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

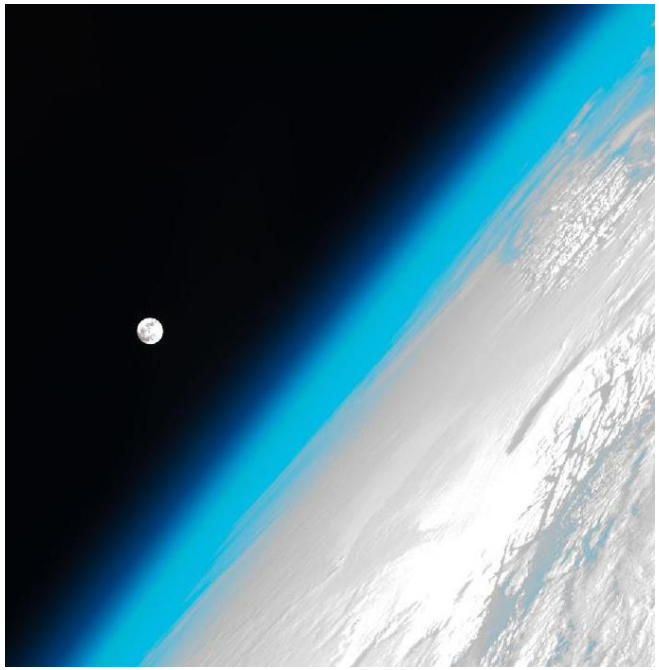


Image: NASA

Link to GLOBE Teacher's Guide Atmosphere Protocol

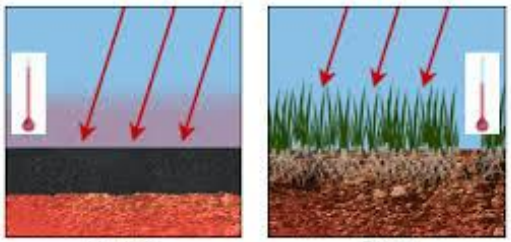
Surface Temperature

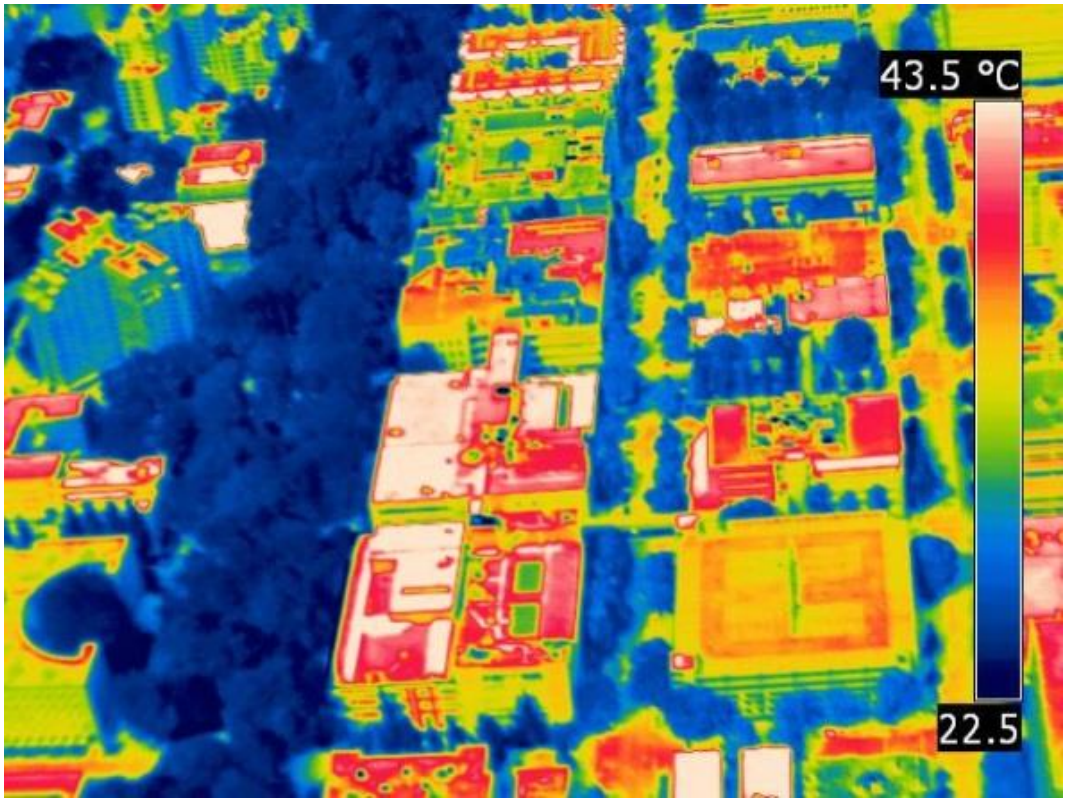
- Is the radiating temperature emitted as electromagnetic energy of the Earth's surface including vegetation, paved surfaces, and the ground, etc.
- Varies depending on the ground cover and the time of day
- Affects all aspects of the Earth's Energy Budget

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

NOAA Visualization: 2015 was the warmest year on record!

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. To help verify surface temperature readings collected by NASA satellites

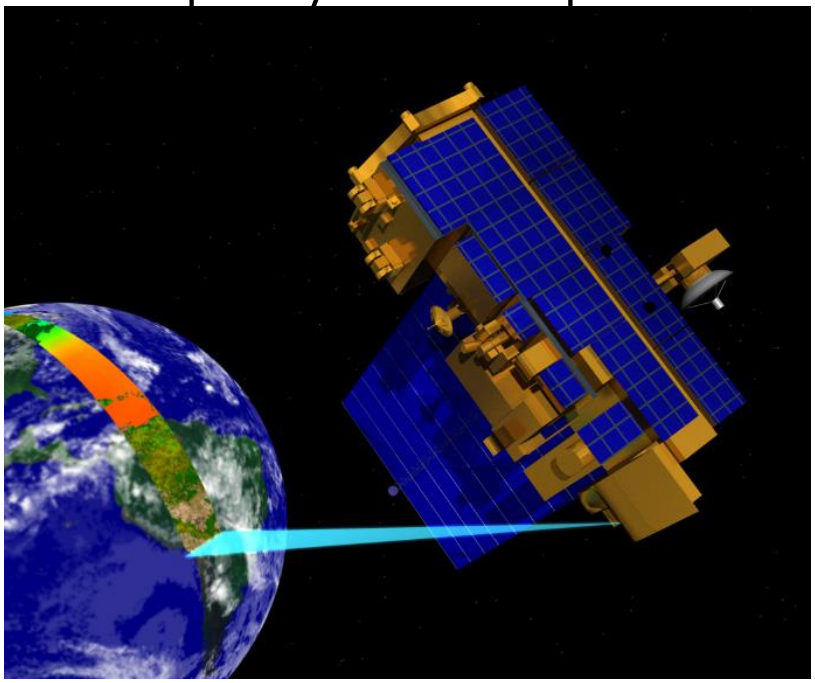


Image: NASA

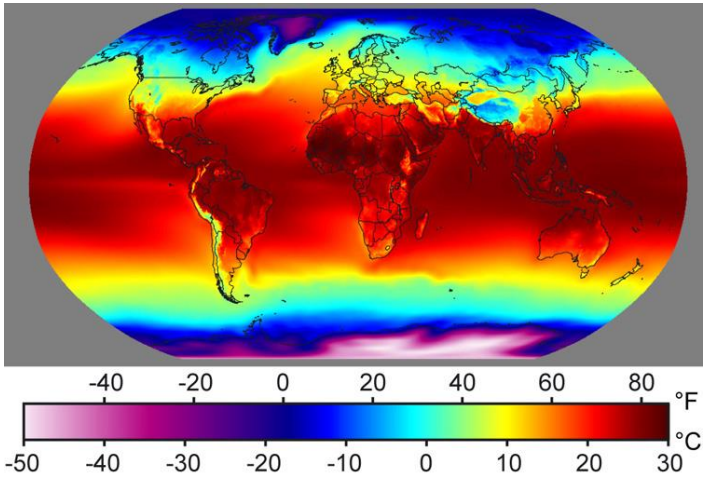


Image: Windows to the Universe

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

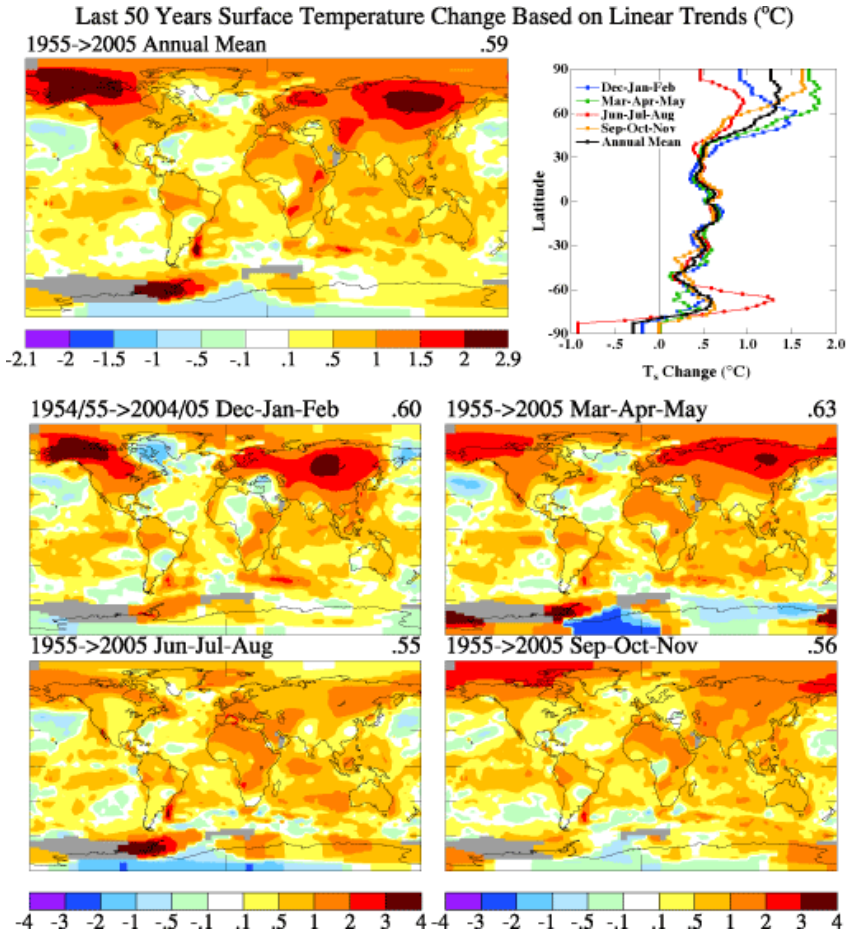


Image: NASA GISS

Recording surface temperature is important-3

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

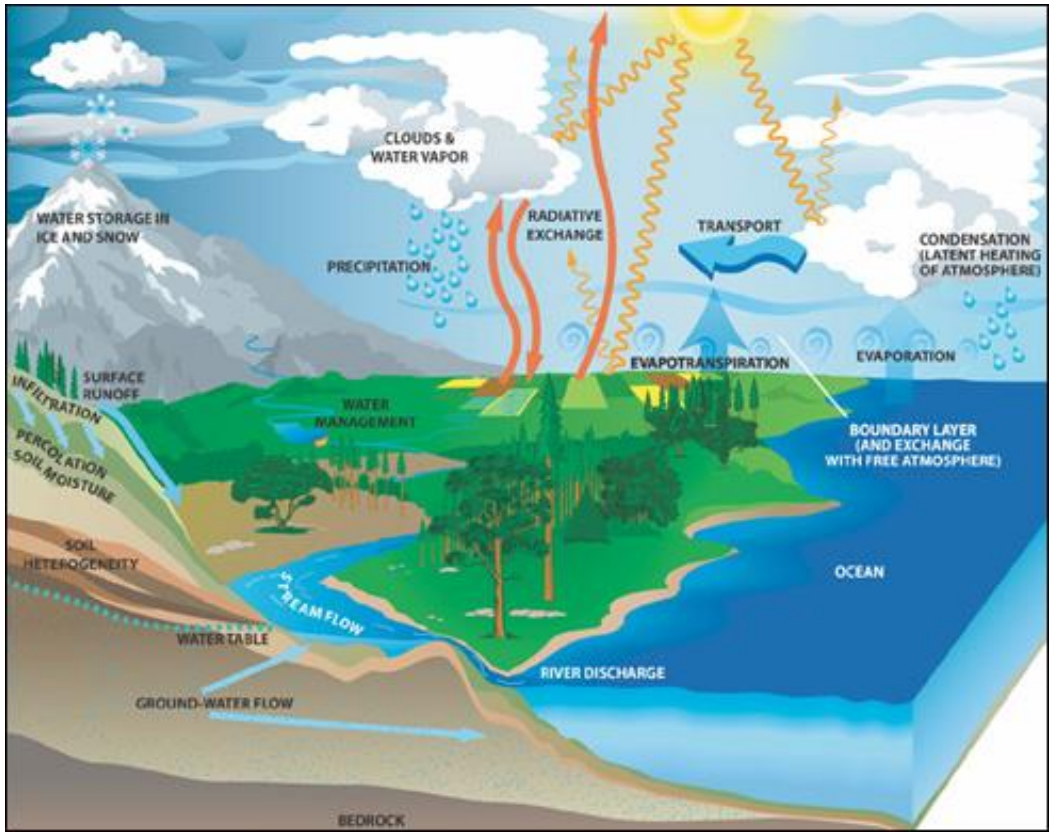
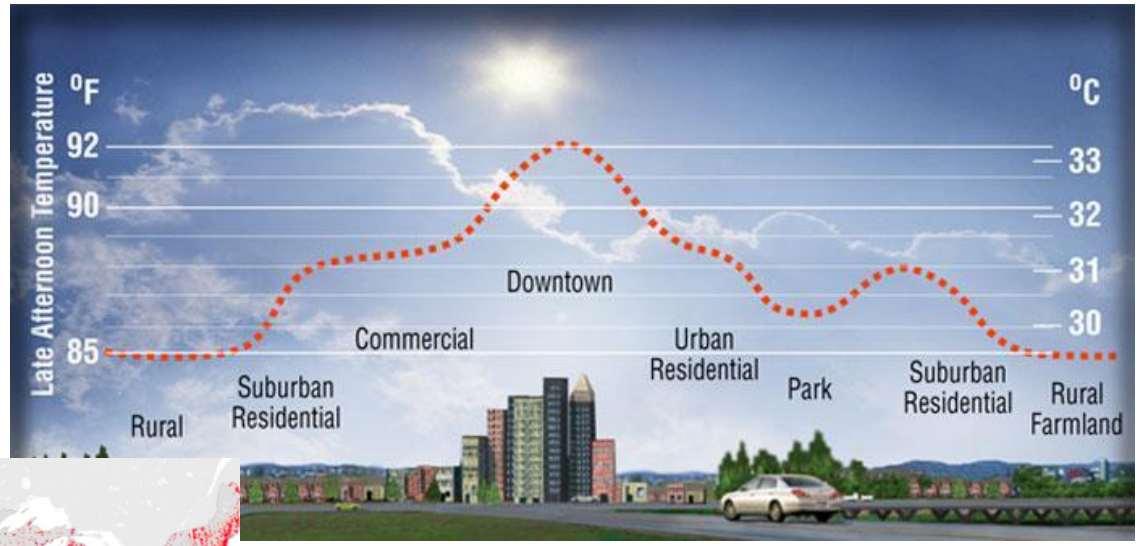
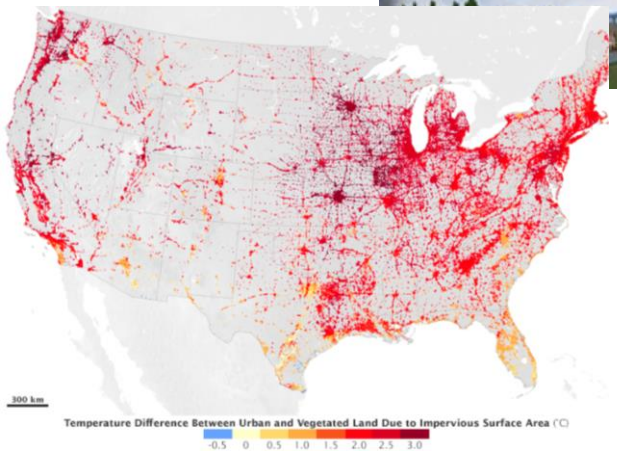


Image: NASA

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 NASA scientists to understand and predict

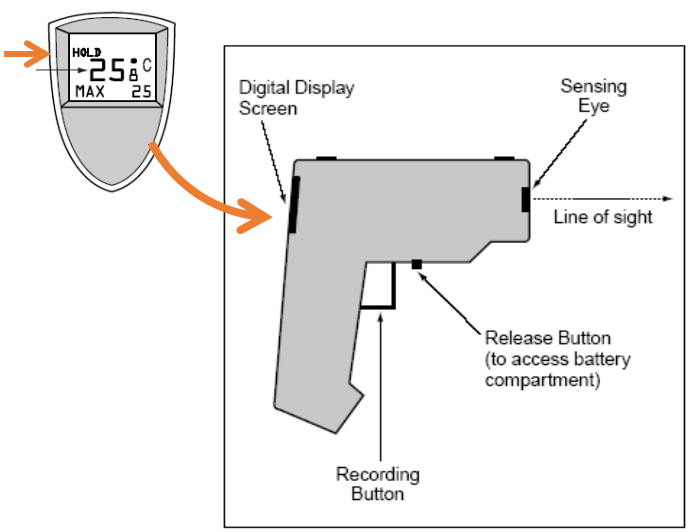
- How do urban areas affect the temperature around them?
- What is the contribution of changing land use and land cover on local energy budgets?
- How are land surface temperatures changing over the long-term?
- How accurate are data from NASA satellites?

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

Calibrate once per year to ensure proper performance!

Calibrate with an ice water bath. Wait until the water reaches 0° C, then see if the infrared thermometer shows a similar reading.

If the temperature observed is more than +2° C or less than -2° C, try changing the battery. If the calibration still is off, the IRT needs to be replaced.

Photo credit: Sara Mierzwiak

Photo credit: Sara Mierzwiak

Collecting Data using an Infrared Thermometer

HOW?

Hold your arm at arms length and point the instrument at the ground. After you pull the trigger then read the value including the tenths of a degree Celsius.

Photo credit: Kevin Czajkowski

WHEN?

Surface temperature measurements can be taken any time during the day.

Data Collection: Overview

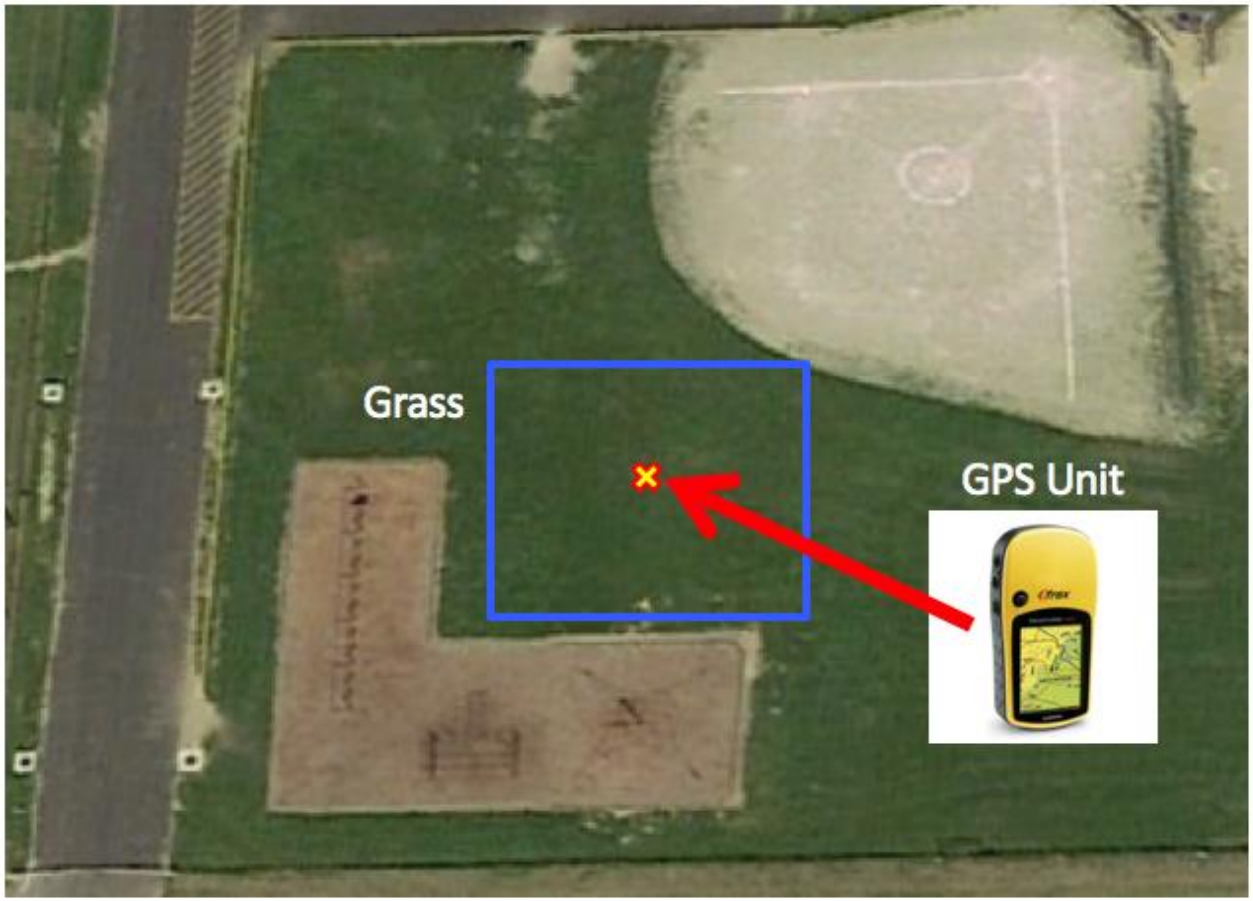
1) Choose a site that is homogenous at least 30 meters square (if possible). Can be grass, asphalt, etc.
2) Collect GPS data for the **center** of the site (latitude, longitude and elevation).
3) Pick nine random observation spots in the study site
   - Read and record surface temperature
   - Record 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.
6) Log into the *GLOBE website* .
7) Create a Surface Temperature site.
8) Go back to Data Entry, select the new Surface Temperature site you just created, and enter your data.

1. Choose homogenous study areas.

Choose study areas that are as large as possible and that have homogeneous cover. If the only area you have is smaller, take observations there and measure the size of the area. At this school, students took surface temperature observations on the asphalt and the nearby grassy outfield of a softball field.

2. Collect GPS data of the center of each study area.

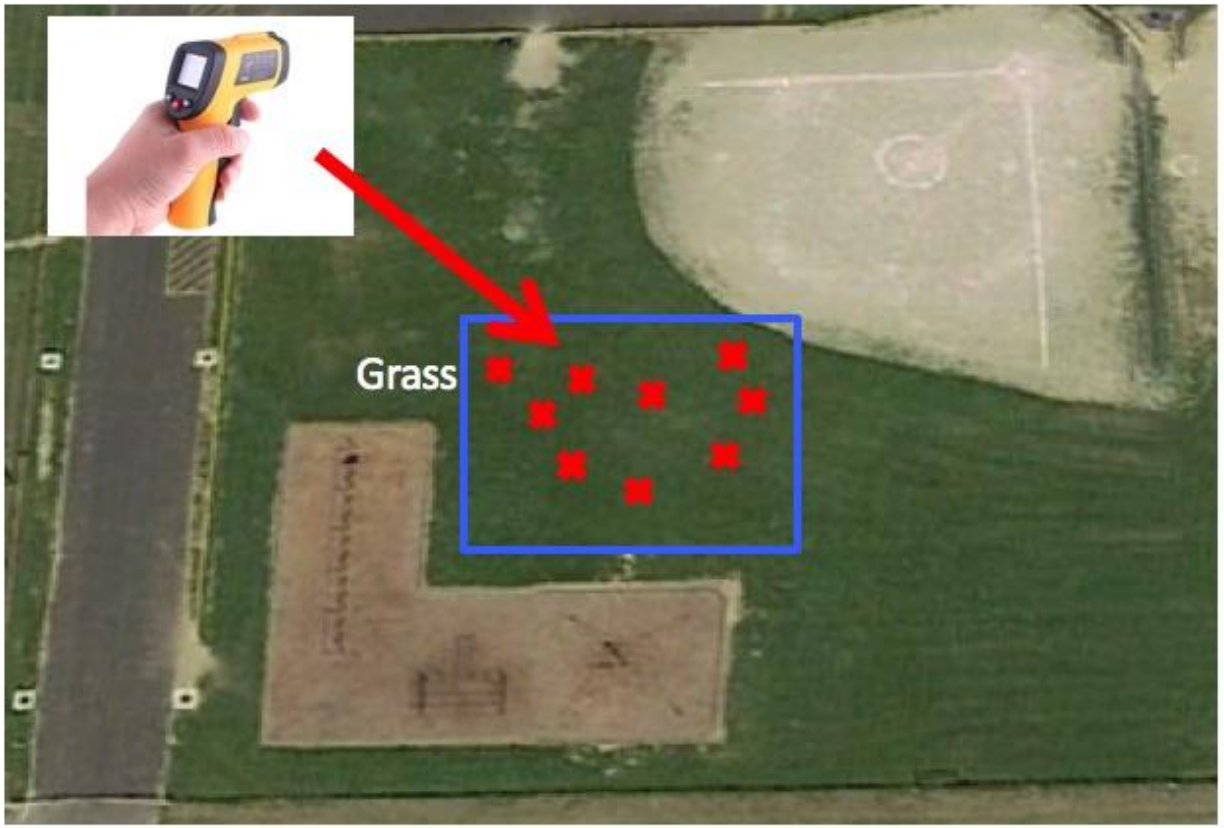
Record latitude, longitude and elevation.



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.

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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.

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Caution! Thermal Shock

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.

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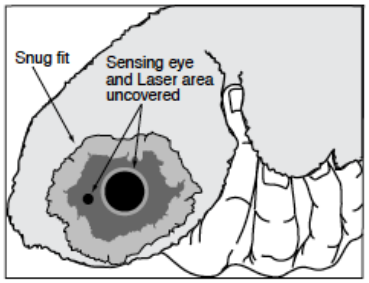
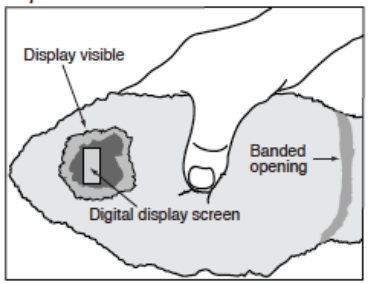
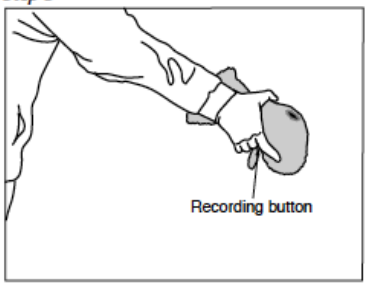


Step 3 and 4



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.

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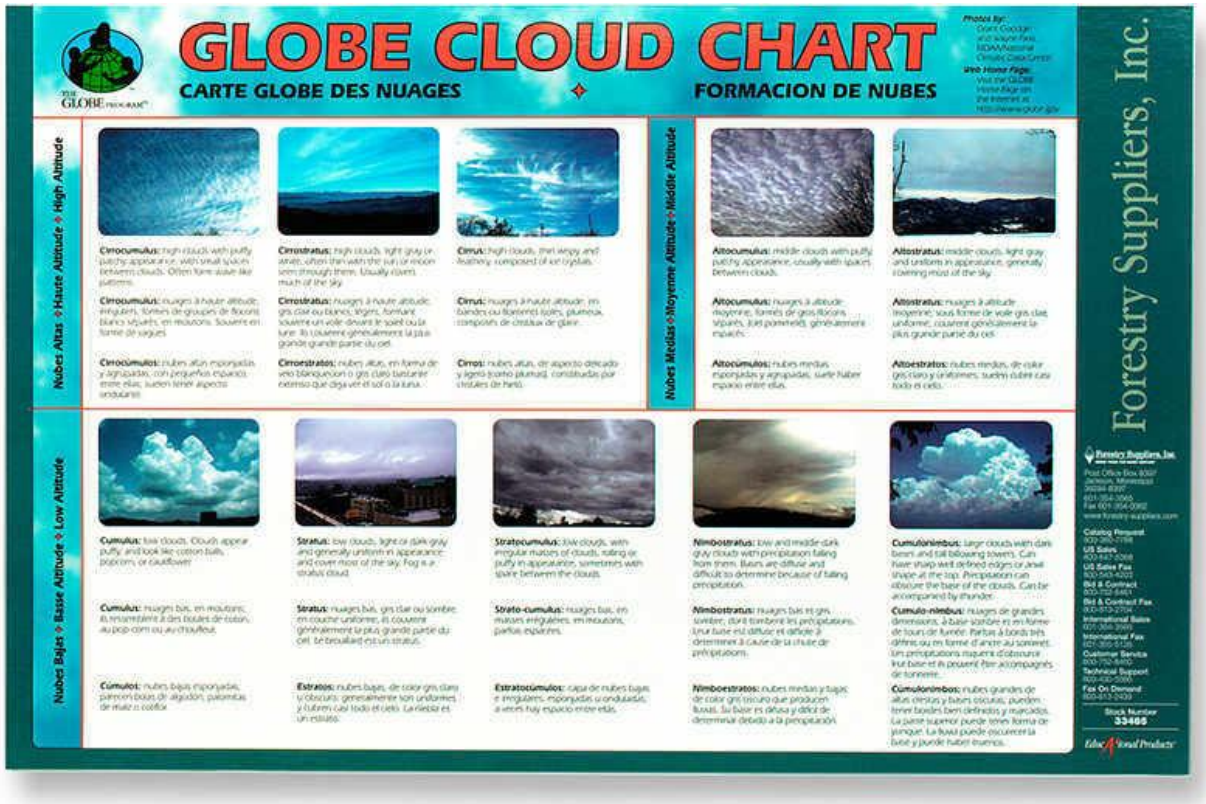
4. Record cloud and contrail data using the GLOBE Cloud Protocol



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

A. What is surface temperature?

B. Why collect surface temperature data?

C. How your measurements can help!

D. How to collect your data.

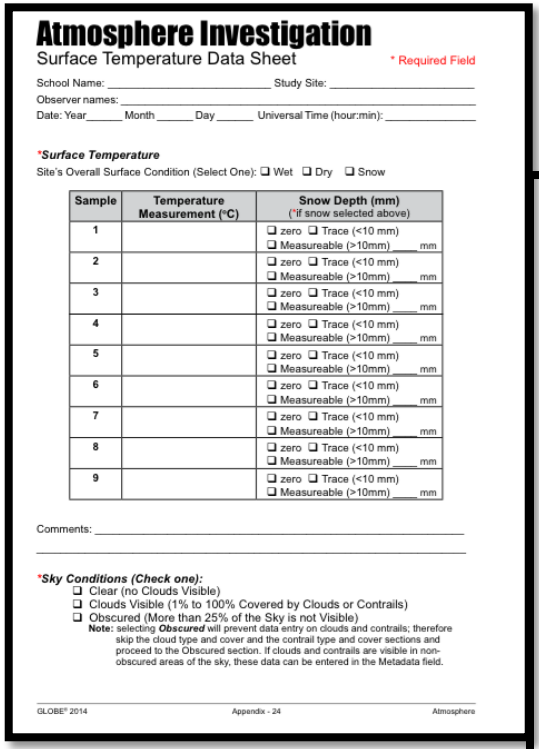
E. How to report data to GLOBE.

F. Understand the data.

G. Quiz yourself!

H. Further resources.

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.

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Atmosphere Investigation: Surface Temperature Data Sheet - Page 2 * Required Field
Study Site: _____ Date: _____ Time (UT): _____

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	Clear	Isolated	Scattered	Broken	Overcast
❑ 0%	❑ >0 to10%	❑ 10 to 25%	❑ 25 to 50%	❑ 50 to 90%	❑ >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	Persistent Non-Spreading	Persistent Spreading
Number Observed ☐	Number Observed ☐	Number Observed ☐

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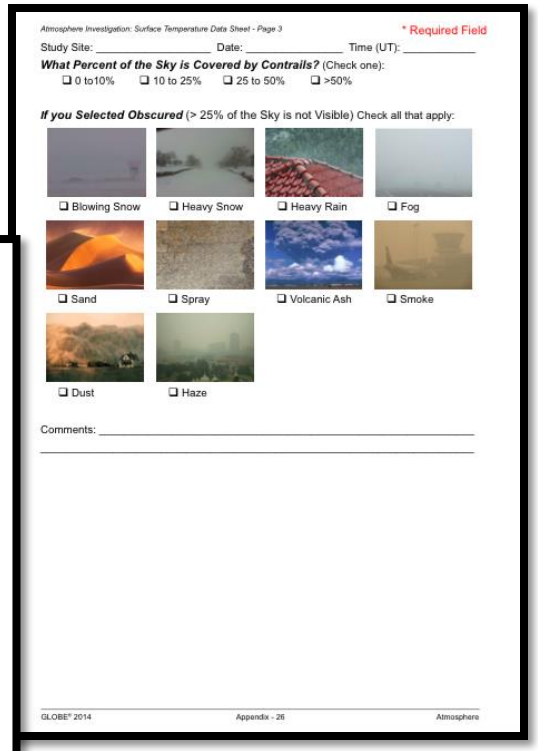

Atmosphere Investigation: Surface Temperature Data Sheet - Page 3 * Required Field
Study Site: _____ Date: _____ Time (UT): _____

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: _____

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Be sure to enter your school, study site, observers 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 is worthless

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.

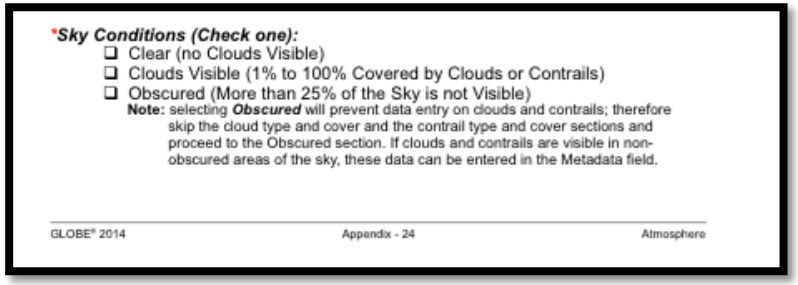
***Surface Temperature**

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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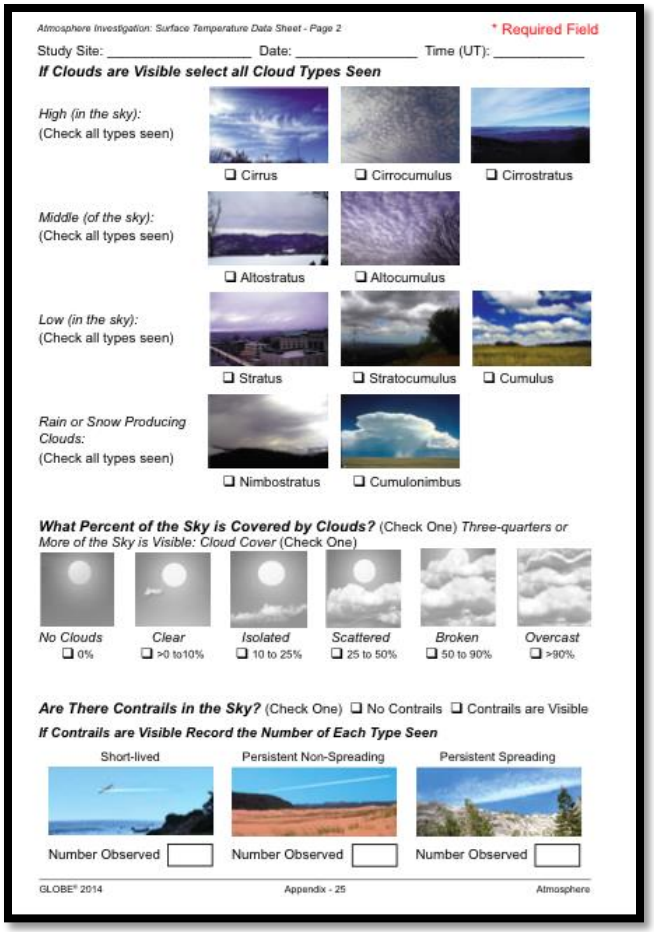

Atmosphere Investigation: Surface Temperature Data Sheet - Page 2 * Required Field

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

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	Clear	Isolated	Scattered	Broken	Overcast
❑ 0%	❑ >0 to10%	❑ 10 to 25%	❑ 25 to 50%	❑ 50 to 90%	❑ >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	Persistent Non-Spreading	Persistent Spreading
Number Observed ☐	Number Observed ☐	Number Observed ☐

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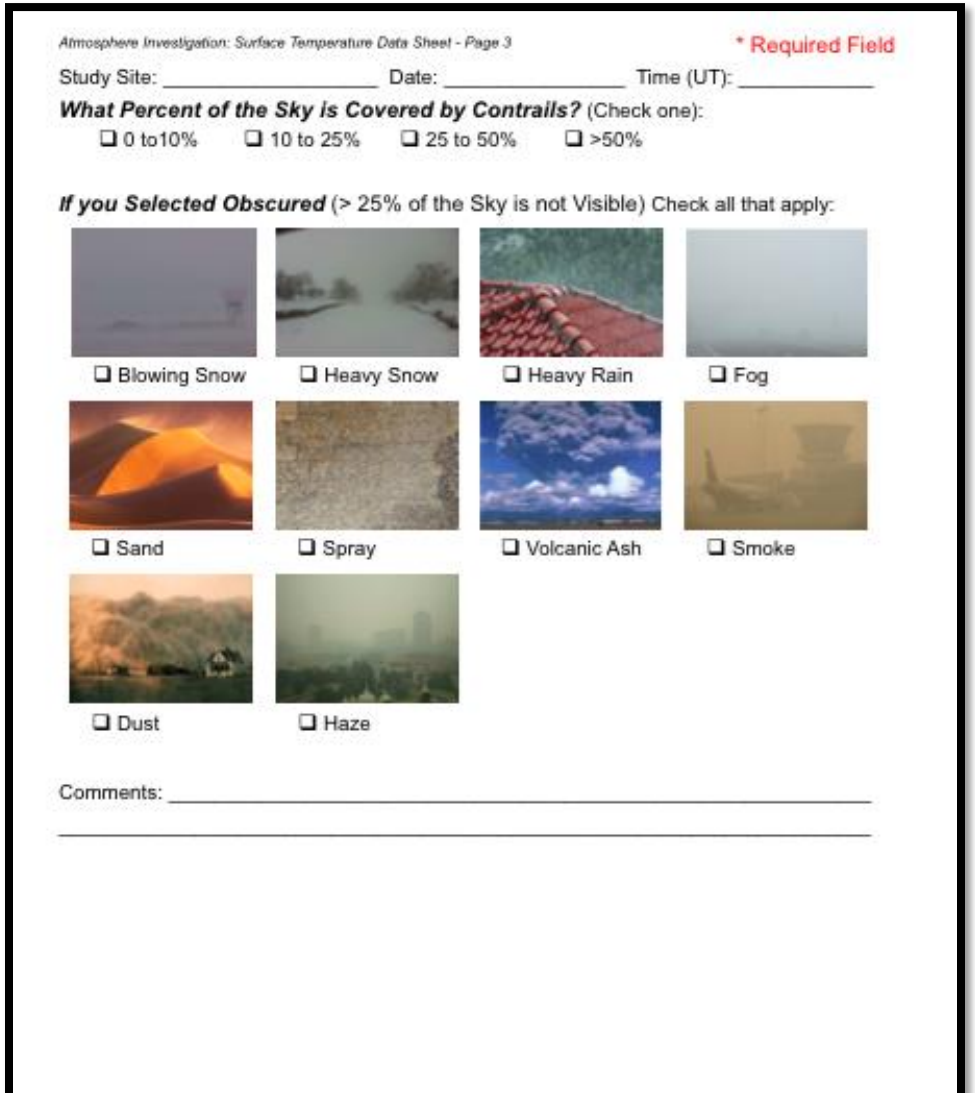
Record the sky condition.

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: _____

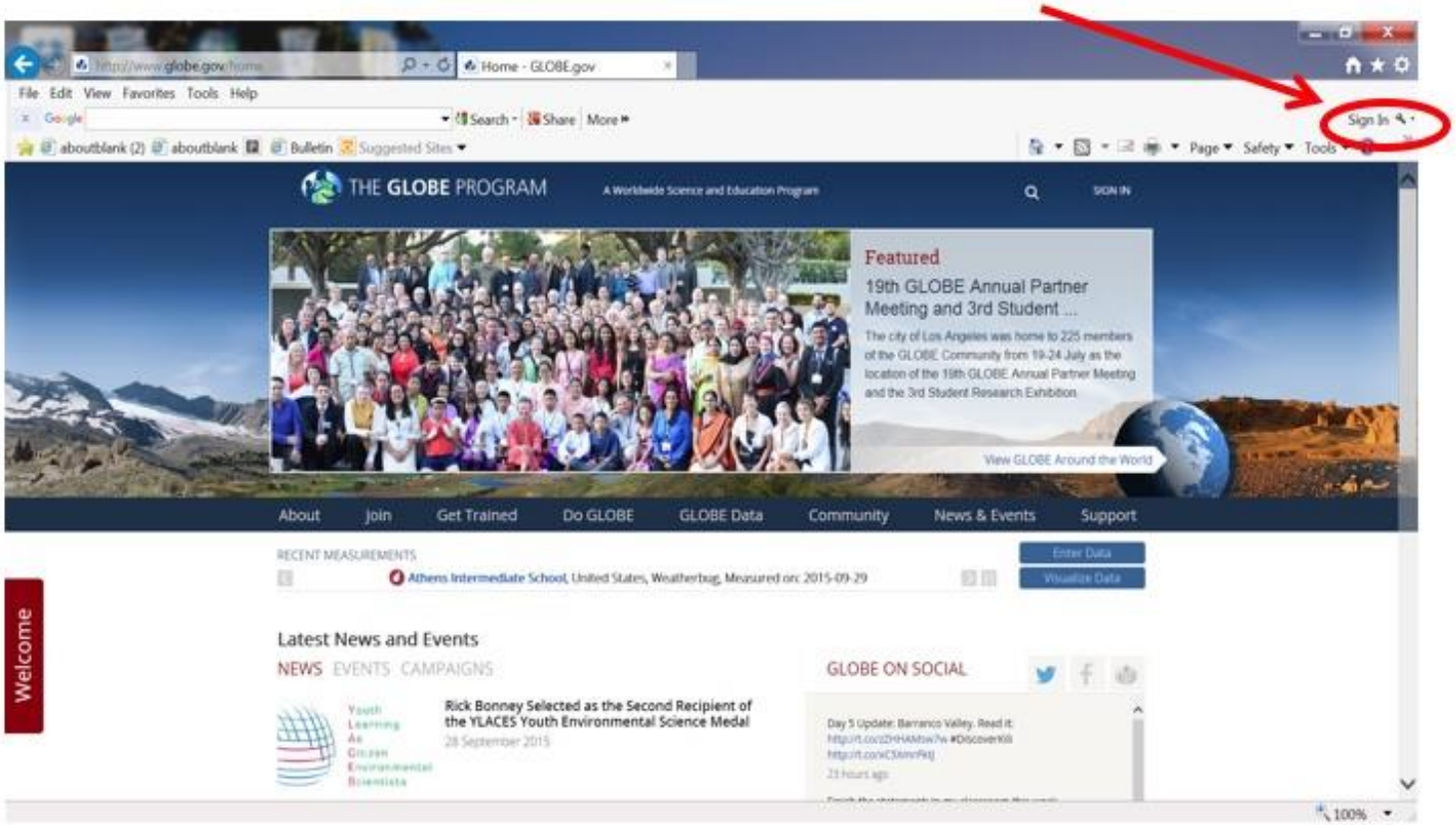
Entering Data

You have 3 options:

- Download the Data Entry app from the **App Store**
- **Live Data Entry**: These pages are for entering environmental data – collected at defined sites, according to protocol, and using approved instrumentation – for entry into the official GLOBE science database.
- **Email Data Entry** : If connectivity is an issue, data can also be entered via email.

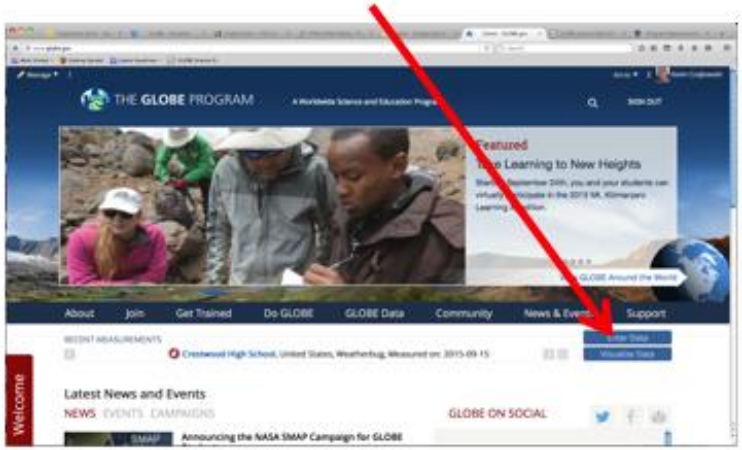
Entering Data-Step 1

Go to the GLOBE website and click sign in.

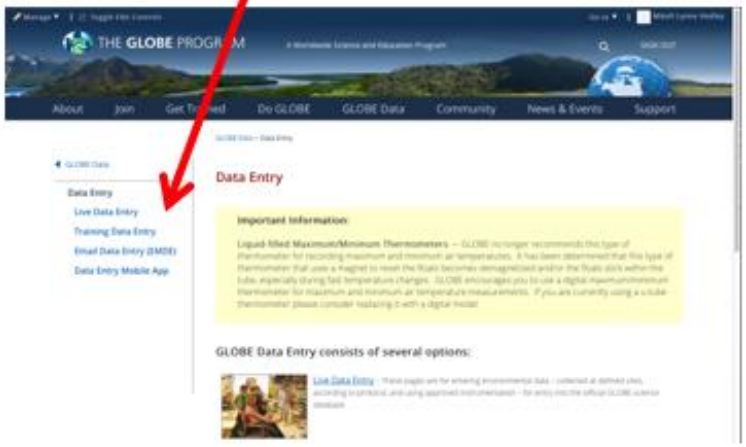


Entering Data-Step 2 and 3

2) Choose ***Enter Data.***



3) Choose ***Live Data Entry.***



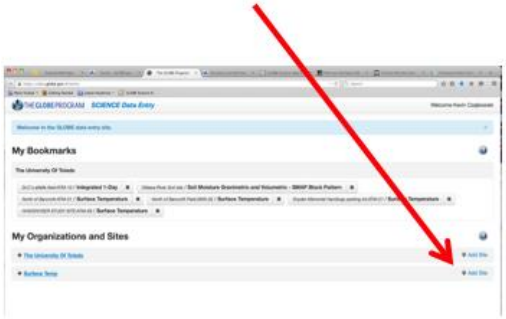
Set up a new surface temperature site.

If you have already done this step, skip to the next step. If you have not, set up a surface temperature site. You must first create one by following the steps below.

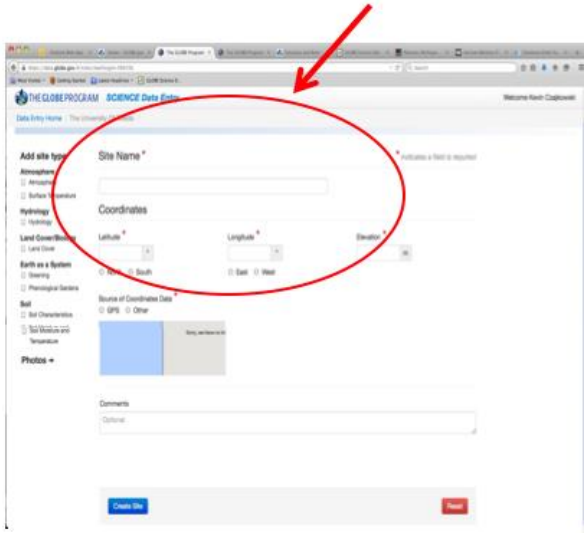
- Select "Surface Temperature Site Selection" from the atmosphere data entry menu
- Select site and initial, correcting, or updating information option
- Enter date & supplemental site definition data from the surface temperature data sheet
- Confirm data entries on verification page

Create a New Surface Temperature Site-1

6) Add a surface temperature site.

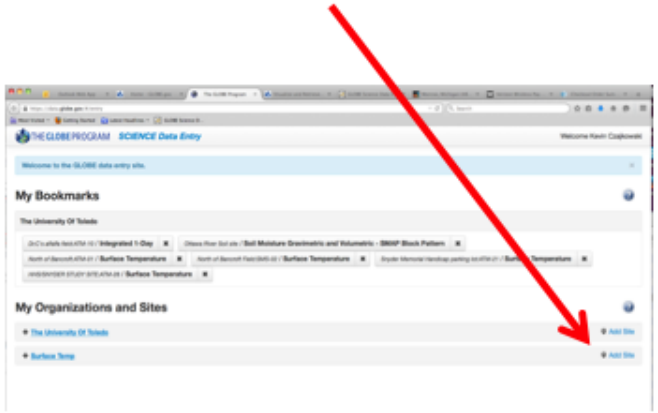


7) Enter a site name, latitude and longitude for the center of your site, and click on ***Create Site***.

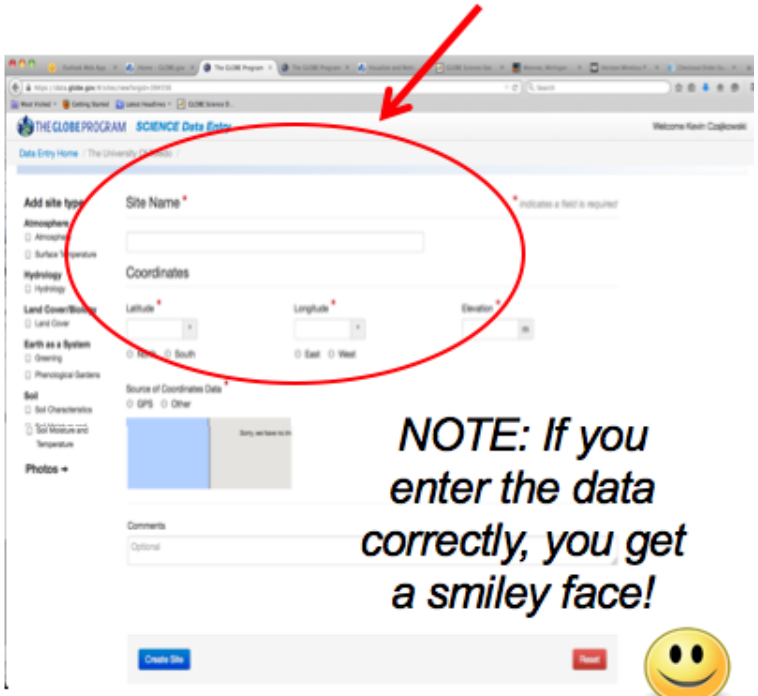


Create a New Surface Temperature Site-2

6) Add a surface temperature site.

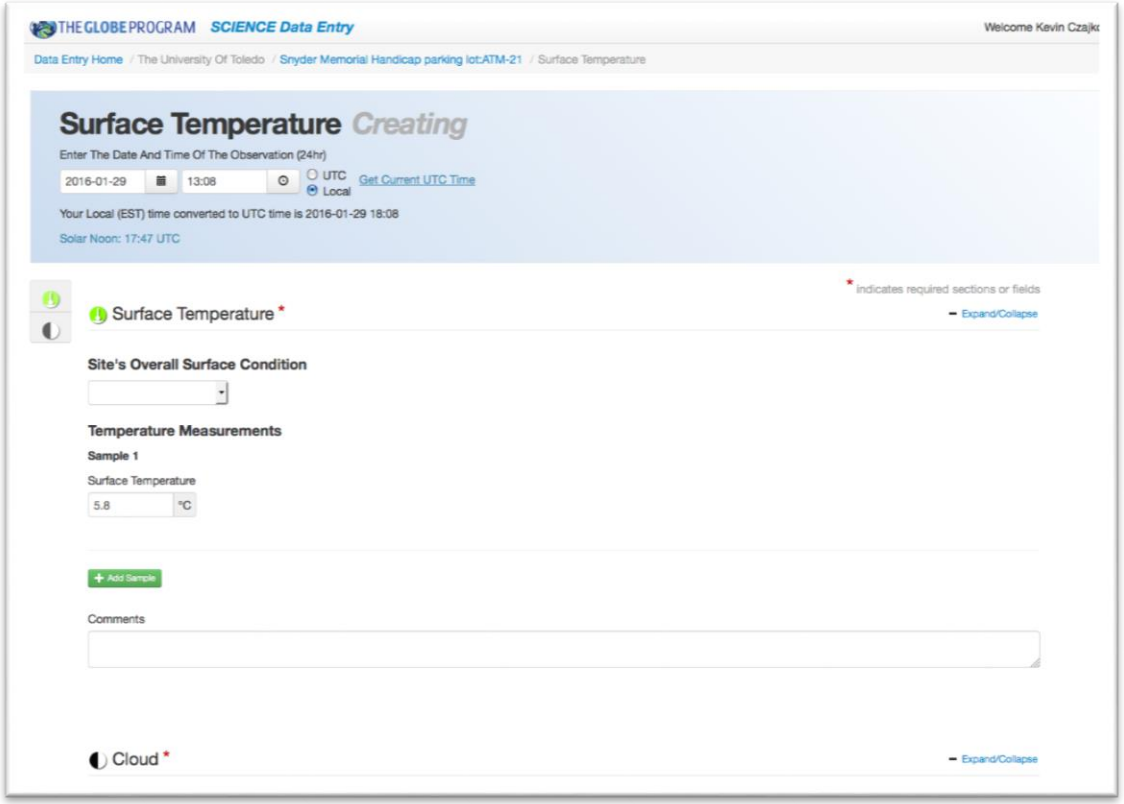


7) Enter a site name, latitude and longitude for the center of your site, and click on ***Create Site*.**

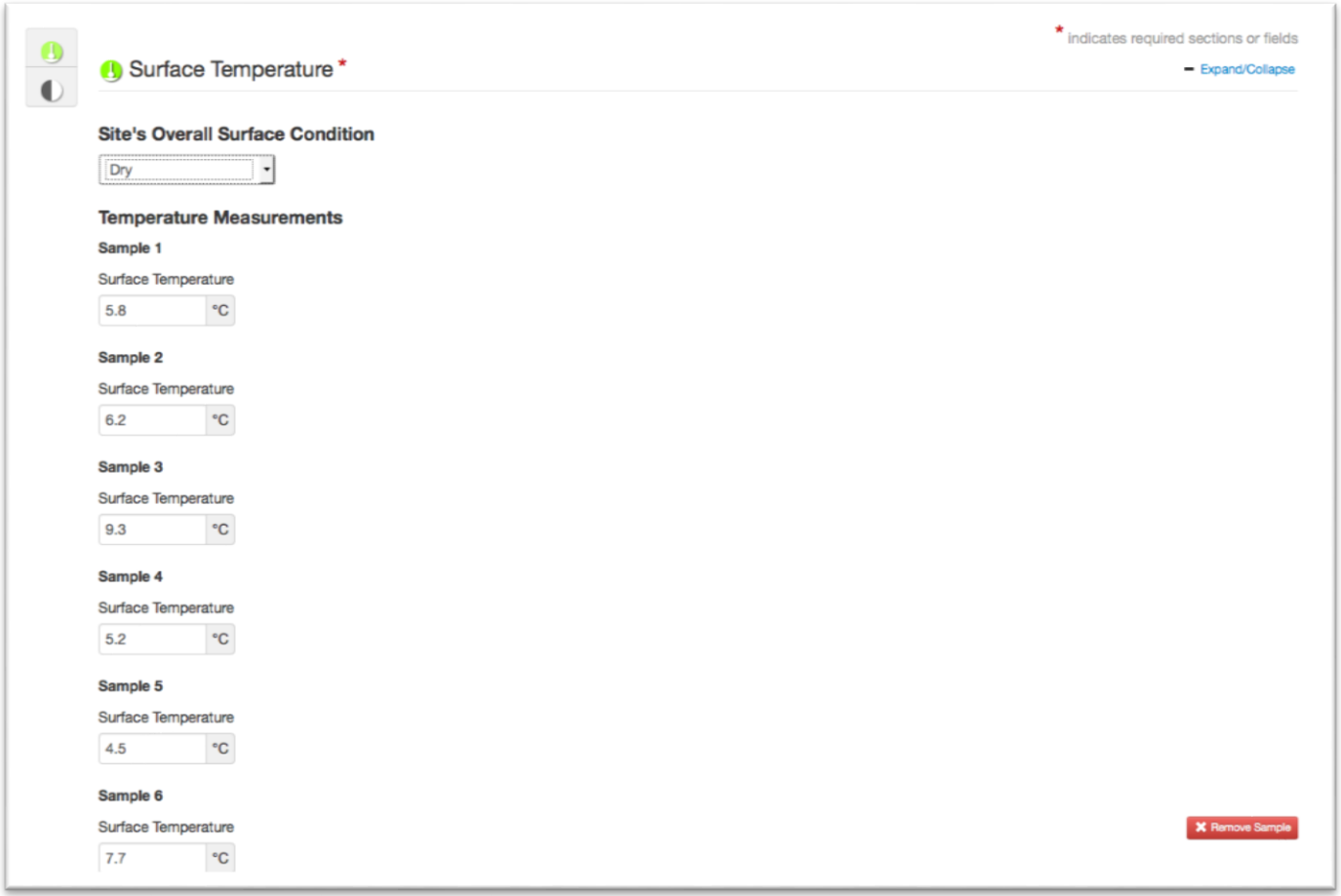


Continue to enter your data

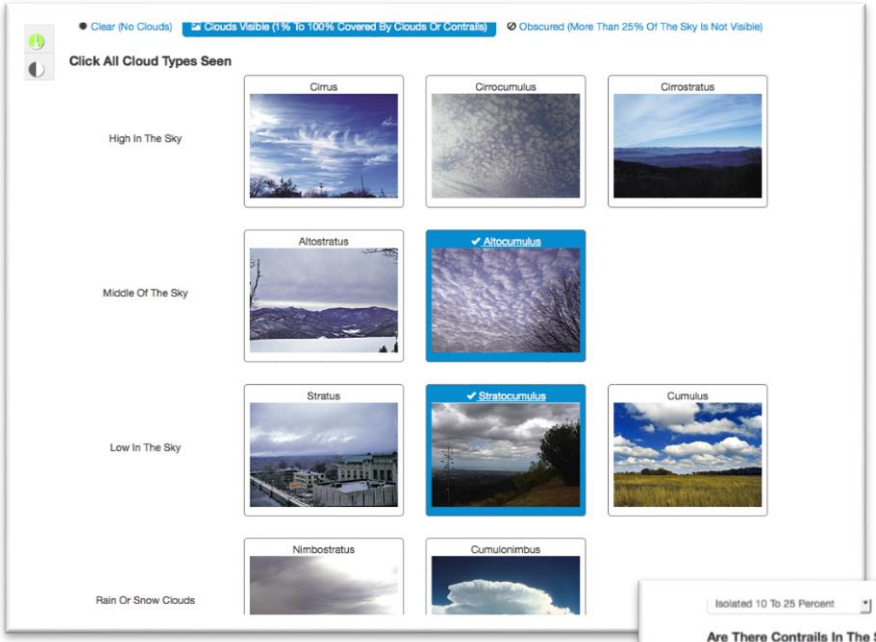
Once you've created the Surface Temperature site, go back to Data Entry, select the site you just created, and enter your data.

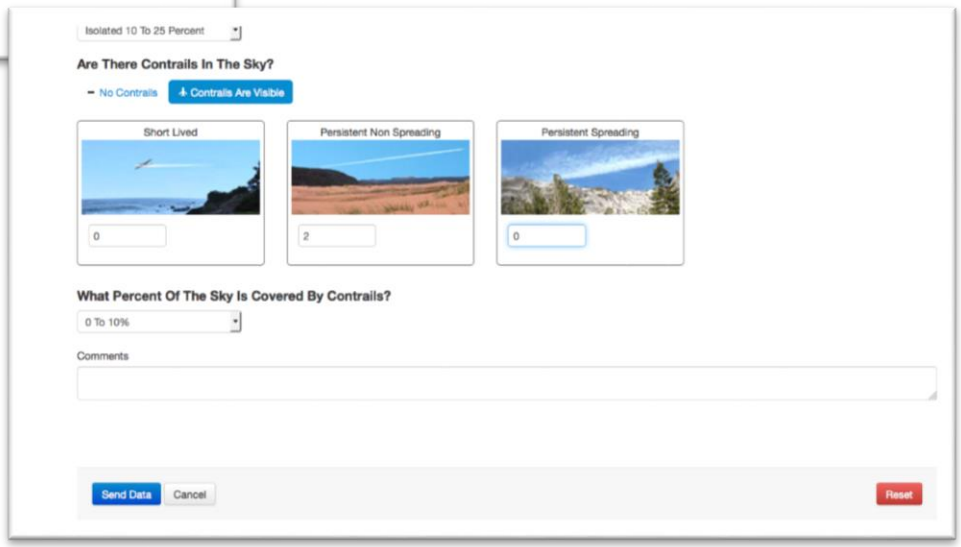


Continue to enter all 9 of the random observations you collected within your Surface Temperature study area

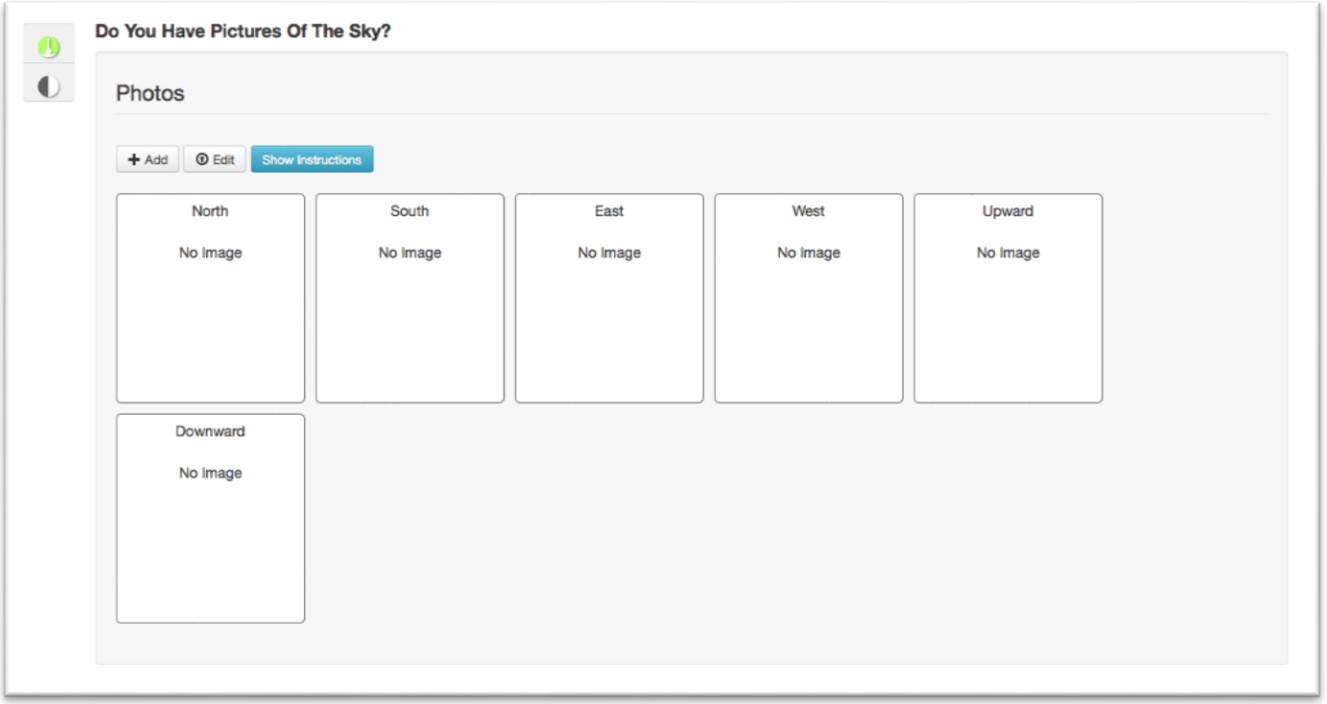


Then enter your Clouds and Contrails Observations





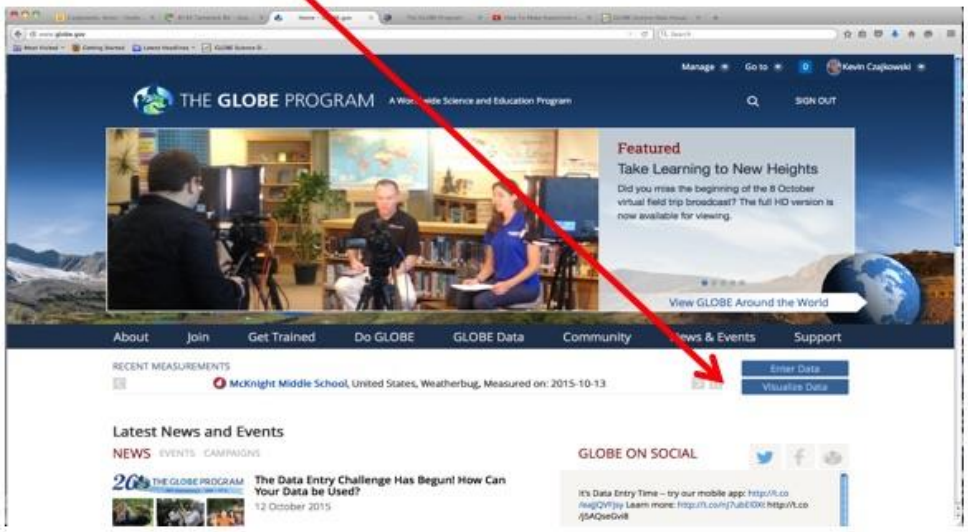
Once you've successfully entered your data, you can upload any photos you took of the sky



Adding photos to your site is a fun way to get others (students, family members, etc.) involved, AND it helps NASA scientists corroborate your data!

Retrieving Data from the GLOBE Visualization System

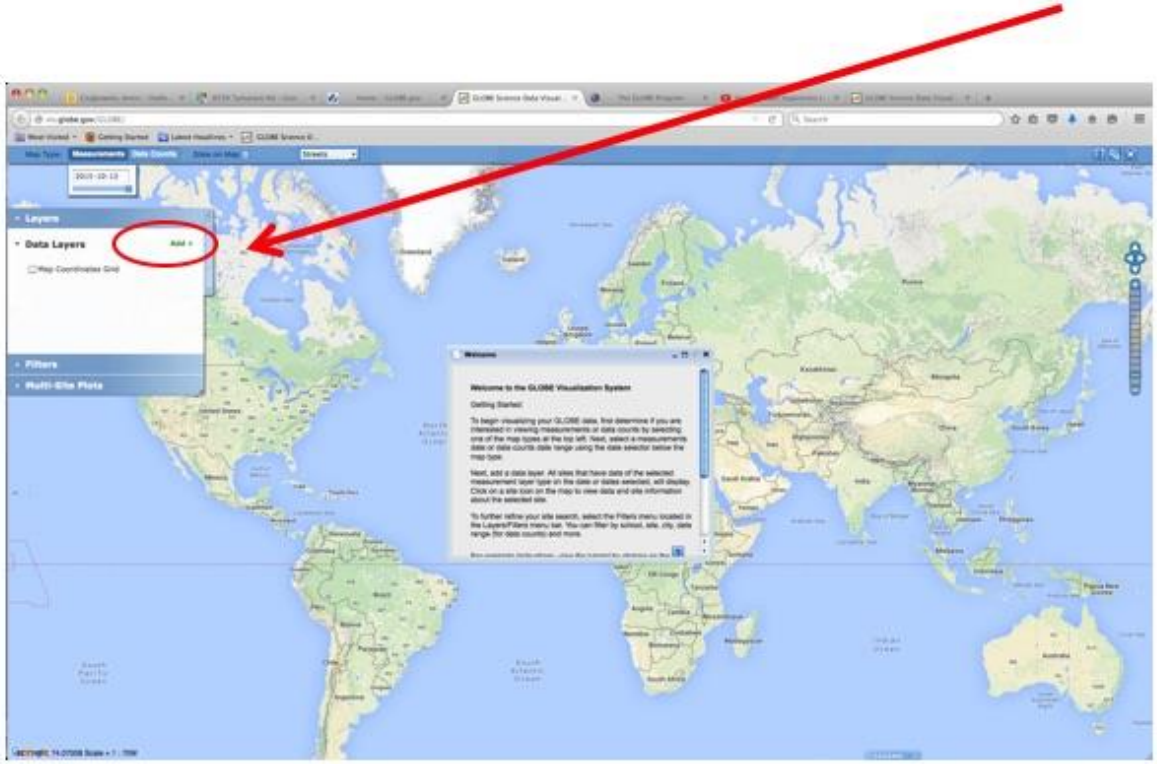
Click on **Visualize Data**



E-training is available to explore the full power of the visualization system.

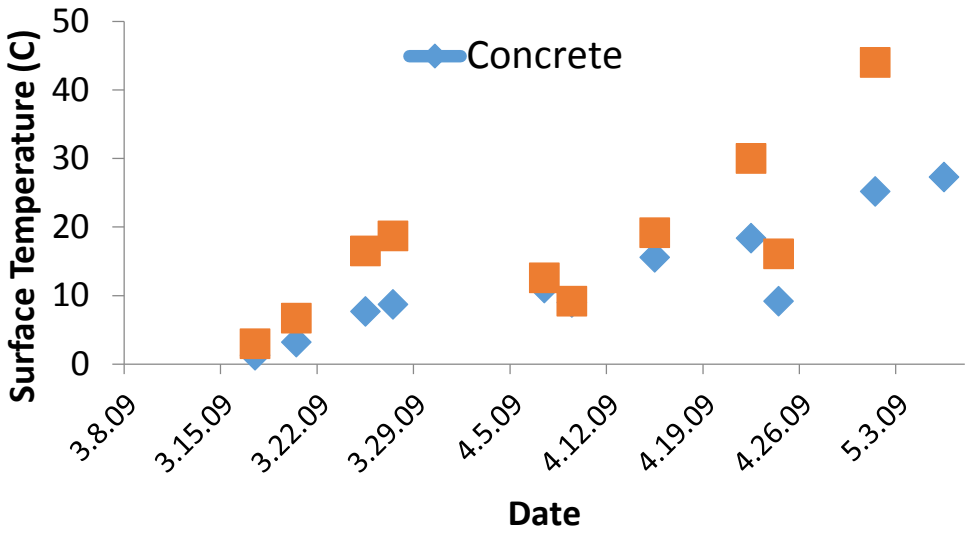
View data on a map in the GLOBE Visualization System

Close the **Welcome** box and click on ***Add +*** to add a layer



Once the data is entered, you can view it.

Comparison of Asphalt versus concrete temperature, Ida Elementary School, Michigan



GLOBE allows you to analyze your data. For example, surface temperatures of different surface materials can be very different!

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!
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Questions about Module: Contact GLOBE eTraining rlow@ucar.edu

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