THE GLOBE PROGRAM
A Worldwide Science and Education Program

Soil (Pedosphere)

Soil Temperature

Soil Temperature Overview

This module:

- Tells why to measure soil temperature
- Provides a step-by-step introduction of the protocol

Learning Objectives

After completing this module, you will be able to:

- Explain the role of soil temperature in the environment
- Decide when and where to take soil temperature measurements
- Correctly take soil temperature measurements
- Upload these data to the GLOBE database
- Visualize these data using GLOBE's Visualization Site

Estimated time needed for completion of this module: 1.5 hours

The Importance of Soil Temperature

Soil Temperature is a physical property that regulates chemical and biological processes taking place within the soil.

Weather & Climate

Bud Burst & Leaf Fall

Plant Growth

Evaporation and Decomposition Rates

Other Images courtesy, Izolda Trakhtenberg

Soil Temperature is Linked to Air Temperature

Other Images courtesy, Izolda Trakhtenberg

The temperature of soil is directly linked to the temperature of the atmosphere because solar energy is primarily absorbed at Earth's surface.

Soil is an insulator for heat flowing between the surface and the solid earth.

Soil and rocks have greater heat capacity (heat capacity is the number of heat units needed to raise the temperature of a body by one degree Celsius) than air so soil temperatures are often cooler than the air in the summer and warmer than the air in the winter.

Soil temperatures can range from 50° C for near-surface desert soils in summer (warmer than the maximum air temperature) to values below freezing in the winter.

Soil Temperature

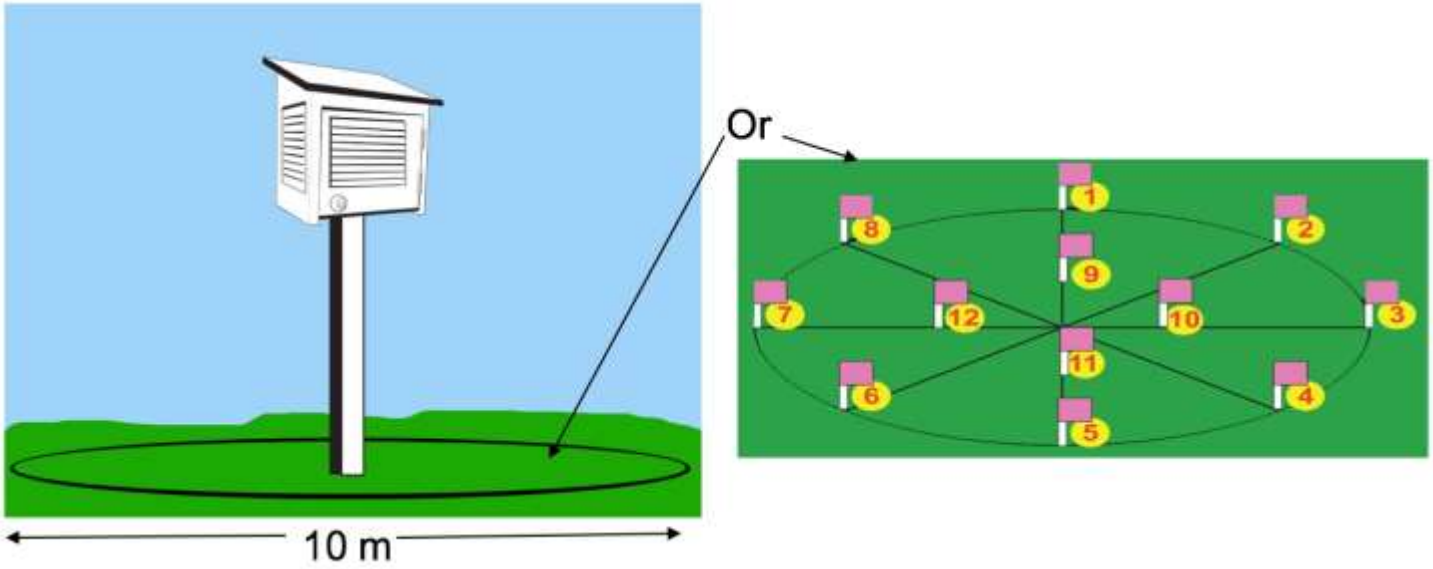
Other Images courtesy, Izolda Trakhtenberg

Soil temperature has a significant effect on the budding and growth rates of plants as well as leaf fall and decomposition.

As soil temperatures rise, it signals seeds that it is time to sprout. Farmers use soil temperature data to predict when to plant crops.

At higher temperatures, chemical reactions speed up. Bacteria, worms, and fungi become more active and this accelerates decomposition of organic materials.

Soil Temperature: Measurement Frequency and Location



Measure Soil Temperature at least weekly at approximately the same time of day each time.

Take data within 10 m of the atmosphere shelter or near the soil moisture site if you are taking either of those measurements.

GLOBE encourages you to take Soil Temperature measurements daily, if you can, and to conduct the Soil Temperature Diurnal Measurement Protocol every three months.

Summary of Protocol

Where	Soil Temperature Site
Main instrument used	Dial or digital soil thermometer
Prerequisites	Site definition using the Site Definition Sheet
Needed Documents	Soil Temperature Protocol
	Soil Temperature Data Sheet
Time Required	1—15 minutes
Level	All
Frequency	Soil temperature measurements can be taken daily or weekly. Seasonal measurements are taken every three months at 2-3 hour intervals for two consecutive days (diurnal cycle measurement).

Required Equipment

For Soil Thermometer Calibration:

- Calibrated Soil thermometer
- Calibration thermometer (determined to be accurate to + 0.5˚ C using the ice bath method)
- 500-mL beaker
- Water
- Wrench that fits nut on soil thermometer

For Soil Temperature Measurement:

- A Defined Soil Temperature Sampling Site
- Soil Thermometer
- Soil Calibration Thermometer
- Thermometer spacers (for both 5 cm and 10 cm temperature measurements)
- 12 cm or longer nail marked at 5 cm, 7 cm, 10 cm and 12 cm from its point (if the soil is firm)
- Watch
- Science Log/Data Entry App
- Pen or pencil
- Hammer (if soil is extra firm)

Soil Thermometer Calibration

1. Pour about 250 mL of water at room temperature into a beaker (enough to cover the lower 4 cm of your thermometers).
2. Place both the calibration thermometer and the soil thermometer into the water.
3. Wait 2 minutes.
4. Read the temperatures from both thermometers. If the temperature difference between the thermometers is less than 2° C, stop; your soil thermometer is calibrated.
5. If the temperature difference is greater than 2° C, wait two more minutes.
6. If the temperature difference is still greater than 2° C, adjust the soil thermometer by turning the calibration nut at the base of the dial with the wrench until the soil thermometer reading matches the calibration thermometer.

Keep the thermometer sensor (the lower 4 cm) in the water as you adjust the calibration.

Soil Thermometer Spacers

The temperature sensor in the soil thermometer is 2 cm up from the tip so it is helpful to make spacers to position the thermometer correctly when inserting it into the soil.

To measure at 5 cm depth, the thermometer's tip must go 7 cm into the soil.

To measure at 10 cm depth, the thermometer's tip must go 12 cm into the soil.

PVC pipe that is 1.5 cm to 4.0 cm in diameter may be used. It will fit around the calibration screw under the face of the thermometer.

You may also use wood blocks as your spacers.

Drill holes in wood blocks that will allow both 7 cm and 12 cm to poke through the blocks.

Note that the holes in wood blocks will not accommodate the calibration screw under the face of the thermometer.

Constructing the Spacer for Measuring at 5 cm Depth

To measure soil temperature at a 5 cm depth, the thermometer must be inserted 7 cm into the soil.

The tip of the probe on the standard GLOBE Soil Thermometer is 20.5 cm from the underside of the instruments face, so to make the 5 cm measurement spacer the appropriate length, cut the PVC pipe to a length of 13.5 cm.

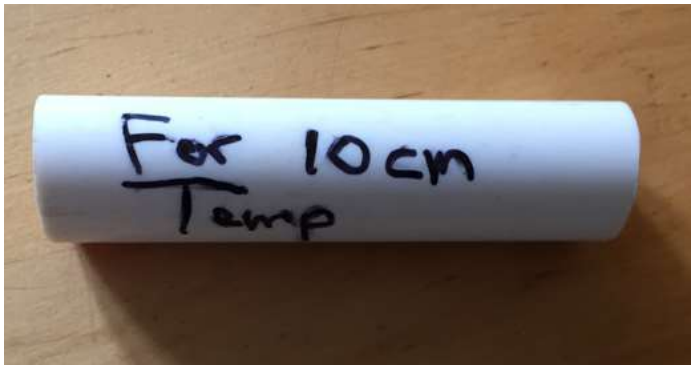
Label the spacer, “For 5 cm Temperature,” to ensure that you and those you instruct will measure the correct depth with it.

Constructing the Spacer for Measuring at 10 cm Depth

To measure soil temperature at a 10 cm depth, the thermometer must be inserted 12 cm into the soil.

To make the 10 cm measurement spacer the appropriate length, cut the PVC pipe to a length of 8.5 cm.

Label it, “For 10 cm Temperature,” to ensure that you will measure the correct depth with it.



Remember, the longer PVC pipe spacer helps measure the more shallow depth, and the shorter PVC pipe helps measure the deeper depth.

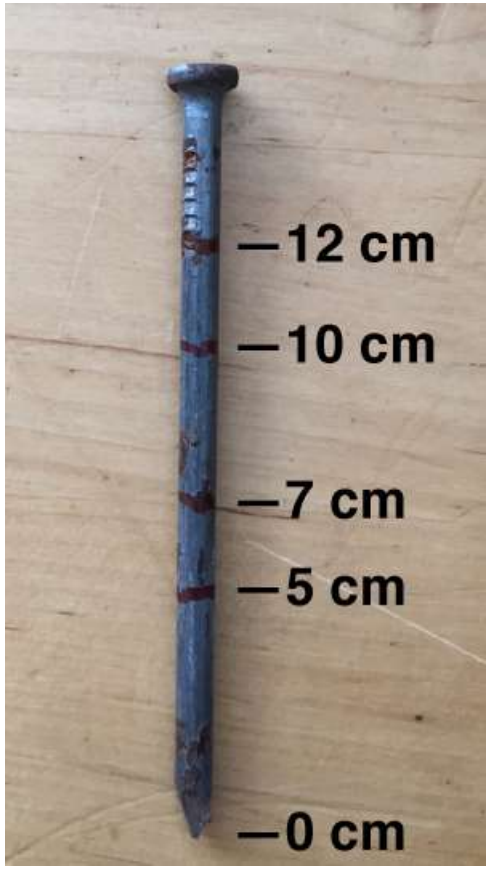
Preparing a Nail to Make Pilot Holes in Hard Soils

When the soil is hard, pushing the thermometer into the ground can damage the instrument. Use a nail to make sure that the thermometer is not damaged.

A nail that is the same diameter as the thermometer probe is used to make a pilot hole.

Mark a nail at 5 cm, 7 cm, 10 cm, and 12 cm from its tip.

Depending on the situation, pilot holes may be needed at these depths.



Soil Temperature Protocol

- Define a Soil Moisture and Temperature Study Site following the procedures presented in the Pedosphere Introduction module.
- At close to local solar noon or other measurement time, go to your site and locate your sampling point.
- Enter the appropriate sample date and sampling event in the Data Entry app or record it on the Data Sheet.
- See Soil Temperature Data Entry towards the end of this slide set.

Soil Temperature Protocol

Use the nail to make a 5 cm deep pilot hole for the thermometer.

If the soil is so firm that you have to use a hammer, make the hole 7 cm deep.

Pull the nail out carefully, disturbing the soil as little as possible. Twisting as you pull may help. If the soil cracks or bulges up, move 25 cm and try again.

Broken, bulging hole Move over 25 cm and try again.

Unbroken, non-bulging hole.

Inserting the Soil Thermometer for the 5 cm Measurement

Insert the thermometer through the longer spacer so that 7 cm of the probe extends below the bottom of the guide.

The back of the dial should be against the top of the spacer.

Gently push the thermometer into the soil.

Reading the 5 cm Soil Temperature

Wait 2 minutes. Record the temperature and time in your Science Log.

Wait an additional minute. Record the temperature and time in your Science Log.

If the 2 readings are within 1.0° C of each other, record this value and the time on the Soil Temperature Data Sheet as Sample 1, 5 cm reading.

If the 2 temperatures are not within 1.0° C, continue taking temperature readings at 1-minute intervals until 2 consecutive readings are within 1.0° C.

Enter that final temperature and the time into the Data Entry app under 5 cm Temperature.

Remove the thermometer from the hole.

Extending the Guide Hole for the 10 cm Measurement in Firm Soil

- In the same hole, use the nail to make a 10 cm deep pilot hole for the thermometer.
- If the soil is extra firm and you have to use a hammer, make the hole 12 cm deep.
- Again, pull the nail out carefully, disturbing the soil as little as possible. Twisting as you pull may help.

Broken, bulging hole. Move over 25 cm and try again.

Unbroken, non-bulging hole

Inserting the Soil Thermometer for the 10 cm Measurement

Insert the thermometer through the shorter spacer so that 12 cm of the probe extends below the bottom of the guide.

The dial should be against the top of the spacer.

Gently push the thermometer into the soil.

Reading the 10 cm Soil Temperature

Wait 2 minutes. Record the temperature and time in your Science Log.

Wait an additional minute. Record the temperature and time in your Science Log.

If the 2 readings are within 1.0° C of each other, record this value and the time on the Soil Temperature Data Sheet as Sample 1, 10 cm reading.

If the 2 temperatures are not within 1.0° C, continue taking temperature readings at 1-minute intervals until 2 consecutive readings are within 1.0° C.

Enter that final temperature into the Data Entry app under the 10 cm Temperature.

Remove the thermometer from the hole.

Take Two More Pairs of Soil Temperature Readings

Repeat steps above for 2 other holes 25 cm away from the first hole. Record these data on the Soil Temperature Data Sheet as Sample 2, 5 and 10 cm and Sample 3, 5 and 10 cm.

These three sets of measurements must all be taken within 20 minutes.

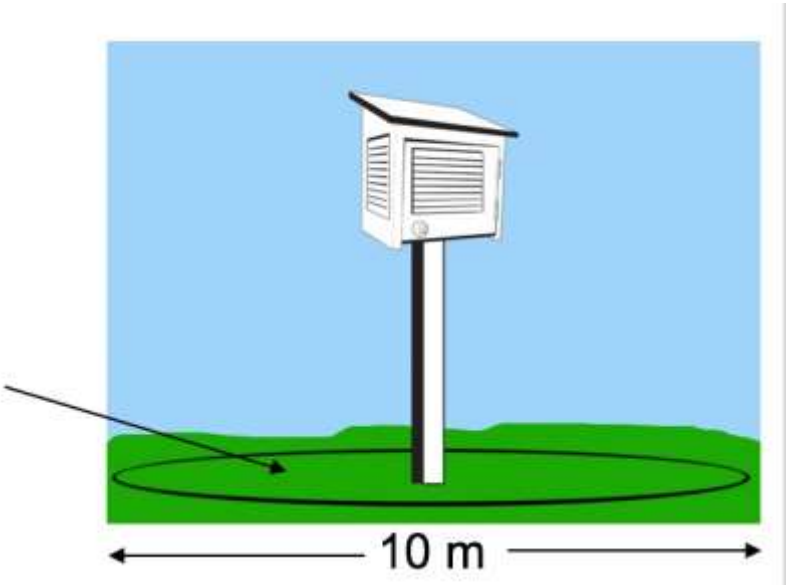
If possible, read and record the current air temperature from the thermometer in the instrument shelter or by following the Current Temperature Protocol in the Atmosphere Investigation.

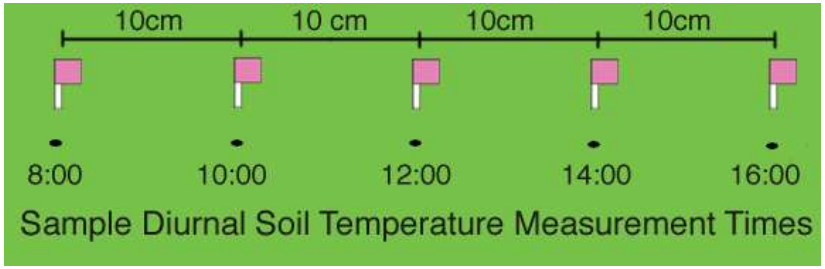
Also if possible measure, record, and report the surface temperature following the Surface Temperature Protocol in the Atmosphere Investigation.

Wipe and clean all the equipment.

Diurnal Soil Temperature Sampling Frequency and Location

- Seasonally (4 times a year), measure soil temperature every few hours during the day for 2 consecutive days.
- If you can, take the diurnal soil temperature measurements in March, June, September, and December.
- Take data within 10 m of the atmosphere shelter or near the soil moisture site if you are taking either of those measurements.
- Offset the measurement locations by 10 cm.





Sample Diurnal Soil Temperature Measurement Times

Diurnal Soil Temperature Sampling

When finished, wipe clean all the equipment.

The second day, repeat the measurements at about the same times.

Each time, if possible, measure, record and report:

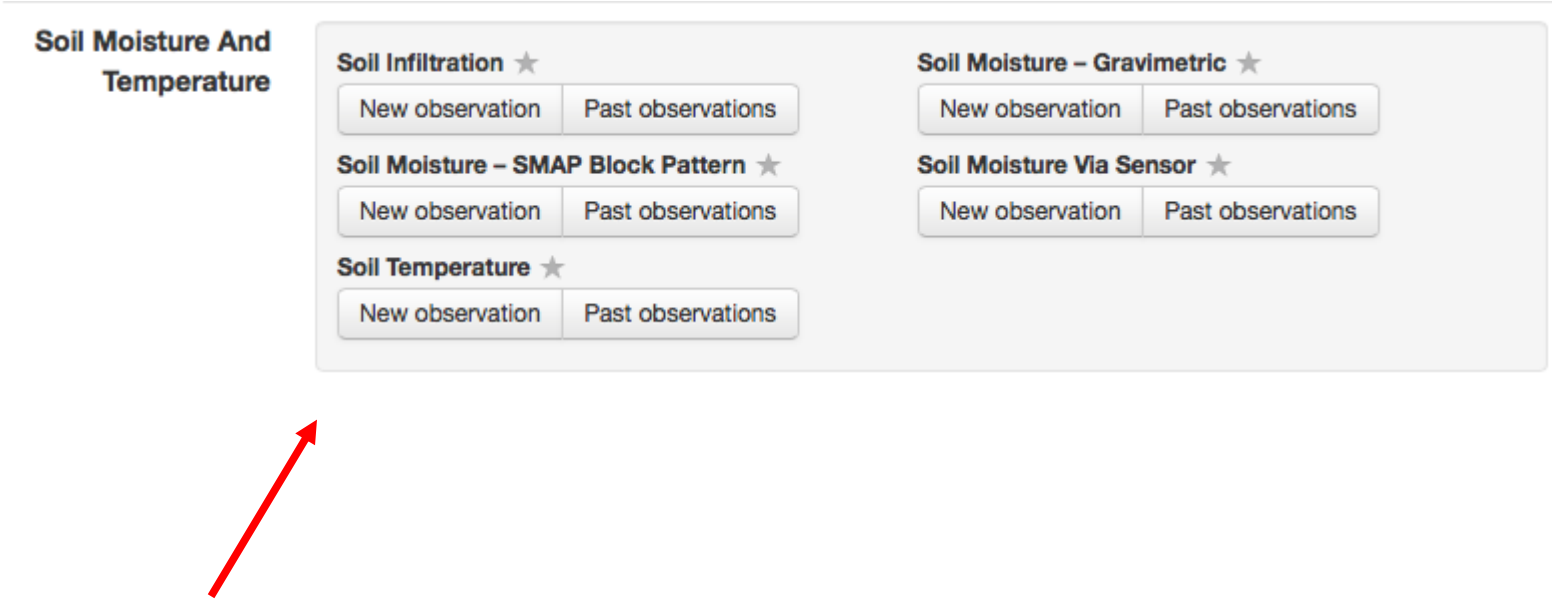
- Surface temperature following the Surface Temperature Protocol from the Atmosphere Investigation and
- Current air temperature from the thermometer in the instrument shelter or by following the Current Temperature Protocol in the Atmosphere Investigation.

Be sure to record all measurements in degrees Celsius.

While a typical diurnal cycle is a full 24 hours, the intention for this protocol is to measure soil temperature during the day.

Soil Temperature: Entering a New Observation

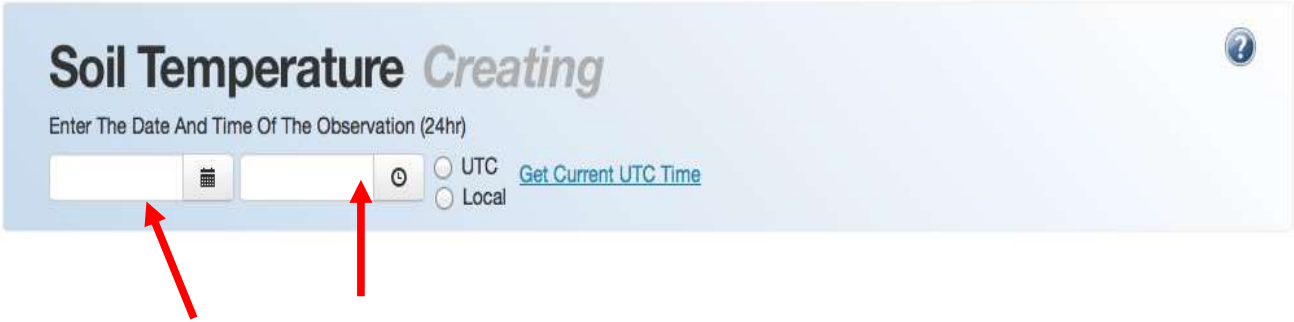
On the GLOBE home page or in the GLOBE Data Entry app select “Live Data Entry”.



Under Soil Moisture And Temperature, click “New Observation.”

Entering Data and Time of your Measurements

On the GLOBE home page or in the GLOBE Data Entry app select “Live Data Entry”.

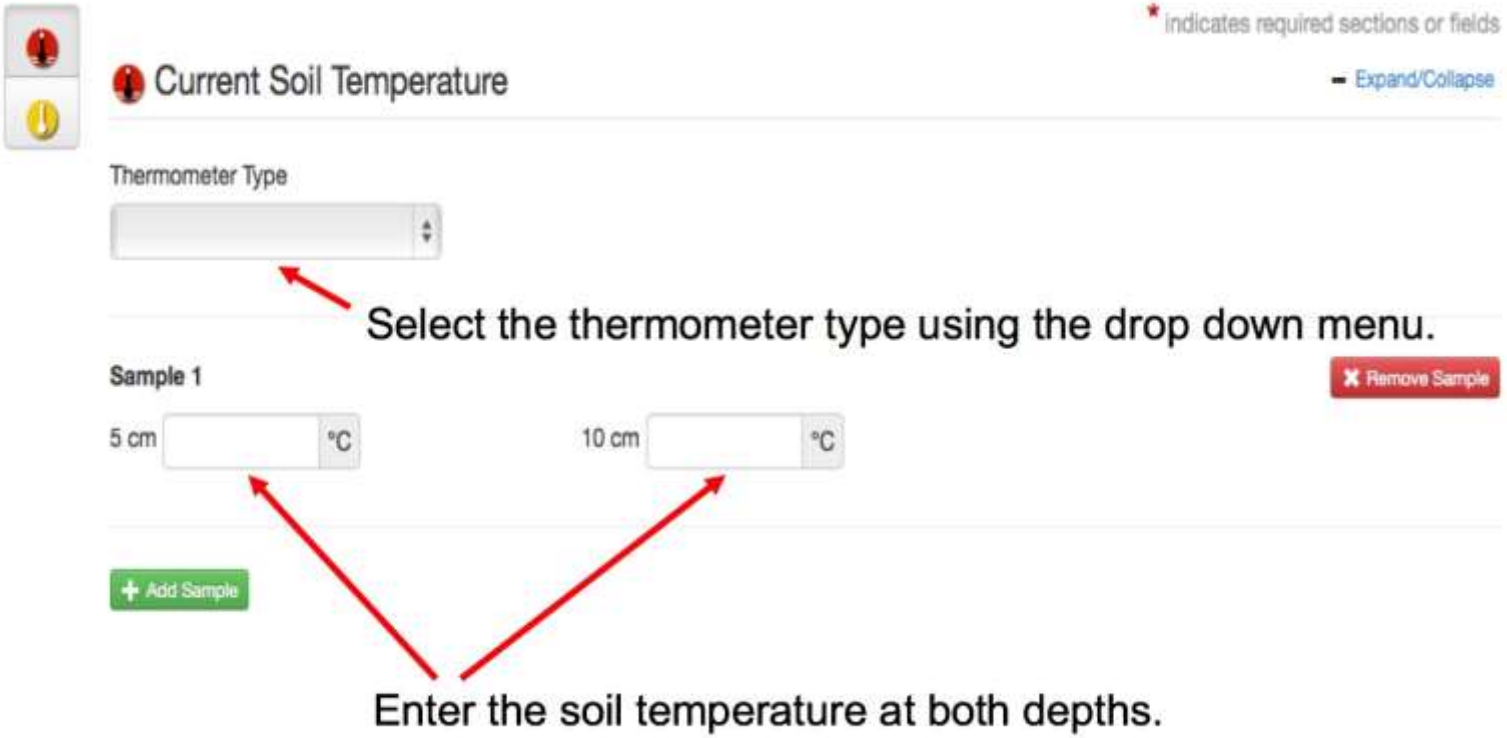


Enter the date and time you took the measurements.

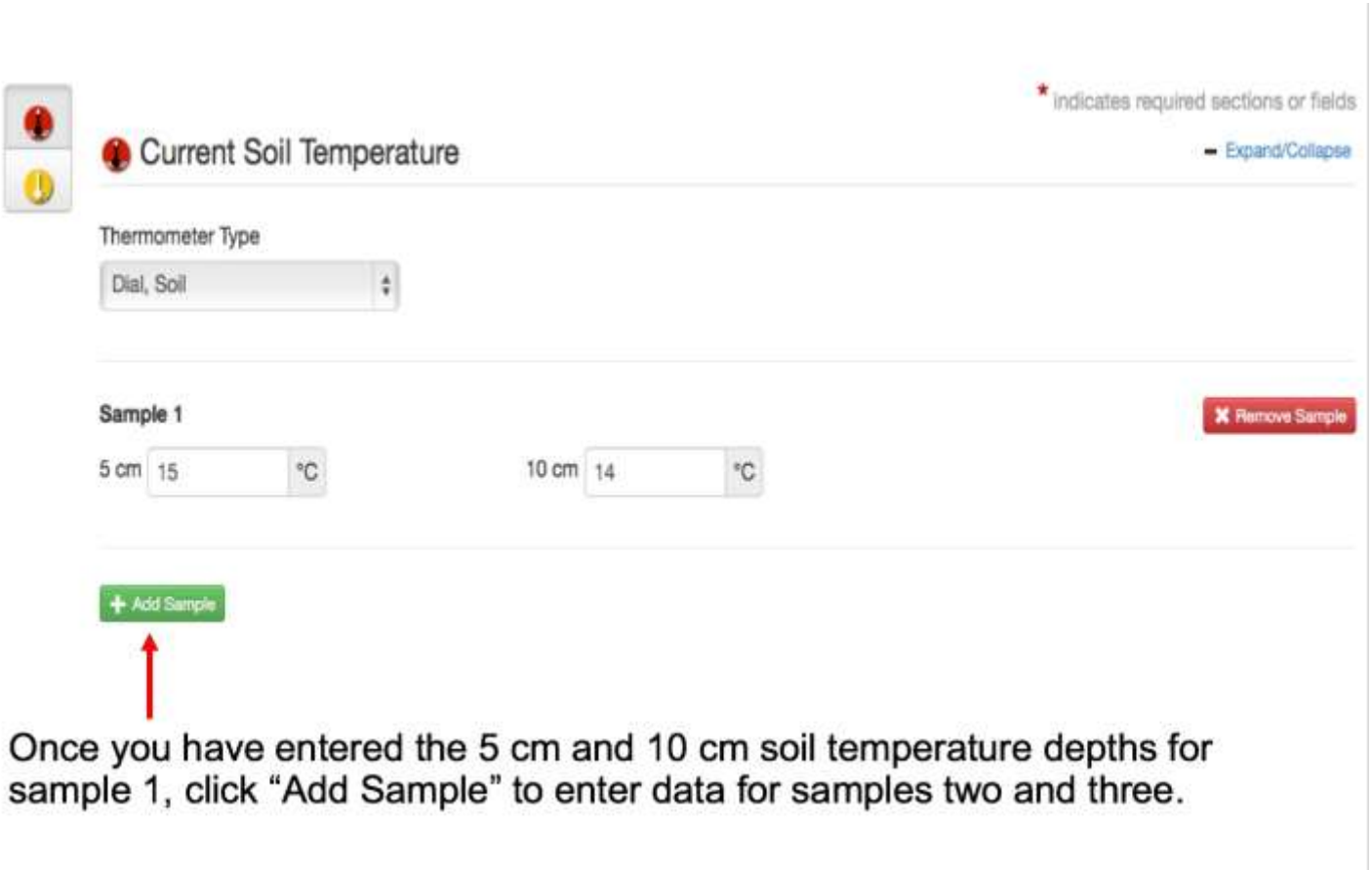
Be sure to choose Local or UTC time.

Once you enter the date, the soil temperature data entry page will appear.

Entering the First Pair of Soil Temperature Observations

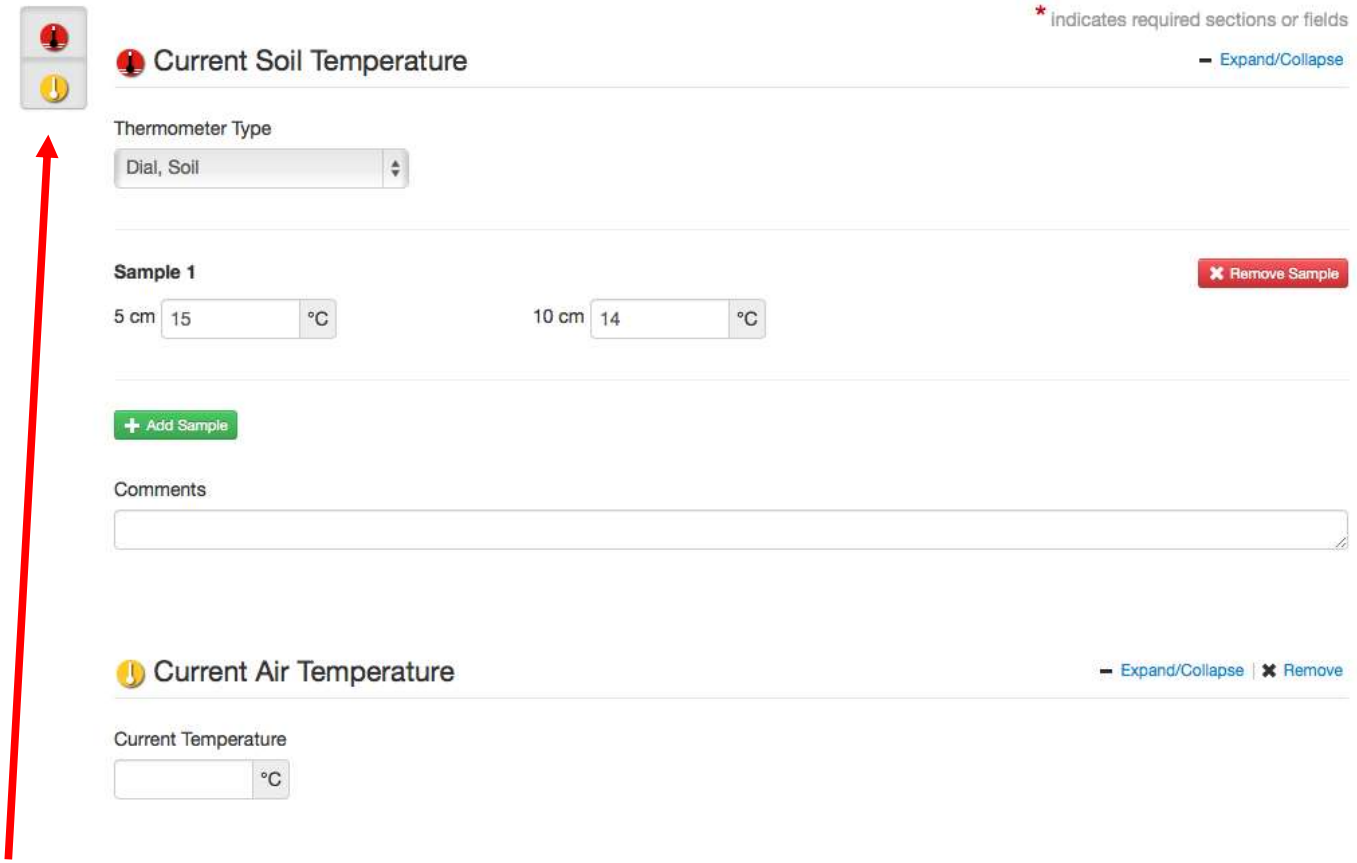


Adding More Soil Temperature Observations



Once you have entered the 5 cm and 10 cm soil temperature depths for sample 1, click “Add Sample” to enter data for samples two and three.

Recording Current Temperature



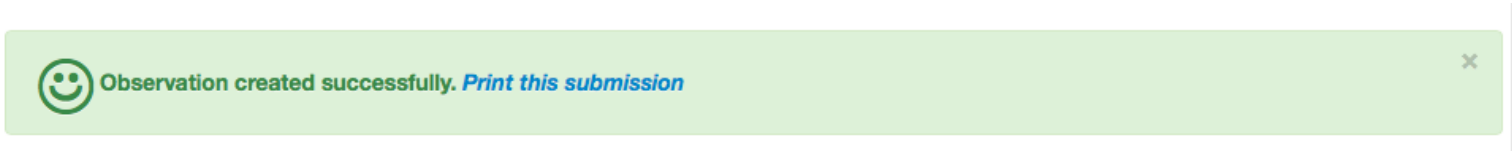
If you are also entering the current air temperature measurement, click the thermometer to bring up that data entry page.

Entering Diurnal Soil Temperature Data

If you are entering diurnal soil temperature measurements, go back to the beginning of data entry for each new observation time. Select “New Observation” and enter the data.

GLOBE Website Responses to Data Entry

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



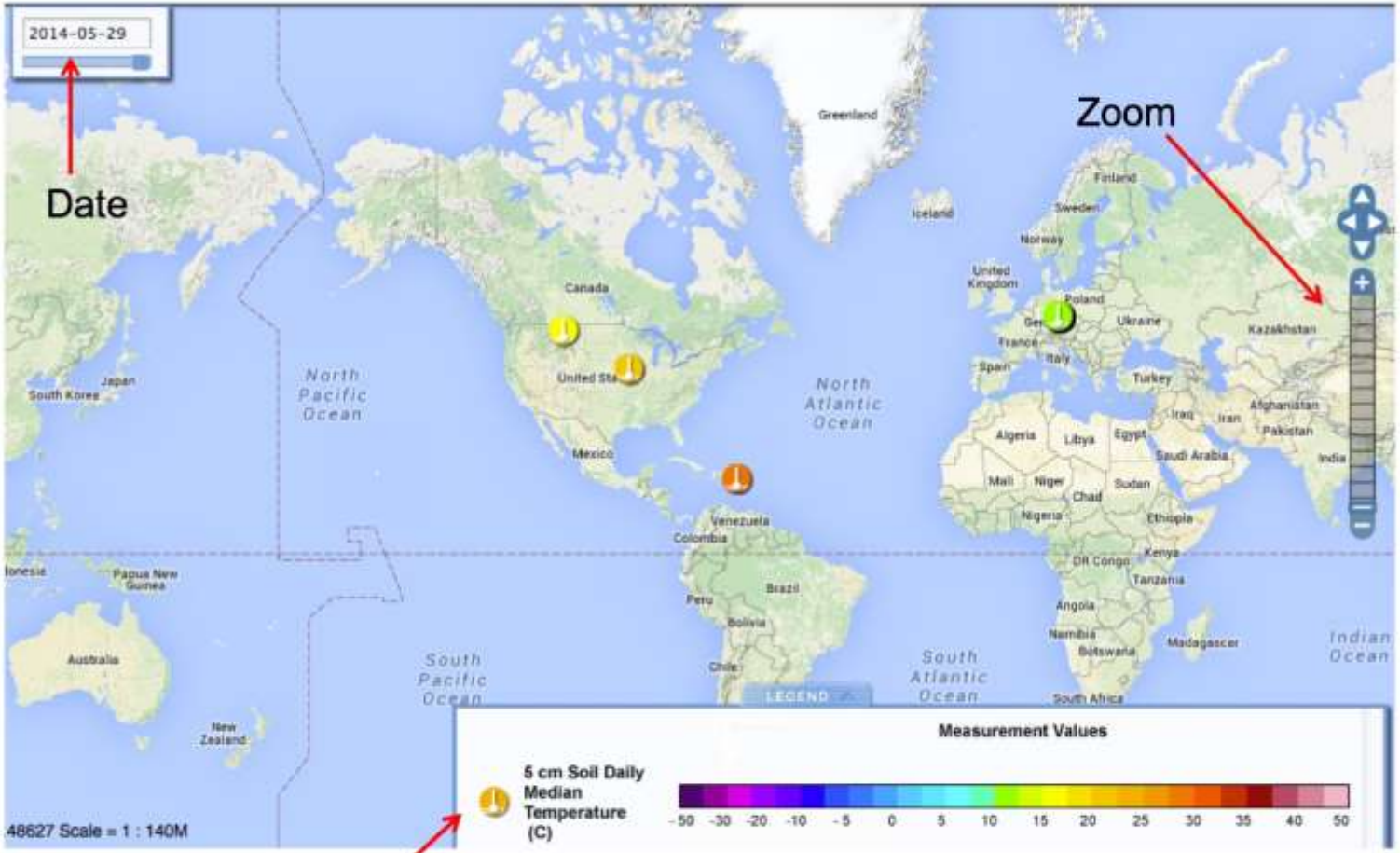
If your data is not within the appropriate range or has other issues, you will see the following.

Address the errors identified in the message and resubmit your data.

If your data are outside the accepted range of values, contact GLOBE Community Support.

Sometimes this has led to GLOBE updating the acceptable ranges for data entry.

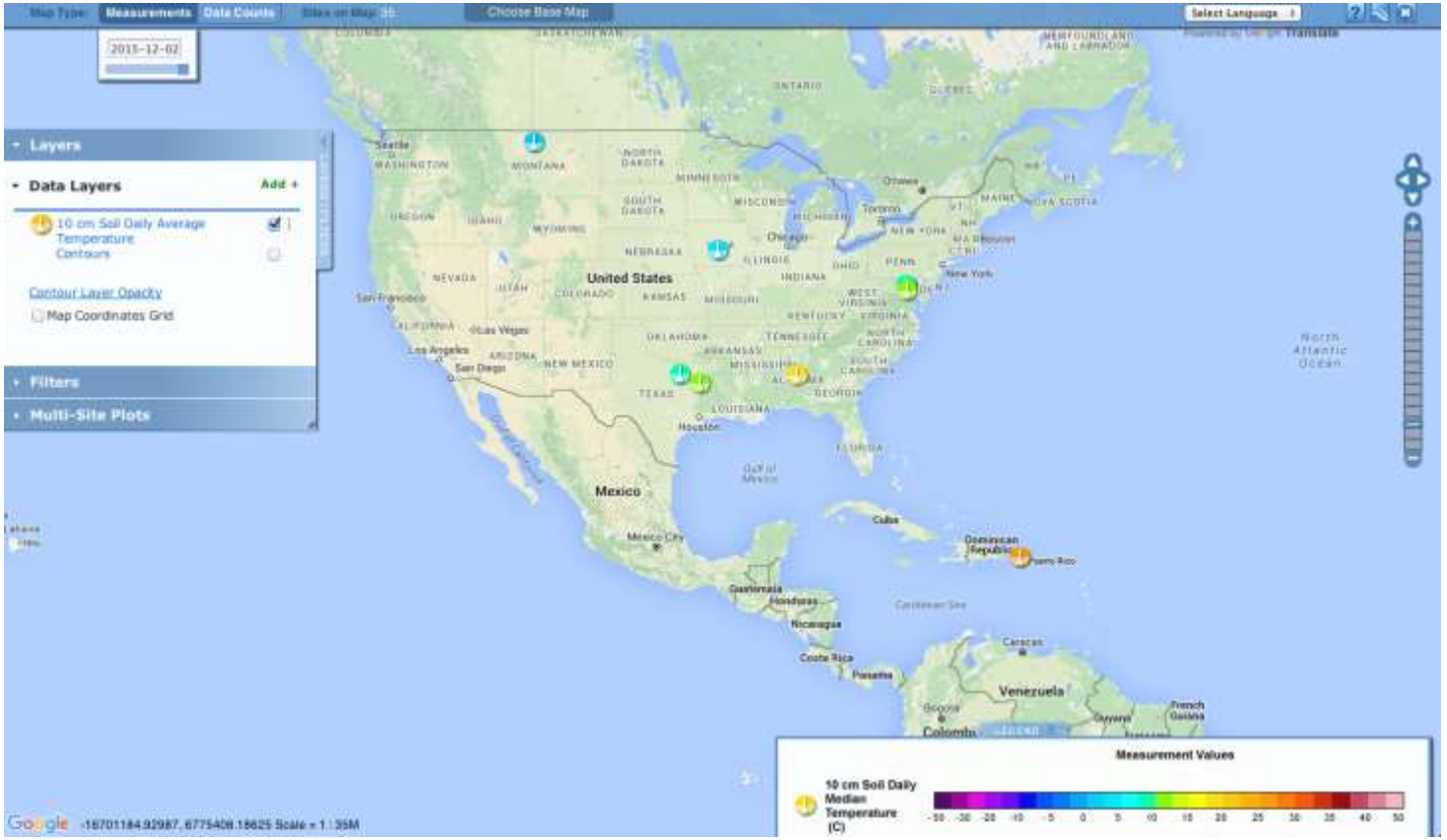
Soil Temperature Data Visualization – 5 cm



Soil Temperature Data Visualization – 5 cm

Data for December 4. 2015 for the Arabian Peninsula

Soil Temperature Data Visualization – 5 cm



Data for December 4. 2015 for North America

Please provide us with feedback about this module. This is a community project and we welcome your comments, suggestions and edits! Comment here: eTraining Feedback

Questions after reviewing this module? Contact GLOBE eTraining: rlow@ucar.edu

Credits

Slides: Izolda Trachtenberg, Dixon Butler, Russanne Low

Photographs: Izolda Trachtenberg

Cover Art: Jenn Glaser, *ScribeArts*

More Information:

The GLOBE Program

NASA Earth Science

NASA Global Climate Change: Vital Signs of the Planet

The GLOBE Program is sponsored by these organizations:

Version 12/1/16. If you edit and modify this slide set for use for educational purposes, please note "modified by (and your name and date) " on this page. Thank you.