GLOBEPROGRAM®
A Worldwide Science & 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 over 90° C for desert soils in direct sunlight (far warmer than the maximum air temperature) to values below freezing in the winter.

Soil Temperature

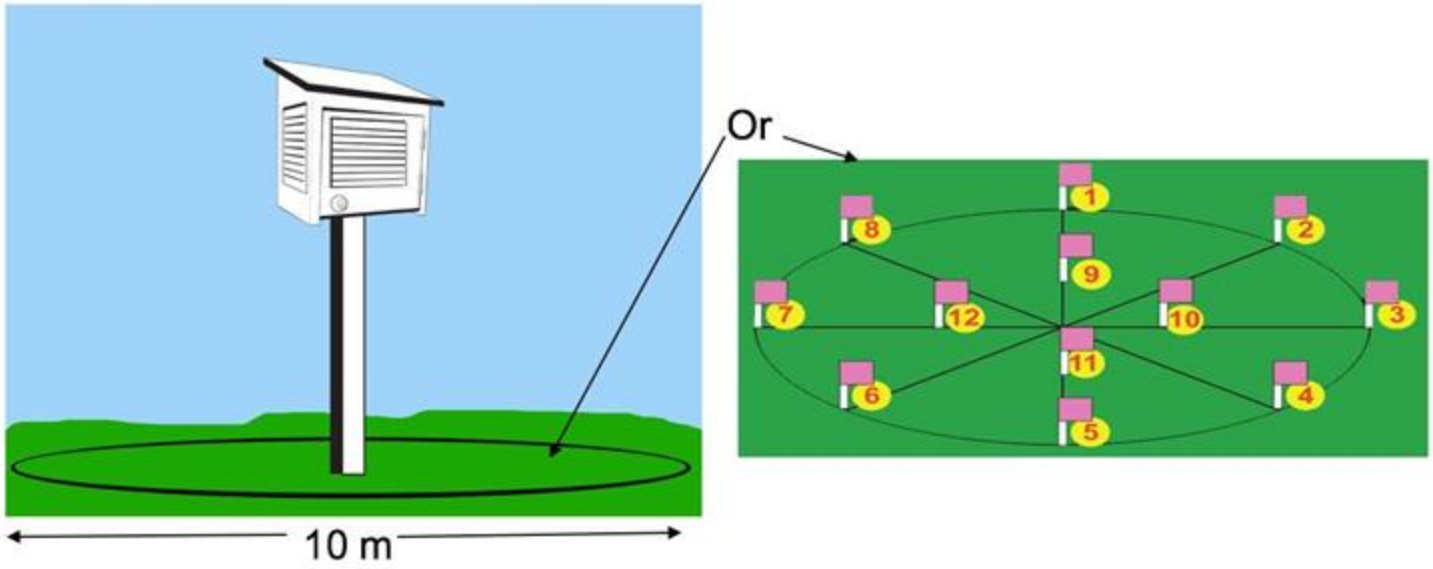
Other Images courtesy, Izolda Trakhtenberg

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

As soil temperature rises, it signals seeds that it is time to sprout. Farmers use soil temperature data, particularly at a depth of 10 cm, to predict when to plant crops.

As temperatures rise, chemical reactions speed up. Bacteria, worms, and fungi become more active and this accelerates decomposition of organic materials. Extreme high temperatures can effectively sterilize soil.

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
- Watch or timer

For Soil Temperature Measurement:

- A Defined Soil Temperature Sampling Site
- Dial or Digital Thermometer (calibrated using a calibrated 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 digital or dial 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.

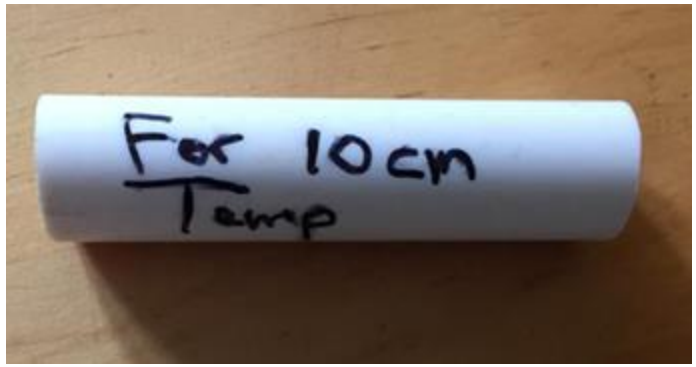
Label the spacer, “For 5 cm Temperature,” to ensure that you and those you instruct will measure the correct depth with it.

Constructing the Spacer for Measuring at 10 cm Dept

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.

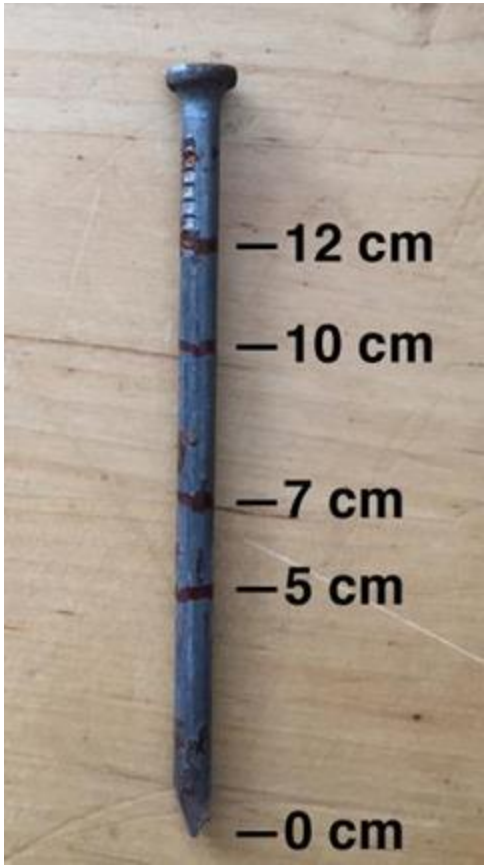
Preparing a Nail to Make Pilot Holes in Hard Soils

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.

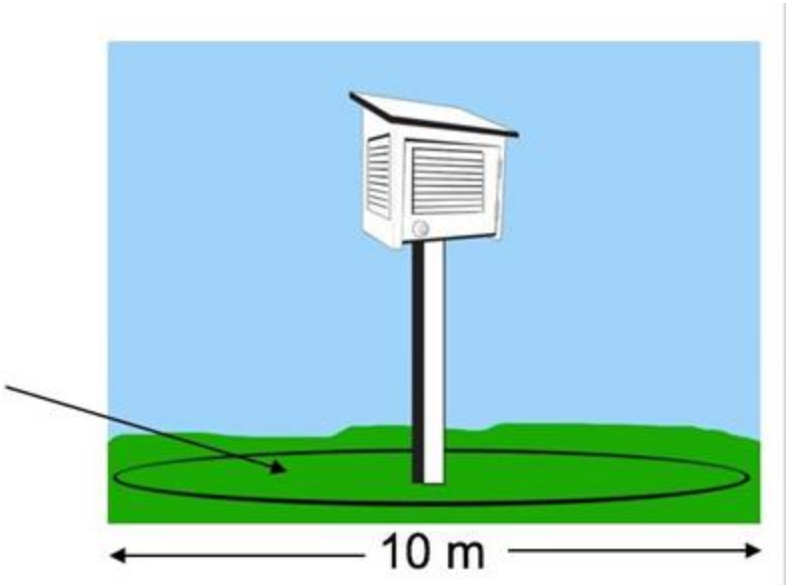
If possible, read and record the current air temperature from the thermometer in the instrument shelter or by following the Current Temperature Protocol in the Atmosphere Investigation.

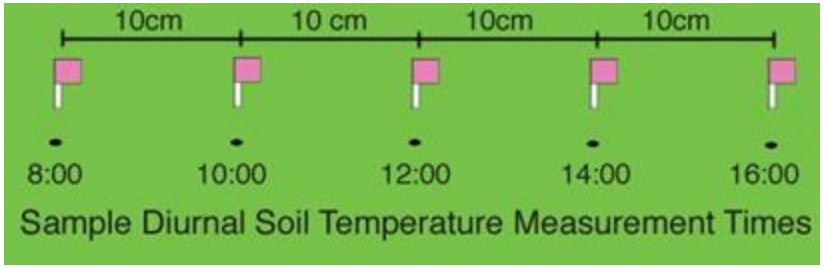
Also if possible measure, record, and report the surface temperature following the Surface Temperature Protocol in the Atmosphere Investigation.

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.

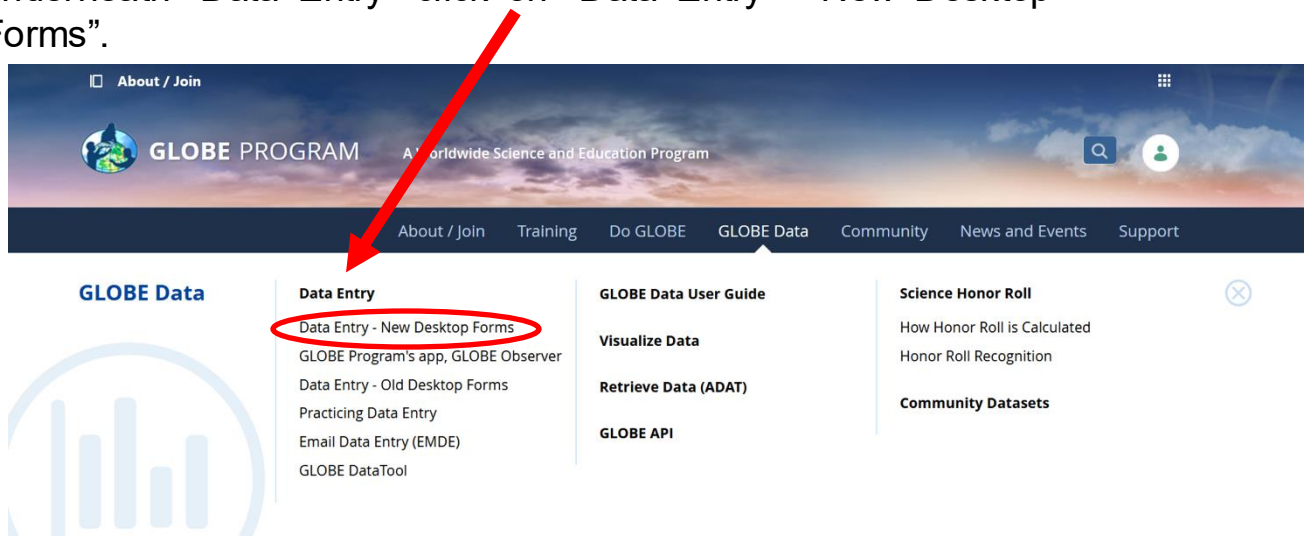
Reporting Data to GLOBE

Two Options for Uploading Data:

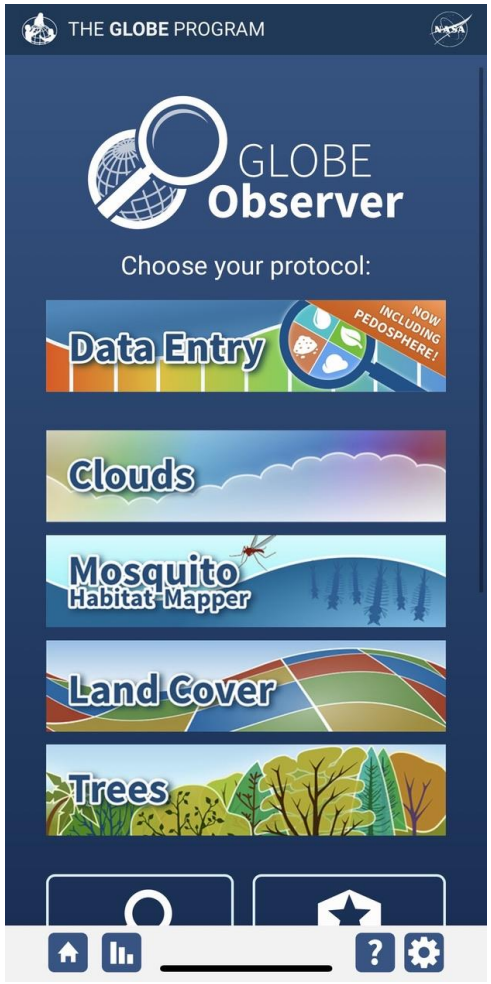
These methods all allow users to submit environmental data – collected at defined sites, according to protocol, and using approved instrumentation – for entry into the official GLOBE science database.

1. Download the GLOBE Observer mobile app from the App Store.

2. Data Entry: Visit globe.gov, click on the "GLOBE Data" tab, then underneath "Data Entry" click on "Data Entry – New Desktop Forms".



Soil Temperature Site Creation

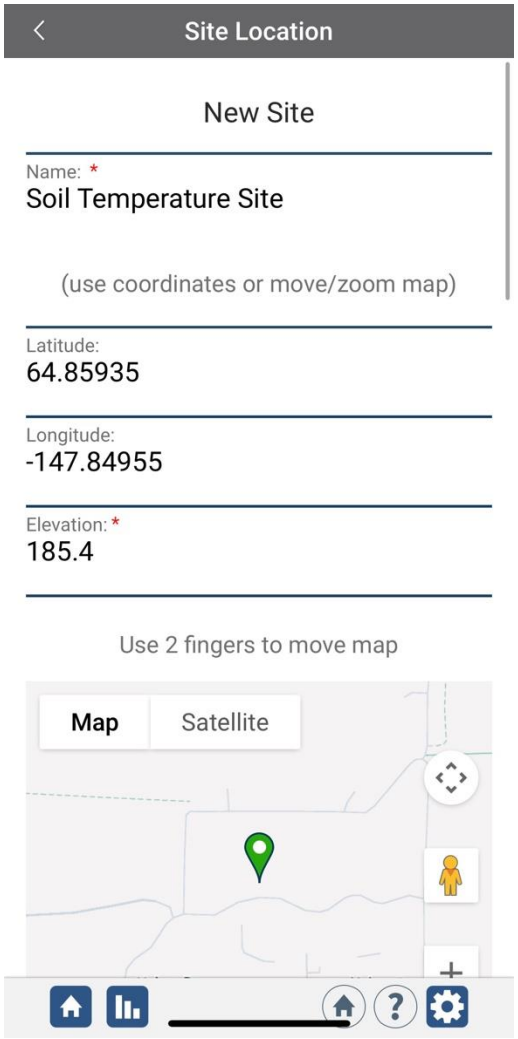


If this is your first time making Soil Moisture observations at this location, you will need to create a new site before entering data.

Open the GLOBE Observer App and select “Data Entry”.

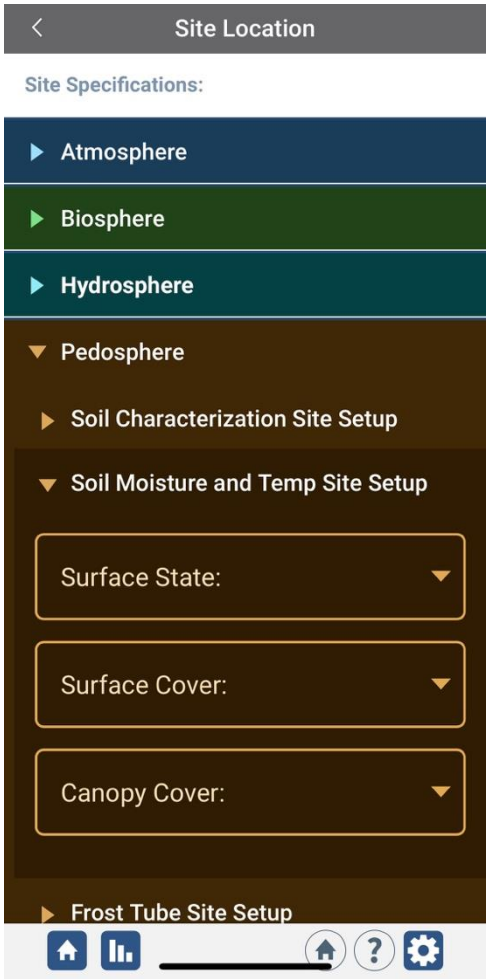
Next, click “Create/Edit My Sites”

Soil Temperature Site Creation



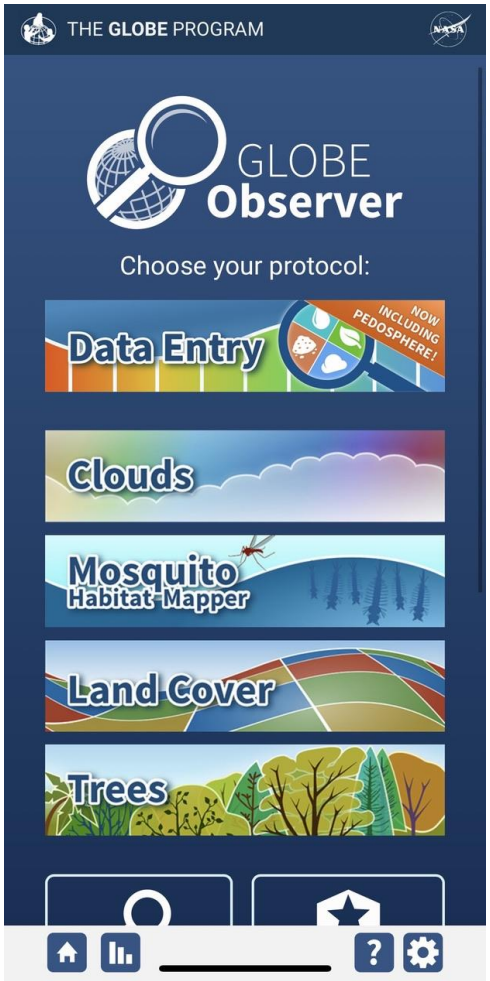
- Enter a name for your new site.
- Use the map box to make sure the green popup is in the correct site location.
- If you used a separate GPS device to locate your site, you can enter the coordinates manually.

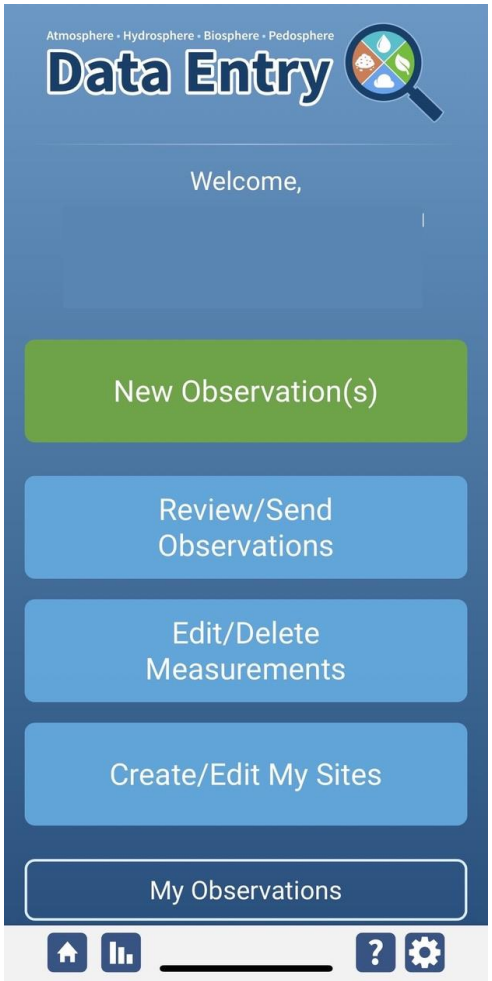
Soil Temperature Site Creation



- Scroll down to the Pedosphere tab
- Select Soil Moisture and Temp Site Setup
- Enter the surface state, surface cover, and canopy cover information for you new site.
- At the bottom of the page, select “Send Site”

Soil Temperature Data Entry



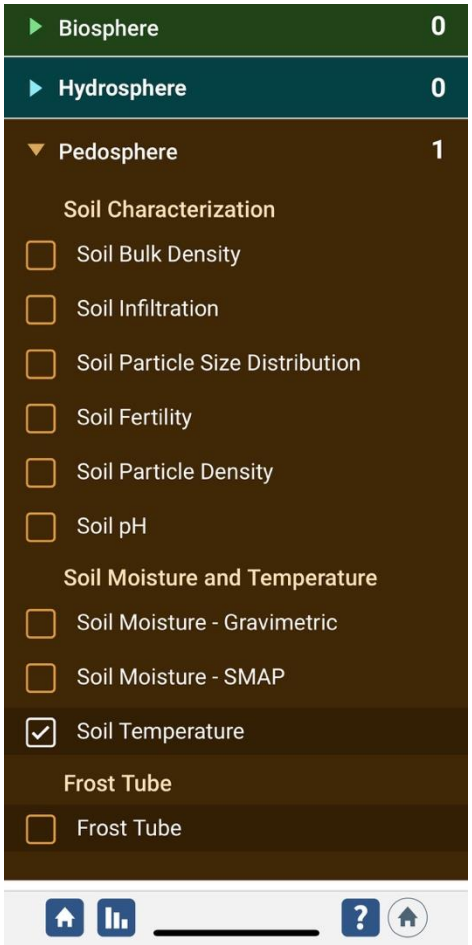


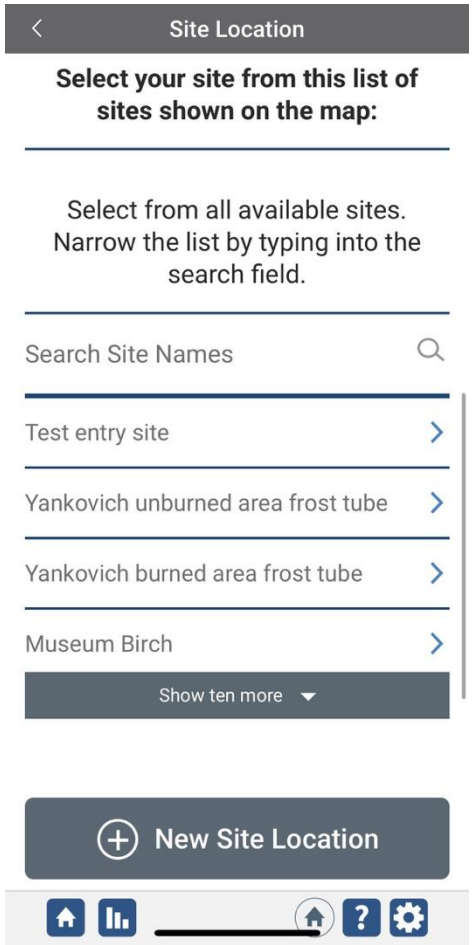
To enter data, first return to the GLOBE Observer main page by clicking the home button in the bottom left.

Select “Data Entry”.

Next, click “New Observation(s)”

Soil Temperature Data Entry

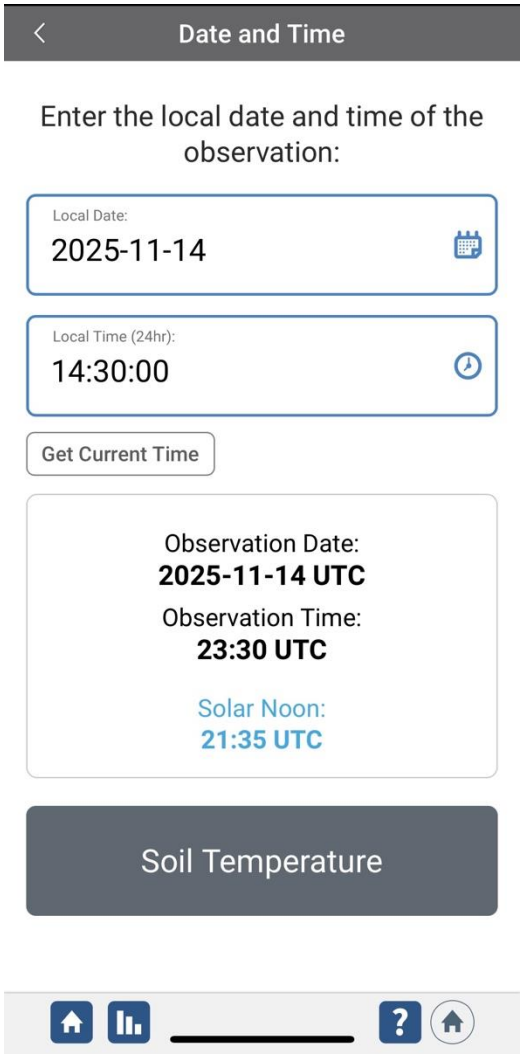




Under the Pedosphere tab, select “Soil Temperature” then click Continue at the bottom of the page.

Next, select your Soil Temperature Site. Existing sites near you will show up below “Search Site Names”

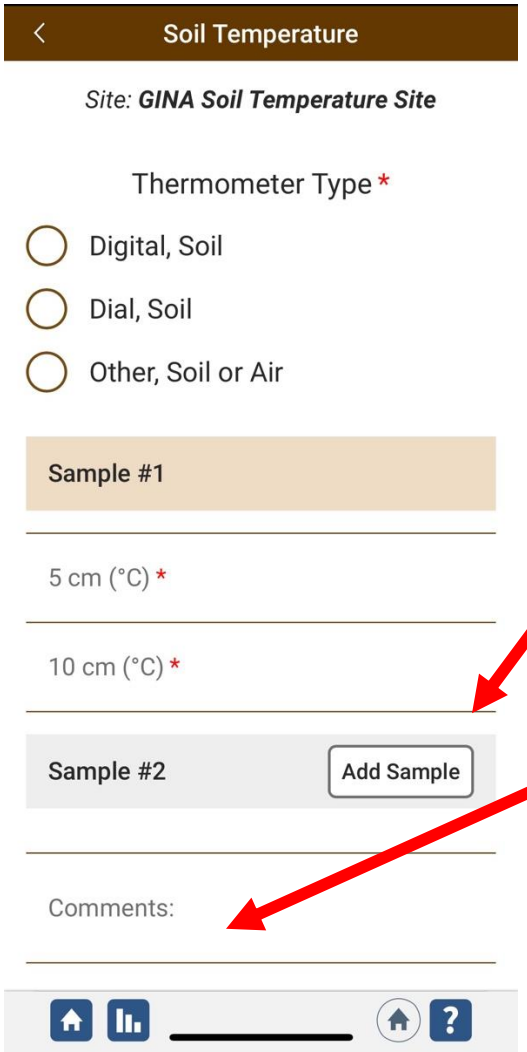
Soil Temperature Data Entry



Next, enter the date and time you took the measurements.

Select Soil Temperature to enter your data.

Soil Temperature Data Entry



Select your thermometer type, then enter the temperatures measured at 5 cm and 10 cm depths.

Click “Add Sample” to add another observation.

Add any comments or additional metadata to the Comments box.

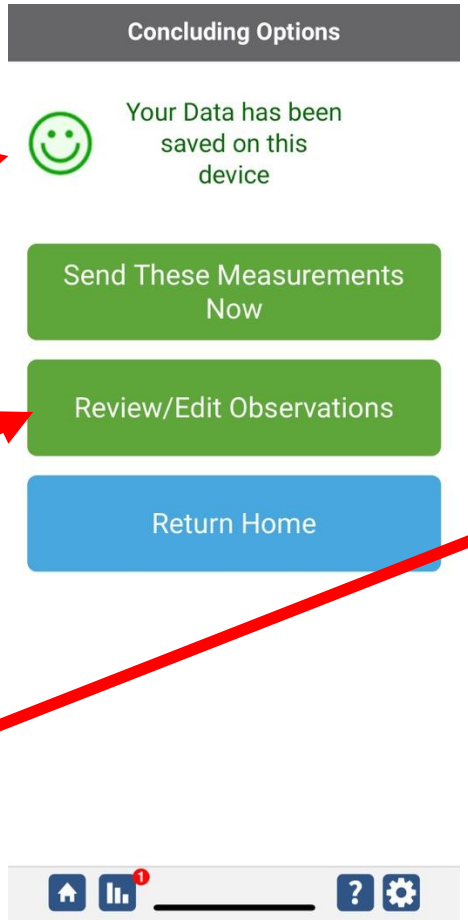
Click Review to review your data before submitting.

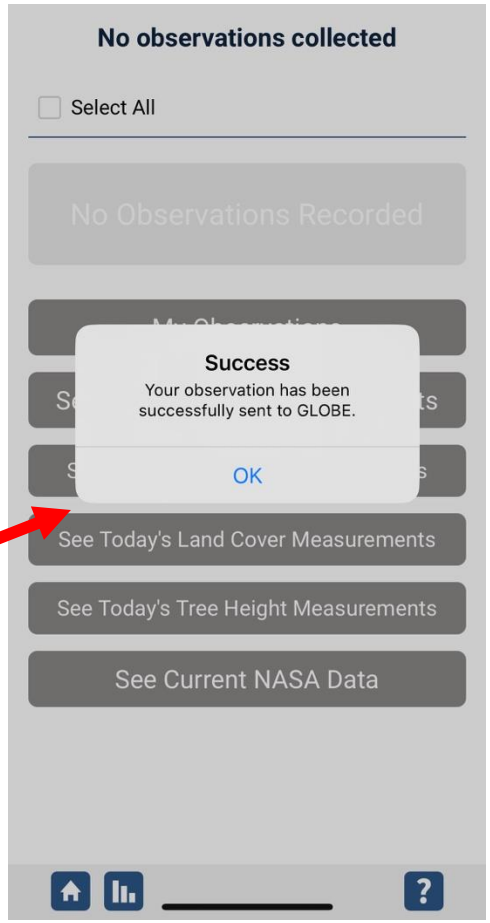
Data Entry System Responses

If your observations are within the appropriate ranges, you will see a green smiley face.

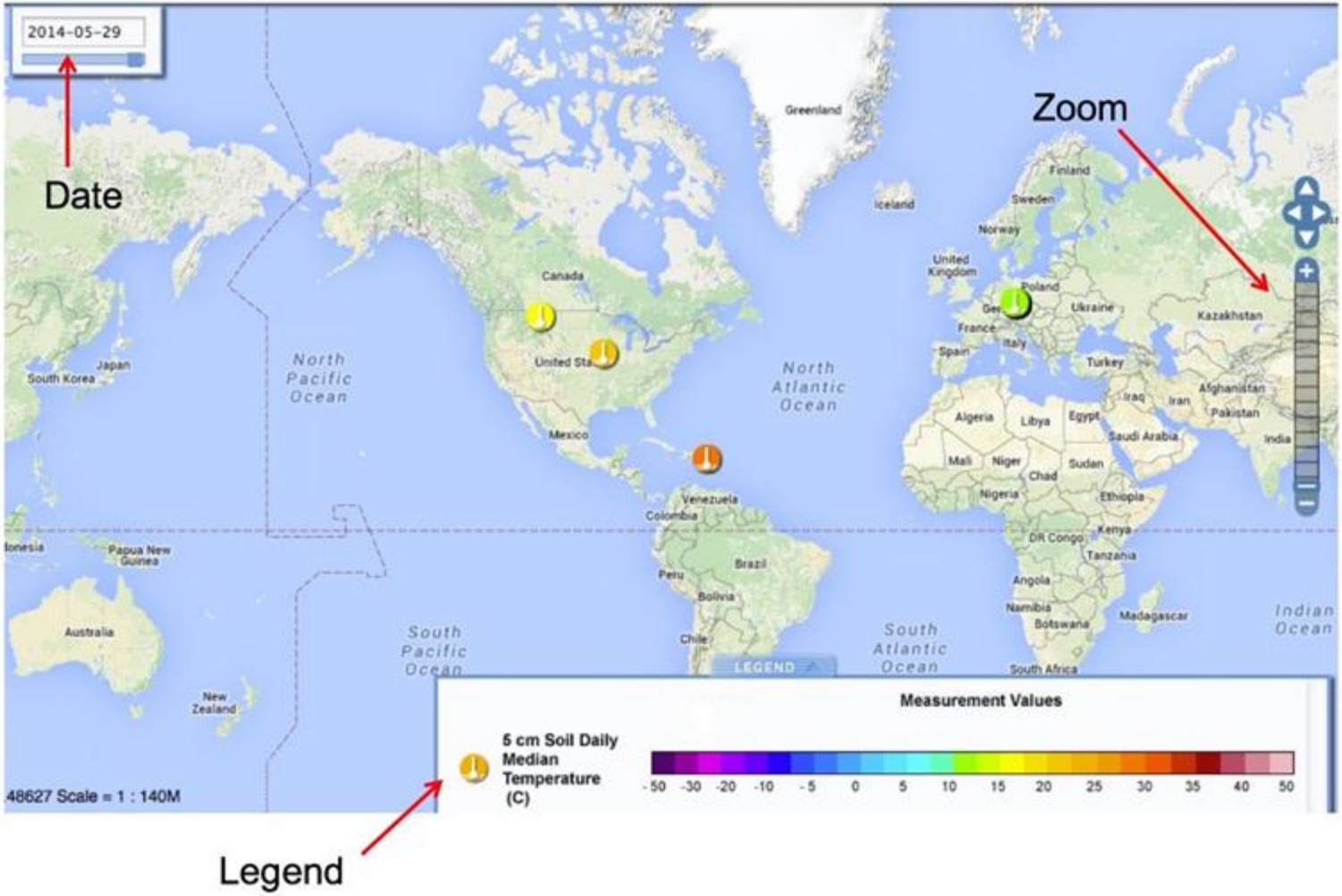
You can review or edit your observation if needed.

When ready, select “Send these measurements now” to send your data to GLOBE. When it has been sent, you will see a “Success” message.

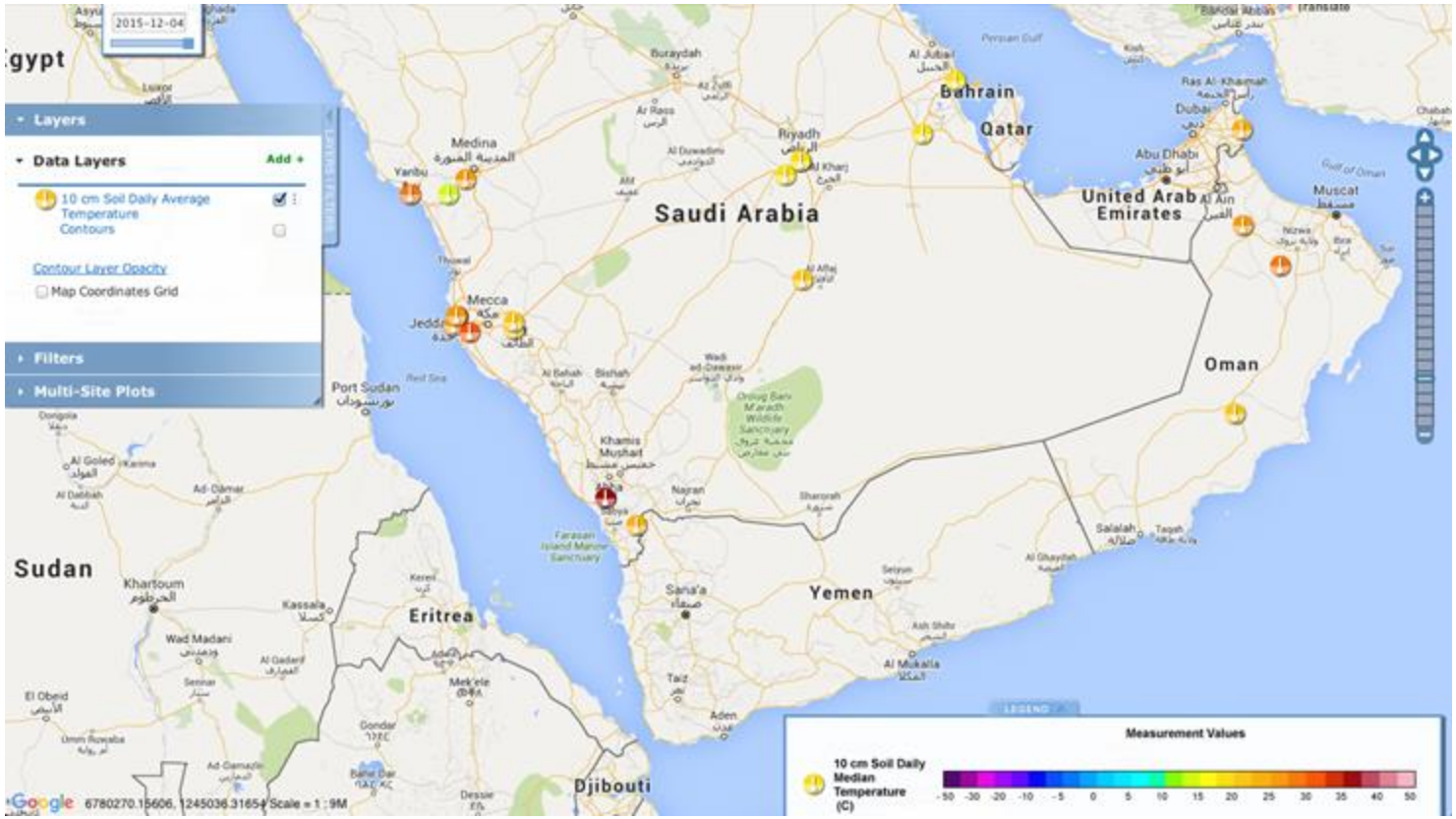




Soil Temperature Data Visualization – 5 cm

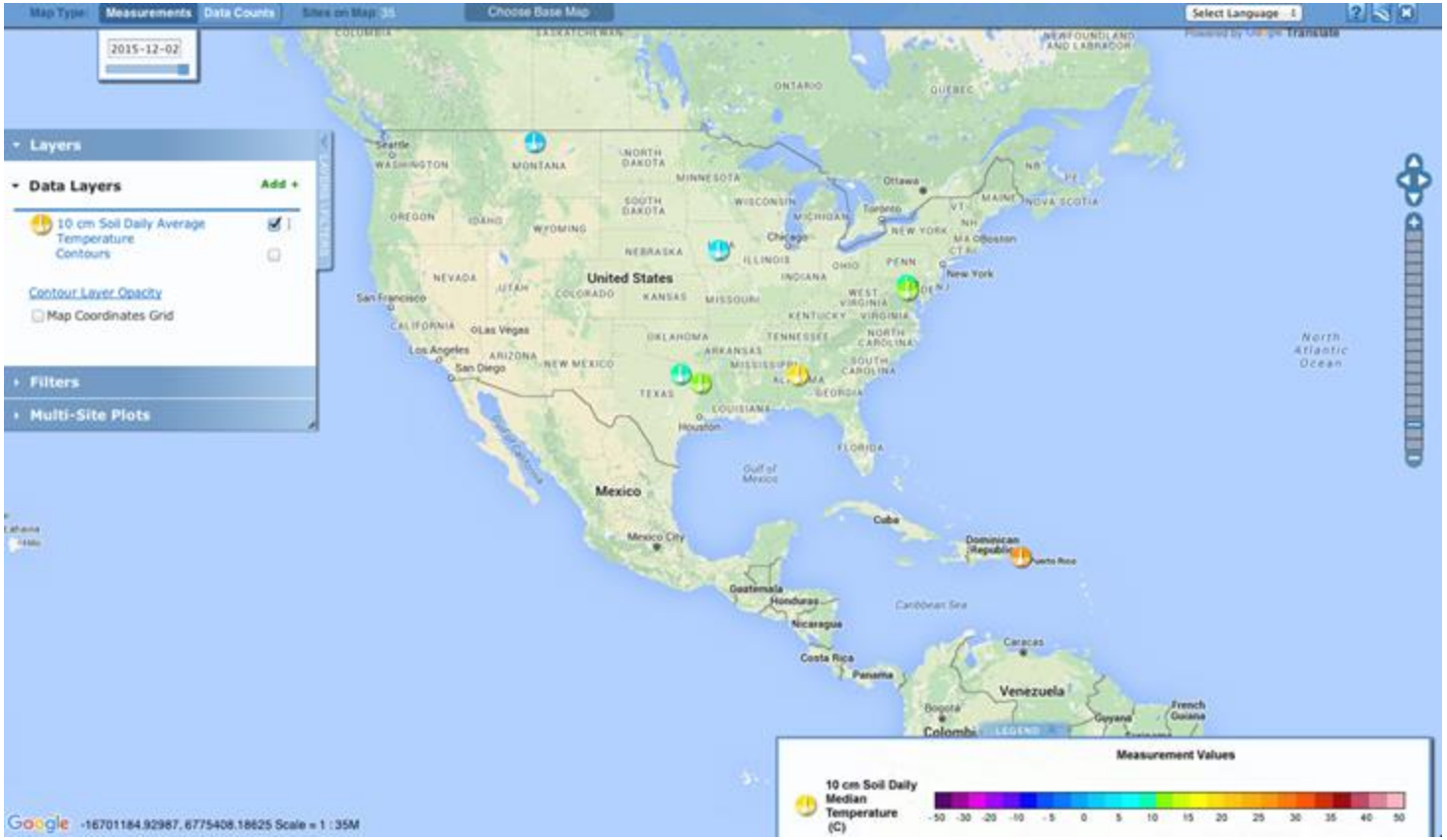


Soil Temperature Data Visualization – 10 cm



Data for December 4, 2015 for the Arabian Peninsula

Soil Temperature Data Visualization –10 cm (Cont'd)



Data for December 2, 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!

Questions after reviewing this module? Contact GLOBE: help@nasaglobe.org

Credits

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More Information:

GLOBE Program

NASA Earth Science

NASA Global Climate Change: Vital Signs of the Planet

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