your infiltration measurement will consist of a single interval.

Recording and Calculating the Time Interval

- Record your end time in the Data Entry app. or on the Data Entry Sheet.
- Calculate the time interval by taking the difference between the start and end times.
- Record this interval on the Data Entry app. or on the Data Entry Sheet.

3:39-2:37=1:02

Repeat Measurement

Refill the two cans to the level of the top of the band.

Repeat timing the fall of the water level in the inner ring for 45 minutes or until two consecutive interval times are within 10 seconds of one another.

After you have finished the previous steps, **wait five minutes**. If the water has not soaked into the soil, remove the cans.

3:39-2:37=1:02

Infiltration Measurement of a Top 5 cm Soil Moisture Sample- 1

Take a single 0-5 cm soil moisture sample from where the inner ring sat.

Proceed to measure the gravimetric soil moisture of this sample following the Gravimetric Soil Moisture Protocol.

Infiltration Measurement of a Top 5 cm Soil Moisture Sample- 2

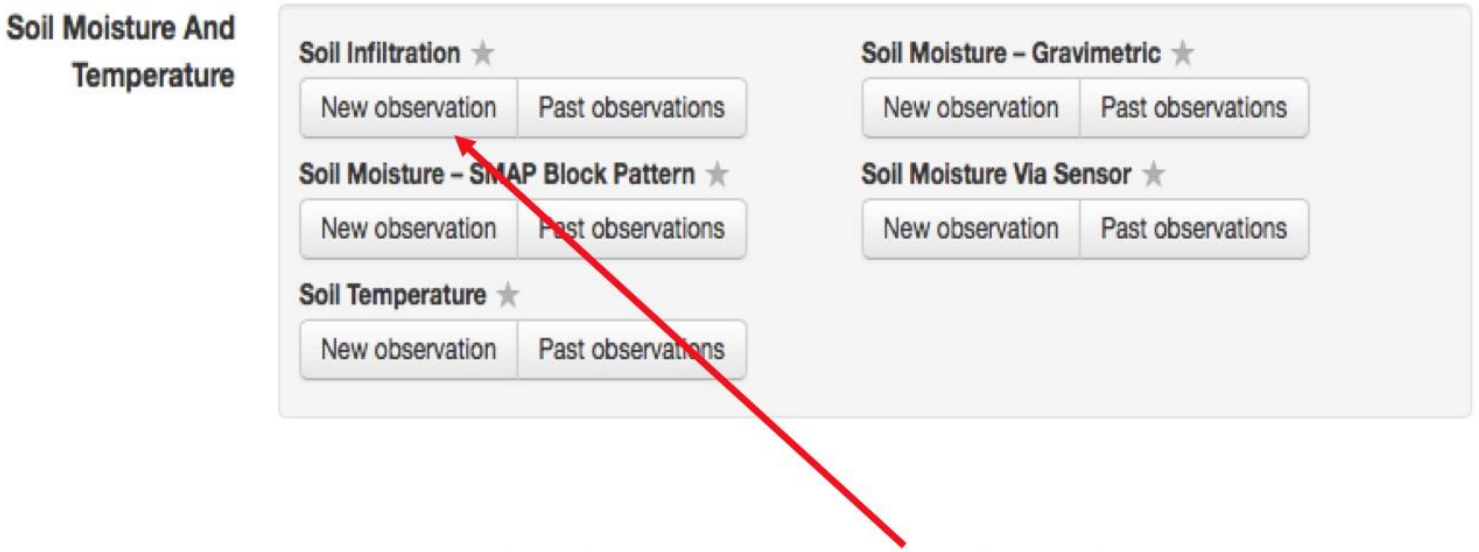
Make two other infiltration measurements within a 5 m diameter area of your first sample site. These measurements can be done at the same time using other groups or over several days (if the near-surface soil water content is not changed by rain).

It is not critical that multiple runs have the same number of reading sets, but do not submit runs that are incomplete (e.g. a run that was cut short due to lack of time).

Report your data to GLOBE even if you conduct one or two series of infiltration measurements. If you take more than three sets of measurements, enter your three best sets on the Data Entry app.

Soil Infiltration Protocol Data Entry

Select "Live Data Entry."

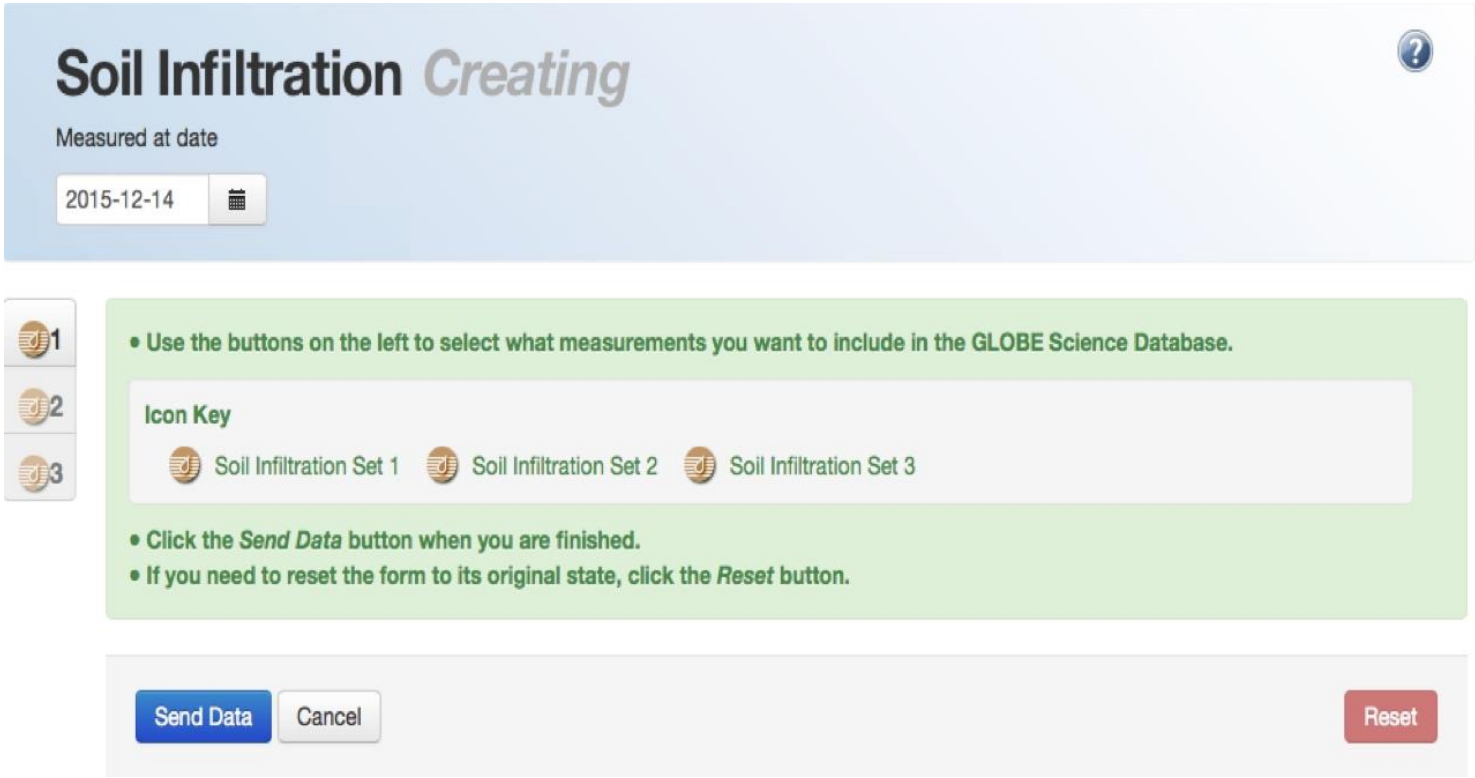


Under Soil Moisture And Temperature, click "New Observation."

Entering Measurement Data

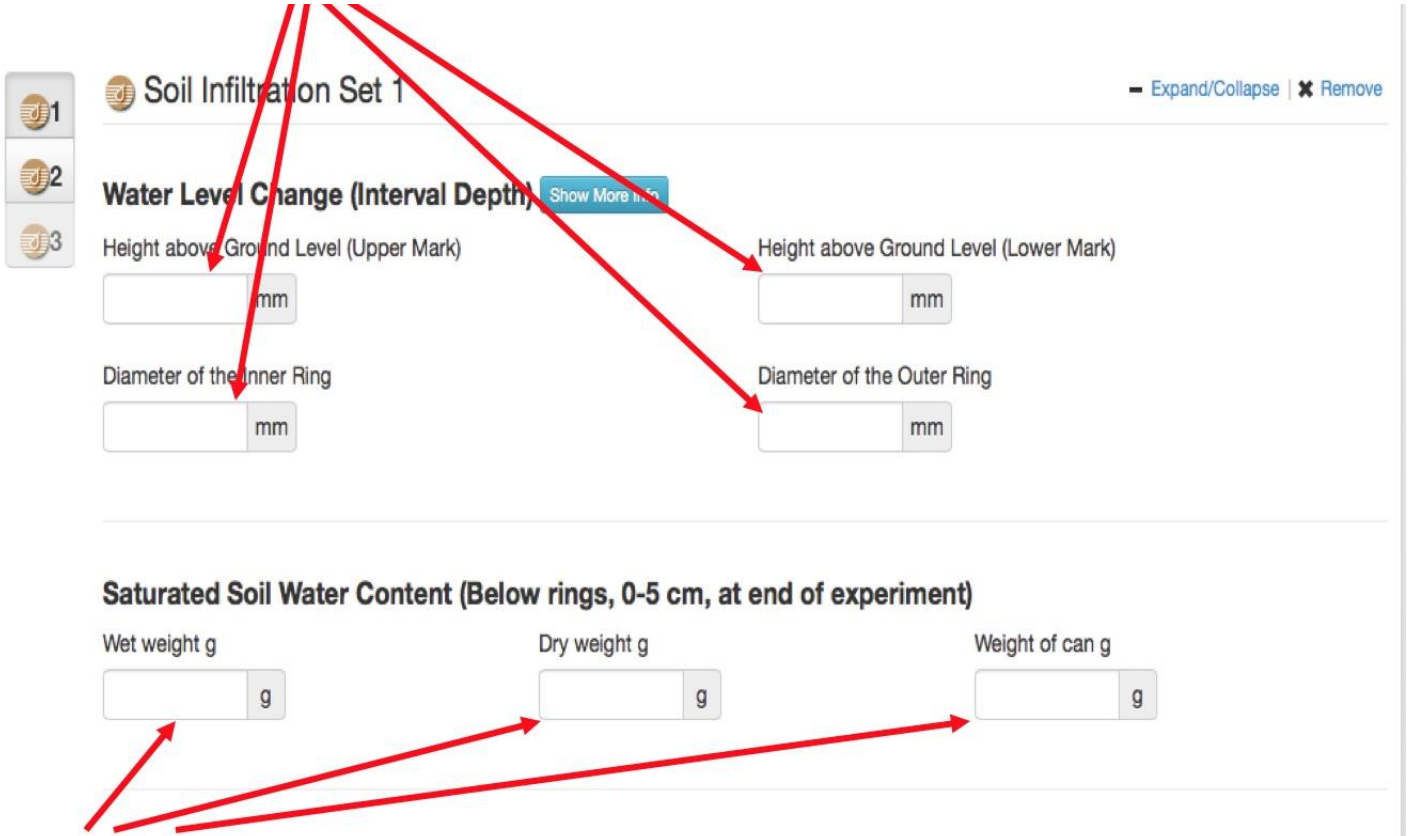
- Enter the date you took the measurements.
- Once you enter the date, the data entry portion of the page will appear.

Selecting Appropriate Data Set



- Choose which of your sets of data to enter.

Enter Specifications of your Dual Ring Infiltrometer



Enter the soil moisture data you collect for the saturated soil from the center of the infiltrometer at the end of the protocol.

Example Data

1
2
3

* indicates required sections or fields

Soil Infiltration Set 1 — Expand/Collapse | Remove

Water Level Change (Interval Depth) Show More Info

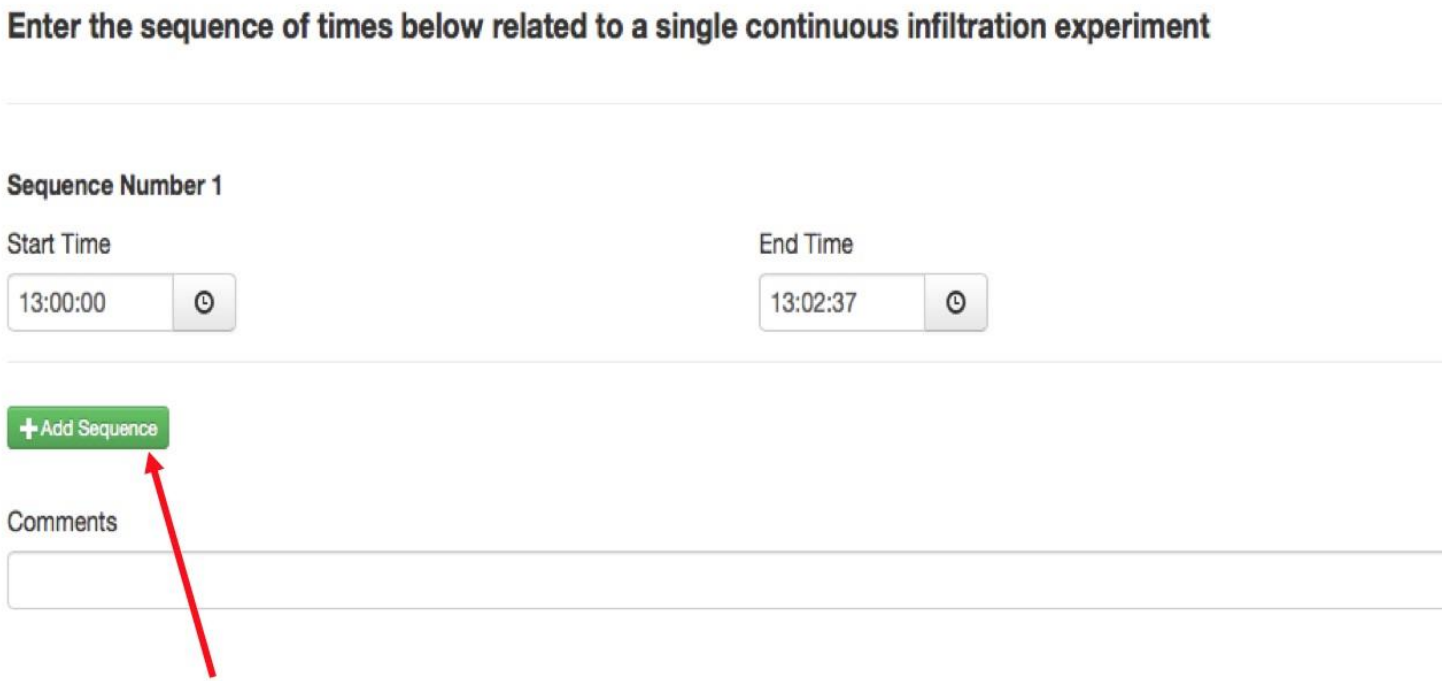
Height above Ground Level (Upper Mark)	Height above Ground Level (Lower Mark)
100 mm	80 mm

Diameter of the Inner Ring	Diameter of the Outer Ring
200 mm	250 mm

Saturated Soil Water Content (Below rings, 0-5 cm, at end of experiment)

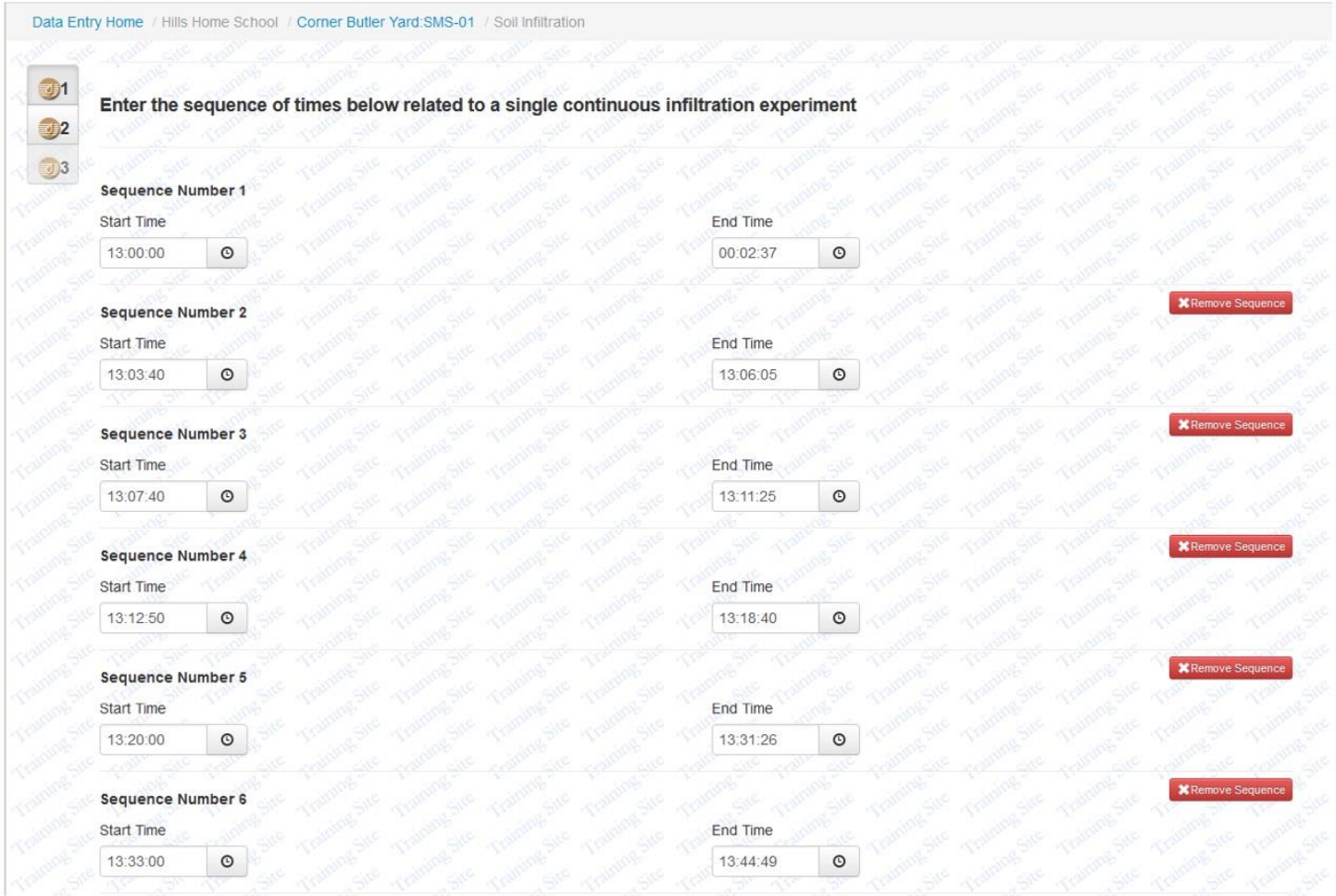
Wet weight g	Dry weight g	Weight of can g
272.5 g	196.9 g	30.9 g

Adding an Additional Sequence

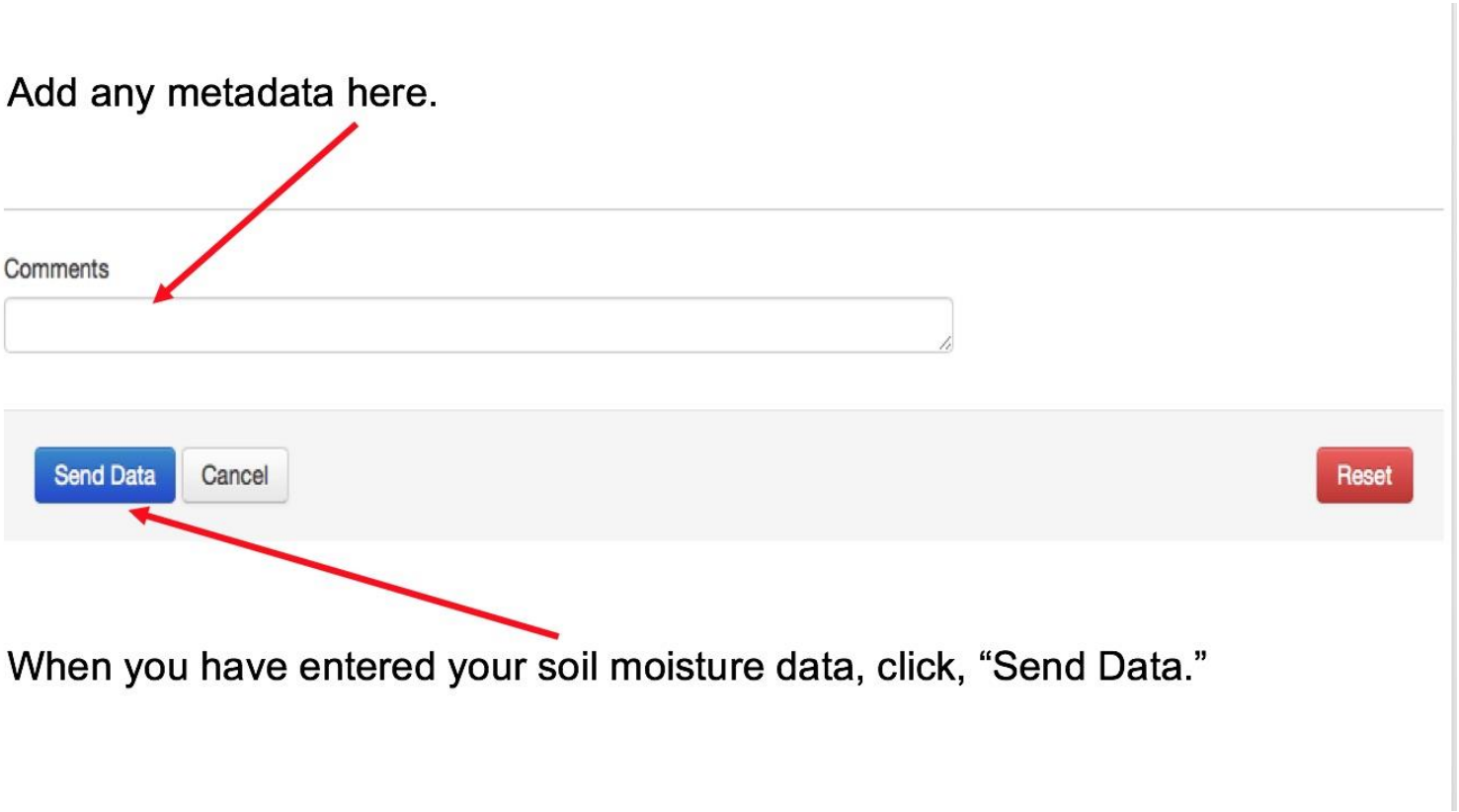


To add the next sequence of start and end times for the same continuous infiltration measurement, click, “Add Sequence.”

An Example Sequence



Enter Comments and Send Data



Data System Responses

If your data are within the appropriate ranges for Soil Infiltration, you will see the image below.

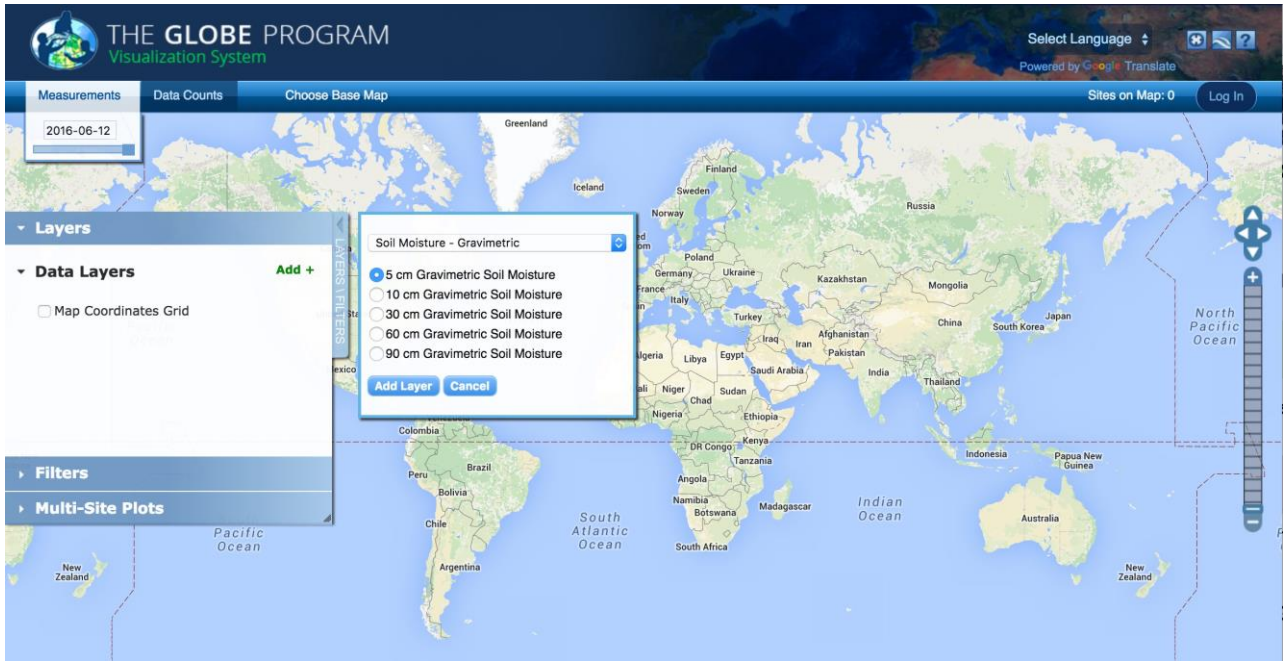
If your data are not within the appropriate range or has other issues, you will see the following.

Address the errors the page details and resubmit your data.

If data are not within the accepted range, contact GLOBE Community Support.

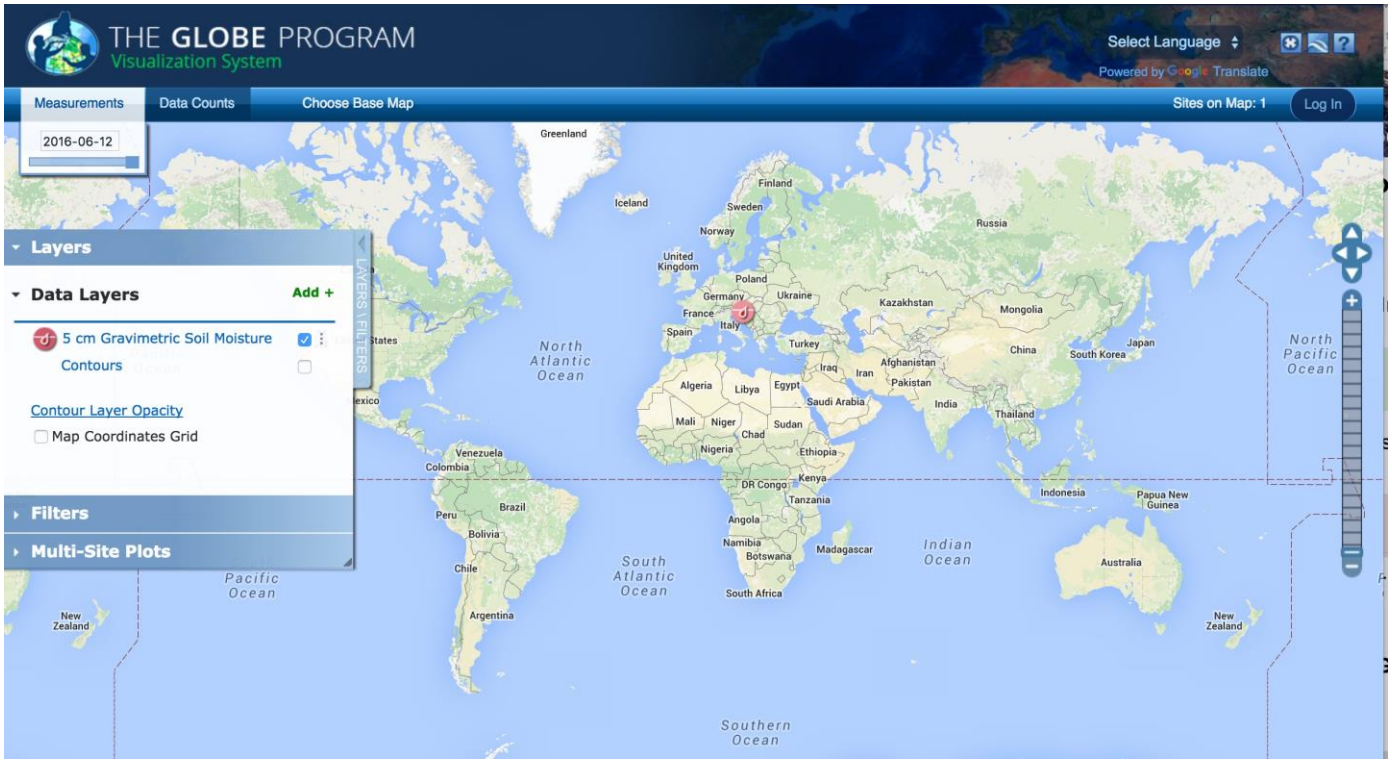
Visualizing Data-1

Currently soil infiltration data is not available in the GLOBE Visualization System. However, soil moisture data are available and are shown below.



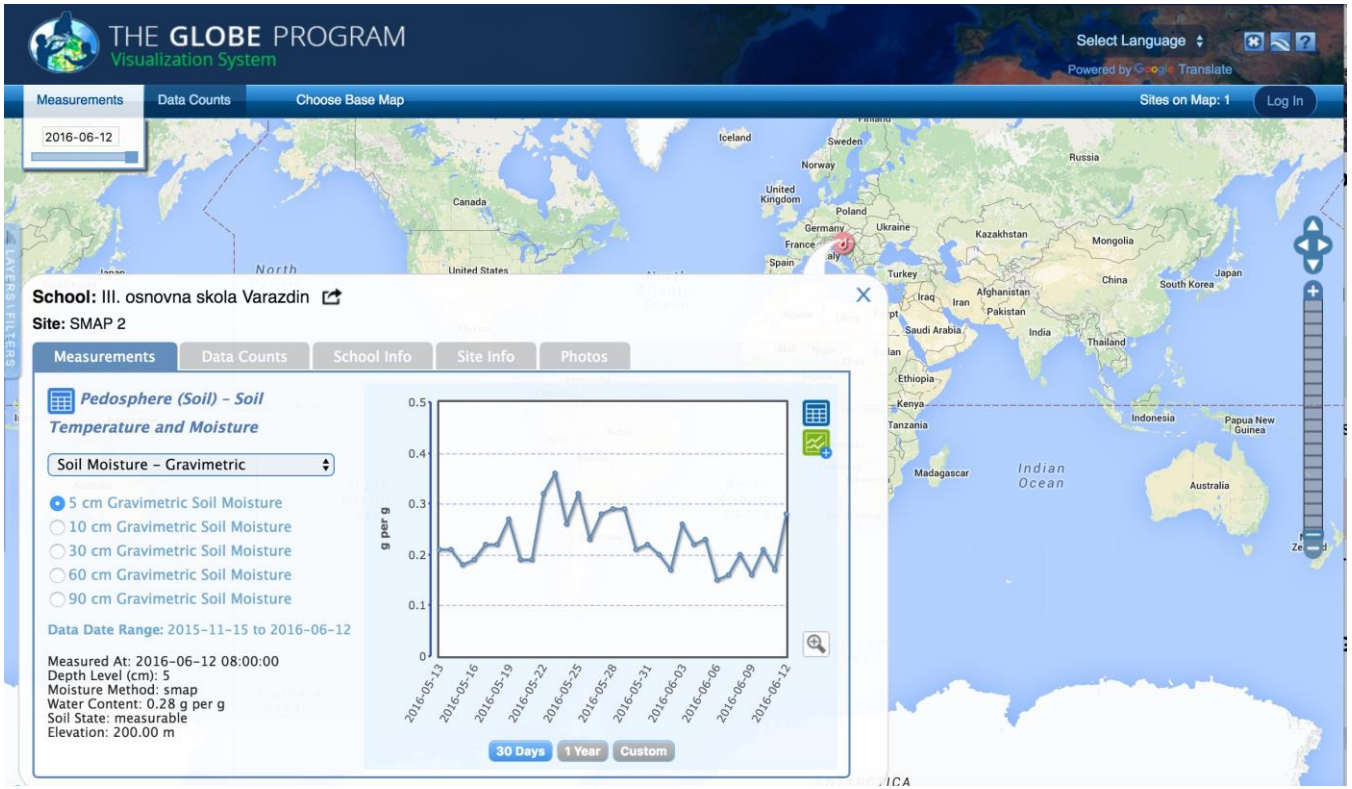
Visualizing Data-2

Currently soil infiltration data is not available in the GLOBE Visualization System. However, soil moisture data are available and are shown below.



Visualizing Data- 3

Currently soil infiltration data is not available in the GLOBE Visualization System. However, soil moisture data are available and are shown as an example below.



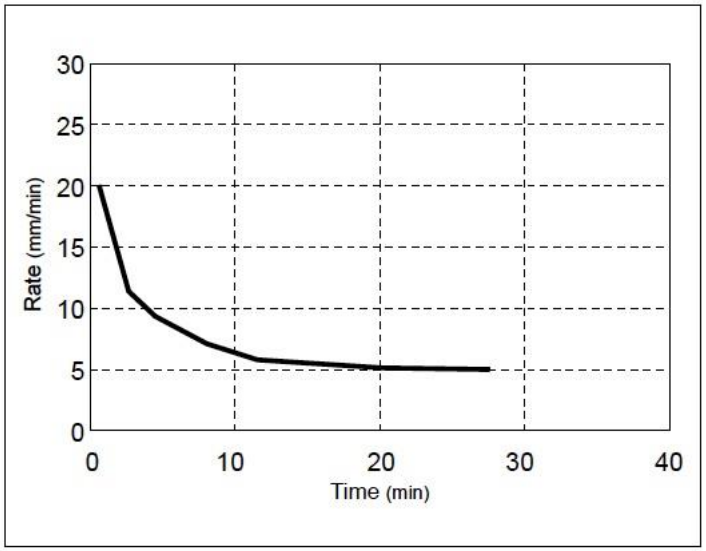
Looking at the Data

Infiltration rate is determined by dividing the distance that the water level decreases by the time required for this decrease. For GLOBE measurements this is equal to the width of the reference band on the infiltrometer divided by the difference between the start and end times for an interval.

The Infiltration Data Sheet can be used to record and help calculate the values needed to plot measurement results. The flow rate for each timing interval is the average value during an interval. The flow rate should be plotted at the midpoint of the interval times.

Infiltration should decrease with time and it is important to keep track of the cumulative time from when water was first poured into the inner ring. The table and graph below demonstrate how to calculate infiltration rates and plot them on a graph.

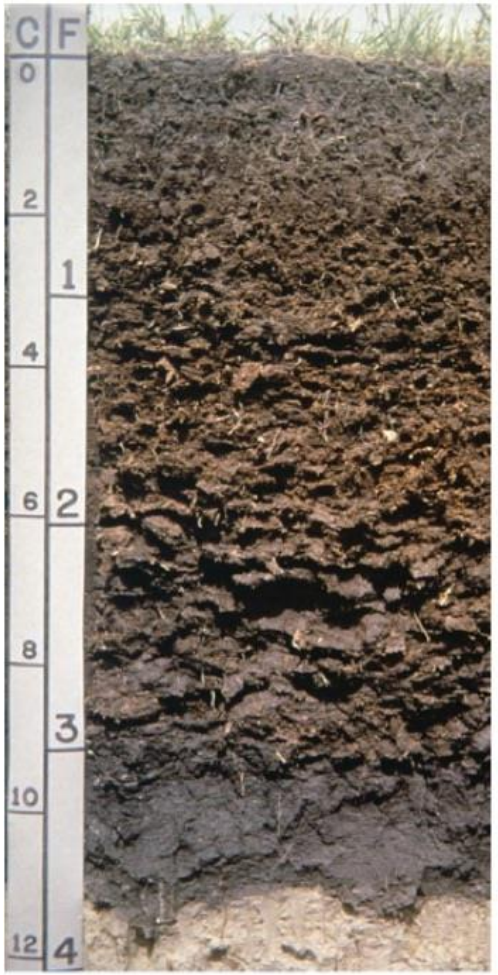
Figure SOIL-IN-3: Infiltration



The Soils on Planet Earth

By studying the soil in your area and reporting these data to GLOBE, you will make an invaluable contribution to our knowledge of planet Earth.

As you take your soil measurements, remember that you are likely the only ones who will study your specific soil. For much of this critical information, there exists no other way to study the soil in your community. Your contribution to science will be important and unique.



Courtesy of the Natural Resources Conservation Service

Frequently Asked Questions (FAQs)

How often should I conduct the soil protocols?

It depends on which soil property you are examining. Soil properties change over time on different timescales. Properties such as temperature, moisture content, and local composition of air change over a period of minutes or hours. Other properties change over months or years, including soil pH, soil color, soil structure, bulk density, soil organic matter, soil fertility, and the microorganisms, animals and plants in the soil. Over much longer timescales, that is, tens to hundreds and thousands of years, changes in mineral content, particle size distribution, horizons and particle density take place. These last measurements you need to do only once.

Frequently Asked Questions (FAQs)

How can I use soil protocols in my classroom?

The GLOBE Implementation Guide provides an example of a classroom soil unit and many tips for using GLOBE investigations to meet your curriculum requirements.

Request for your feedback on this module! Please provide us with feedback about this module. This is a community project and we need your comments, suggestions and edits!
Comment here: eTraining Feedback
Questions after reviewing this module? Contact GLOBE eTraining:rlow@ucar.edu

Credits

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