



A. Why measure frost depth?

B. Properties that affect frost depth.

C. When & where to measure.

D. Required materials.

E. Making a frost tube.

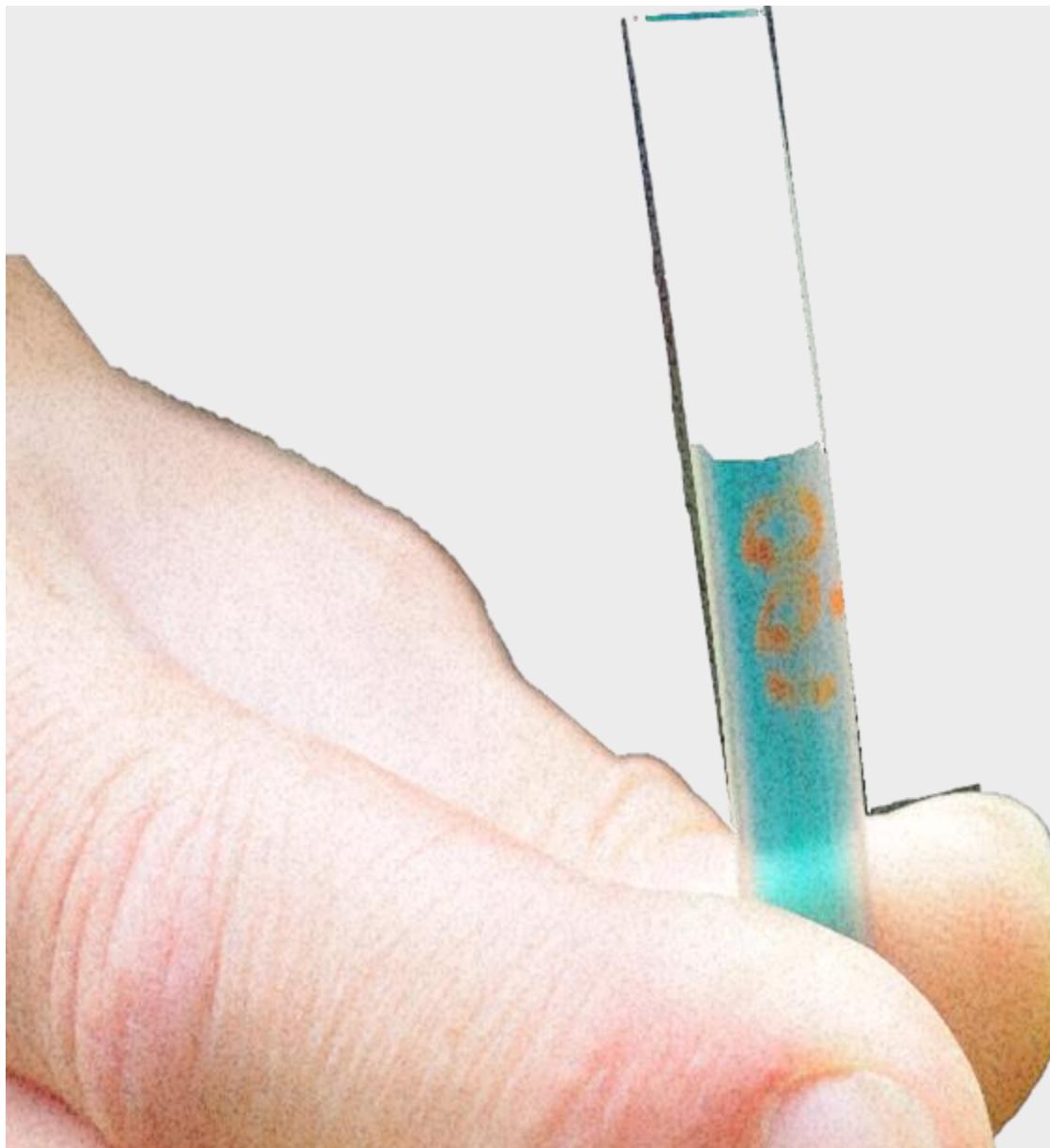
F. Installing a frost tube.

G. Measuring frost depth.

H. Report data to GLOBE.

I. Data Visualization.

J. Additional Information.





## Soil (Pedosphere)



## Frost Tube

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# Frost Tube Overview & Learning Objectives

Frost tube measures the depth of freezing in soils that seasonally freeze and thaw.

The soil frost tube protocol allows GLOBE participants and scientists to see what part of the soil freezes and when the freezing starts and thaws in different seasons and parts of the world.

### Learning Objectives:

After completing this module, you will be able to

- Explain why depth of freezing is worth measuring
- Decide where to install a Frost Tube
- Determine a schedule for taking Frost Tube measurements
- Measure frost depth using a Frost Tube
- Report these data to GLOBE

*Estimated time needed for completion of this module: 1.5 hours*



## Soil (Pedosphere)



## Frost Tube

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### What is frost depth?

**Frost depth** (also known as the depth of freezing) is the depth below the soil surface to which soil is frozen. The soil underneath this depth is unfrozen.

GLOBE participants use a Frost Tube to measure the depth of freezing as the ground cools.

The boundary in the inner tube between clear ice and colored unfrozen water indicates depth of freezing measured from the soil surface to the underlying unfrozen soil.





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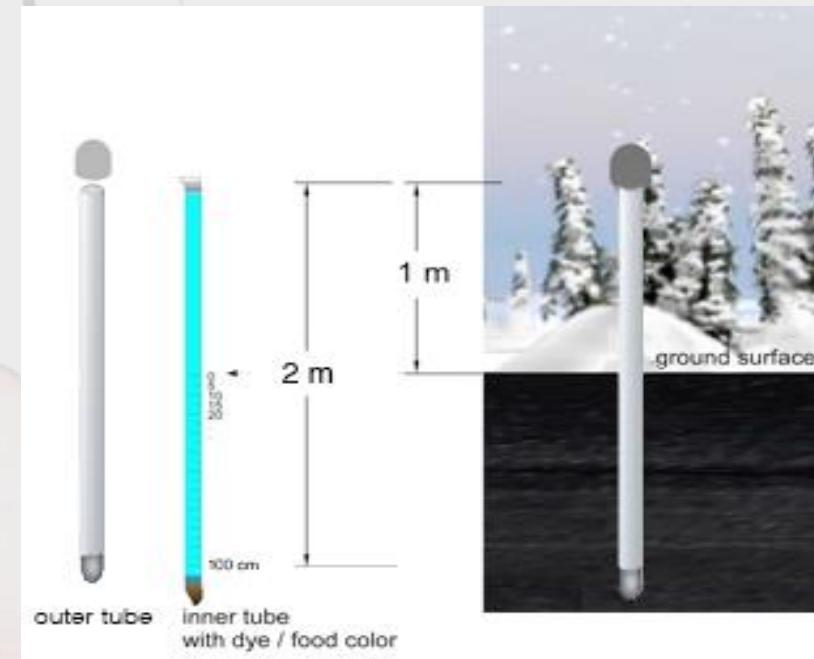
H. Report data to GLOBE.

I. Data Visualization.

J. Additional Information.

## Why measure frost depth?

- Changes in frost depth, timing of freezing, and length of freezing period are important because of their effects on
  - Plant growth and stability of vegetation
  - Floods
  - Construction
  - Transportation
  - Frost heave
  - Grave digging
  - Permafrost





# Soil (Pedosphere)



# Frost Tube

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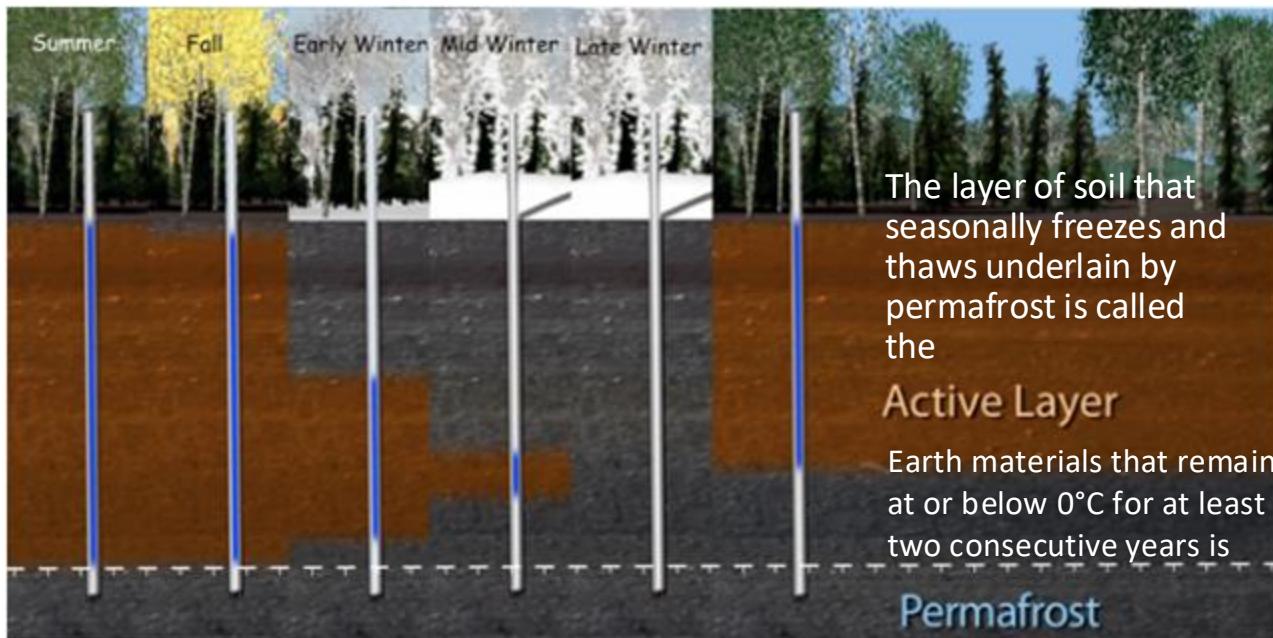
H. Report data to GLOBE.

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**In areas with permafrost , almost all biological activity takes place in the active layer.**

- As permafrost thaws, the active layer above it becomes larger, releasing carbon that had been stored for hundreds of thousands of years.
- Studying the active layer helps scientists predict feedbacks and rates of climate change.





# Soil (Pedosphere)



# Frost Tube

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## Properties that affect frost depth

- Temperature of the atmosphere. When air temperatures are  $< \text{ or } = 0^\circ\text{C}$ , soils freeze from the top down.
- Aspect (e.g. North-facing slope)
- Moss, leaf litter, organic layer thickness
- Snow depth
- Soil texture
- Soil moisture content
- Bulk density
- Permafrost
- Salinity





# Soil (Pedosphere)



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## Overview of Protocol

<b>Where</b>	<ul style="list-style-type: none"><li>Anywhere that soil or ground seasonally freezes and thaws.</li><li>Undisturbed and un-compacted soil on a flat slope.</li></ul>
<b>Time</b>	Construction of Frost Tube: 1 hour Selection of site, set up, installation of Frost Tube <u>in summer/early fall</u> : 1 - 2 hrs. Visits to and from site: 10 minutes (5 minutes to the site and 5 minutes to return) Time to read measurements: 5 minutes
<b>Frequency</b>	Measure at the same time of day (preferably within one hour of solar noon) <u>once a week</u> beginning when air temperatures reach freezing
<b>Documents Needed</b>	<ul style="list-style-type: none"><li>Frost Tube Site Definition Field Guide,</li><li>Frost Tube Site Definition Sheet,</li><li>Frost Tube Field Guide at Air Temperatures Warmer Than -20 C, Frost Tube Field Guide at Air Temperatures Colder Than -20 C,</li><li>Frost Tube Data Sheet,</li><li>GPS Protocol Field Guide (if using a new site), GPS Protocol Data Sheet,</li><li>Optional protocols (air temp, surface temp, snowpack)</li></ul>



# Soil (Pedosphere)



# Frost Tube

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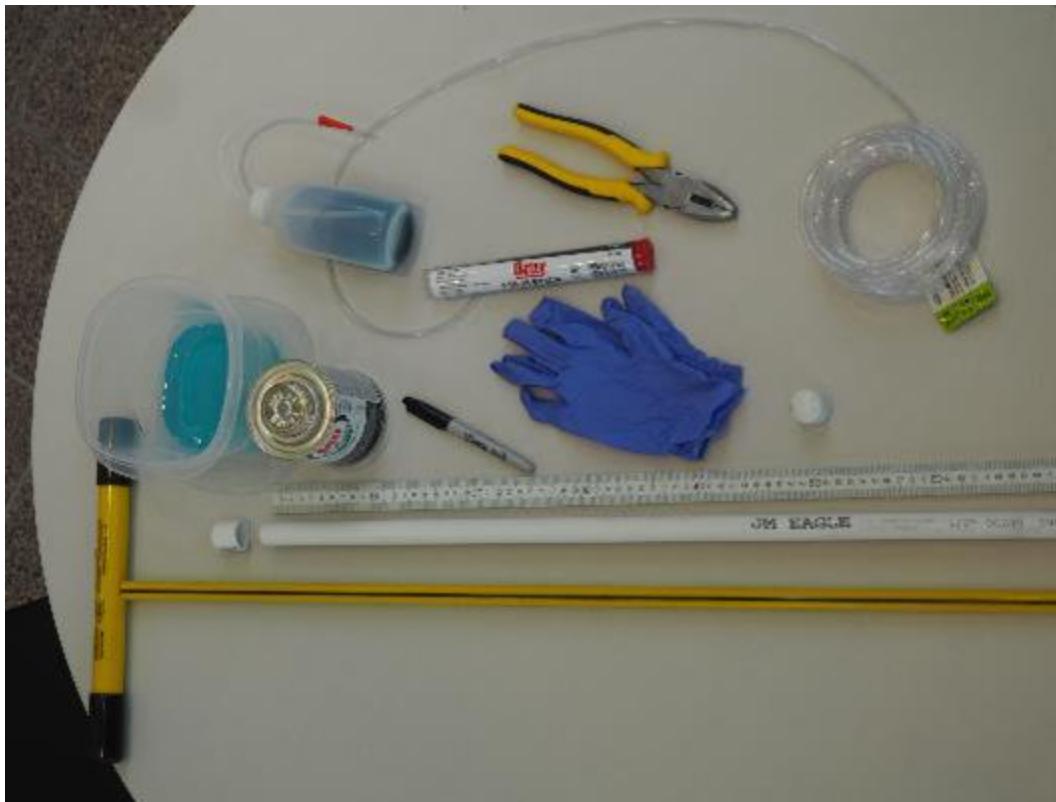
G. Measuring frost depth.

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# Materials



- Inner tube of clear tubing
- Outer tube of PVC pipe
- PVC cap for top
- PVC or epoxy plug for bottom
- PVC cement
- Gas burner, alcohol lamp, or lighter
- Pliers
- Gloves
- Food coloring and water
- Black waterproof marker
- Meter stick
- Soil probe or steel rod
- Flag
- Frost Tube Definition Sheet



# Soil (Pedosphere)



# Frost Tube

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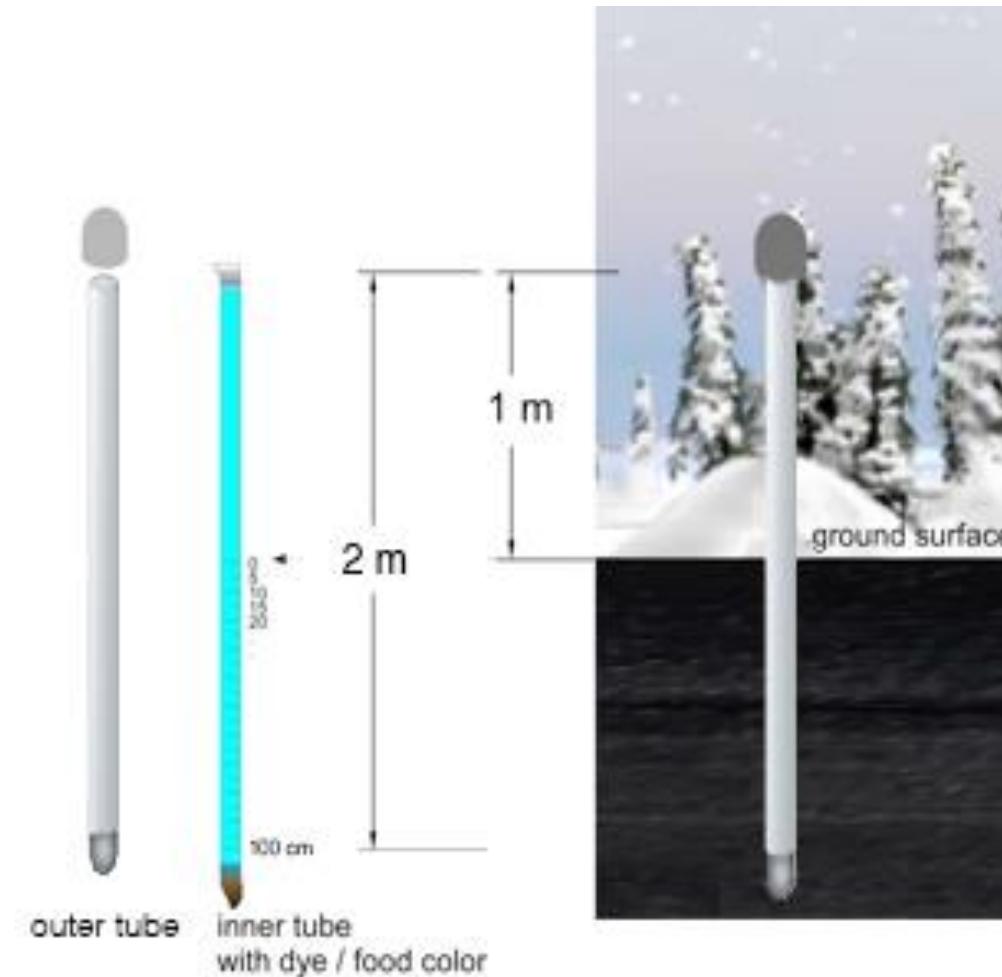
G. Measuring frost depth.

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## Make a Frost Tube





# Soil (Pedosphere)



# Frost Tube

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G. Measuring frost depth.

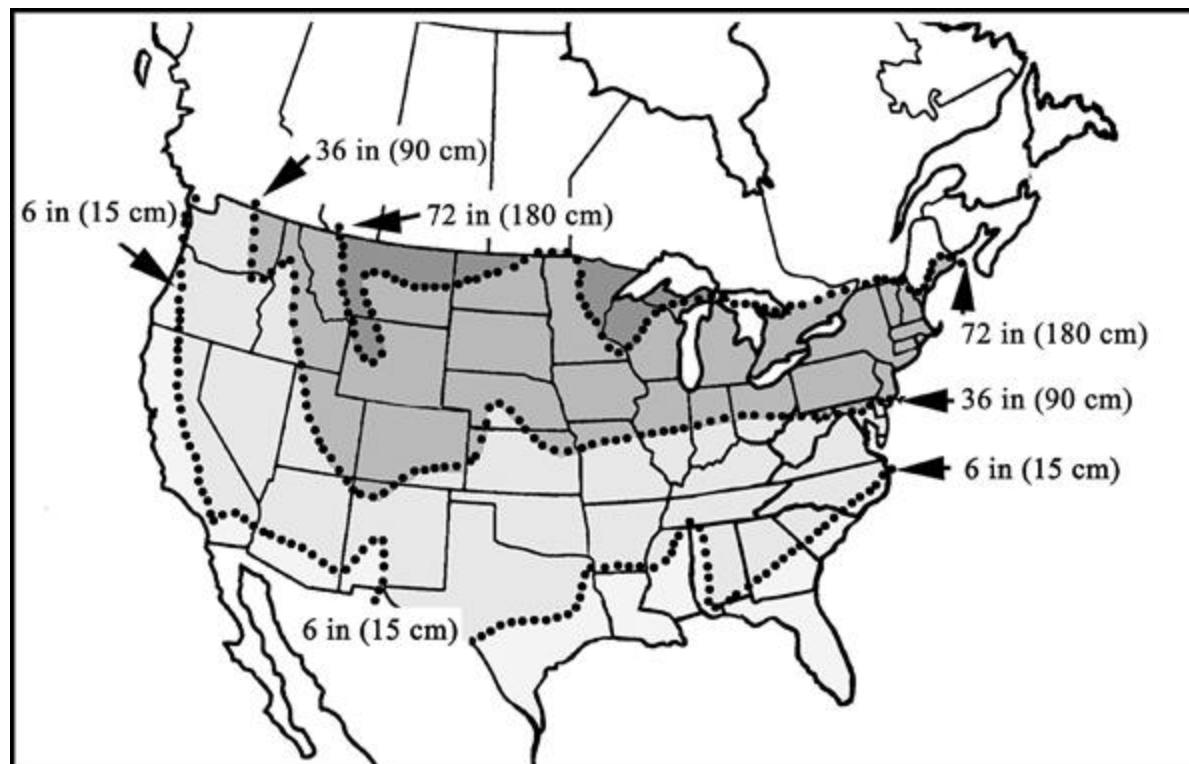
H. Report data to GLOBE.

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J. Additional Information.

## Step 1: Determine the Length of the Frost Tube

*In areas of seasonally frozen ground:* The length of the Frost Tube should be a little longer than the depth to which the ground freezes in winter. A length of 1 m below the ground may be long enough.



Source: National Snow & Ice Data Center

[https://nsidc.org/sites/nsidc.org/files/images/NA\\_permafrost\\_0.jpg](https://nsidc.org/sites/nsidc.org/files/images/NA_permafrost_0.jpg)



# Soil (Pedosphere)



## Frost Tube

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## Step 1: Determine the Length of the Frost Tube

*In areas with permafrost:* The length of the Frost Tube depends on the depth of the active layer.

- The layer of soil above permafrost that seasonally freezes and thaws is called the active layer.
- Check the thickness of the active layer using a steel stick (thaw probe) at the end of the summer.
- Pound the probe into the ground until you hit permafrost. It will feel like you have hit rock or something very hard.





## Soil (Pedosphere)



## Frost Tube

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## Step 2 & 3: Cut & Seal Outer Tube

- Add 1 meter to the estimated below-ground length. The height of 1 m above ground allows the top of the Frost Tube to stick out of the snow (in most areas), be protected from runoff and animals, and be accessible.
- Cut both tubes (inner and outer tubes) to the final length.
- Use a PVC end plug or cap and/or epoxy to seal the bottom of the outer tube. Wear gloves. Secure the end plug/cap to the pipe with PVC cement.



# Soil (Pedosphere)



# Frost Tube

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## Step 4-8: Add colored water & seal inner tube

- In a large bowl mix water and food coloring to make bright but transparent color.
- Fill inner tube with the colored water up to 15 cm from the top. (careful to keep it from pouring out)
- Seal both ends using gas burner, clamping with pliers
- Cap top of outer tube



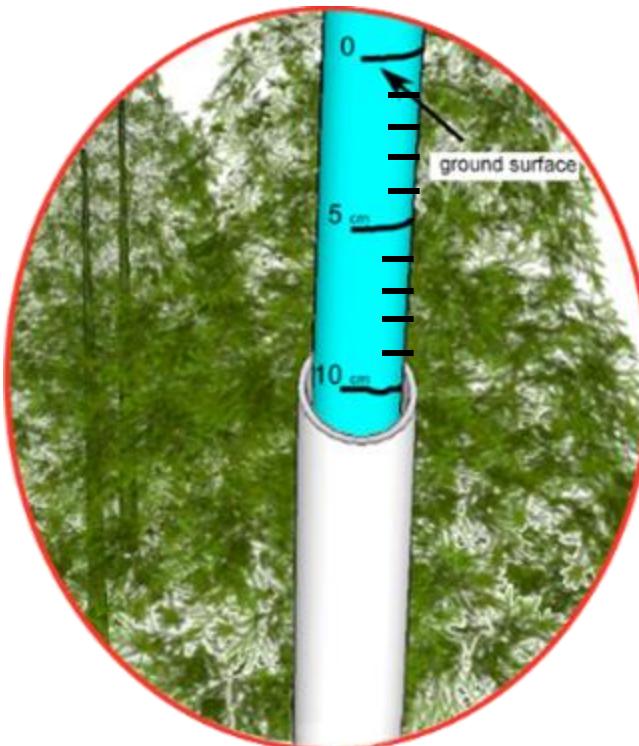


# Soil (Pedosphere)



# Frost Tube

- Make hole in ground with probe
- Insert Frost Tube
- Label ground surface on outer tube



- Pull out inner tube, mark ground surface & 5 cm increments



## Soil (Pedosphere)



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# Install in Summer, Measure in Fall, Winter, Spring



Venetie, Alaska  
GLOBE students checking  
Frost Tube

NASA Explorers: CryoKids bonus episode  
[https://www.youtube.com/watch?v=uu-K\\_S4IOA&list=PL2aBZuCeDwlQqXdZ\\_hXEX0OSI1vX\\_p9Cj&index=12&t=150s](https://www.youtube.com/watch?v=uu-K_S4IOA&list=PL2aBZuCeDwlQqXdZ_hXEX0OSI1vX_p9Cj&index=12&t=150s)



## Soil (Pedosphere)



## Frost Tube

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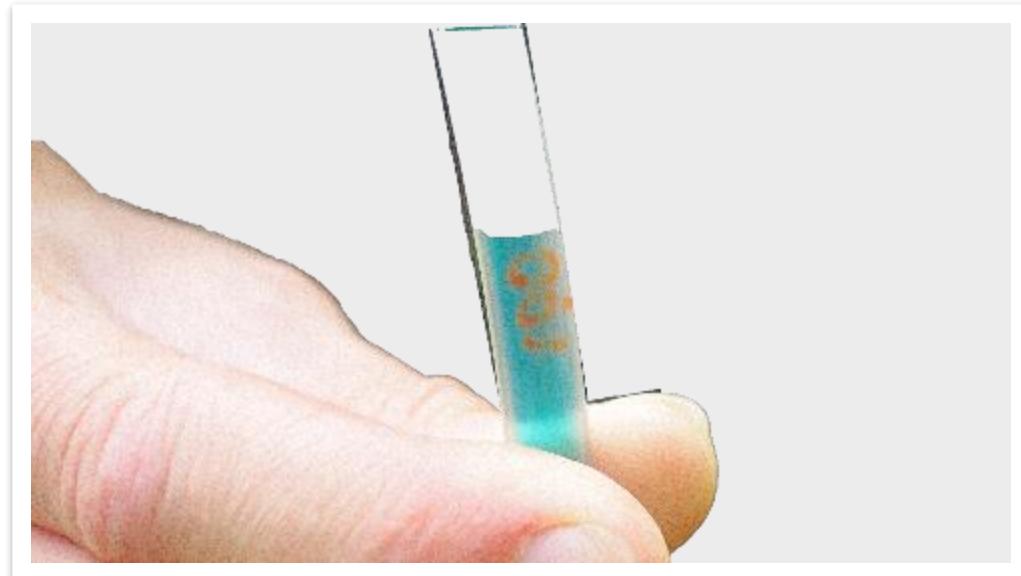
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## Install in Summer. Measure in Fall, Winter, Spring

Find the boundary between the ice at the top of the clear tubing and the water below it.



The ice appears relatively clear while the water is colored.

Measure the depth of this boundary to the nearest centimeter (by holding meter stick next to the inner tube).



# Soil (Pedosphere)



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Step 1: Go to data entry: <https://www.globe.gov/globe-data/data-entry>

Step 2: Click on “Data Entry - New Desktop Forms.”

**Data Entry**

- [Data Entry - New Desktop Forms](#)
- [GLOBE Program's app, GLOBE Observer](#)
- [Data Entry - Old Desktop Forms](#)
- [Practicing Data Entry](#)
- [Email Data Entry \(EMDE\)](#)
- [GLOBE DataTool](#)



[Learn more about how to enter data with GLOBE.](#)

**Important:** Due to issues with float demagnetization, GLOBE discourages the use of U-tube thermometers for recording maximum and minimum air temperatures. Instead, replace any liquid-filled thermometers with digital models.

Once your site is established, you can click on New Observation(s) from the Data Entry page.



# Soil (Pedosphere)



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## 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](#).
1. Data Entry: Visit [globe.gov](http://globe.gov), click on the “GLOBE Data” tab, then underneath “Data Entry” click on “Data Entry – New Desktop Forms”.





# Soil (Pedosphere)



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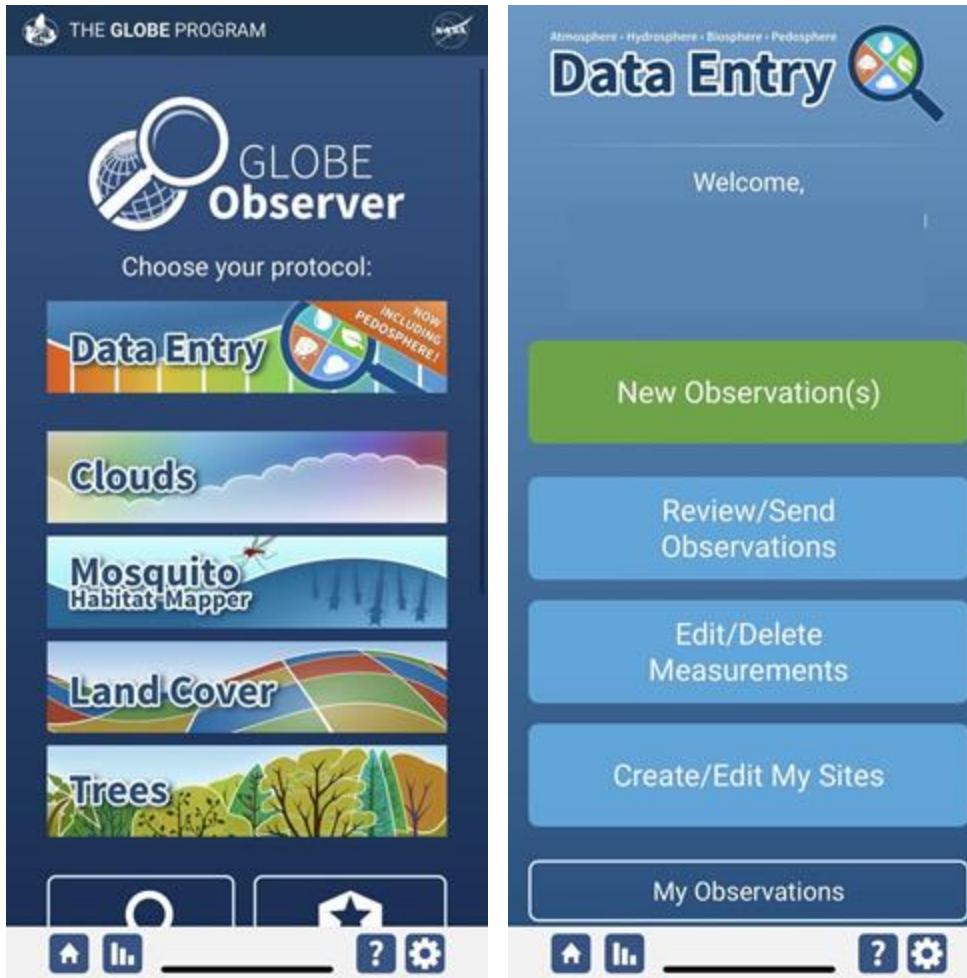
G. Measuring frost depth.

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## Frost Tube Site Creation



If this is your first time making Frost Tube 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”



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## Frost Tube Site Creation

< Site Location

New Site

Name: \* GINA Frost Tube Site

(use coordinates or move/zoom map)

Latitude: 64.85940

Longitude: -147.84950

Elevation: \* 185.2

Use 2 fingers to move map

Map Satellite

- 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.



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The image shows two screenshots of the GLOBE mobile application interface. The left screenshot shows the 'Site Location' screen with a 'Site Specific Comments' field and a 'Site Specifications' section containing links to 'Atmosphere', 'Biosphere' (which is highlighted in green), 'Hydrosphere', 'Pedosphere', 'Soil Characterization Site Setup', 'Soil Moisture and Temp Site Setup', and 'Frost Tube Site Setup'. The 'Frost Tube Site Setup' section displays a date of '2025-11-14' and a 'Height Above' field. The right screenshot shows the 'Frost Tube Site Setup' screen with fields for 'Date Installed' (2025-10-14), 'Height Above' (100 cm), 'Depth Below' (150 cm), 'Total Length' (250 cm), and a 'Water body within 100m of site' section with a 'No' radio button selected. It also includes a 'Landscape position' diagram with points A, B, C, D, and E, and a note 'A - Composite'. Both screens have a bottom navigation bar with icons for home, data, settings, and help.

- Scroll down to the Pedosphere tab
- Select Frost Tube Site Setup
- Enter the installation date of your frost tube, the height, depth, and length of the tube, and landscape position.



# Soil (Pedosphere)



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## Frost Tube Site Creation

Site Location

- A. Summit
- B. Slope
- C. Depression
- D. Large Flat Area
- E. Stream Bank

Surface Cover:  
Closed Forest (Trees interlocking) ▾

Ground Cover:  
Moss ▾

Save Site

Once you have entered all the site information for your frost tube, select “Save Site”



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## Frost Tube Data Entry

The image consists of two side-by-side screenshots of the GLOBE Observer mobile application. The left screenshot shows the main menu with various protocols listed: Data Entry, Clouds, Mosquito Habitat Mapper, Land Cover, and Trees. The right screenshot shows the 'Data Entry' screen with options for New Observation(s), Review/Send Observations, Edit/Delete Measurements, Create/Edit My Sites, and My Observations.

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 (Pedosphere)



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## Frost Tube Data Entry

- ▶ Biosphere 0
- ▶ Hydrosphere 0
- ▼ Pedosphere 1
  - Soil Characterization
  - Soil Bulk Density
  - Soil Infiltration
  - Soil Particle Size Distribution
  - Soil Fertility
  - Soil Particle Density
  - Soil pH
  - Soil Moisture and Temperature
  - Soil Moisture - Gravimetric
  - Soil Moisture - SMAP
  - Soil Temperature
  - Frost Tube
  - Frost Tube

Site Location

Select your site from this list of sites shown on the map:

Select from all available sites. Narrow the list by typing into the search field.

Search Site Names

Test entry site >

Yankovich unburned area frost tube >

Yankovich burned area frost tube >

Museum Birch >

Show ten more

New Site Location

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

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



# Soil (Pedosphere)



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## Frost Tube Data Entry

< Date and Time

Enter the local date and time of the observation:

Local Date: 2025-11-14 

Local Time (24hr): 14:02:00 

[Get Current Time](#)

Observation Date: 2025-11-14 UTC

Observation Time: 23:02 UTC

Solar Noon: 21:35 UTC

[Frost Tube](#)

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

Select Frost Tube to enter your data.



# Soil (Pedosphere)



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The screenshot shows a mobile application interface for data entry. The title 'Frost Tube' is at the top. Below it, the 'Site' is listed as 'GINA Frost Tube'. The 'Depth of Freezing' is set to '52 cm'. Under 'Permafrost', the 'Absent' radio button is selected. A 'Comments' field is empty. At the bottom is a large 'Review' button. The bottom navigation bar includes icons for home, back, and help.

Enter the depth of freezing in centimeters.

Select whether permafrost is present.

Add any additional comments or metadata in the Comments box.



# Soil (Pedosphere)



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## Frost Tube Data Entry

Review	
▶ Date/Time	2025-11-07 / 12:05:00
▶ Atmosphere	0
▶ Biosphere	0
▶ Hydrosphere	0
▼ Pedosphere	1
Frost Tube	✎ ↴
Depth Of Freezing:	
52 cm	
Permafrost:	
Absent	
<b>Finish</b>	
<a href="#">Home</a> <a href="#">Help</a> <a href="#">?</a> <a href="#">Settings</a> <a href="#">Logout</a>	

Review the data you entered and check for errors.

When complete, select Finish to complete the send the observation to GLOBE.



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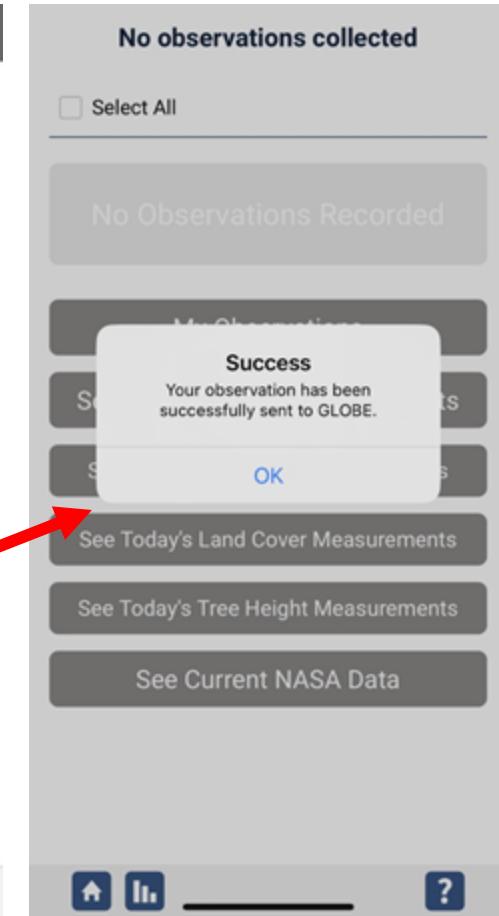
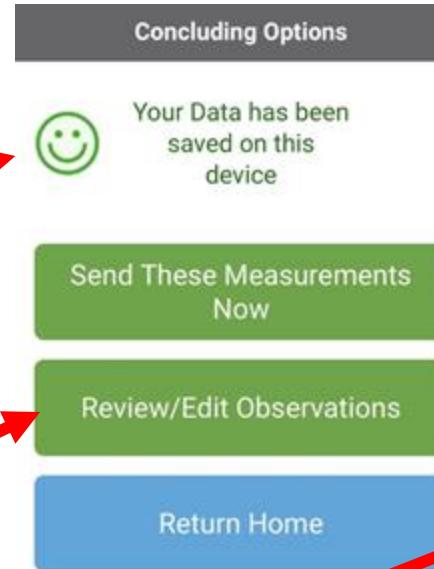
J. Additional Information.

## Data 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 (Pedosphere)



## Frost Tube

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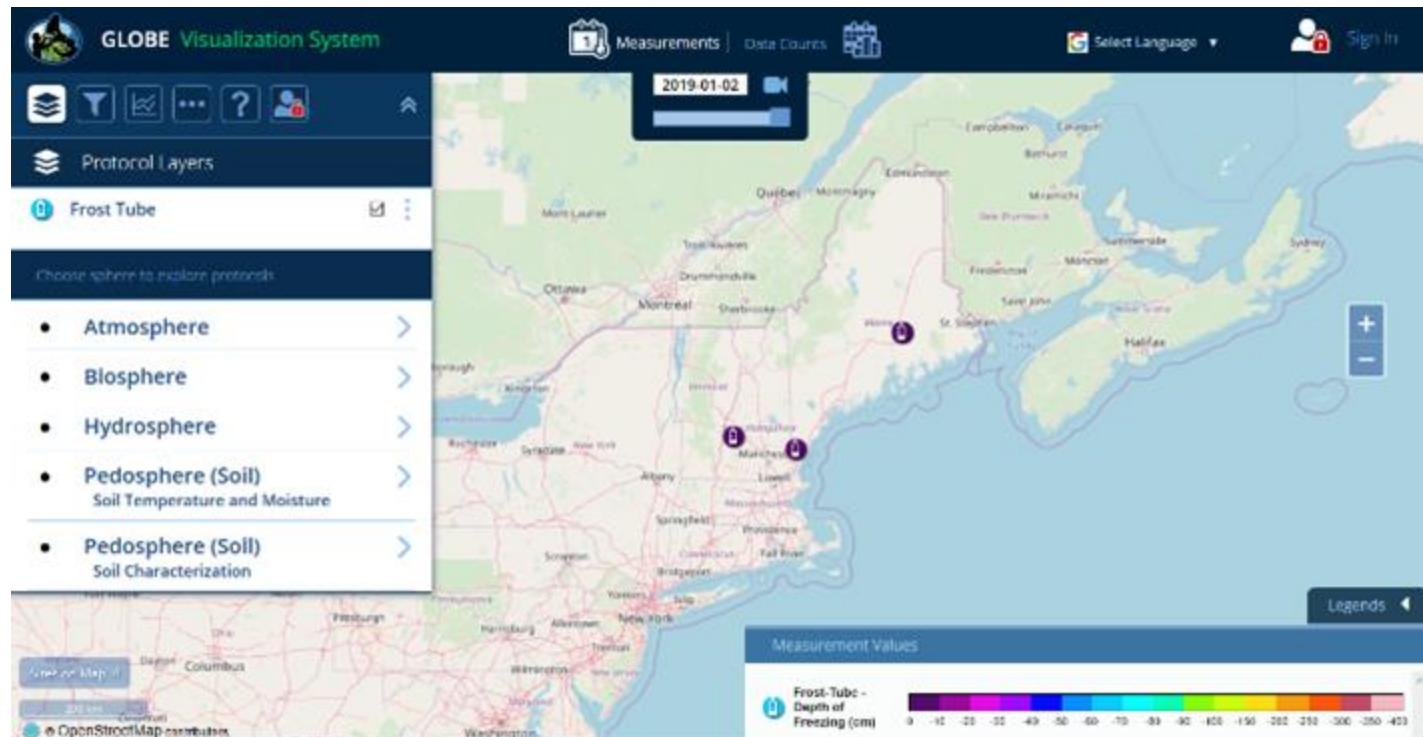
I. Data Visualization.

J. Additional Information.

# Visualizing Data

Frost Tube is a Protocol under Pedosphere.

See Frost Tube measurements for the day selected.





## Soil (Pedosphere)



## Frost Tube

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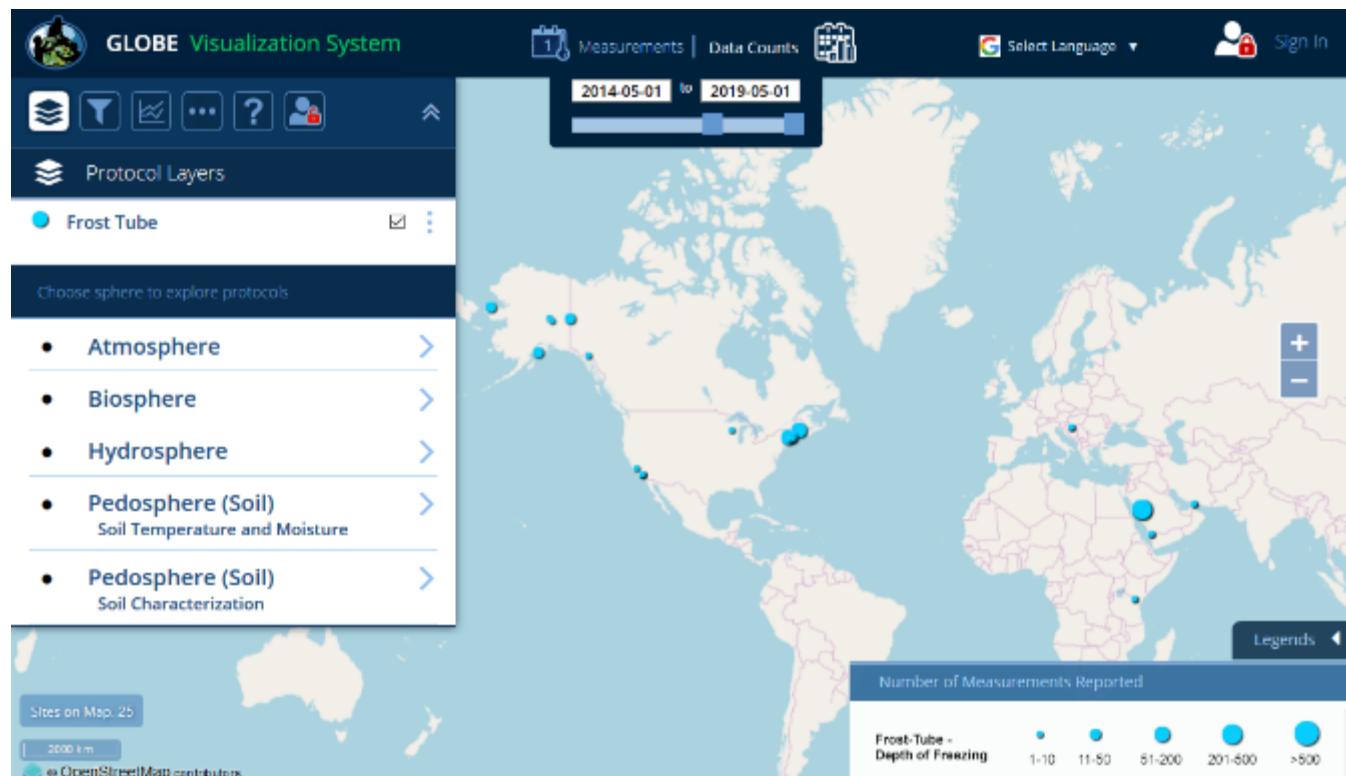
H. Report data to GLOBE.

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# Visualizing Data

You can see all the places monitoring frost depth by entering a date range.





# Soil (Pedosphere)



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**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](mailto:help@nasaglobe.org)**

## Credits

**Slides:** Christina Buffington, Elena Sparrow, Kenji Yoshikawa, Amy Barfield

**Photographs:** Robin Ellis, Christina Buffington

**Cover Art:** Christina Buffington

**Graphics:** Kenji Yoshikawa, Robin Ellis, Jenn Glaser, *ScribeArts*

## More Information:

[GLOBE Program](#)

[Frost Tube Protocol, Field Guides, Data Sheet](#)

[NASA Explorers: Cryokids](#)

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