GLOBEPROGRAM®
A Worldwide Science & Education Program

Introduction to Soil (Pedosphere)

Overview

This module:

- Introduces the Soil (Pedosphere) Investigation
- Describes soil's role in the Earth System
- Explains how soils form
- Provides instructions on how to define soil sites
- Explains how to report soil site definitions to GLOBE

Learning Objectives:

After completing this module, you will be able to:

- Explain soils important role in the Earth system
- Identify soil horizons
- Explain the soil forming factors
- Define soil moisture and temperature sites
- Define soil characterization sites
- Report soil site definitions to GLOBE

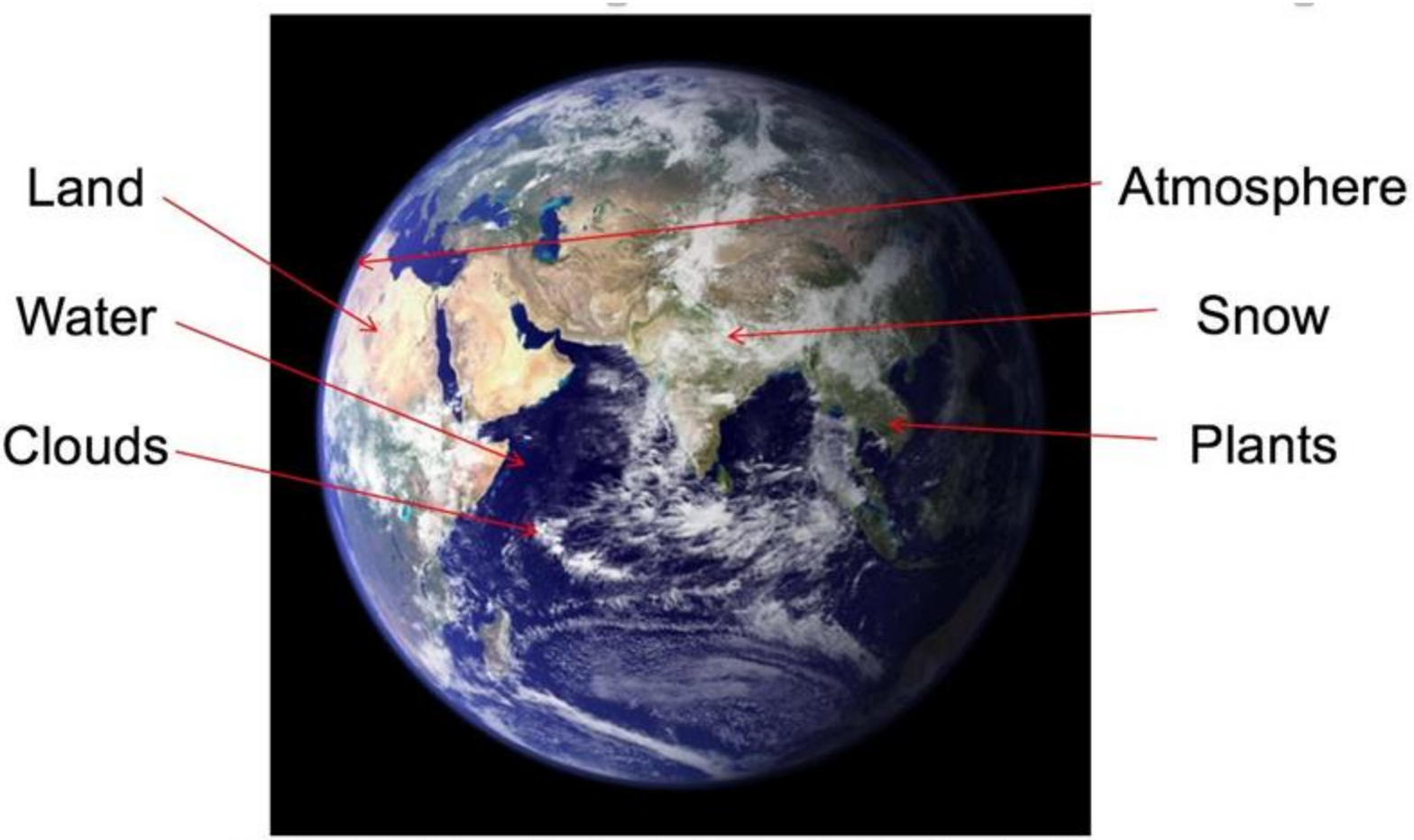
Estimated Time for Completion of Module: 1.5 Hours

Introduction to the GLOBE Soil Investigation

This slide set supports the GLOBE Soil Investigation protocol area.

You will find all the relevant documents in the GLOBE Guide here.

Looking at Earth from Space, what do we see?



NASA's Moderate Resolution Imaging Spectroradiometer (Terra/MODIS).

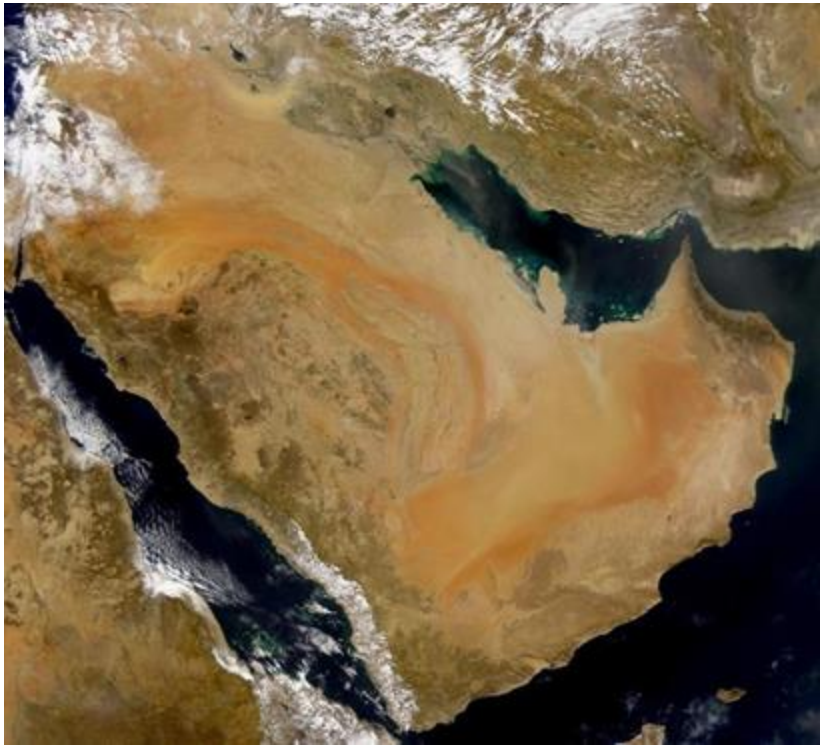
Let's Zoom In!

To study soil, scientists need to be up close and personal.

That's where you come in.

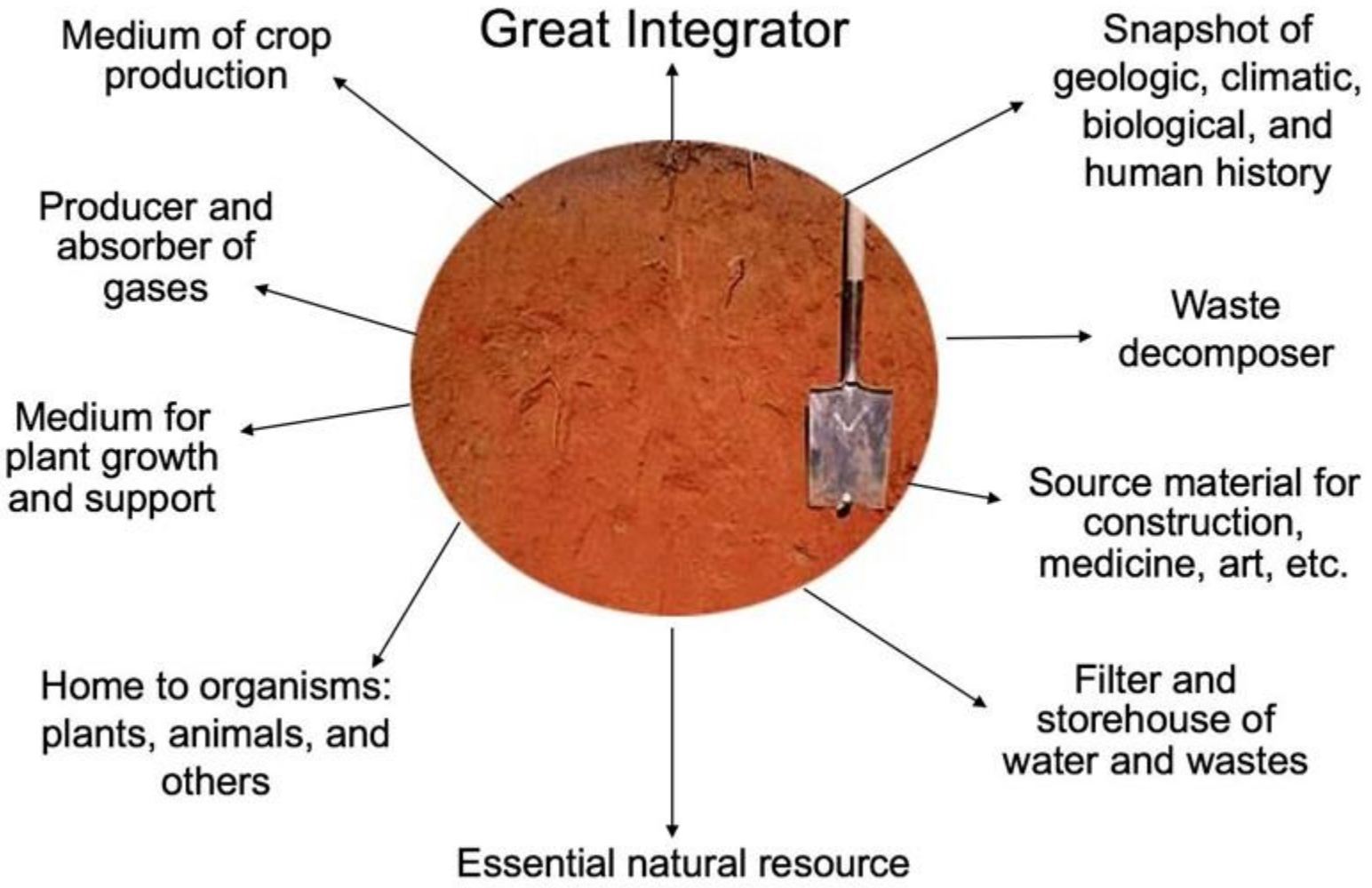
With the Pedosphere investigation, you provide the data that no one else can. You help see below the surface.

Without plant cover, most of what we see is soil.



Arabian Peninsula: NASA Sea-viewing Wide Field-of-View Sensor (SeaWiFS) image

We Study Soil Because It's the



Soil and Water

The amount of water in the soil and how well the soil filters water through greatly affect plant growth, water quality, relative humidity, evaporation, and many other aspects of the Earth System.

The absorbed water is held on soil particle surfaces and in pore spaces between particles. This water is available for use by plants during times of little precipitation.

Some of this water evaporates back into the air; some is transpired by plants; some drains through the soil into groundwater, and some runs off, carrying with it surface particles, causing erosion.

Water For Plant Use

Water Storage

Atmospheric Humidity

Evaporation

Soil (Pedosphere)

Introduction to Soil

A. Why study soil?

B. What is a soil profile?

C. How does soil form?

D. Soil protocols

E. How to define soil sites

F. How to report data to GLOBE

G. Further Resources

What is a soil profile?

- This is an example of a soil profile. A soil profile is a series of soil layers below the soil surface that have certain properties because of how the soil was formed.
- The layers of a soil are called horizons. Horizons differ from each other by their characteristics such as color, texture, structure, consistence, thickness, and other properties.
- Because every soil forms differently, looking closely at them can help us read a story of what has happened at its location.

A Maryland Soil (Photo © Dr. Ray Weil, University of Maryland)

A Soil's Story

- If we look at the horizons in this soil profile, we can understand something about the history of what happened here. Notice that there are some layers at the top and then a dark layer called 3C3 in the middle. This soil is located near a stream and each of the horizons above the 3C3 were deposited on top of it when the stream flooded.

- **Question:** We know from special dating techniques that the dark gray substance visible at Horizon 3C3 was deposited here approximately 150-250 years ago over a period of 100 years. What do you think it is?

- **Answer:** It's ash from forest fires set by farmers practicing slash and burn agriculture. The results of some of that practice of burning down forest to make room for farms were deposited in this soil.

A Maryland Soil (Photo © Dr. Ray Weil, University of Maryland)

A Soil's Story

- The nodules showing in the horizon labeled 4C4 were deposited in this stream bed about 250-350 years ago. They are clam and oyster shells.
- The people living in this area caught clams, oysters, and fish. These shells were what they left behind.
- By reading the horizons in this soil, we have learned that this location was a place where people fished, burned down trees and farmed, and was sometimes flooded by the nearby stream.

A Maryland Soil (Photo © Dr. Ray Weil, University of Maryland)

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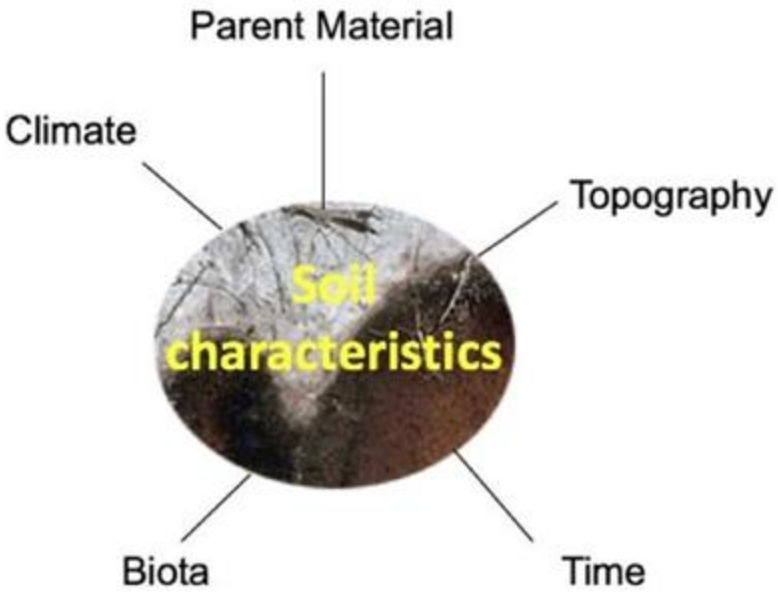
Soil Forming Factors



Forest soil, Florida USA

These five factors work together to create a unique soil profile made of layers called horizons. The characteristics of the soil profile and horizons and the story the soil tells is based on these five soil forming factors. Soil characterization is the way we measure the soil profile characteristics and this information is important to study soil moisture and each of the other parts of the ecosystem.

The Importance of Soil Characteristics

The way the soil forming factor interacts to create a soil profile varies greatly. Each soil profile will have different characteristics and different ways it can be used to grow food, store and filter water, retain heat, produce and exchange gases, build on, and other uses. It is important to know and understand the soil forming factors in order to study soil characterization and soil moisture.

The degree to which the various soil forming factors affect the soil produces the different soil horizons.

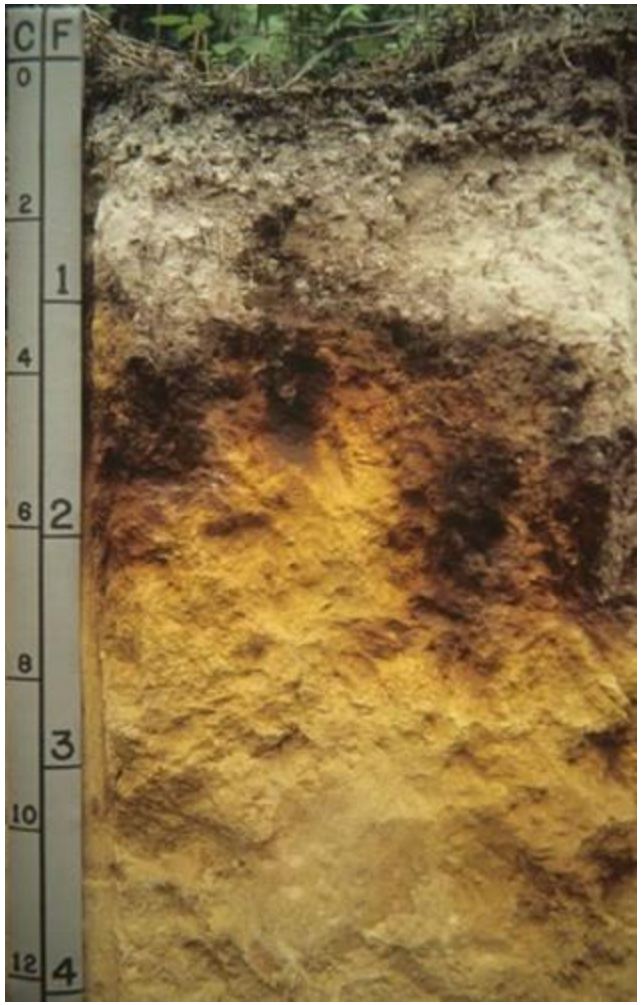
Courtesy Izolda Trakhtenberg

Courtesy Izolda Trakhtenberg

The Five Soil Forming Factors Produce Great Variations in Soils.

The degree to which each soil forming factor affects soil formation will vary greatly. That will yield a large variety of soil types. Each soil type will have different characteristics and potential to grow food, store and filter water, retain heat, and produce and exchange gases.

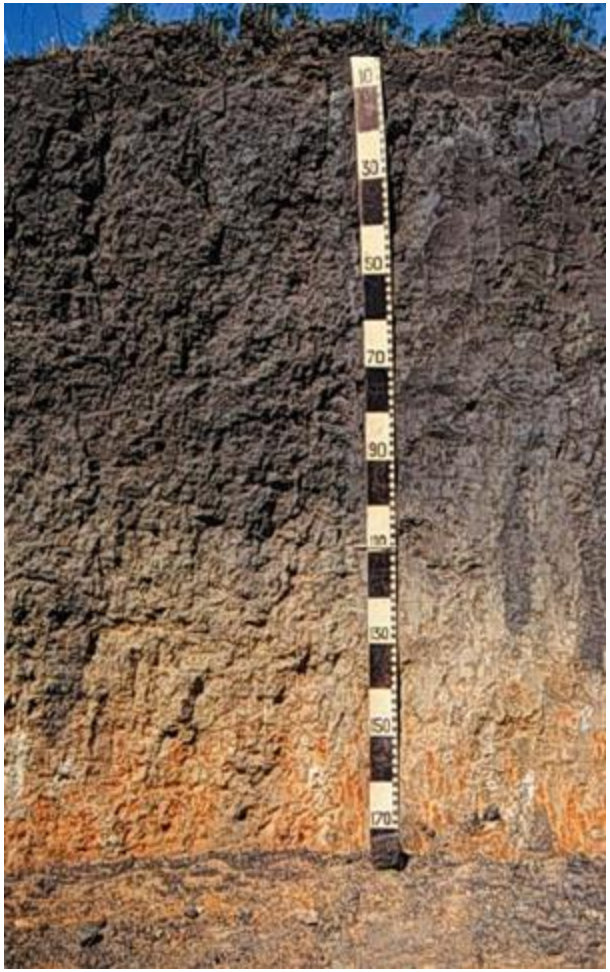
In GLOBE, you can measure the soil characteristics as well as measure the soil temperature, moisture, and the rate at which water infiltrates into the soil.



Courtesy of the Natural Resources Conservation Service

Example of a Grassland Soil Profile

These soils are common in the mid-western USA, and in the grasslands of Argentina and Ukraine. They are usually deep and dark in color, and are among the best soils for growing crops. Their dark color is caused by many years of grass roots dying, decomposing, and building up the organic matter content that allows the soil to hold the water and nutrients needed for excellent plant growth.



Grassland soils sampled in the southern part of Texas in the USA

Example of a Forest Soil Profile

- Most of the organic matter in this soil comes from the leaves and roots of coniferous trees that die and decompose near the surface. When this decomposed organic matter mixes with rain, acids form that *leach*, or remove, materials from the top horizons of the soil.
- The white layer you see below the dark surface layer was caused by organic acids that removed the nutrients, organics, clays, iron, and other materials in the layer and left behind soil particles that are only mineral in composition.
- Below this horizon is a dark horizon that contains materials that were leached from the horizon above and deposited or **illuviated**. This horizon has a dark color because of the organic matter deposited there.
- The next horizon has a red color due to iron oxide brought in from the horizon above and coating the soil particles. The horizon below this one has fewer or different types of iron oxides coating the inorganic soil particles creating a yellow color.
- The lowest horizon in the profile is the original parent material from which the soil formed. At this site, the parent material is a sandy deposit from glaciers. At one time, the whole soil looked like this bottom horizon, but over time, soil-forming processes changed its properties.

Soil formed under a forest in far eastern Russia, near the city of Magadan

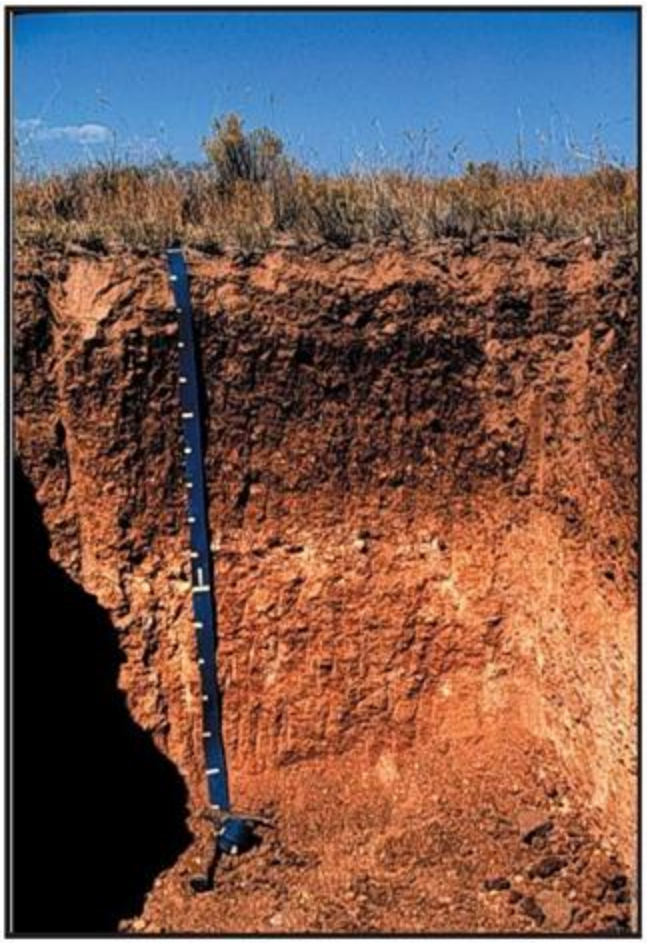
Example of a Tropical Soil Profile

Notice the bright red colors and the depth to which the soil is uniform. It is very difficult to distinguish unique horizons. Hot temperatures and lots of rain help to form weathered soils like this. In tropical climates, organic matter decomposes very quickly and transforms into inactive material that binds with clay. Most of the nutrients have been leached from this soil by intense rainfall. Left behind are weathered minerals coated by iron oxides giving the soil its bright red color.

Tropical environment in Northern Queensland, Australia

Example of a Soil Profile Formed under Very Dry Conditions

- A light brown horizon at the surface is often found in environments where organic matter is limited. High amounts of organic matter form dark soils. In dry places, organic matter is not returned to the soil because very little vegetation grows there. When rainfall does occur in this environment, the sandy texture of the soils allow materials to be carried downward into the lower horizons of the profile. The white streaks near the bottom of this profile are formed from deposits of calcium carbonate that can become very hard as they accumulate over time.



Soil formed under very dry or arid conditions in New Mexico, USA

Example of a Soil Profile Formed under Wet Conditions

- Wet soils are found in many parts of the world. The surface horizon is usually dark because organic matter accumulates when the soil is saturated with water. When these conditions occur, there is not enough oxygen for organisms to decompose the organic material.
- Colors of the lower horizon are usually grayish. Sometimes, as in this picture, the gray soil color has orange or brown streaks within it, which are called *mottles*.
- The gray colors indicate that the soil was wet for a long period of time, while the mottles show us where some oxygen was present in the soil.

Wet soil sampled in Louisiana, USA

Example of a Soil Profile Formed in a Very Cold Climate

The "hummocky" or wavy surface of this soil is caused by freezing and thawing of water stored in the soil year after year. The black zones indicate places where organic materials have accumulated during freezing and thawing cycles. The process of freezing and thawing and churning of the soil is called *cryoturbation*. This soil is not very developed and has only slight indications of horizons that can be seen by faint color differences. At the bottom of the profile is a layer called *permafrost*, which consists of ice, soil, or a mixture of both. The permafrost layer stays below 0˚C throughout the year. The dark, thick organic material in this soil accumulates because decomposition is very slow in cold climates.

Soil formed under a very cold climate near Inuvik in the Northwest Territory of Canada

GLOBE Soil Protocols

- The characteristics of a soil profile usually change slowly over centuries as the soil forms, but human activity can cause rapid changes.
- Soil properties such as temperature and moisture content can change quickly, particularly near the surface.
- GLOBE protocols are different depending on the rate at which the property being measured changes.

Soil (Pedosphere)

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Soil Protocols

Soil Characterization

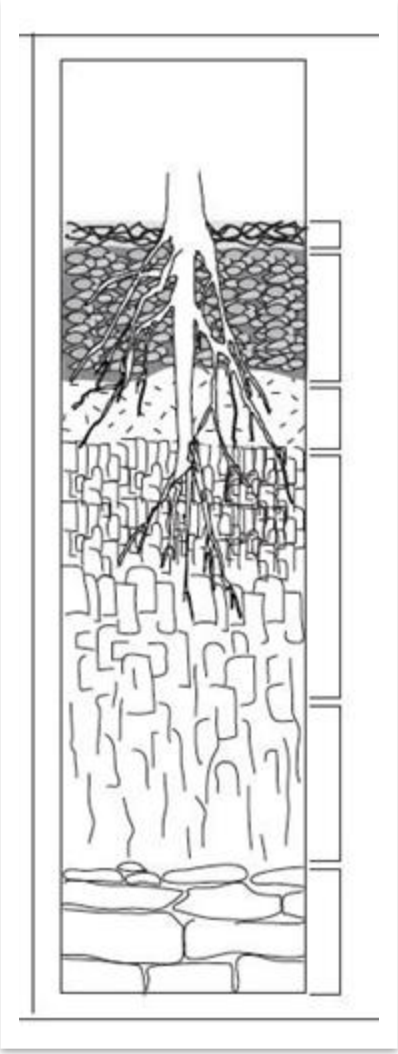
- Usually measured only once at Soil Characterization Sites with horizon definition, field observations, sample collection, and lab measurements

Soil Temperature & Soil Moisture

- Measured repeatedly at Soil Moisture and Temperature Sites
- Different protocols for different measurement techniques

Infiltration

- Measured: Occasionally at Soil Moisture and Temperature Sites and once at Soil Characterization Sites



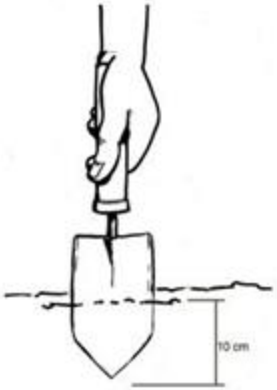
Soil Characterization Sampling Options

Soil Pit

Exposed Profile (Road Cut)

Auger

Surface Sample



Illustrations courtesy, Rich Potter

Defining a Soil Site Introduction

Before you conduct your Soil Investigation, you must define either your:

Soil Characterization Site or Soil Moisture and Temperature Site.

In both cases, in GLOBE you can provide either **basic** or more detailed, **supplemental** information describing your study site.

Image courtesy, Izolda Trakhtenberg

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Choosing a Location: Considerations

What is near your site?

Is the site under ground cover similar to the rest of the landscape and relatively undisturbed?

Is it at least 3 meters from buildings, roads, paths, and playing fields?

If so, good. If not, be sure to report the exceptions as part of your site definition.

Lawns, agricultural sites, or other managed landscapes are acceptable if this is the cover that is located at the atmosphere and/or soil moisture and temperature measurement sites.

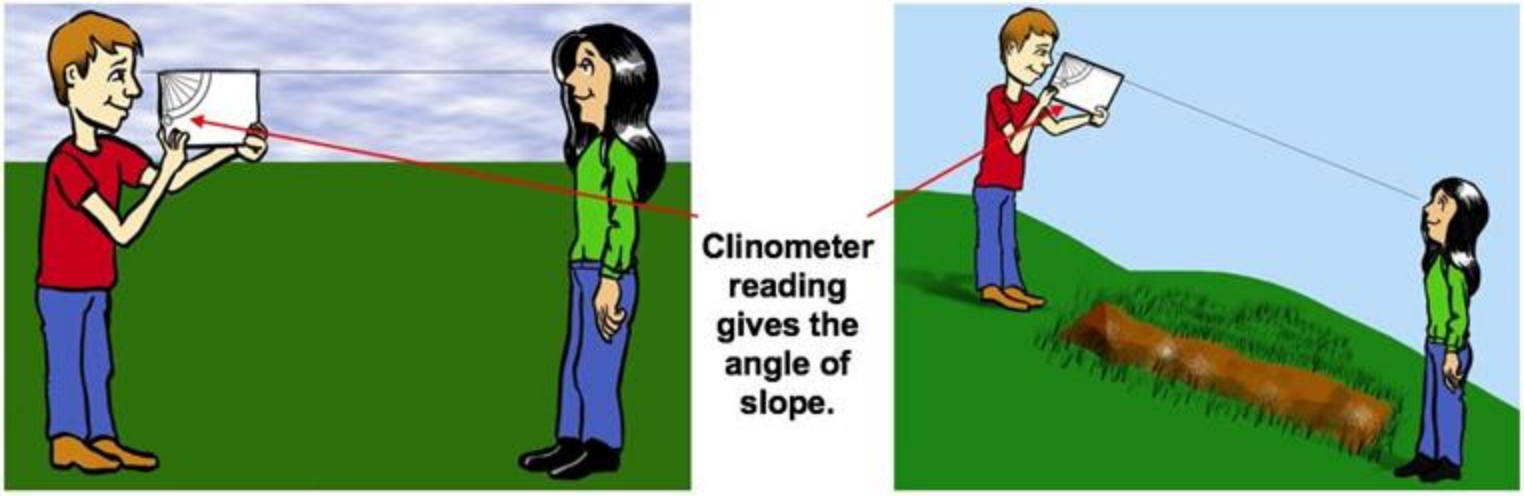
Image courtesy, Izolda Trakhtenberg

Determine Slope of a Site

To identify the greatest slope across your site's location use a clinometer.

Two people whose eyes are at about the same height should measure the slope.

- Two people whose eyes are at about the same height standing on a horizontal plane looking at each other through the straw on a clinometer should get a 0° angle reading.
- If those same people stand on the greatest slope across the Soil Sample Site, the reading on the clinometer will give the angle of slope.



Illustrations courtesy, Rich Potter

Defining the Aspect of a Soil Site

Aspect is the direction of the steepest slope across the soil site.

This information indicates how the sun will influence soil properties.

To determine aspect:

1. Face up the steepest slope across the exposed soil area.

Illustrations courtesy, Rich Potter

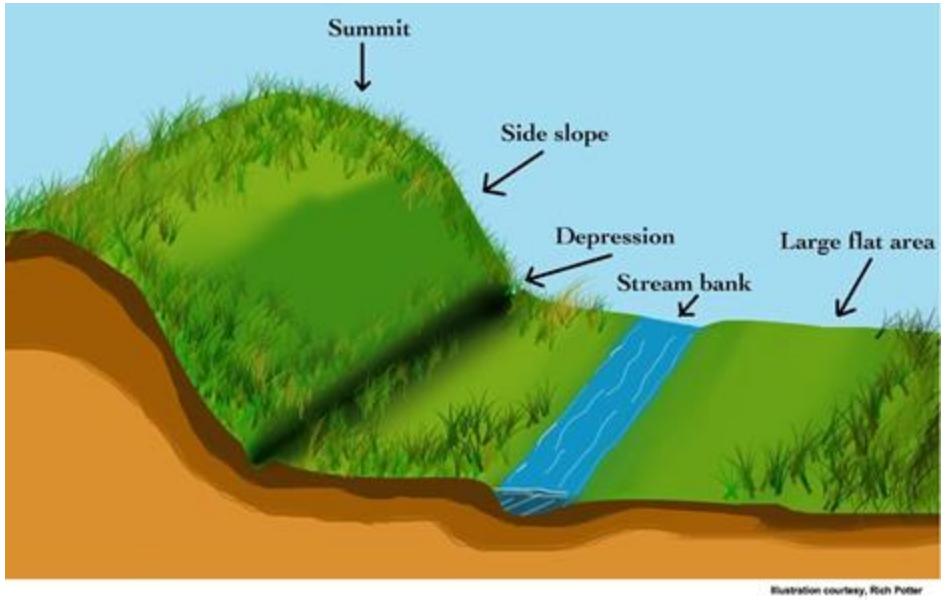
Reading a Compass

2. Hold the compass in your hand so that the red arrow is lined up with the North position on the compass.

3. Read the number on the edge of the compass housing (which can range from 0 to 360). This aspect is 28°.

Defining Soil Site Landscape Position

- The Landscape position, along with slope and aspect, give information about the soil forming factor ***topography*** that greatly influences the formation of the soil.
- The landscape position describes where a site is located on the contours of the land.
- Landscape position, along with slope and aspect give information about the processes that formed this soil.
- In your site description your will identify on which part of the landscape your soil site is located, and report this as part of your Soil Site definition.



Defining the Cover Type of a Soil Site

Cover type is a description of the vegetation (another important soil forming factor) or other material (such as gravel, cement, mulch, etc.) on the surface. Describe and record the cover type of the site (Bare Soil, Rocks, Grass, Shrubs, Trees, or Other).

Bare Soil

Rocks

Grass

Shrubs

Trees

Other

Landscape Photos

Observe and describe your site. Record its characteristics and take some photos.

Take landscape photographs of the site to the North, East, South, and West of the profile.

Images courtesy,
Izolda Trakhtenberg

Defining a Soil Characterization Site

Image courtesy, Izolda Trakhtenberg

Choosing a Soil Characterization Site

A Soil Characterization Study Site may be located anywhere you can safely expose the soil profile. It is useful to have a site near your Soil Moisture and Temperature Study Site and within your Land Cover study site.

Images courtesy, Izolda Trakhtenberg

Orienting your Site Relative to the Sun

When you choose a location for your soil profile, pick an orientation so that the sun will shine on the profile when you conduct your observations and make measurements. Check to make sure there are no shadows on the profile.

Used with permission from St. Peter's School, Waldorf, MD, USA

Describe Land Use

How is the land used? Is it a natural or wilderness environment, urban, agricultural, recreational or other?

Urban

Agricultural

Recreational

Wilderness

Other

Recording other Features

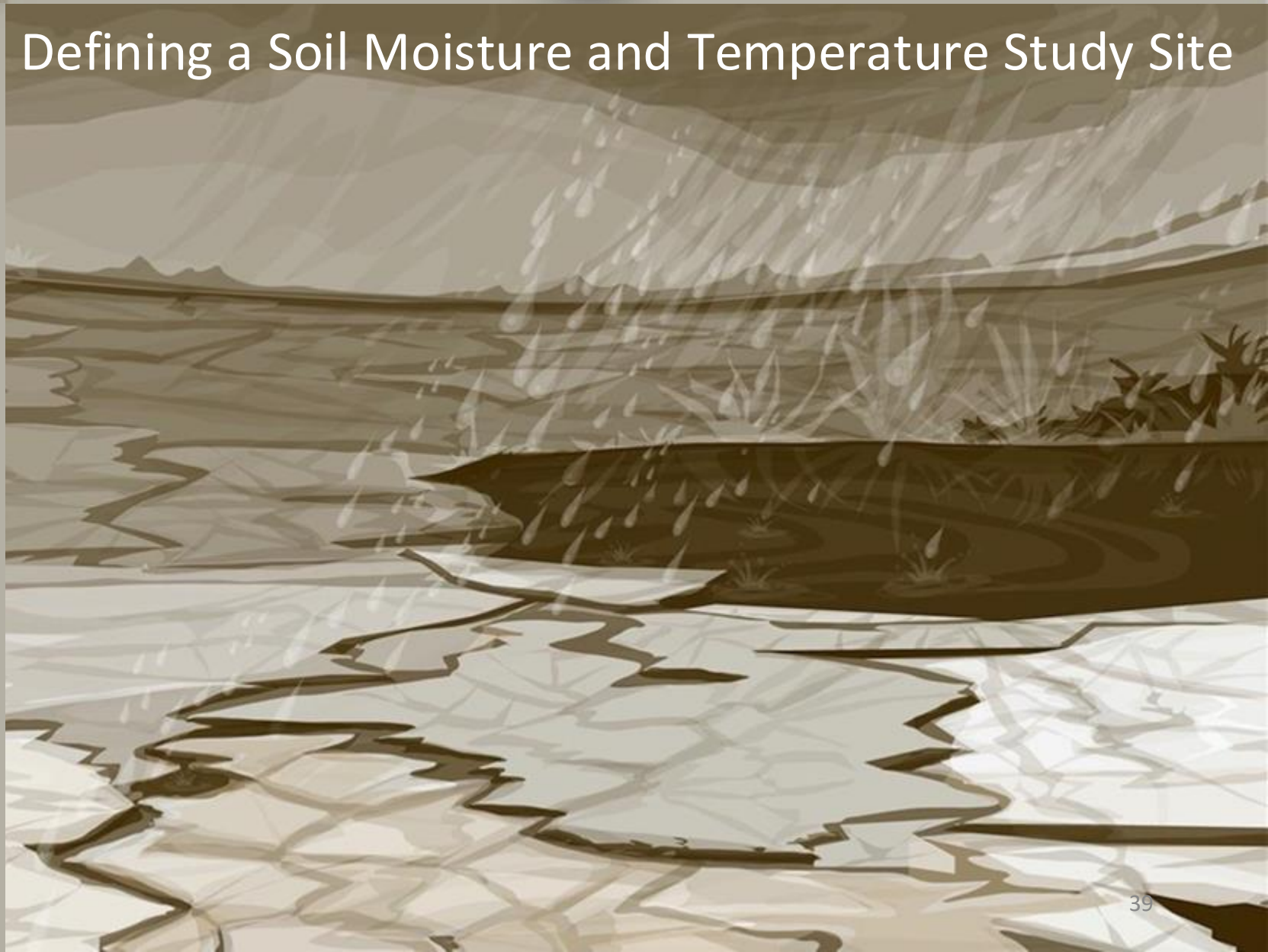
Measure and record the distance between the soil profile and major features at the site (such as a house or swing set or basketball court or any other feature). Any other information or metadata about the site that does not fit into any of the above categories should also be recorded as metadata.

Once you have completed the Supplemental Information, you can continue to explore and make observations about the properties of your soil profile. If you are also conducting Land Cover and/or Soil Moisture measurements, you may want to select another position to perform an additional soil profile characterization.

Courtesy Izolda Trakhtenberg

Courtesy Izolda Trakhtenberg

Defining a Soil Moisture and Temperature Study Site



Defining a Soil Moisture Study Site

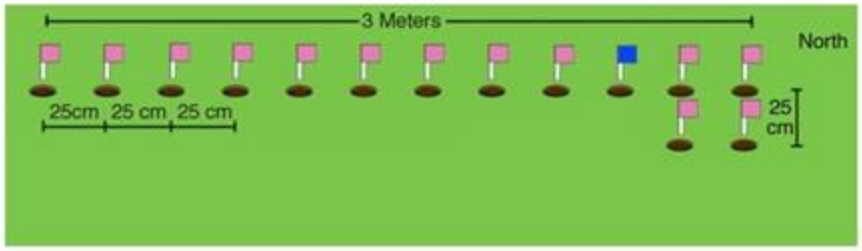
Record these properties at your Soil Moisture Study Site :

1. Describe the surface: vegetation, plowed, etc.
2. Describe Canopy Cover.
3. Describe surface vegetation cover.

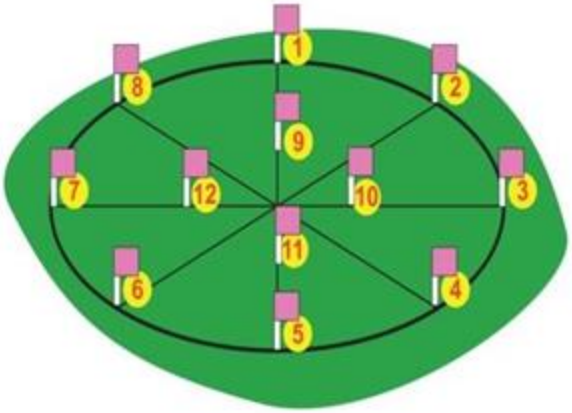
Image courtesy, Izolda Trakhtenberg

Soil Moisture Sampling Options

SMAP Soil Moisture

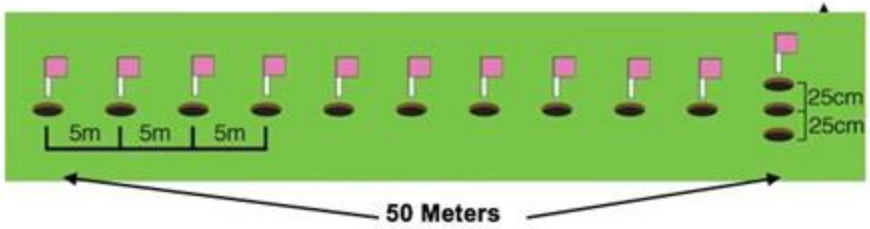


Gravimetric Star Surface & Gravimetric Depth



Gravimetric Transect

Soil Moisture Watermark Sensor



Illustrations courtesy, Rich Potter. Image courtesy, Izolda Trakhtenberg

How to Report Data to GLOBE

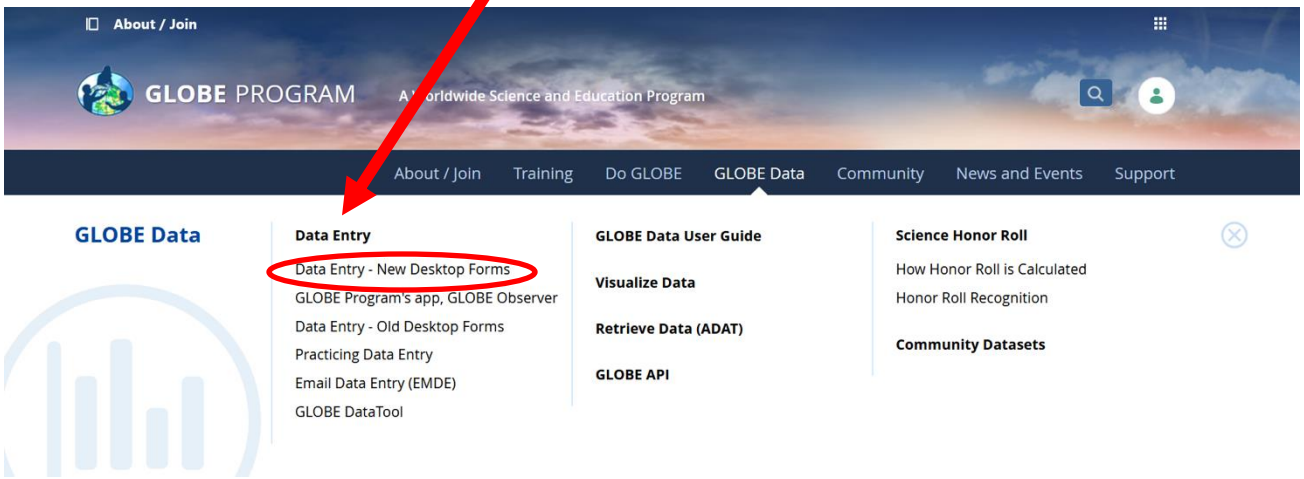
Reporting Data to GLOBE

Two Options for Uploading Data:

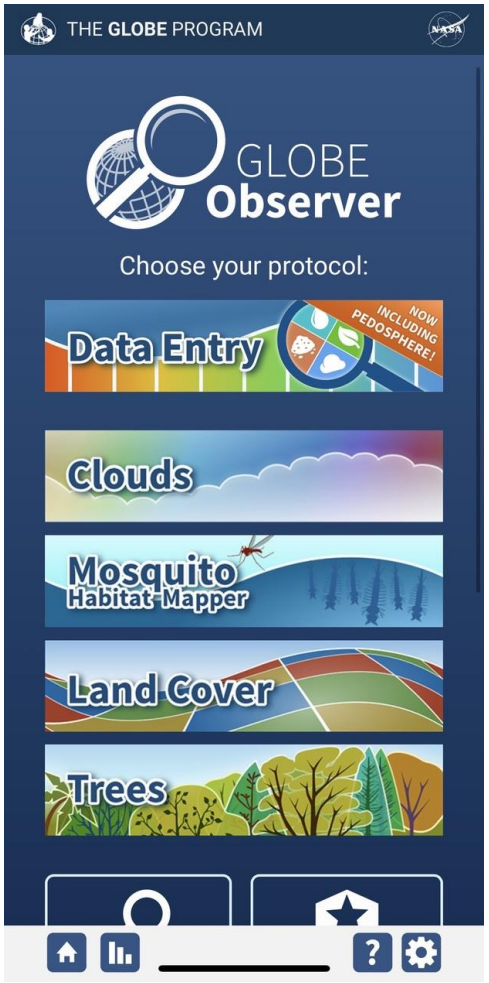
These methods all allow users to submit environmental data – collected at defined sites, according to protocol, and using approved instrumentation – for entry into the official GLOBE science database.

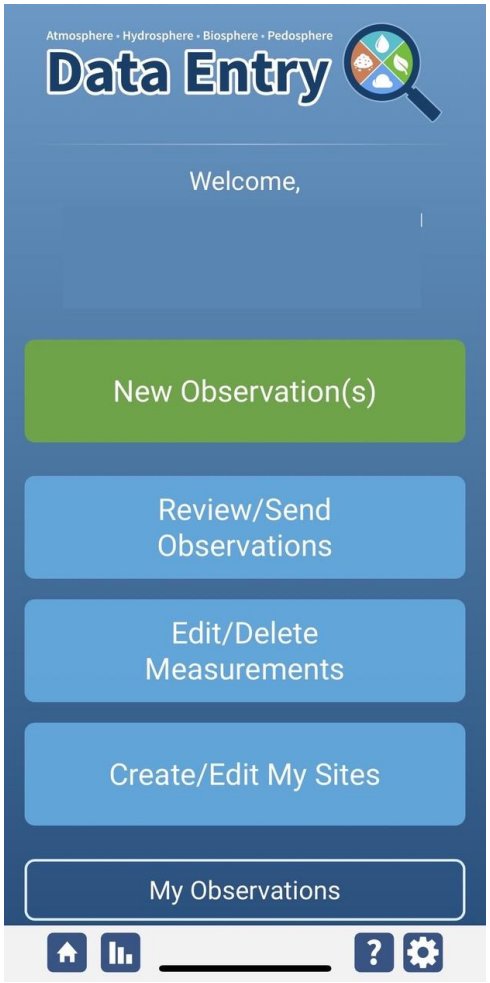
1. Download the GLOBE Observer mobile app from the App Store.

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



Entering a Soil Sample Site Definition - Step 1



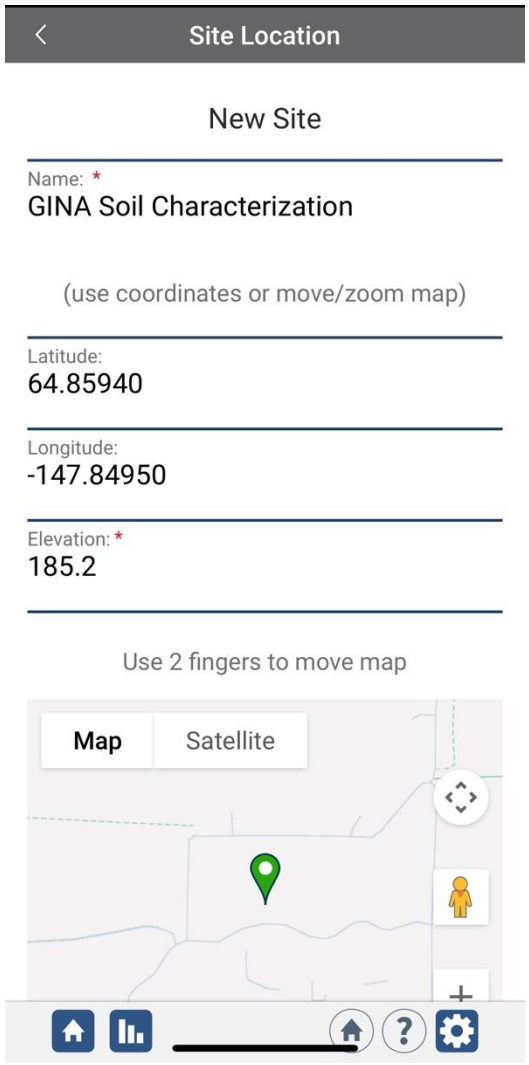


To enter data, first return to GLOBE Observer main page by clicking the home button in the bottom left.

Select “Data Entry”.

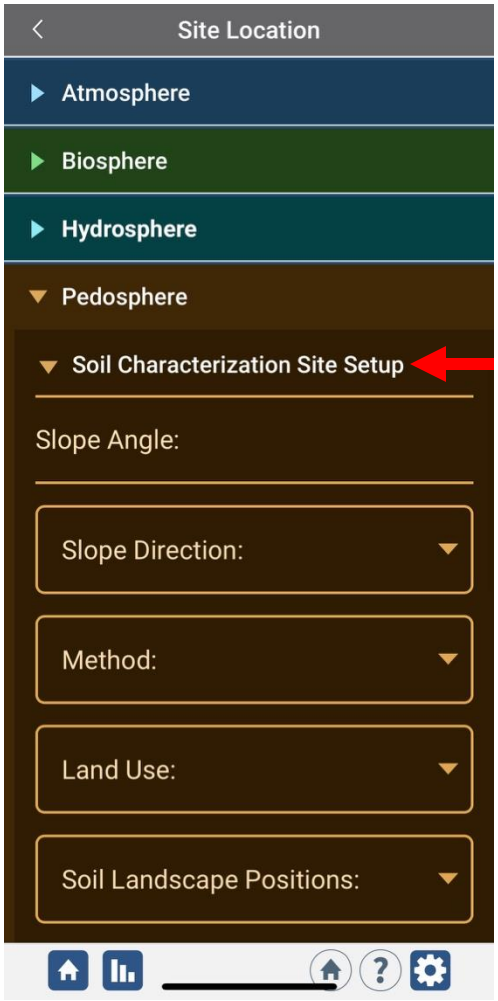
Next, “Create/Edit My Sites”

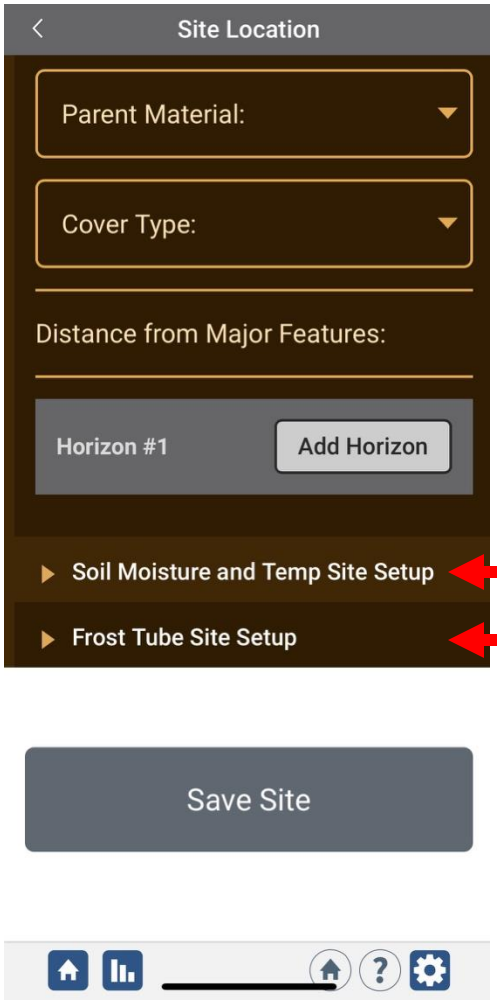
Entering a Soil Sample Site Definition - Step 2



- 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.

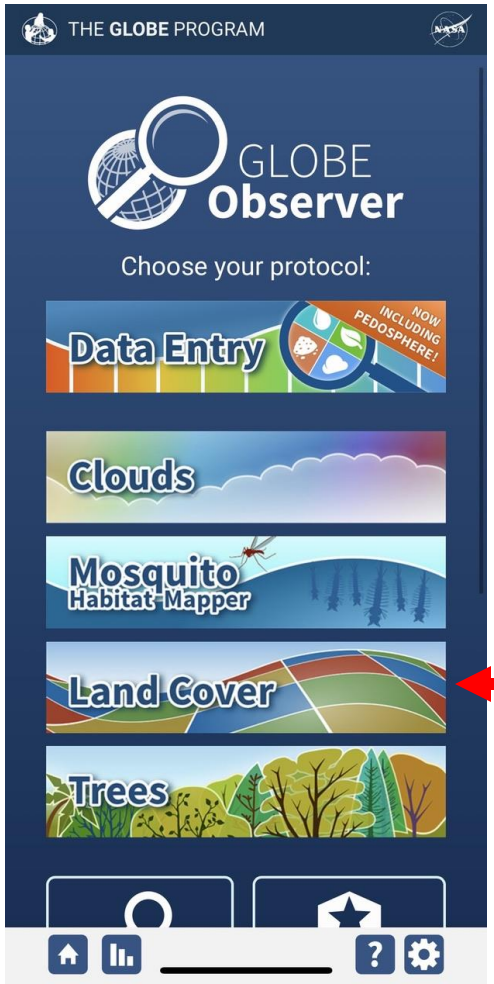
Entering a Soil Sample Site Definition – Step 3

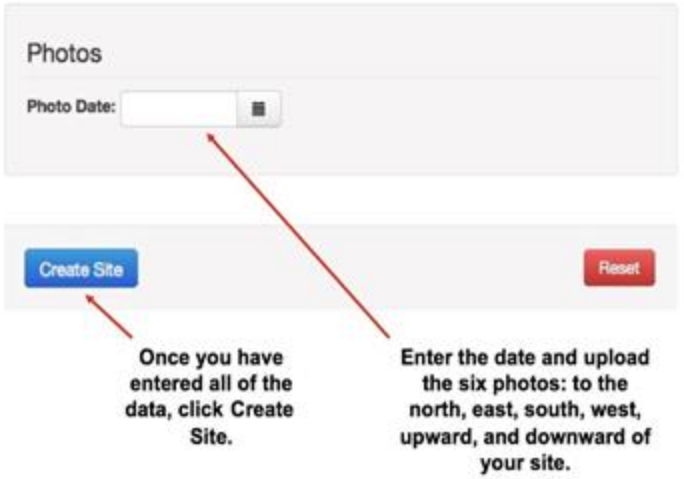




- Scroll down to the Pedosphere tab
- Select Soil Characterization Site Setup, Soil Moisture and Temp Site Setup or Frost Tube Site Setup
- Enter the site information for you new site.
- Save Site

Upload Photos or Use Land Cover Tool – Step 4

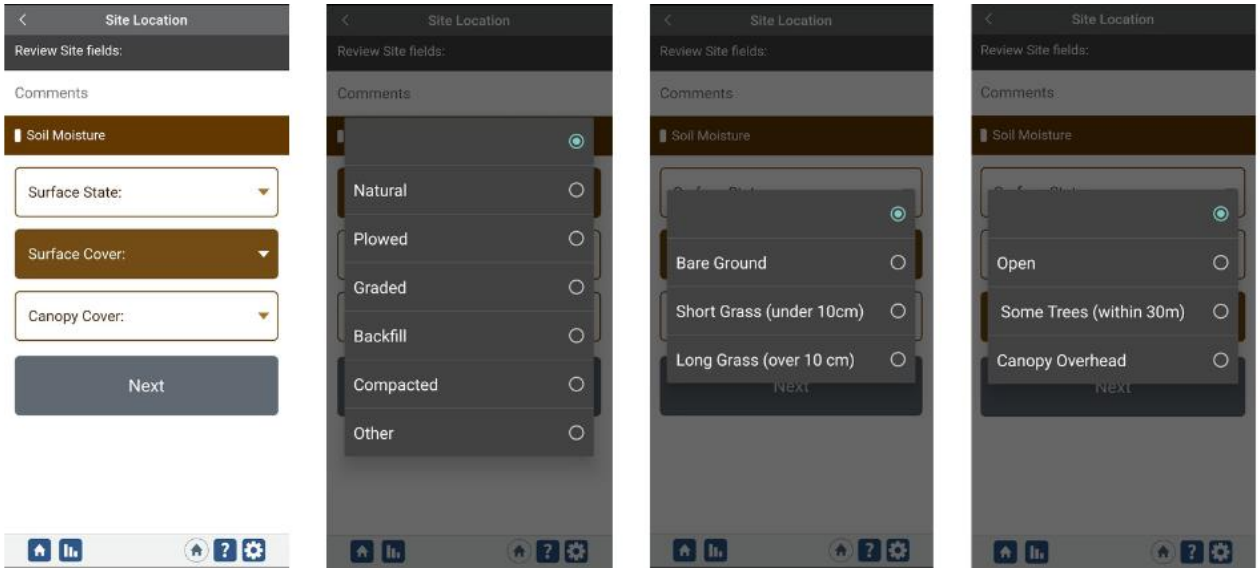




- The "Old Desktop Forms" allowed manual upload of photos.
- Now photos can be uploaded manually or taken automatically by using the Land Cover tool. This will make a new site. Write the Soil Sample Site name in the Comments

Entering Supplementary Information

Enter additional information about the site, such as surface state, surface cover and canopy cover.

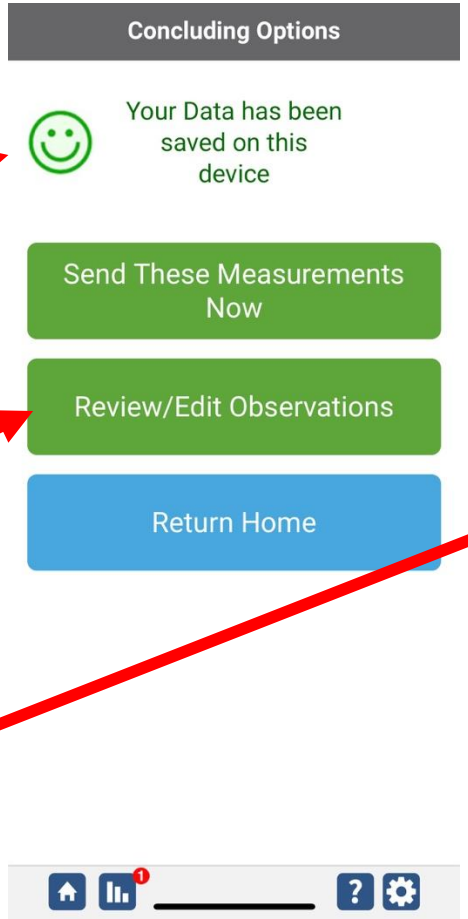


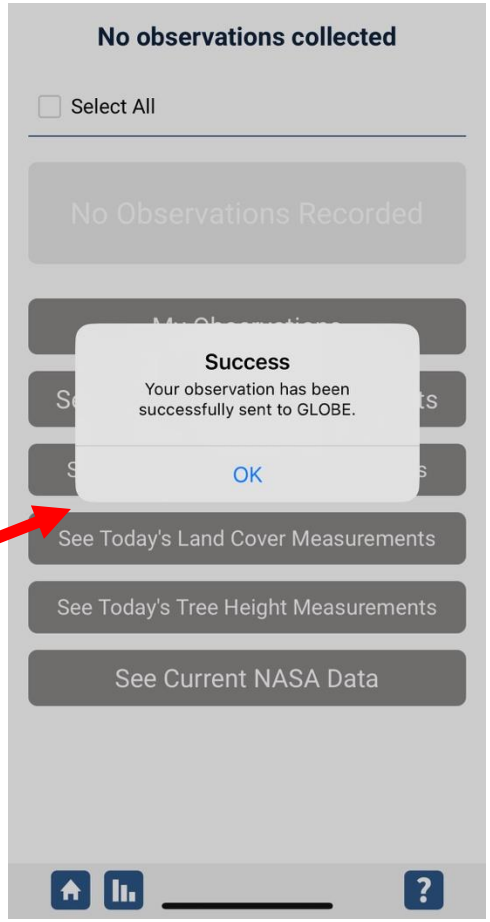
Data System Responses

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.





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.

More Information:

GLOBE Program

NASA Global Climate Change: Vital Signs of the Planet

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

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