Protocol Training Slides for Surface Temperature

Photo credit: Kevin Czajkowski

Overview and Learning Objectives

Overview

This module:

- Describes how to take surface temperature measurements
- Provides instructions on how to enter your data on the GLOBE website

Learning Objectives

After completing this module, you will be able to:

- Describe and define surface temperature
- List reasons why it is important to collect surface temperature data
- Determine the correct locations to take surface temperature readings
- Upload data to the GLOBE website
- Visualize data using GLOBE and formulate your own questions about weather

Estimated time needed for completion of this module: 1.5 hours

The Atmosphere

- Extremely thin blanket of air extending about 300 miles from Earth's surface to edge of space
- Protects us from the blasts of heat and radiation coming from the Sun

Image: NASA

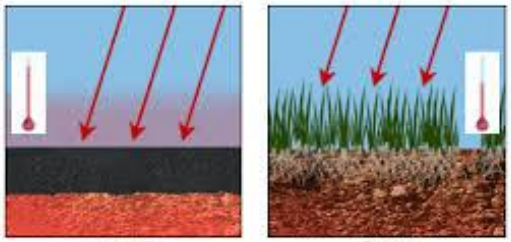
Link to GLOBE Facilitator's Guide Atmosphere Protocol

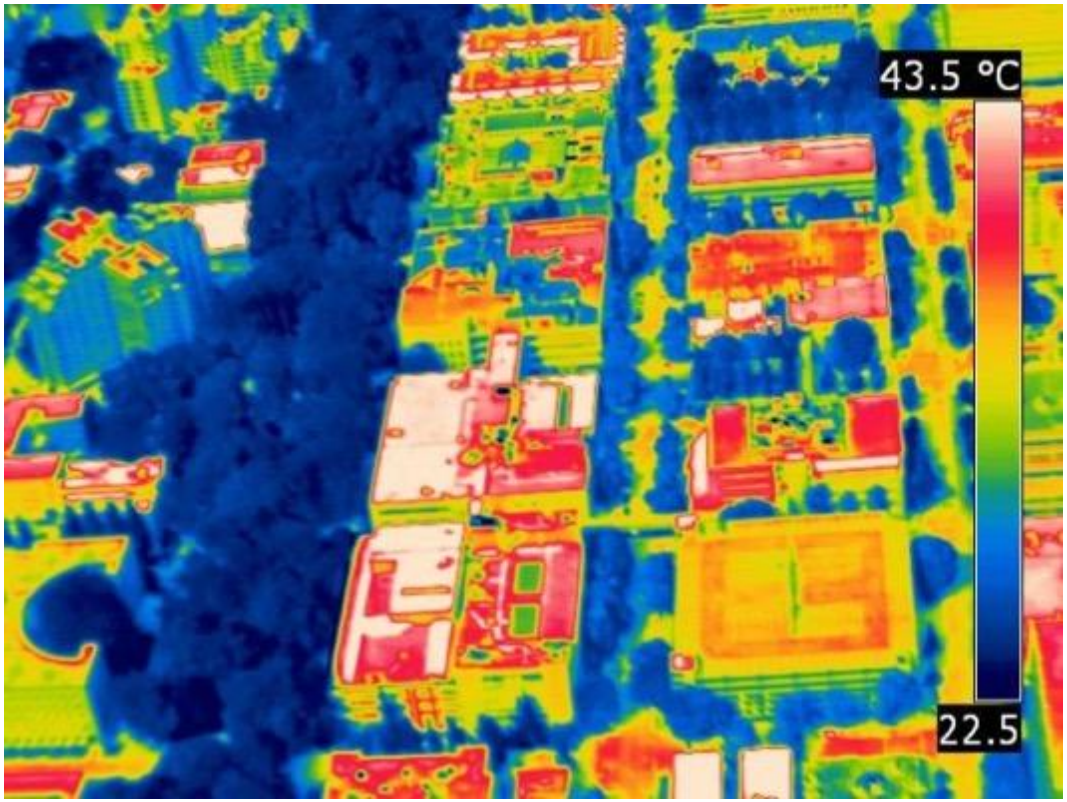
Surface Temperature

- Is the radiating temperature emitted as electromagnetic energy of the Earth's surface including vegetation, paved surfaces, and the ground, etc.
- Varies depending on the ground cover and the time of day
- Affects all aspects of the Earth's Energy Budget

Aerosols
Air Temperature
Albedo
Barometric Pressure
Clouds
Precipitation
Relative Humidity
Surface Ozone
Surface Temperature
Water Vapor
Wind

Surface temperature is the temperature at the Earth's surface, including the land, water and structures





Not all surfaces have the same temperature!

Recording surface temperature is important-1

1. *Your observations are valuable contributions to the scientific community and may be used by educators, students, researchers, and the general public to increase environmental awareness and STEM literacy, as well as advance Earth system science.*

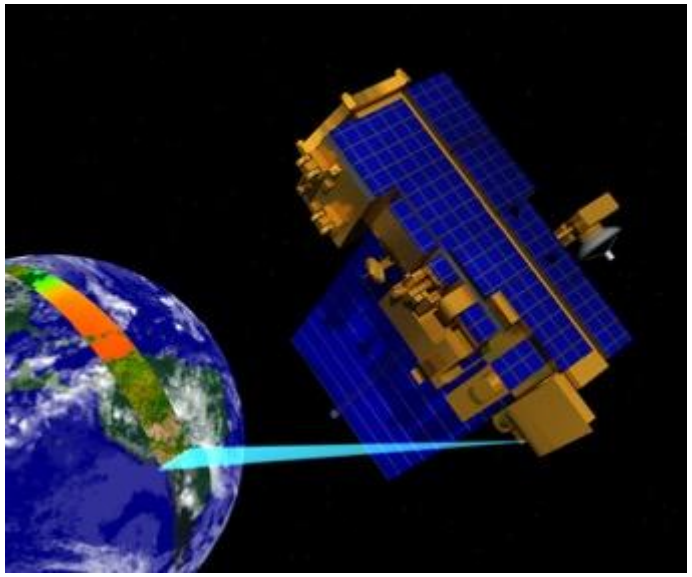


Image: NASA

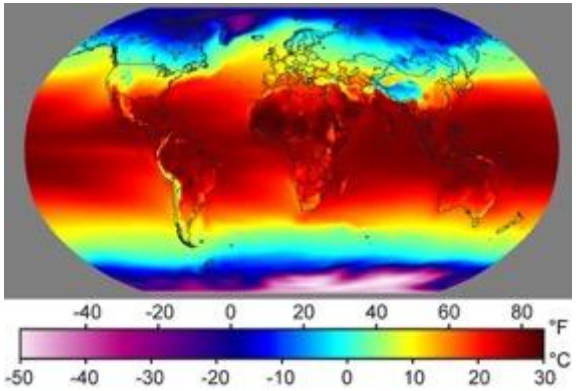


Image: Windows to the Universe

Find out more about
NASA's MODIS Imagery

Image: Kevn Czajkowski

Recording surface temperature is important-2

2. To help understand seasonal changes in Earth's surface.

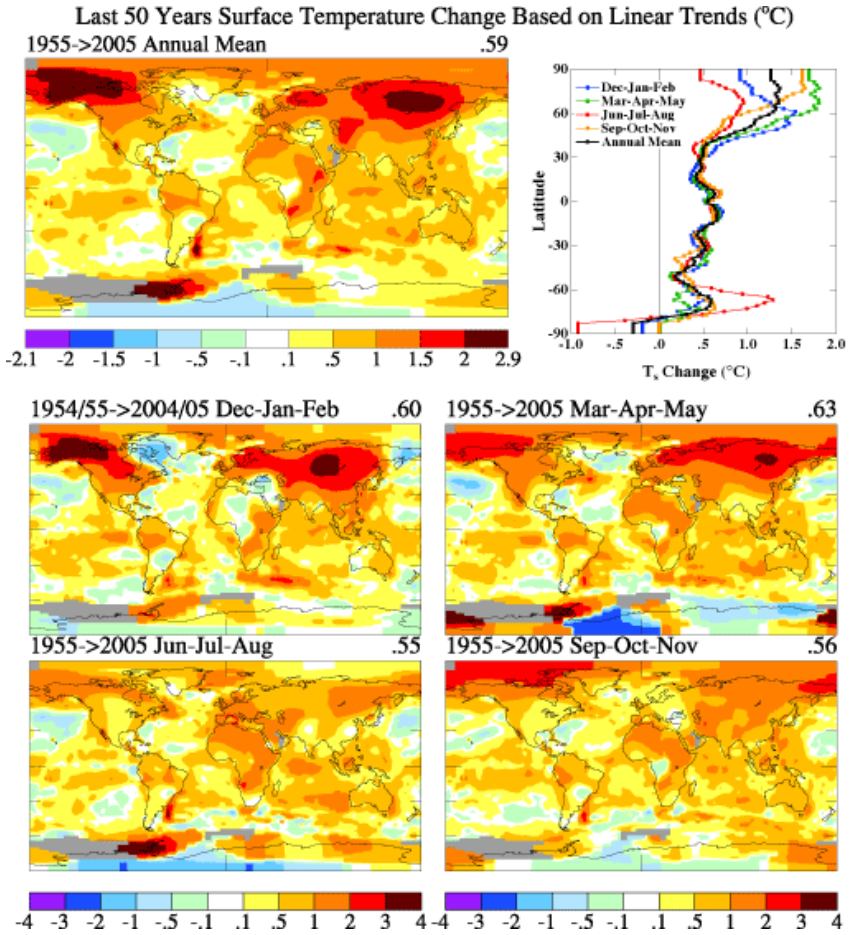


Image: NASA GISS

Recording surface temperature is important-3

3. To help understand the rate of heat and moisture exchange between the atmosphere and Earth.

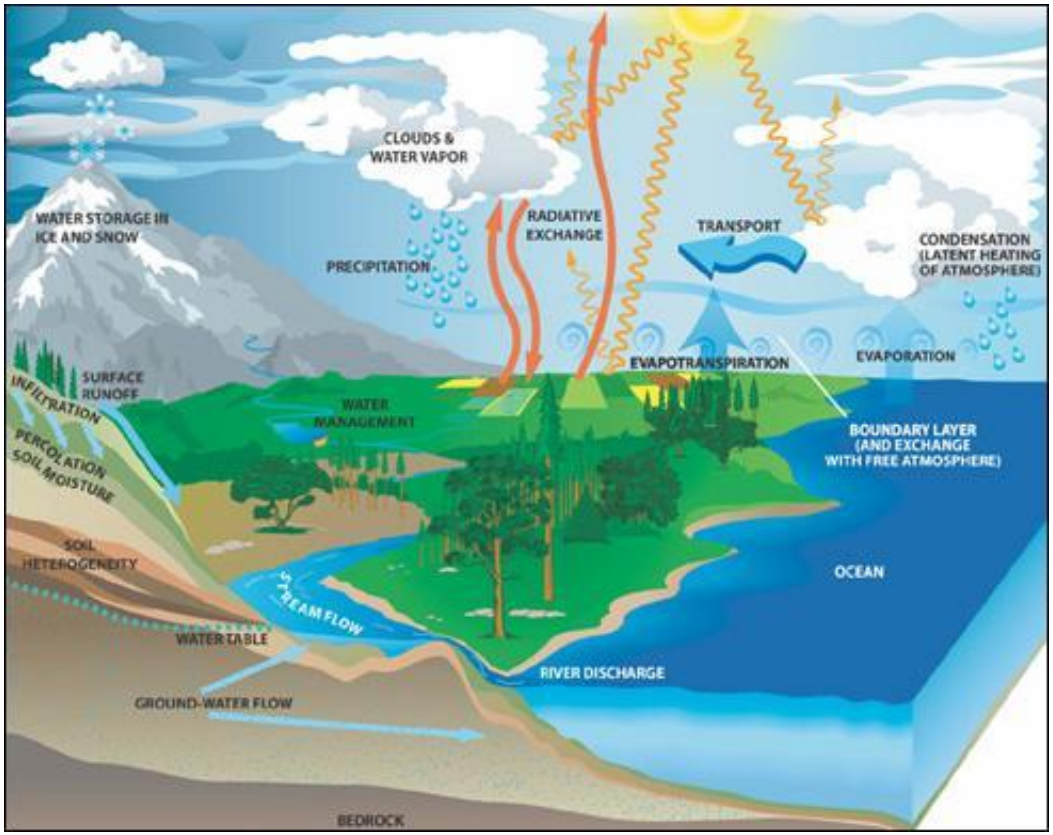
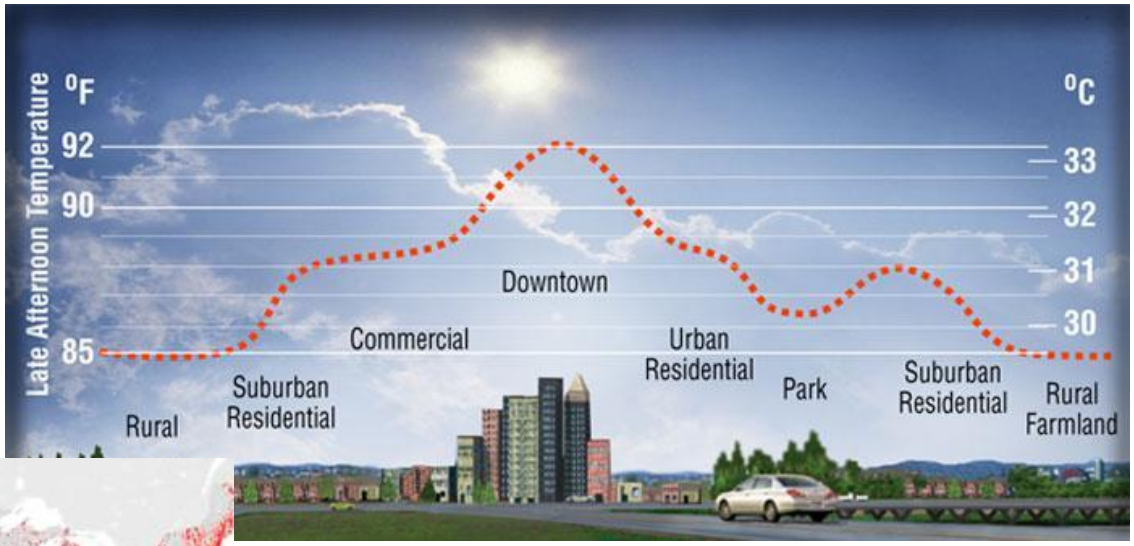
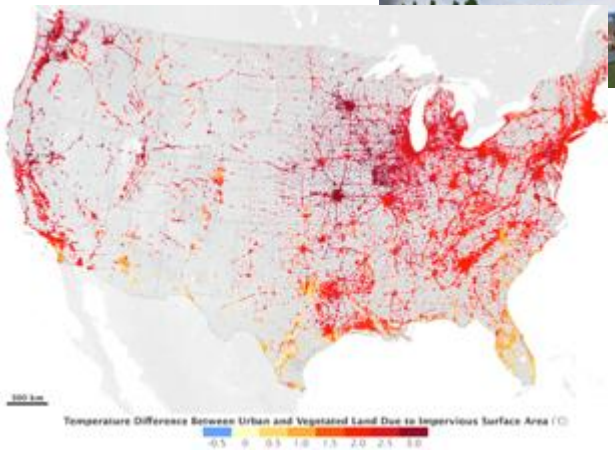


Image: NASA

Recording surface temperature is important-4

4. To assist in urban planning and to help understand the *Urban Heat Island Effect.*





YOUR measurements can help researchers understand and predict

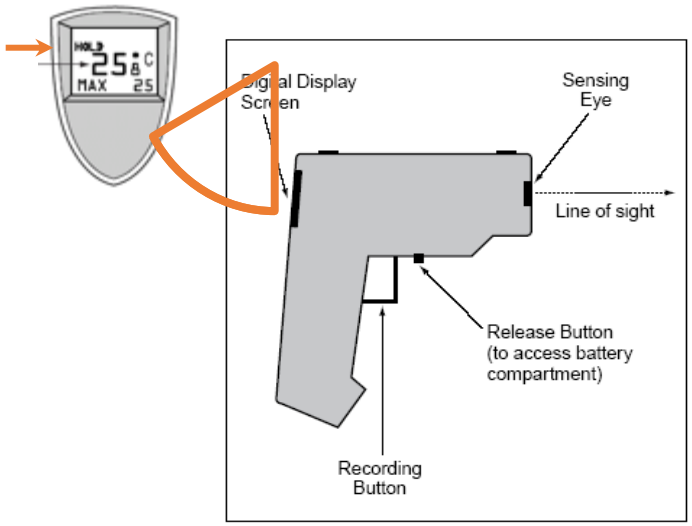
- How do urban areas affect the temperature around them?
- What is the contribution of changing land use and land cover on local energy budgets?
- How are land surface temperatures changing over the long-term?
- How your data compares with data from NASA satellites?

What you need to collect data:

Instruments	Your eyes, GPS unit, Infrared Thermometer, Meter Stick
References	*GLOBE cloud chart*
When	Good: Any time **Better**: Within one hour of *local solar noon* **Best:** Within +/- 15 minutes of a *satellite overpass*
Where	A good observation site (See *Documenting your atmosphere study site*)
Form	*Surface Temperature Data Sheet*

Instrument: Infrared Thermometer

Measures infrared (heat) radiation emanating from a surface and converts it to temperature.



Surface temperature can be observed by sensing the infrared part of the electromagnetic spectrum.

Infrared Thermometer Specifications

Accuracy: ±2 °C

Range: make sure that the instrument's temperature range is large enough to capture the variations in your area.

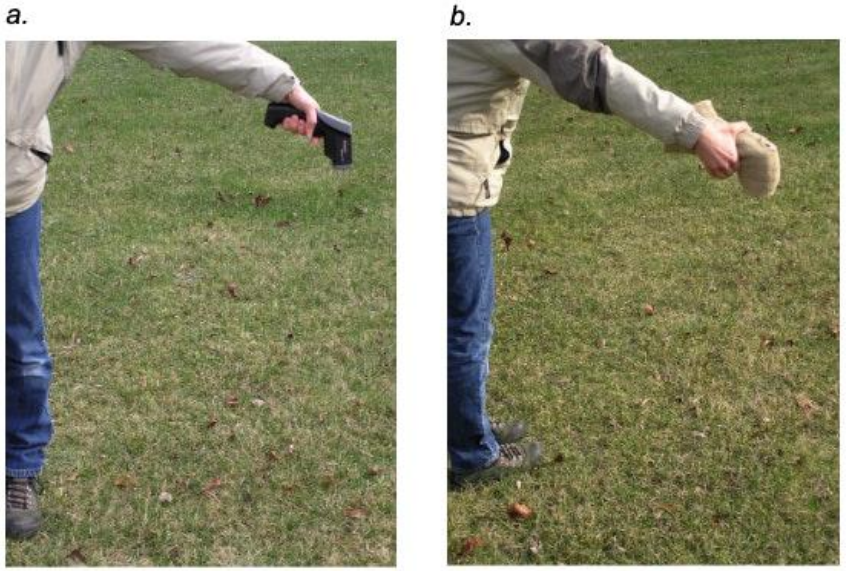
Where do I get one?
Handheld infrared thermometers can be purchased from a number of stores and online retailers. Prices range from $25-$300 USD

Maintenance of instrument:

- -proper cleaning of lenses is important since accumulated particles on the lens can reduce the accuracy
- -do not use solvents to clean the lens

Calibrate your Infrared Thermometer

1. When the air temperature at the study site varies by more than 5°C from the air temperature where the hand-held infrared thermometer (IRT) has been stored, either wrap the IRT in a thermal glove before going to your study site or place the IRT outdoors for at least 60 minutes before data collection.



The above pictures show correct use of IRT, a) without a Thermal Glove and b) with Thermal Glove

Data Collection Procedure

2. Complete the top section of the Surface Temperature Data Sheet.

3. Take cloud observations by following the GLOBE Cloud protocols.

4. If there is no snow on the ground anywhere in your site, then check either “Wet” or “Dry” for the Site’s Overall Surface Condition field on your Surface Temperature Data Sheet. If snow is present, check “Snow.”

5. Select nine homogenous (the same surface type throughout) observation spots in open areas of your site, ensuring they are at least 5 meters apart from each other. The observation spots should be located away from trees and buildings that cast shadows on the land, and in areas that have not been recently disturbed by human or animal activity. (Note: Take readings at the nine observation spots within seconds of each other.)

6. Go to one of the nine observation spots and stand so you do not cast a shadow on the spot.

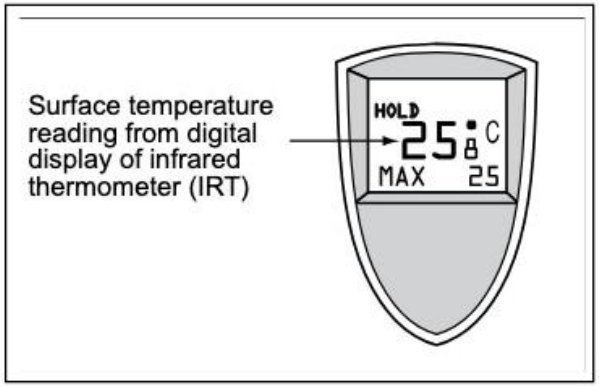
7. Record the current time and its corresponding Coordinated Universal Time (UTC) on your Surface Temperature Data Sheet.

Collecting Data using an Infrared Thermometer

HOW?

8. Hold the IRT (wrapped in a thermal glove when necessary) with your arm extended straight out and point the instrument straight down at the ground.
9. Hold the IRT as still as possible. Press and release the recording button (Note: You MUST release the recording button for the instrument to register your spot's surface temperature).
10. Read and record the surface temperature from the digital display screen located on the top of the IRT. (Note: Surface temperature is recorded in Celsius to the nearest tenth degree, e.g., 25.8°C)
11. If there is snow on the ground, measure and record the snow depth in millimeters at the observation spot. Refer to the Solid Precipitation protocol field guide for measuring the depth of snow on the ground.
12. Repeat steps 7–11 at each of the remaining eight observation spots.
13. Describe any other information that explains the environmental conditions of the day or the site in the Comments field.

Photo credit: Kevin Czajkowski



Data Collection: Overview

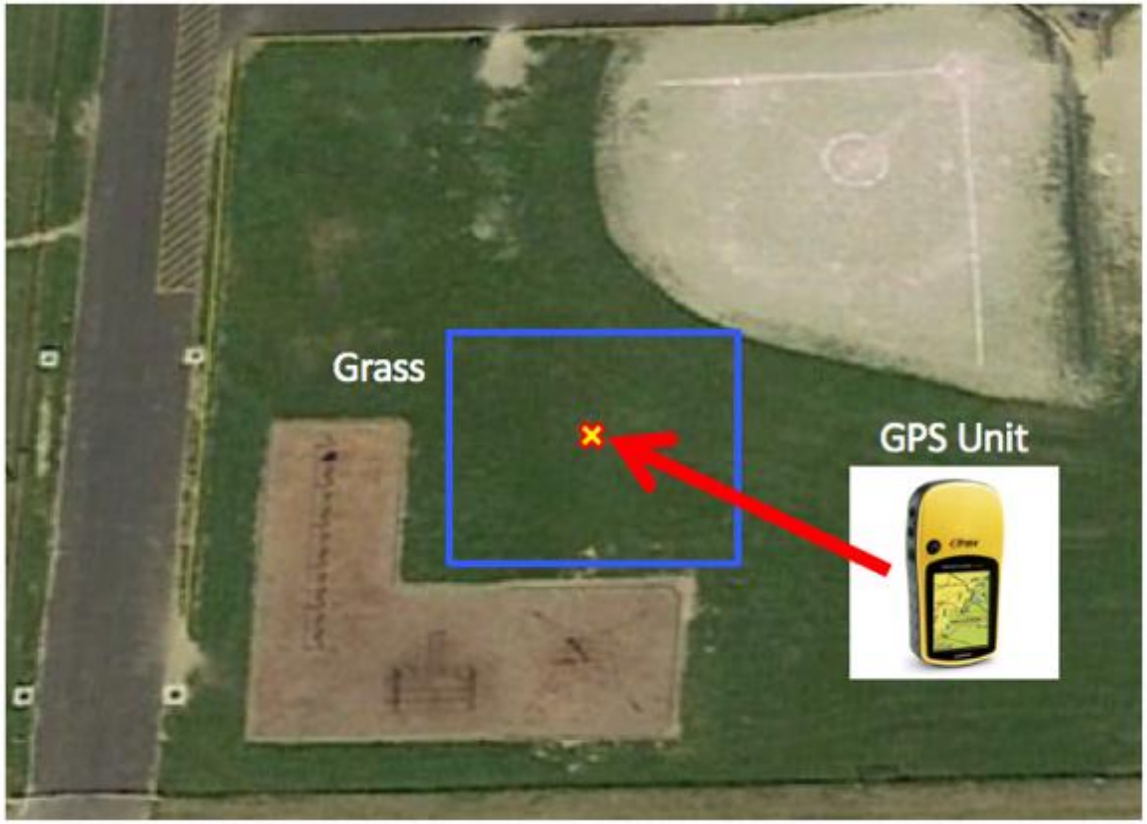
1) Choose a site that is homogenous at least 30 meters square (if possible). Can be grass, asphalt, etc.
2) Collect GPS data for the **center** of the site (latitude, longitude and elevation).
3) Pick nine random observation spots in the study site:
   - Read and record surface temperature
   - Record the time
   - Measure and record snow depth (if present)
4) Use the *Cloud Protocol* to record cloud observations.
5) Record your data on the Surface Temperature Data sheet.

1. Choose homogenous study areas.

Choose study areas that are as large as possible and that have homogeneous cover. free from shadows from trees or buildings, ensures that you're measuring representative surface temperatures. Be sure to document the size of your homogeneous site. Setting up the site properly means fewer biasing factors and more useful, comparable data for scientists worldwide.

2. Collect GPS data of the center of each study area. If you are using the GLOBE Observer app on your phone, the latitude and longitude are automatically recorded.

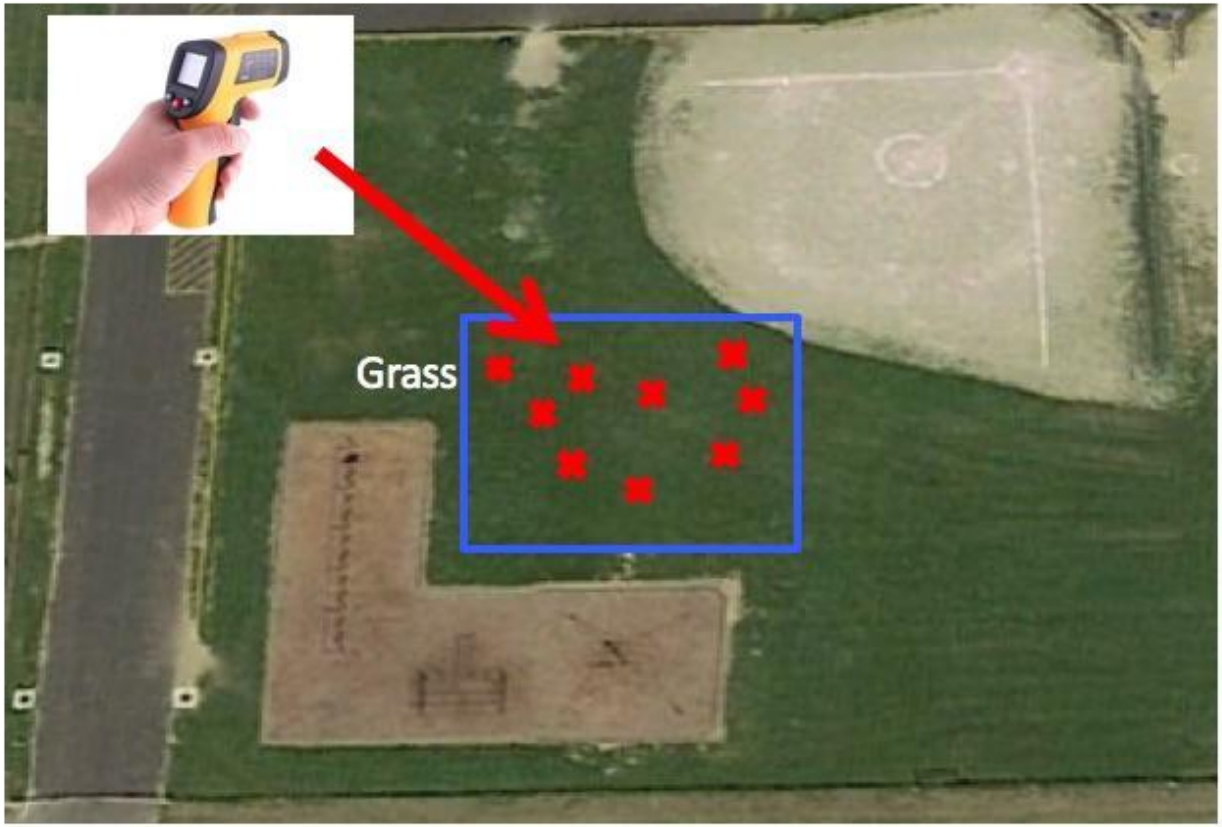
Record latitude, longitude and elevation.



GPS Protocol

3. Take 9 random surface temperature readings

Take 9 random surface temperature readings within **each** study area. The 9 random observations ensure a good average for the site is observed.



Caution!

Do not mix cover types in one study area.

In this case, the study area mistakenly has grass *and* bare ground.

Caution!

Do not take the temperature of shadowed areas including the shadow that your body may cast.

Caution!

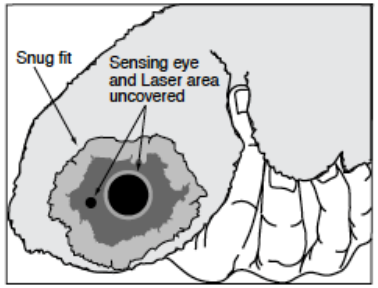
Extend your arm in front of you to take the observations. You don't want to measure the temperature of your feet.

Caution! Thermal Shock

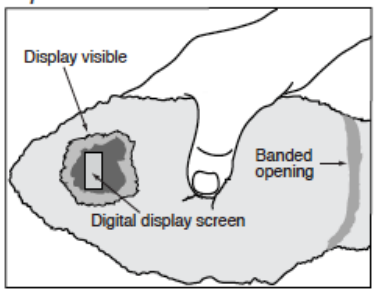
Prepare and acclimate the infrared thermometer properly.

When the air temperature at your study site varies more than 5° C from the air temperature of the storage location of the IRT, place the IRT outdoors for at least 60 minutes prior to data collection.

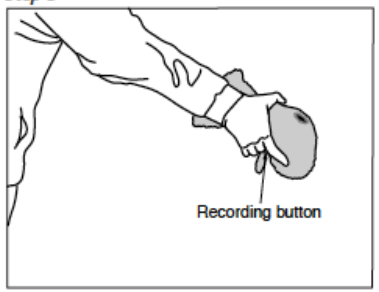
Or, you can make a thermal glove using a terry cloth oven mitt.



Step 3 and 4



Step 5



Directions for Use of IRT with Thermal Glove:

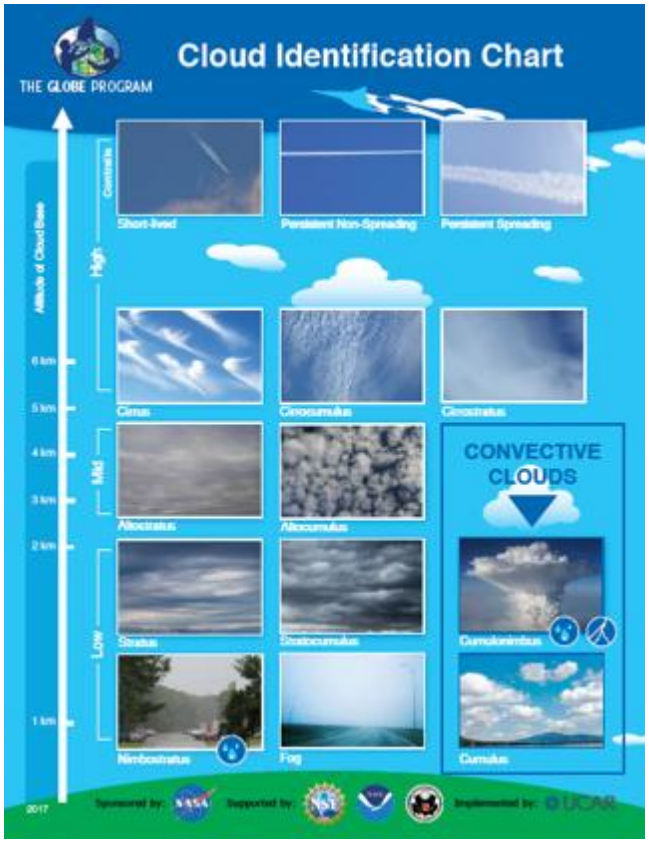
1. Hold the thermal glove so the thumb points down.
2. Position the IRT in the finger section of the thermal glove with the sensing eye pointing out through the cut hole in the end of the finger section. Make sure the thermal glove does not cover the sensing eye and laser areas; however, also make sure that the IRT fits snugly against the front area of the thermal glove to prevent air from flowing through the glove. (Ignore the thumb section of the thermal glove).
3. Position the digital display screen so that it is visible in the upper cut hole (when the thumb is pointing downward.)
4. Take your hand out of the thermal glove and use a rubber band to tighten the thermal glove around the IRT handle at the large bottom opening of the thermal glove.
5. Operate the IRT from **outside** the thermal glove by placing your finger on the recording button and squeezing.

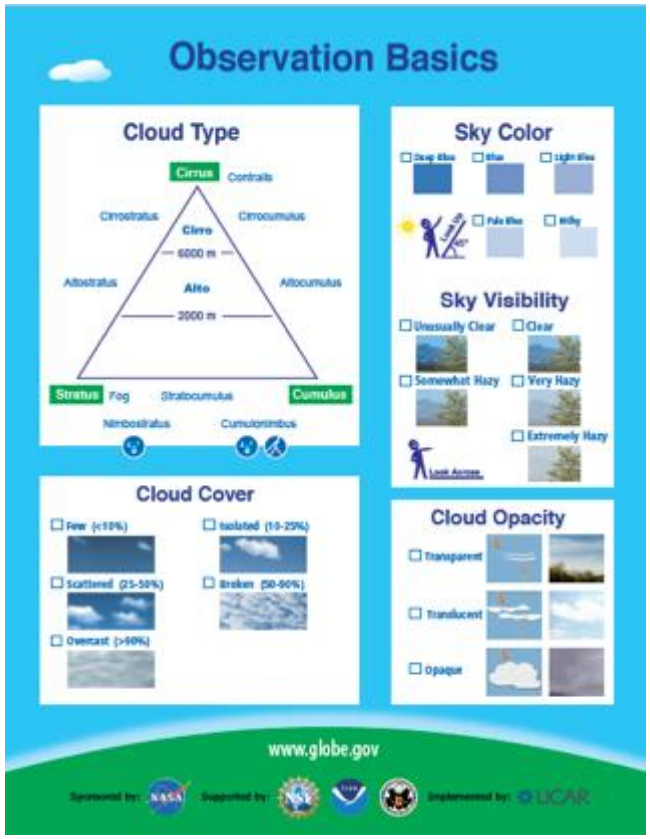
Measuring Surface Temperature in Snow

What if there is snow? Just measure the snow depth for each of the 9 observation locations and then collect your surface temperature readings.

Your footprints will affect the snow but that is ok.

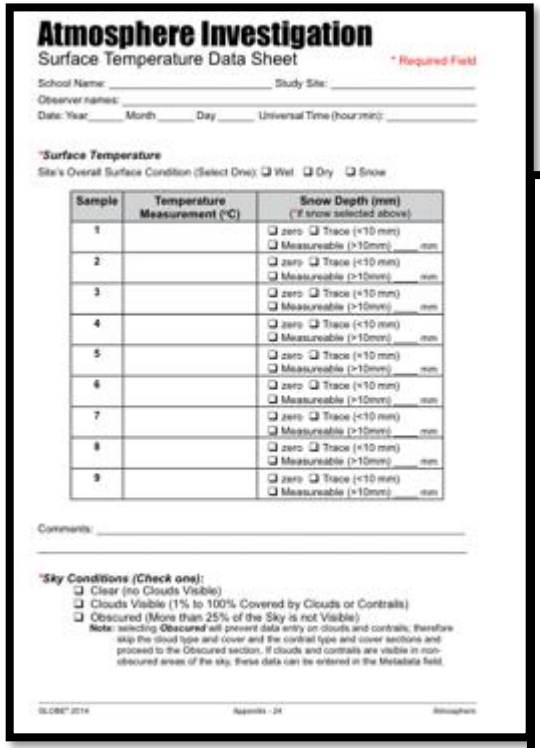
4. Record cloud and contrail data using the GLOBE Cloud Protocol





The *GLOBE Cloud Chart* can help you identify the clouds.

5. Record your data on the *Surface Temperature Data Sheet*



Atmosphere Investigation

Surface Temperature Data Sheet

* Required Field

School Name: _____ Study Site: _____

Observer names: _____

Date: Year_____ Month_____ Day_____ Universal Time (hour:min): _____

Surface Temperature

Site's Overall Surface Condition (Select One): ❑ Wet ❑ Dry ❑ Snow

Sample	Temperature Measurement (°C)	Snow Depth (mm) (If snow selected above)
1		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm)____ mm
2		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm)____ mm
3		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm)____ mm
4		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm)____ mm
5		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm)____ mm
6		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm)____ mm
7		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm)____ mm
8		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm)____ mm
9		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm)____ mm

Comments: _____

Sky Conditions (Check one):

❑ Clear (no Clouds Visible)

❑ Clouds Visible (1% to 100% Covered by Clouds or Contrails)

❑ Obscured (More than 25% of the Sky is not Visible)

Note: selecting **Obscured** will prevent data entry on clouds and contrails, therefore skip the cloud type and cover and the contrail type and cover sections and proceed to the Obscured section. If clouds and contrails are visible in non-obscured areas of the sky, these data can be entered in the Metadata field.

Study Site: _____ Date: _____ Time (UT): _____ * Required Field

If Clouds are Visible select all Cloud Types Seen

High (in the sky): (Check all types seen) ❑ Cirrus ❑ Cirrocumulus ❑ Cirrostratus

Middle (of the sky): (Check all types seen) ❑ Altostratus ❑ Altocumulus

Low (in the sky): (Check all types seen) ❑ Stratus ❑ Stratocumulus ❑ Cumulus

Rain or Snow Producing Clouds: (Check all types seen) ❑ Nimbostratus ❑ Cumulonimbus

What Percent of the Sky is Covered by Clouds? (Check One) *Three-quarters or More of the Sky is Visible: Cloud Cover* (Check One)

No Clouds ❑ 0% | Clear ❑ >0 to 10% | Isolated ❑ 10 to 25% | Scattered ❑ 25 to 50% | Broken ❑ 50 to 90% | Overcast ❑ >90%

Are There Contrails in the Sky? (Check One) ❑ No Contrails ❑ Contrails are Visible

If Contrails are Visible Record the Number of Each Type Seen

Short-lived Number Observed ☐ | Persistent Non-Spreading Number Observed ☐ | Persistent Spreading Number Observed ☐

Study Site: _____ Date: _____ Time (UT): _____ * Required Field

What Percent of the Sky is Covered by Contrails? (Check one): ❑ 0 to 10% ❑ 10 to 25% ❑ 25 to 50% ❑ >50%

If you Selected Obscured (> 25% of the Sky is not Visible) Check all that apply:

❑ Blowing Snow ❑ Heavy Snow ❑ Heavy Rain ❑ Fog

❑ Sand ❑ Spray ❑ Volcanic Ash ❑ Smoke

❑ Dust ❑ Haze

Comments: _____

Be sure to enter your school, study site, observer names, date and time (local or UTC)

Atmosphere Investigation

Surface Temperature Data Sheet

* Required Field

School Name: _____ Study Site: _____

Observer names: _____

Date: Year_____ Month _____ Day _____ Universal Time (hour:min): _____

Surface Temperature

Site's Overall Surface Condition (Select One): ❑ Wet ❑ Dry ❑ Snow

Sample	Temperature Measurement (°C)	Snow Depth (mm) (*if snow selected above)
1		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
2		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
3		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
4		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
5		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
6		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm

CAUTION – An observation without a date or time cannot be used

Atmosphere Investigation

Surface Temperature Data Sheet

* Required Field

School Name: _____ Study Site: _____

Observer names: _____

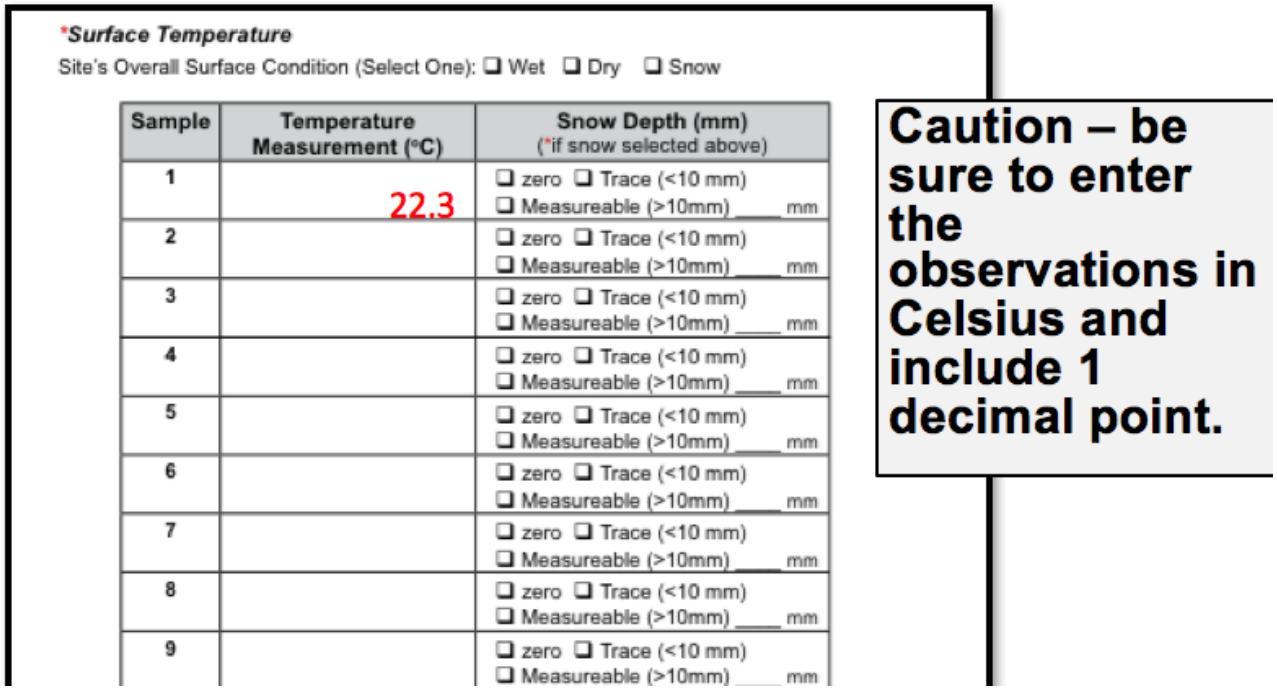
Date: Year_____ Month _____ Day _____ Universal Time (hour:min): _____

Surface Temperature

Site's Overall Surface Condition (Select One): ❑ Wet ❑ Dry ❑ Snow

Sample	Temperature Measurement (°C)	Snow Depth (mm) (*if snow selected above)
1		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
2		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
3		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
4		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
5		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
6		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
7		❑ zero ❑ Trace (<10 mm)

Enter the 9 surface temperature observations and snow depth, add comments of anything interesting about the observation.



*Surface Temperature

Site's Overall Surface Condition (Select One): ❑ Wet ❑ Dry ❑ Snow

Sample	Temperature Measurement (°C)	Snow Depth (mm) (*if snow selected above)
1	22.3	❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
2		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
3		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
4		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
5		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
6		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
7		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
8		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm
9		❑ zero ❑ Trace (<10 mm) ❑ Measureable (>10mm) ____ mm

Caution – be sure to enter the observations in Celsius and include 1 decimal point.

Do the *cloud and contrail protocols*.

Sky Conditions (Check one):
- ❑ Clear (no Clouds Visible)
- ❑ Clouds Visible (1% to 100% Covered by Clouds or Contrails)
- ❑ Obscured (More than 25% of the Sky is not Visible)

Note: selecting ***Obscured*** will prevent data entry on clouds and contrails; therefore skip the cloud type and cover and the contrail type and cover sections and proceed to the Obscured section. If clouds and contrails are visible in non-obscured areas of the sky, these data can be entered in the Metadata field.

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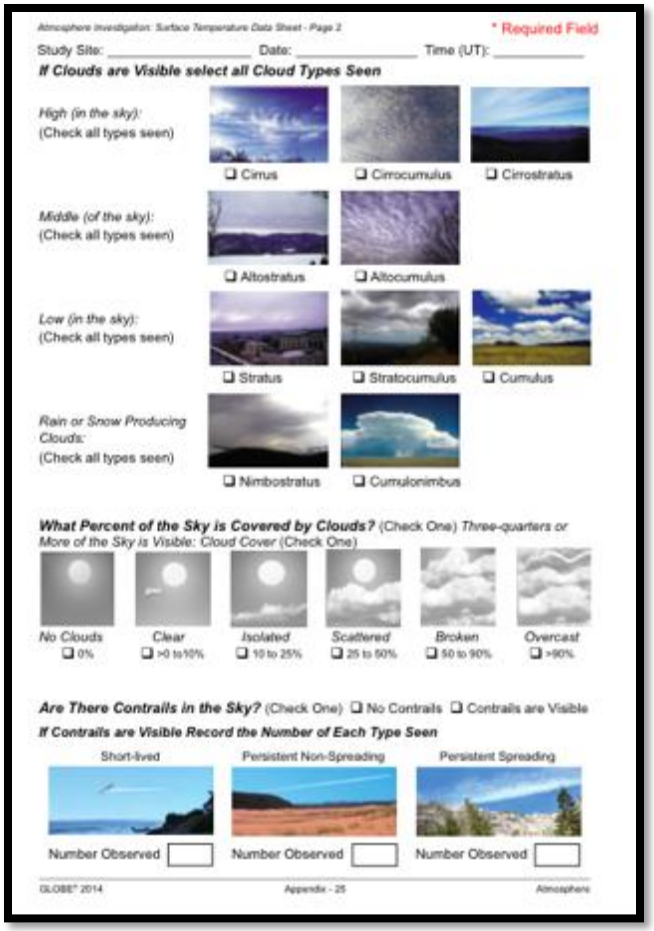
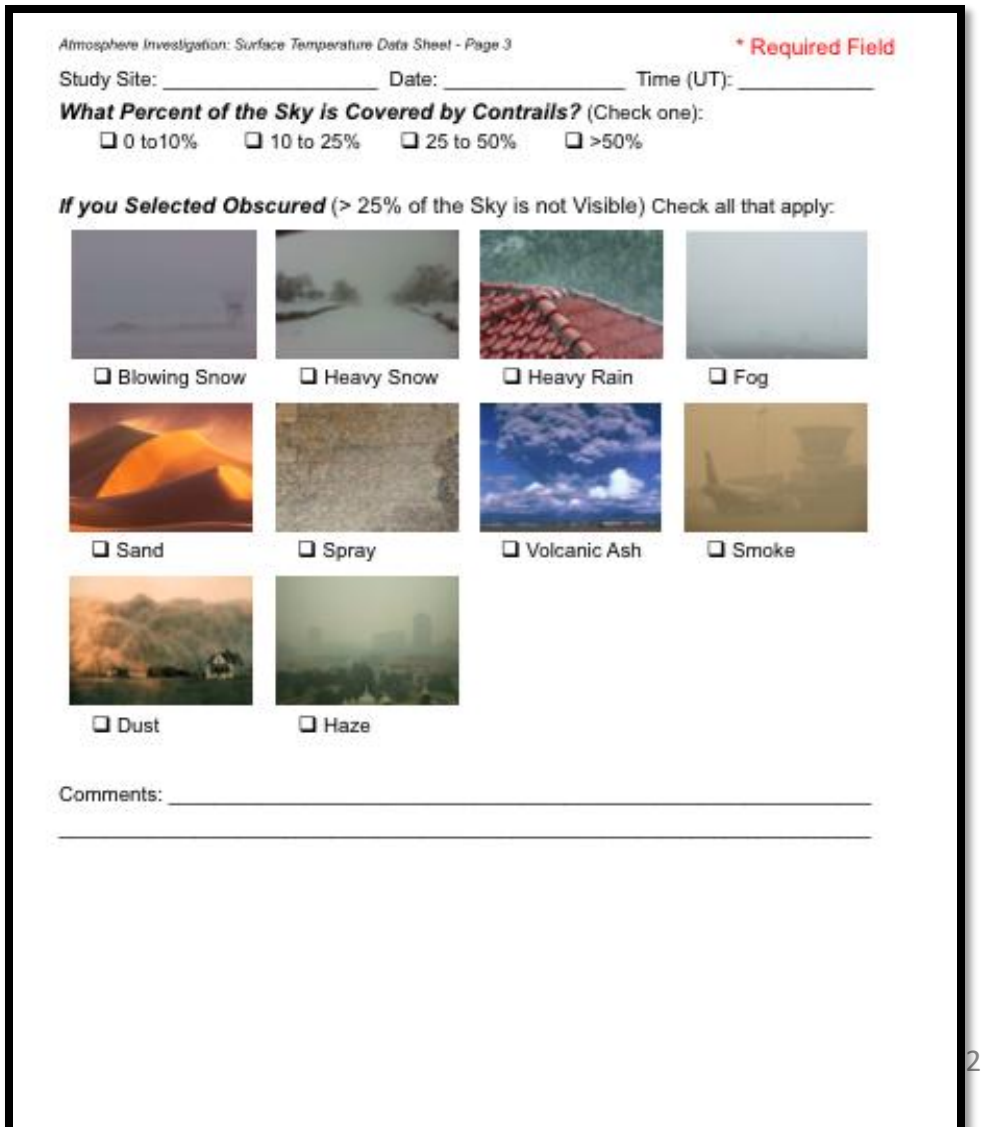


Record the sky condition.

If you can't see the sky, check the reason.

Caution – If you click obscured, clouds cannot be entered.



Atmosphere Investigation: Surface Temperature Data Sheet - Page 3 * Required Field

Study Site: _____ Date: _____ Time (UT): _____

What Percent of the Sky is Covered by Contrails? (Check one):

❑ 0 to10% ❑ 10 to 25% ❑ 25 to 50% ❑ >50%

If you Selected Obscured (> 25% of the Sky is not Visible) Check all that apply:

❑ Blowing Snow ❑ Heavy Snow ❑ Heavy Rain ❑ Fog

❑ Sand ❑ Spray ❑ Volcanic Ash ❑ Smoke

❑ Dust ❑ Haze

Comments: _____

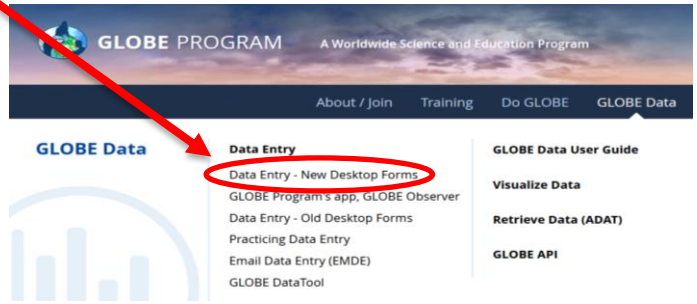
_____

Entering Surface Temperature Data in the GLOBE Observer Data Entry System

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".



Note 1: You will need a GLOBE teacher, trainer, or scientist account to submit GLOBE data.

Note 2: It may take some time after you enter your data for it to appear in the GLOBE data visualization system.

Entering Surface Temperature Data – Step 1&2

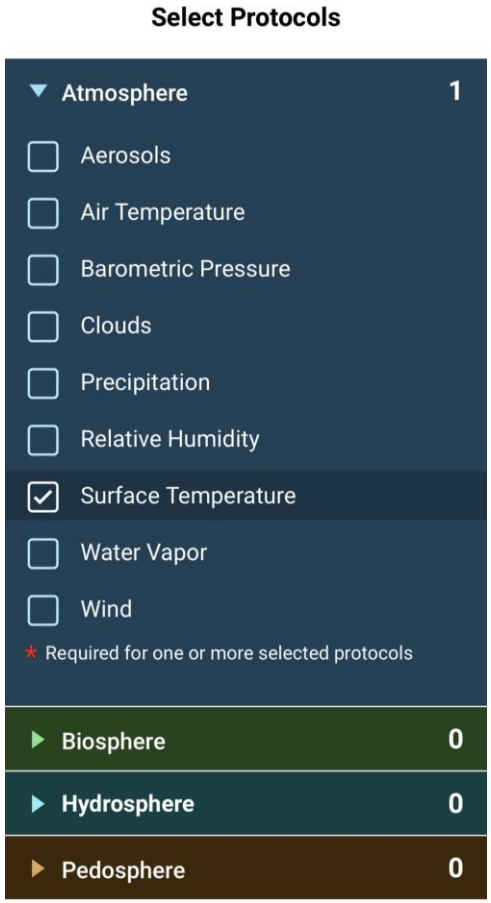
The steps below will walk you through entering your Atmosphere Study Site Information in the GLOBE Observer App, which you can access using your GLOBE or GLOBE Observer login.

1. Click “Data Entry”

2. Click "Create/Edit My Sites"

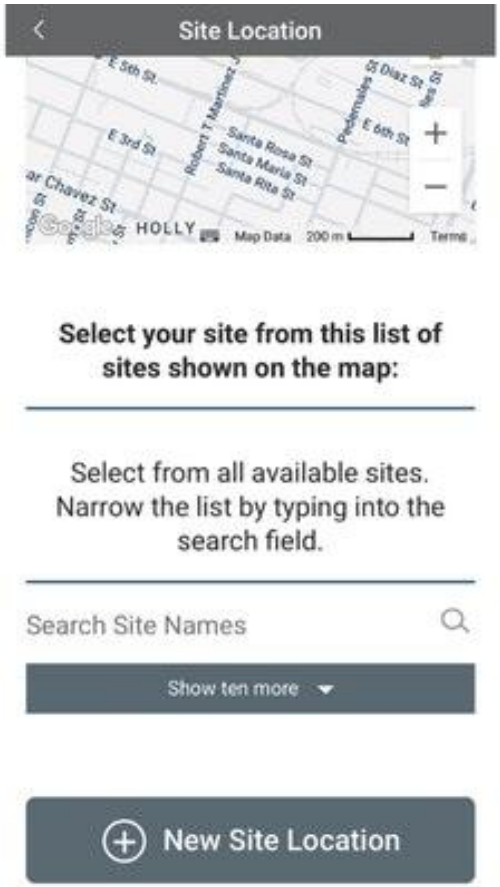
Entering Surface Temperature Data – Step 3

3. Click on the arrow next to "*Atmosphere*" and select "*Surface Temperature*". The other necessary protocols will be automatically selected.



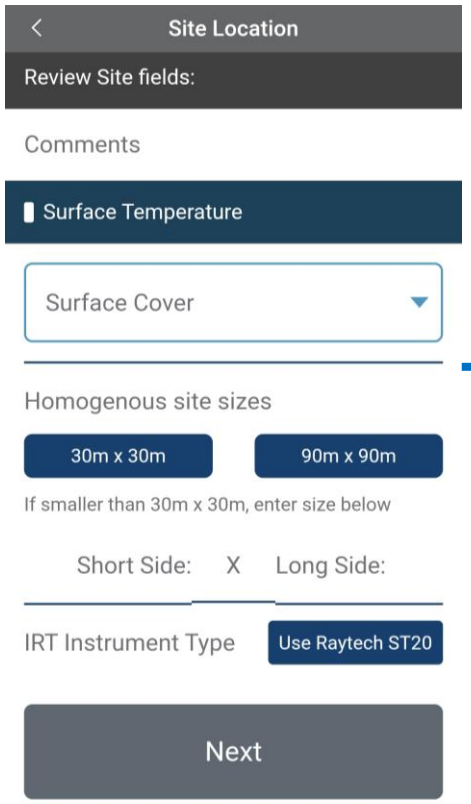
Entering Surface Temperature Data – Step 4

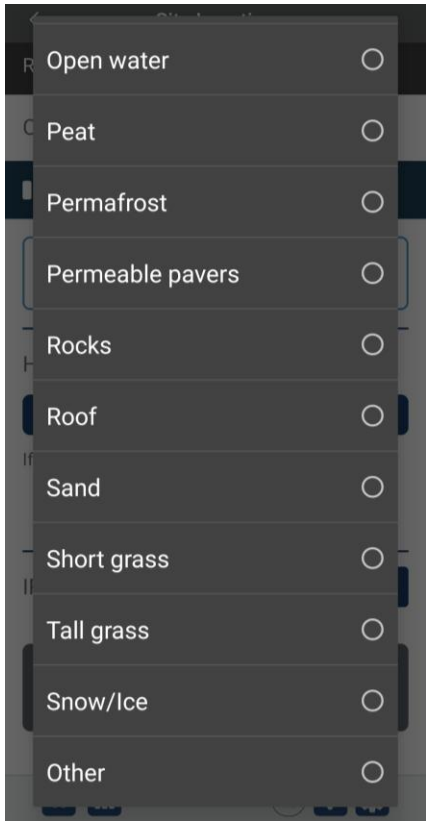
4. At the bottom of the screen, click "*Continue*". When prompted, enter site location details (latitude, longitude, and elevation). Choose an existing site or identify a new site by clicking "+ *New Site Location*"

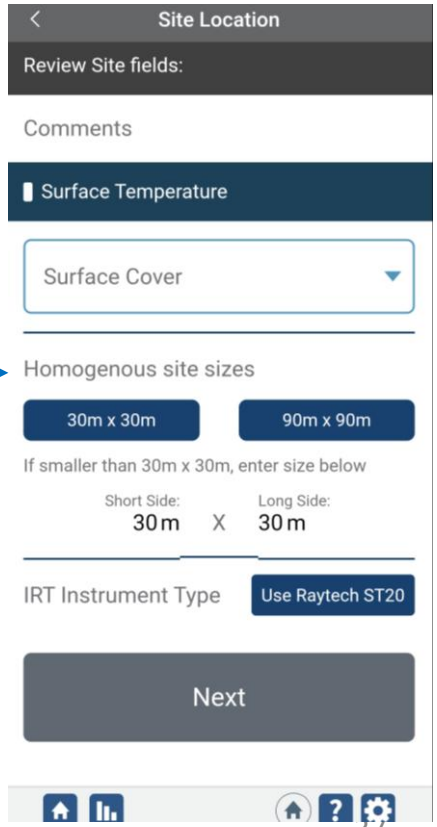


Entering Surface Temperature Data – Step 5

5. When identifying a new site location, click on Surface Cover and choose which option best matches that which you are observing. Then, write in the site size of the location where the observation is taking place. To move on, click "*Next*"

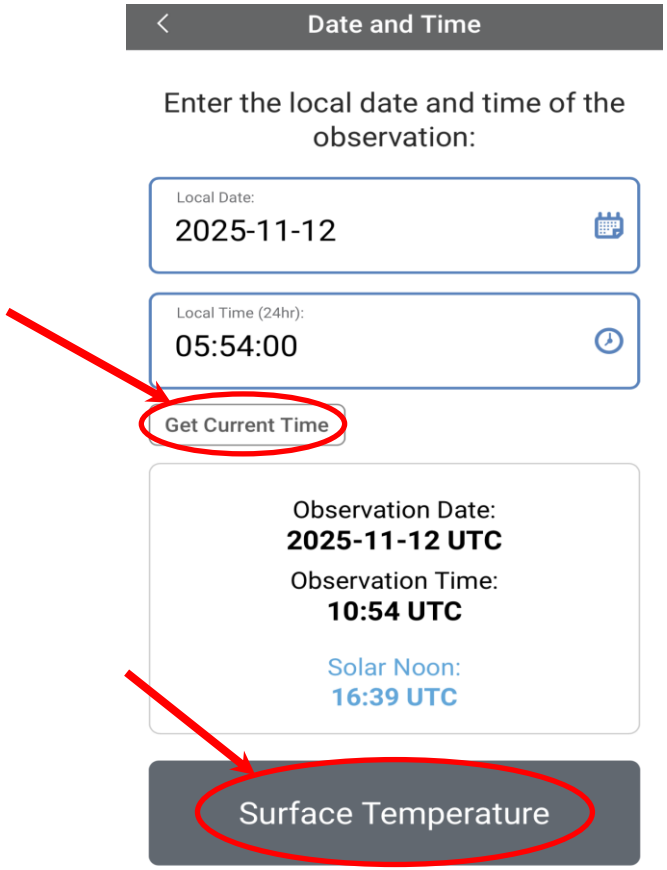






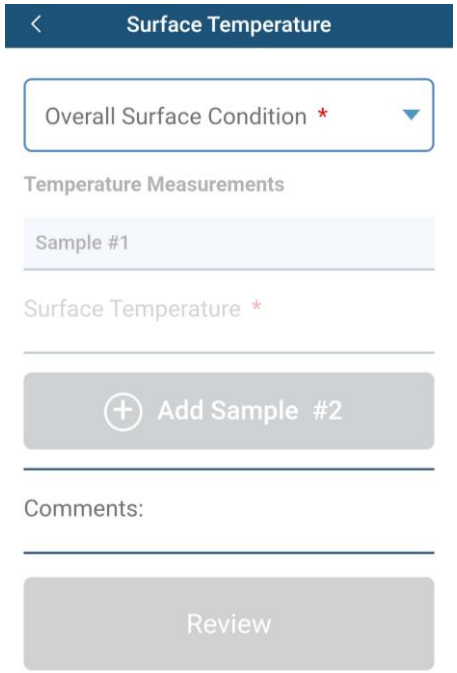
Entering Surface Temperature Data – Step 6

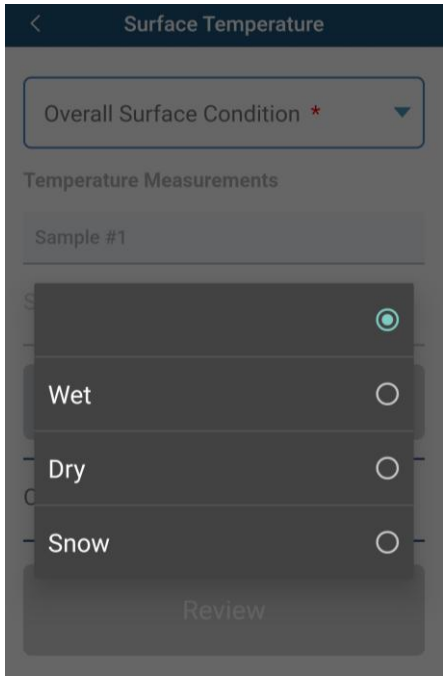
6. Check to see if the "*Date and Time*" are correct, if it is not, click "*Get Current Time*" to update it. Then click "*Surface Temperature*" to move on

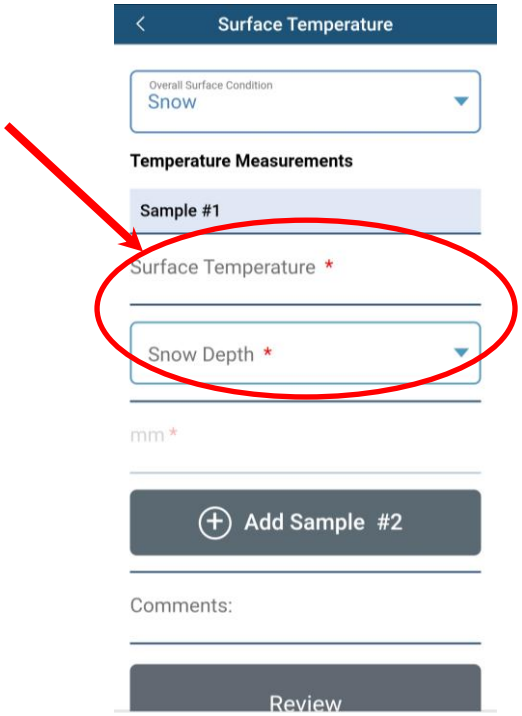


Entering Surface Temperature Data – Step 7

7. Now you will put in some information about your observation. "Click on Overall Surface Condition" to select from "*Wet*", "*Dry",* "*Snow*". If selecting "*Snow*", report snow depth too (in millimeters). **Be sure to report surface temperature using Celsius/ °C in your measurements.** Click *"Review"* when done



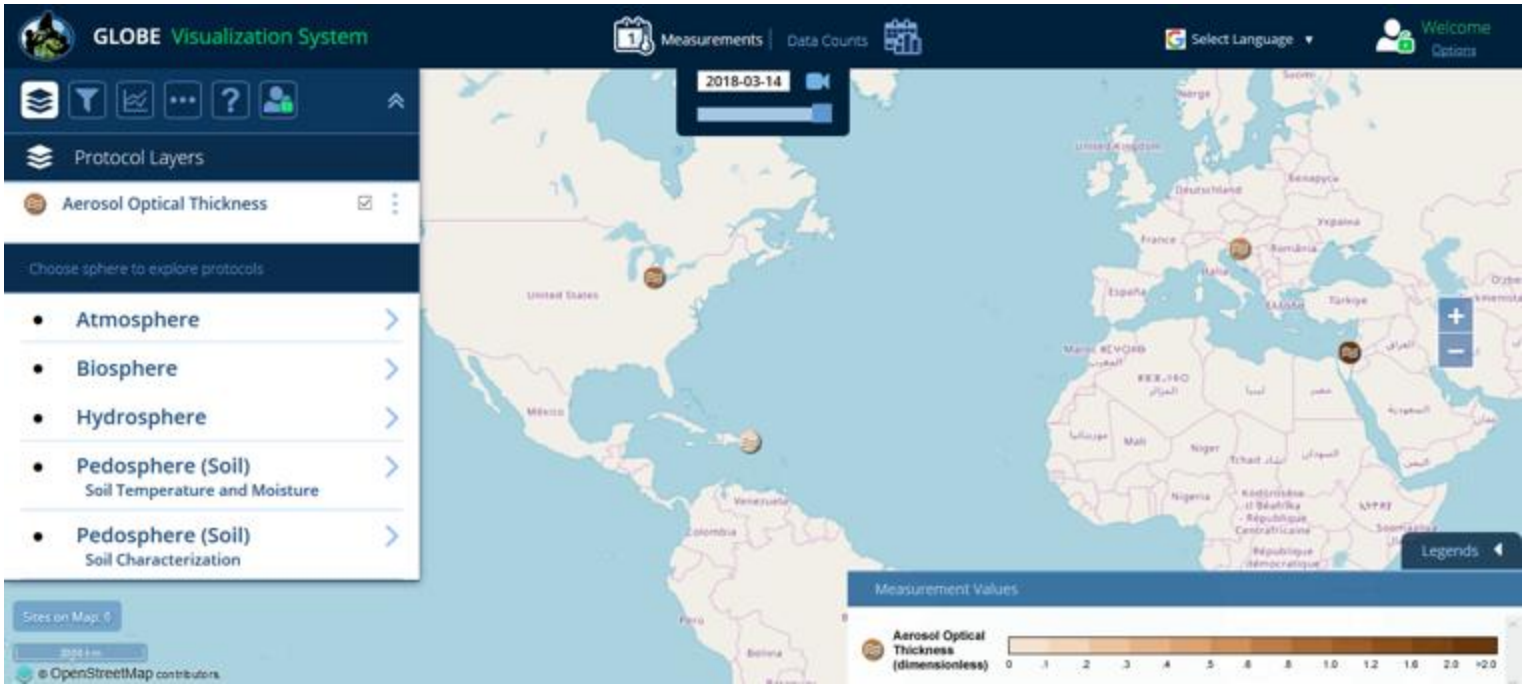




Visualize and Retrieve Data

GLOBE provides the ability to view and interact with data measured across the world. Select our *visualization tool* to map, graph, filter and export data that have been measured across GLOBE protocols since 1995.

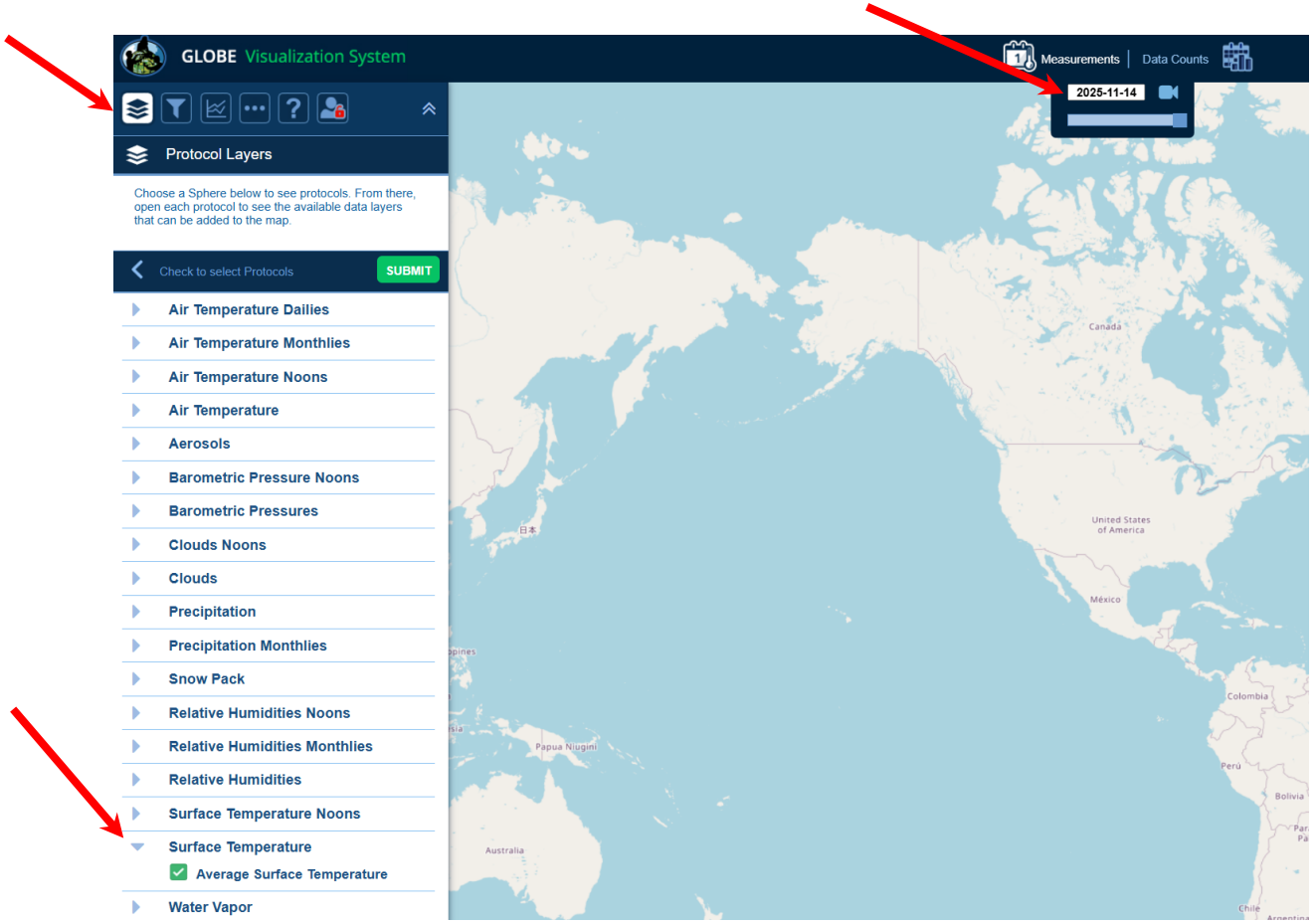
These step-by-step tutorials on using the visualization system will assist you in finding and analyzing data: *PDF version* *PowerPoint version*



http://vis.globe.gov/GLOBE/

Visualize and Retrieve Data – Step 2

Select the date for which you need data, add the protocol layers, and you can see where data is available.



Questions for you to investigate:

- How does surface temperature compare with current air temperature? How does surface temperature compare with soil temperature at 5 cm and 10 cm?
- How does surface temperature vary with land cover (e.g., bare soil, short grass, tall grass, concrete, asphalt, sand, forest litter)?
- How does surface temperature vary with surface soil color?
- How does the surface temperature of the ground, near the outside of the atmosphere shelter, compare with the current air temperature measured inside the shelter?
- How does surface temperature change for different cover types (grass vs. asphalt for instance) on a cloudy day?
- How does the time of year affect the surface temperature?
- How does the surface temperature change for different cover types when it is wet versus when it is dry?

What have you learned?

- What does surface temperature mean?
- Why it is it important to collect surface temperature data?
- What instruments are needed to collect surface temperature data?
- Where can I purchase the instruments?
- Where should I take my surface temperature measurements?
- What data is collected?
- How do I submit data to GLOBE?
- What can I do with the data submitted to GLOBE?

Frequently Asked Questions (FAQs)

Should I turn on the red laser on the IRT to do my measurement?

Some IRT units are equipped with a laser and backlight. You can choose whether or not to activate these. If you choose to put them on, a red laser will shine from the sensing eye area along the approximate line of sight of the instrument when the recording button is pressed. This will cause a red dot to appear where the surface temperature is being measured. A backlight for the digital display screen will remain lit for seven seconds after the recording button is pressed and released.

Using the laser can help you more accurately locate the point where you are measuring the surface temperature. However, it will also reduce battery life and could possibly be a distraction to students. It is imperative that the **laser beam NOT be aimed directly at eyes** or off surfaces where it could reflect into anyone's eyes. The laser and backlight option is controlled by a switch located above the battery in the battery compartment.

Further Resources

For information on purchasing GLOBE supplies

For information on infrared thermometers and how they work

For information about the NASA MODIS Satellite Mission

For information about GLOBE

NASA Wavelength: NASA's Digital Library for Earth and Space Education

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 about Module? Contact GLOBE: help@nasaglobe.org

Power point Developers:

Kevin Czajkowski

Janet Struble

Mikell Lynne Hedley

Sara Mierzwiak

Photos unless otherwise identified:

Kevin Czajkowski

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