

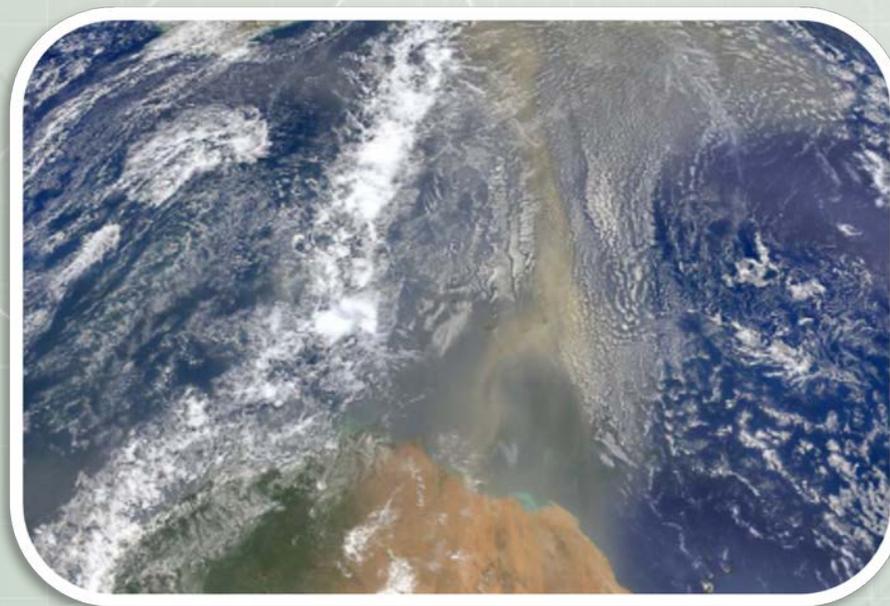


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NASA Global Learning and Observations to Benefit the Environment (GLOBE) Atmospheric Science Investigation



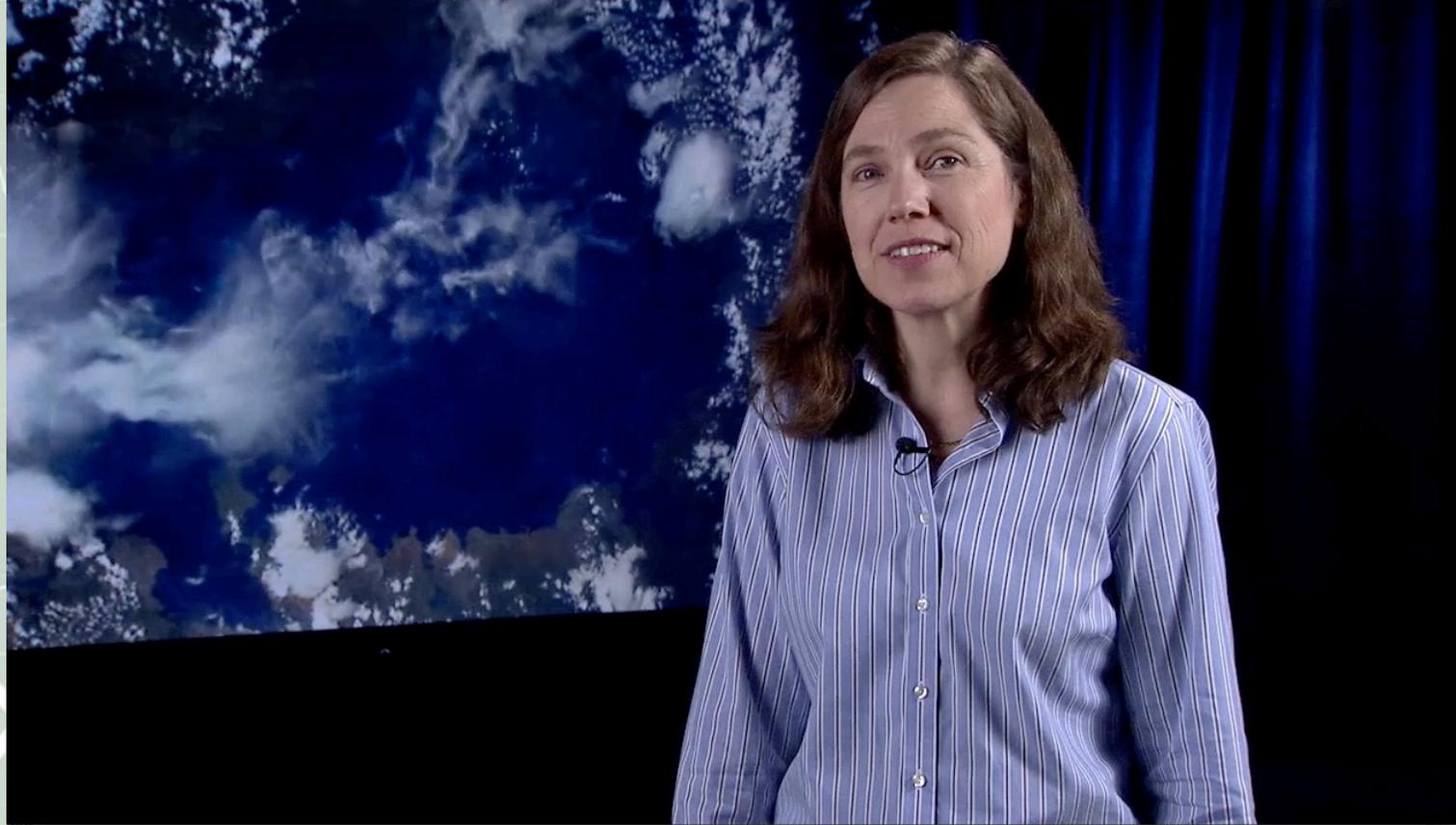


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NASA GLOBE Atmospheric Science Investigation Video



"How do clouds impact Earth's climate?"

View the video at <https://y4y.ed.gov/stemchallenge/nasa>.

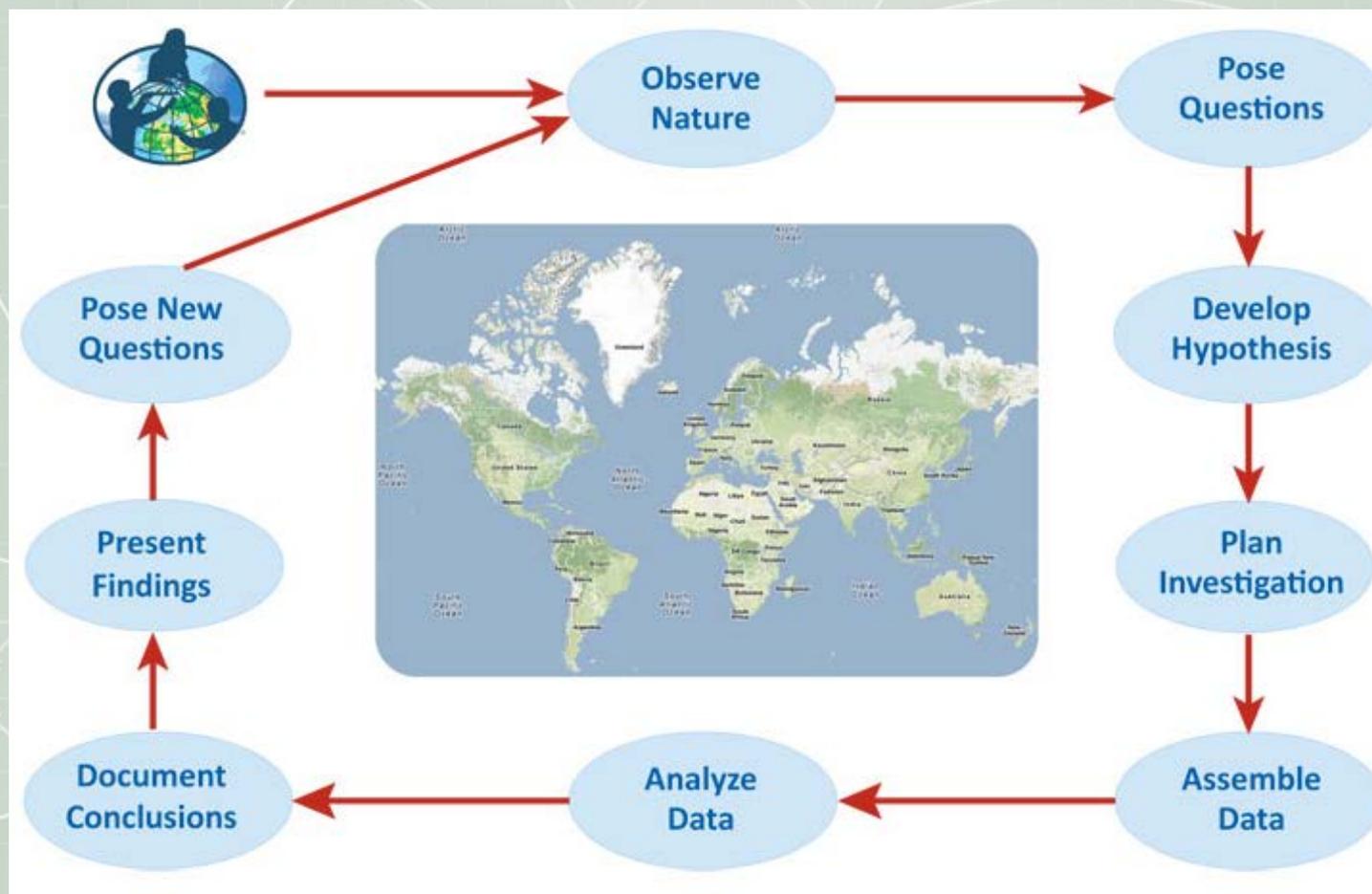


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Scientific Research Process





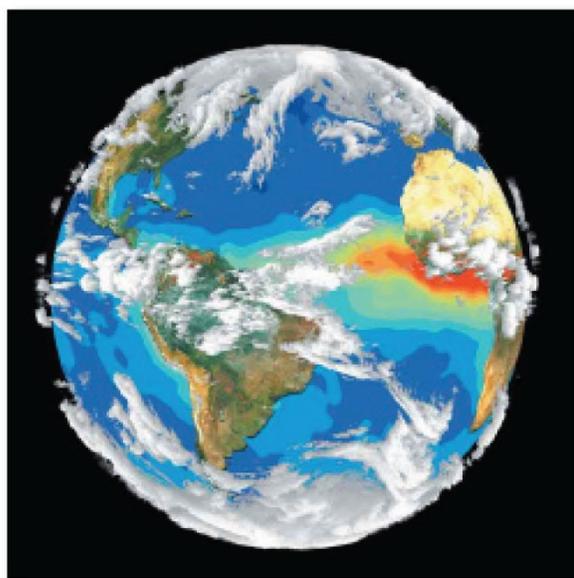
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Steps 1 and 2: Introduction

Step 1: Project Introduction



Why are clouds so important?

Who is studying the clouds?

Step 2: What is GLOBE?

G: _____

L: _____

O: _____

B: _____

E: _____





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Step 3: What Does a Scientist Do?

Draw a picture of a scientist in action. Consider the following: Where does your scientist work? What does your scientist do? What are some characteristics of your scientist? Write down any additional information regarding your scientist below.



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Step 4, Part 1: Observing, Describing, and Identifying Clouds

What do you already know about clouds?

Part 1: What do you see? Draw a picture of the clouds you see in the sky.

A large, empty rectangular box with a blue border, intended for drawing a picture of clouds.



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Step 4, Parts 2 and 3: What clouds did you observe from the GLOBE cloud chart?



GLOBE CLOUD CHART

High Altitude			Middle Altitude		
					
Cirrocumulus: high clouds with puffy, patchy appearance, with small spaces between clouds. Often form wave-like patterns.	Cirrostratus: high clouds, light gray or white, often thin with the sun or moon seen through them. Usually covers much of the sky.	Cirrus: high clouds, thin wispy and feathery, composed of ice crystals.	Alto cumulus: middle clouds with puffy, patchy appearance, usually with spaces between clouds.	Altostratus: middle clouds, light gray and uniform in appearance, generally covering most of the sky.	
Low Altitude					
					
Cumulus: low clouds. Clouds appear puffy, and look like cotton balls, popcorn, or cauliflower.	Stratus: low clouds, light or dark gray and generally uniform in appearance and cover most of the sky. Fog is a stratus cloud.	Stratocumulus: low clouds, with irregular masses of clouds, rolling or puffy in appearance, sometimes with space between the clouds.	Nimbostratus: low and middle dark gray clouds with precipitation falling from them. Bases are diffuse and difficult to determine because of falling precipitation.	Cumulonimbus: large clouds with dark bases and tall billowing towers. Can have sharp well defined edges or anvil shape at the top. Precipitation can obscure the base of the clouds. Can be accompanied by thunder.	



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Step 5: Recording Cloud Observation: Clouds 1-Measurement Data Sheet

Step 5: Cloud Observation

Clouds Measurement Data Sheet

School Name: _____ Study Site: _____

Observer Names: _____

Date: Year ____ Month ____ Day ____ Universal Time (hour:min): _____

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.

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



Alto cumulus

Low (in the sky):
(Check all types seen)



Stratus



Stratocumulus



Cumulus

Rain or snow producing clouds:
(Check all types seen)



Nimbostratus



Cumulonimbus

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

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

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:

Week One Science Journal Reflections:

What have you learned?

What would you like to know more about?



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Step 6: Heating Things Up Learning Activity

Data Table 1 Sheet 1

Time	Temperatures °C				
	Bare Soil	Grass	Gravel/Rocks	Sand	Water
Beginning					
3 minutes					
6 minutes					
9 minutes					
12 minutes					
15 minutes					
————— Shaded or turn off lights —————					
18 minutes					
21 minutes					
24 minutes					
27 minutes					
30 minutes					



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Step 7: GLOBE Cloud Observations Data Collection

Step 7: Cloud Observation

Clouds Measurement Data Sheet

School Name: _____ Study Site: _____

Observer Names: _____

Date: Year ____ Month ____ Day ____ Universal Time (hour:min): _____

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.

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



Altostratus

Low (in the sky):
(Check all types seen)



Stratus



Stratocumulus



Cumulus

Rain or snow producing clouds:
(Check all types seen)



Nimbostratus



Cumulonimbus

Week two

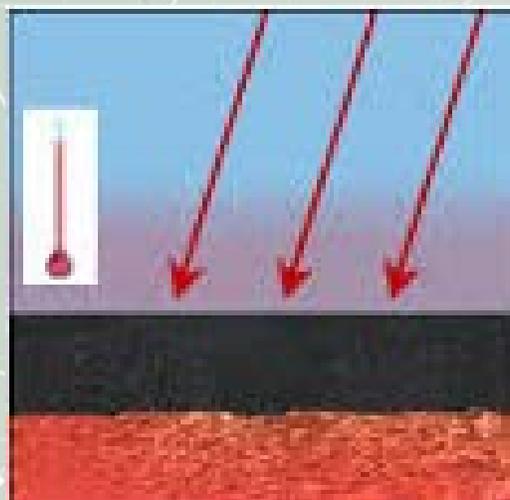


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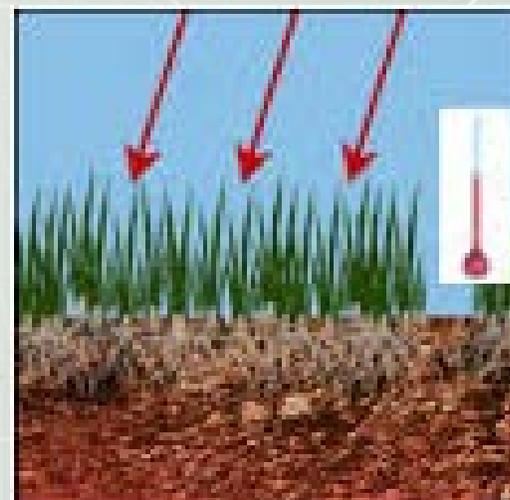
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Steps 8 and 9: How might the surface temperature of the different surface areas around the outside of your school be different?



Asphalt



Grass

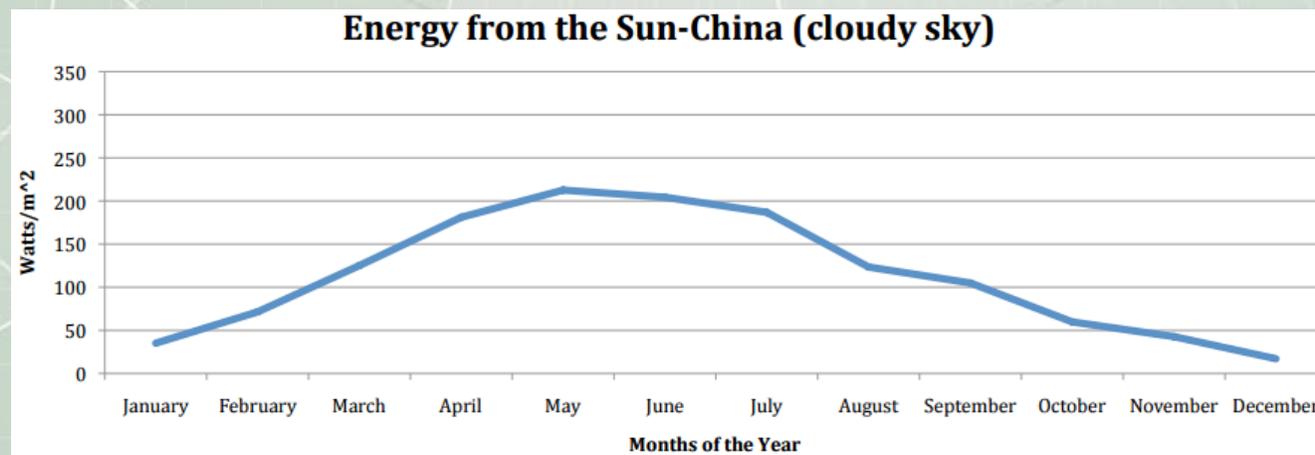
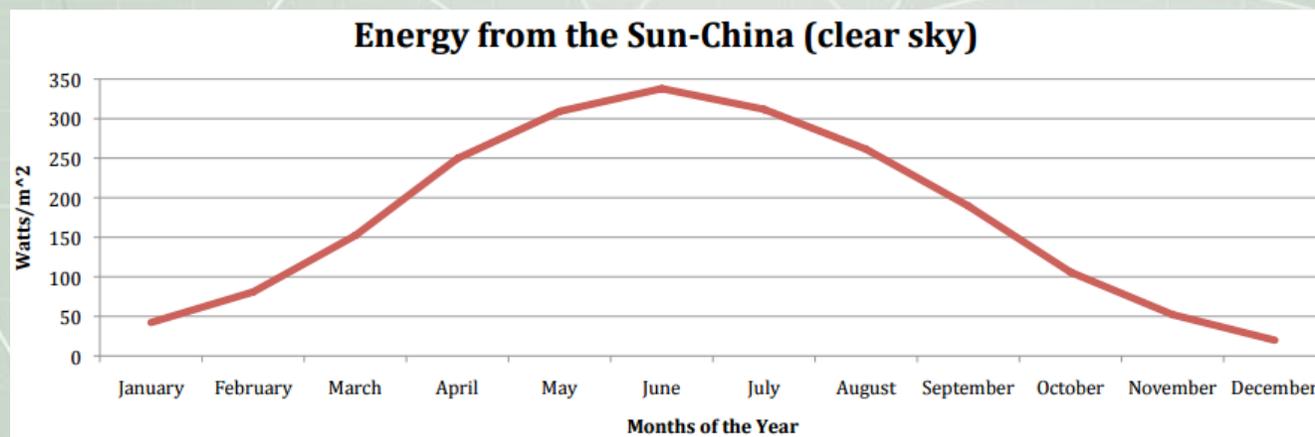


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Step 10: Cloudy vs. Clear My NASA DATA Activity



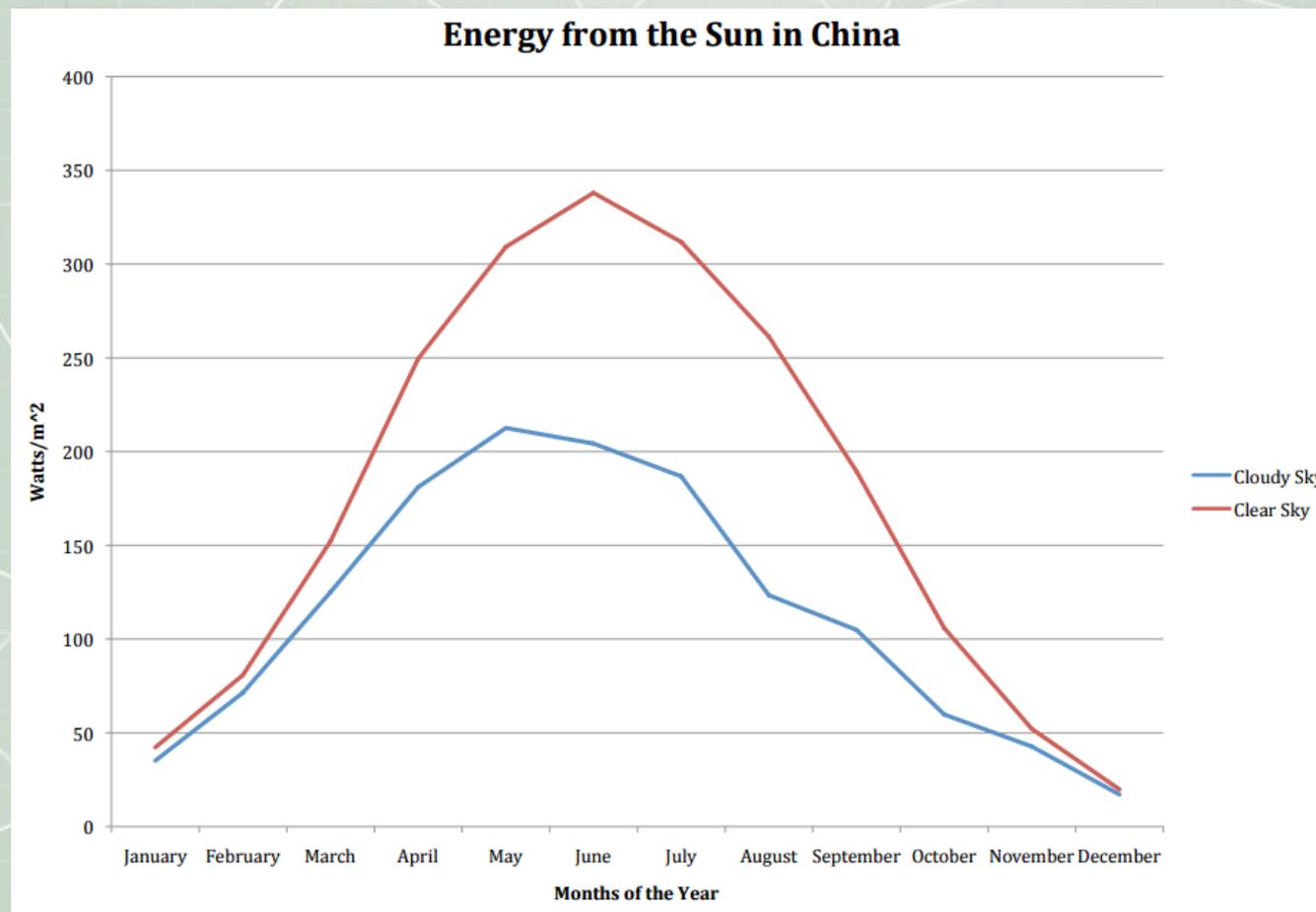


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Step 10: Cloudy vs. Clear My NASA DATA Activity





Step 11: What's Visual Opacity? Learning Activity

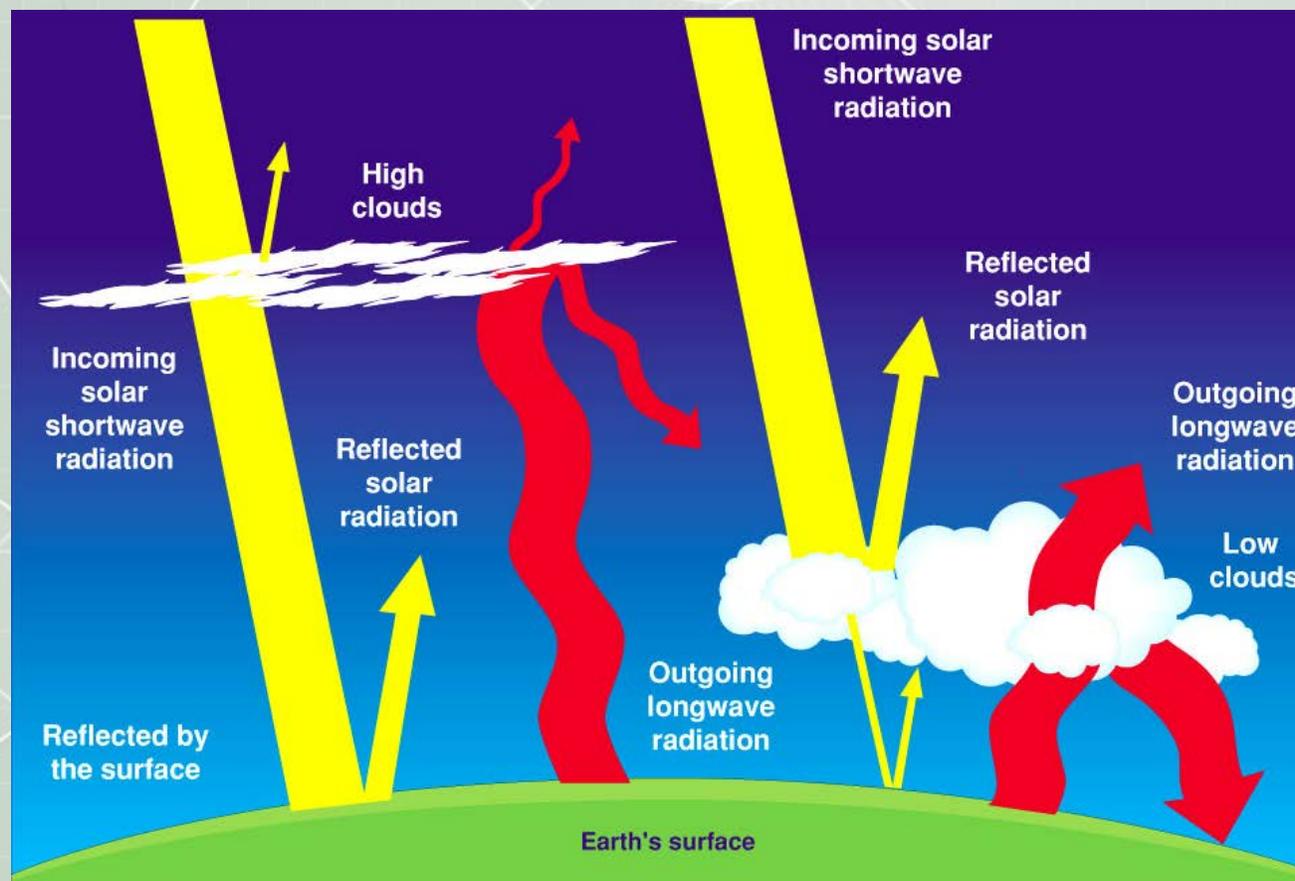
- Transparent—Light passes through the material or objects; things on the other side can be seen clearly.
- Translucent—Light passes through the materials or objects; things on the other side cannot be seen clearly.
- Opaque—Little or no light passes through the materials or objects; things on the other side cannot be seen at all

Transparent	Translucent	Opaque



Step 11: What's Visual Opacity? Learning Activity

Looking at the Science: Cloud Effects on Earth's Radiation





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Step 12: NOVA Connections, *The Climate Wild Card*

<http://www.pbslearningmedia.org/resource/nvcl.sci.earth.wild/the-climate-wild-card/>





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Step 13: Continue Data Collection

Step 13: Surface Temperature Measurement and Cloud Observation Data Sheet

School Name: _____ Study Site: _____

Observer Names: _____

Date: Year ____ Month ____ Day ____ Universal Time (hour:min): _____

Surface Temperature:
Site's overall surface condition (Check one): Wet Dry Snow

Sample	Temperature (°C)	Snow Depth (mm)
1		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm
2		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm
3		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm
4		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm

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)

Sketch the sky below: Comments: _____

week four

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

Alto cumulus

Low (in the sky):
(Check all types seen)

Stratus

Stratocumulus

Cumulus

Rain or snow producing clouds:
(Check all types seen)

Nimbostratus

Cumulonimbus

week four

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

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: _____

week four



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Step 14: What does a NASA Science Research Question Look Like?

Step 14: What Does a NASA Science Research Question Look Like?

week five

As you can see from the previous activities, scientists asking questions and finding answers is extremely important to all of us. All factors of our daily lives are affected by the answers that NASA scientists are seeking. Everything we know about Earth and the world around us has been a result of someone, somewhere, asking a question and setting out to find an answer. It is natural human curiosity that has often resulted in the most important discoveries. So what makes a "GOOD" science research question?

A good research question is a question that is worth answering. It poses a problem that can be answered through scientific investigation or the examination of data that has been collected. Simple yes or no questions may have important practical significance, but they do not make good research questions. A good science research question requires more than looking something up in a book or on the Internet. The answer does not simply depend on one or two missing facts. A good research question should force you to evaluate evidence and compare different possible answers.

Use the Research Question Characteristics Rubric below to identify which of the following questions are "GOOD" science research questions.

1. *Is there a relationship between today's clouds and tomorrow's weather?*
2. *How reliable is a prediction of tomorrow's weather based on today's cloud observations?*

Research Question Characteristics	Points (0 or 1)
The answer is not immediately obvious	
There could be more than one answer - the answer is not just yes or no	
Encourages a new or different view of phenomena	
Narrow in focus so that the necessary research can be done	
Clear enough for other people to understand	
Tests an accepted explanation	
Goes beyond existing explanations	
Possible to answer in the time available to you	
Possible to answer with measurement equipment and techniques available to you	
Any data required from others is available or can be obtained through collaboration	
Will sustain your interest for the time required to complete the research	
Tests your assumptions about the phenomena	
Completes or adapts an existing explanation	
Total Points	



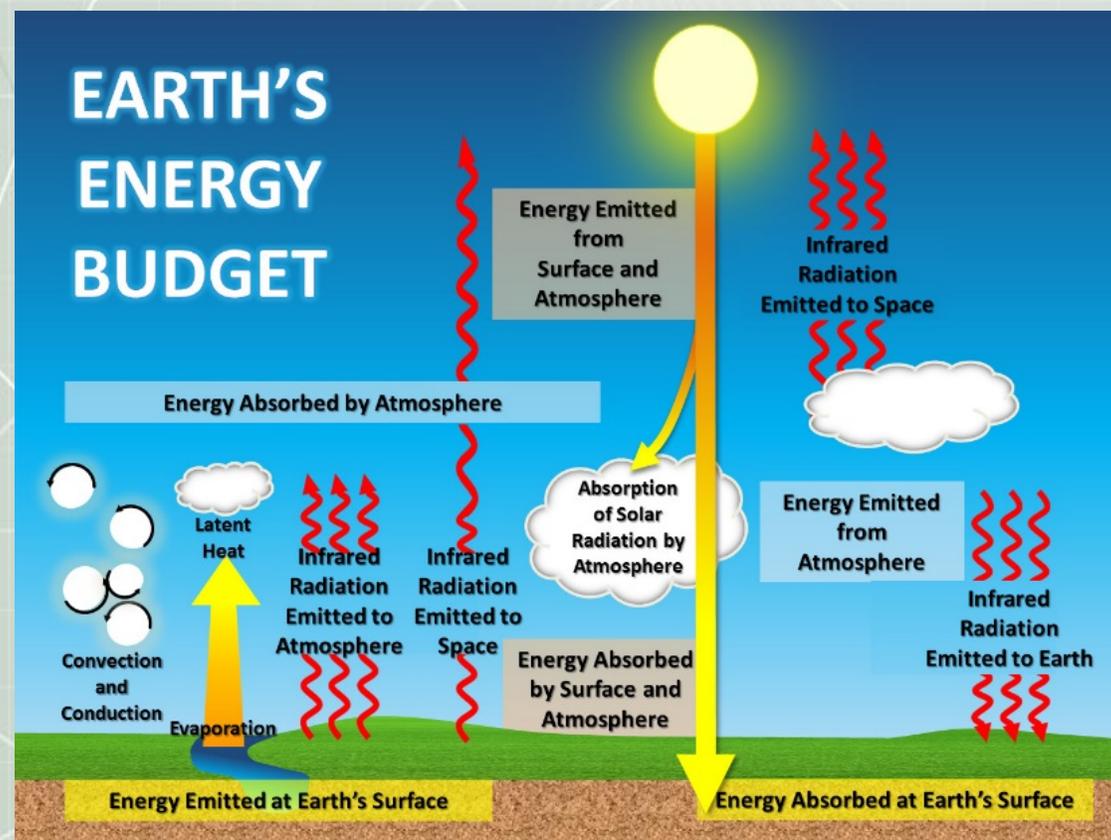
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Step 15: The Science Research Process in Action

One of NASA's Big Research Questions: How do clouds affect the Earth's Energy Budget?





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Step 16: Looking at Your GLOBE Data

Step 16: Looking at Your GLOBE Data Learning Activity

Part 1: Sketch, label, and describe the four surface areas that you have gathered data for during your investigation.

Location #1:

Location #2:

Location #3:

Location #4:

week five



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Step 17: Continue Data Collection Using the Surface Temperature Measurement and Cloud Observation Data Sheet

Step 17: Surface Temperature Measurement and Cloud Observation Data Sheet

School Name: _____ Study Site: _____

Observer Names: _____

Date: Year ____ Month ____ Day ____ Universal Time (hour:min): _____

Surface Temperature:
Site's overall surface condition (Check one): Wet Dry Snow

Sample	Temperature (°C)	Snow Depth (mm)
1		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm
2		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm
3		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm
4		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm

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)

Sketch the sky below:

Comments:

week five

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

If clouds are visible select all cloud types seen:

Clouds in the sky:
(check all types seen)



Cirrus



Cirrocumulus



Cirrostratus



Altostratus



Alto cumulus



Stratus



Stratocumulus



Cumulus



Nimbostratus



Cumulonimbus

Clouds in the sky:
(check all types seen)

Clouds in the sky:
(check all types seen)

Clouds in the sky:
(check all types seen)

week five

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



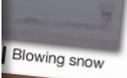
Persistent non-spreading
Number observed



Persistent spreading
Number observed

What percent of the sky is covered by contrails? (Check one):
 0 to 10% 10 to 25% 25 to 50% >50%

How many 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



Haze

Comments:

week five



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Step 18: Graphing Your Data

Measurements | Data Counts | School Info | Site Info | Photos

Atmosphere

Surface Temperature

Average Surface Temperature

Data Date Range: 2012-12-03 to 2015-12-11

Measurement: 1

Measured At: 2015-12-09 00:00:00
 Solar Measured At: 2015-12-08 18:38:00
 Solar Noon At: 2015-12-09 17:21:00
 Average Surface Temperature: 5.9 °C
 Surface Condition: dry
 Number Of Samples Taken: 9
 Surface Cover Type: short grass (< 0.5m)
 Homogeneous Site Short Length M: 15
 Homogeneous Site Long Length M: 15
 Site Area M Squared: 225.0
 Elevation: 367.30 m

Venezuela
 Bogotá
 New Colombia

Plot only displays day's average of values

Date	Temperature (°C)
2015-11-29	5.5
2015-11-30	9.5
2015-12-01	8.0
2015-12-02	-1.0
2015-12-03	-2.5
2015-12-04	-3.0
2015-12-05	-3.5
2015-12-06	-3.5
2015-12-07	8.5
2015-12-08	4.0
2015-12-09	6.0
2015-12-10	9.0
2015-12-11	10.0
2015-12-12	10.5

2015-11-29 | 2015-12-12 | Plot X

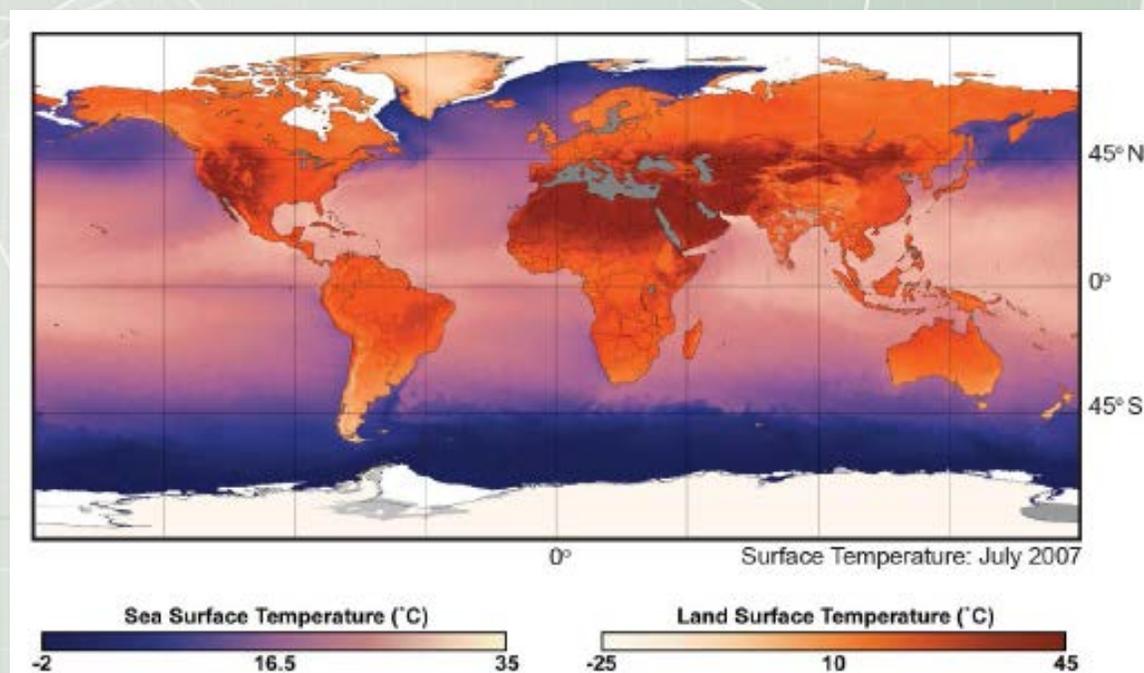
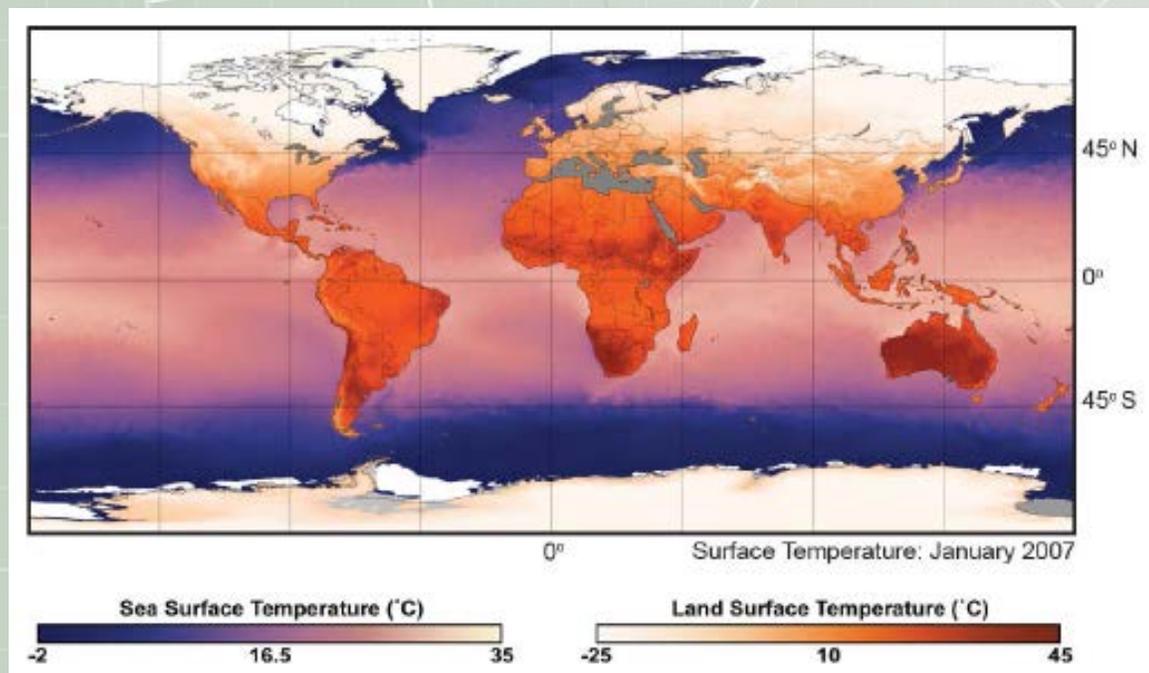


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Step 18: Looking at GLOBE Data—Surface Temperature



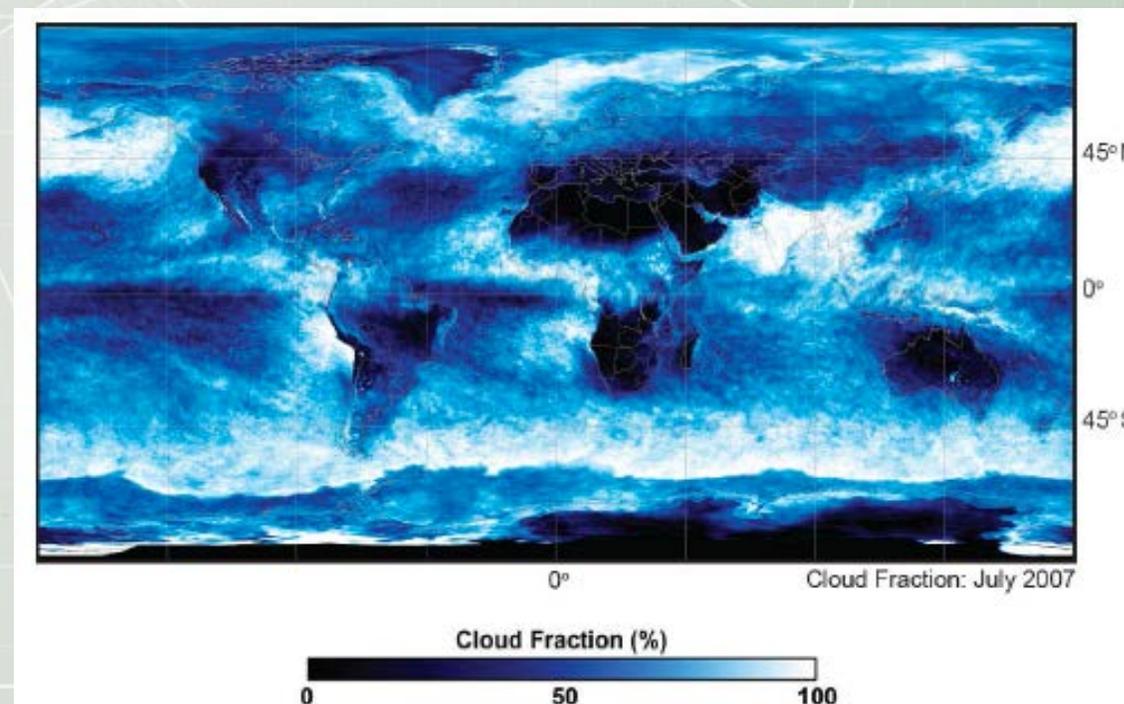
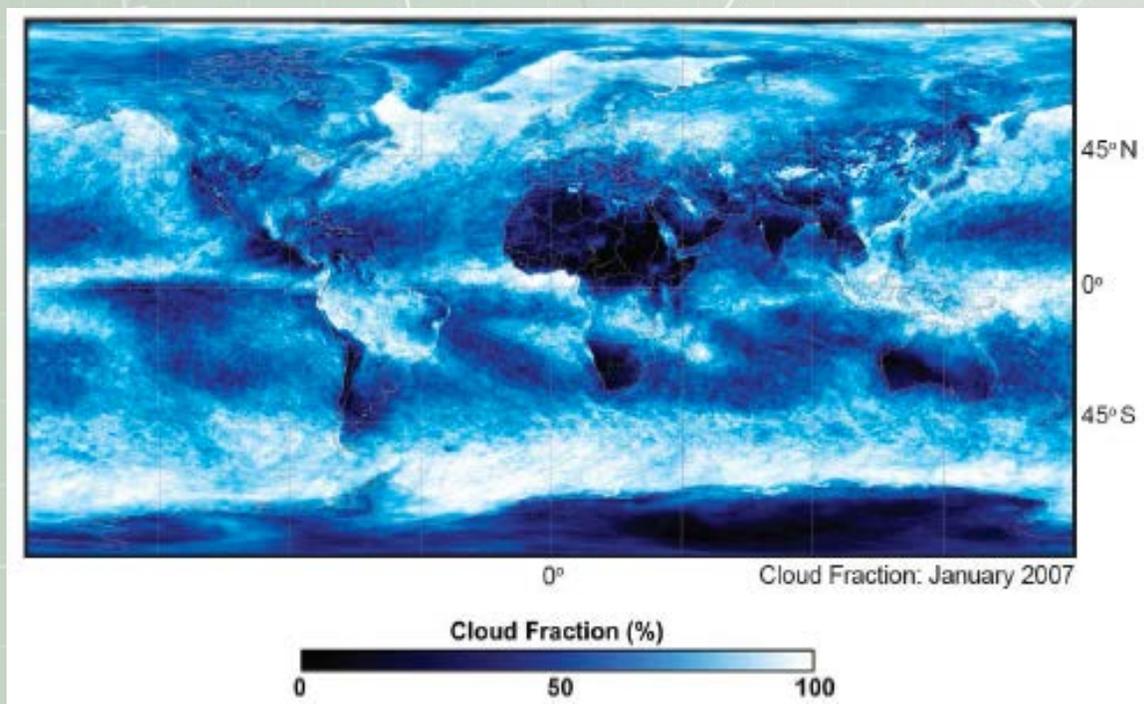


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Step18: Looking at GLOBE Data—Cloud Fraction





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Step 19: Select Your Culminating Project

- Choice 1: Science research poster
- Choice 2: Public service announcement
- Choice 3: PowerPoint presentation



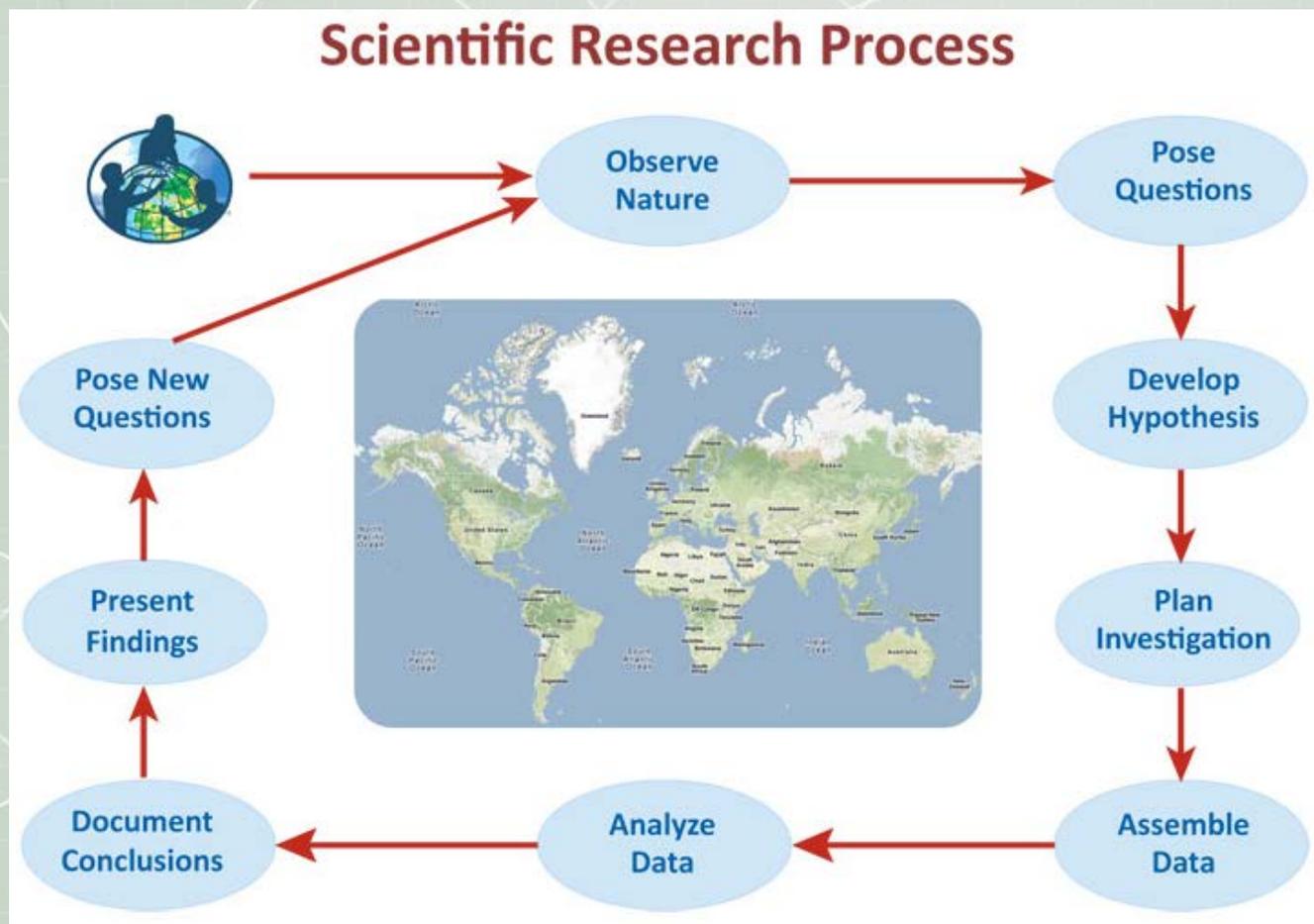


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Step 20: Following the Steps of the Scientific Research Process





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Step 21: Continue Data Collection Using the Surface Temperature Measurement and Cloud Observation Data Sheet

Step 21: Surface Temperature Measurement and Cloud Observation Data Sheet

School Name: _____ Study Site: _____

Observer Names: _____

Date: Year ____ Month ____ Day ____ Universal Time (hour:min): _____

Surface Temperature:
Site's overall surface condition (Check one): Wet Dry Snow

Sample	Temperature (°C)	Snow Depth (mm)
1		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm
2		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm
3		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm
4		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm

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)

Sketch the sky below:

Comments:

Week 6

NASA Langley Research Center 2016

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

Alto cumulus

Low (in the sky):
(Check all types seen)

Stratus

Stratocumulus

Cumulus

Rain or snow producing clouds:
(Check all types seen)

Nimbostratus

Cumulonimbus

Week 6

Student Science Research Journal - 66

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

What percent of the sky is covered by contrails? (Check one):
 0 to 10% 10 to 25% 25 to 50% >50%

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:

Week 6

Student Science Research Journal - 67



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Step 22: Assemble and Graph Your Data

Step 22: Assemble Your Data (Continuing the development of your science research project)

Week seven

Describe the data you will use to show the results of your investigation:

Components to consider for your graph: (Depending on the data you have selected to use for your project, consider the following components and fill in the information that you will use to complete your graph.)

Title: _____

What variable will you plot on the X-Axis? _____

vw _____

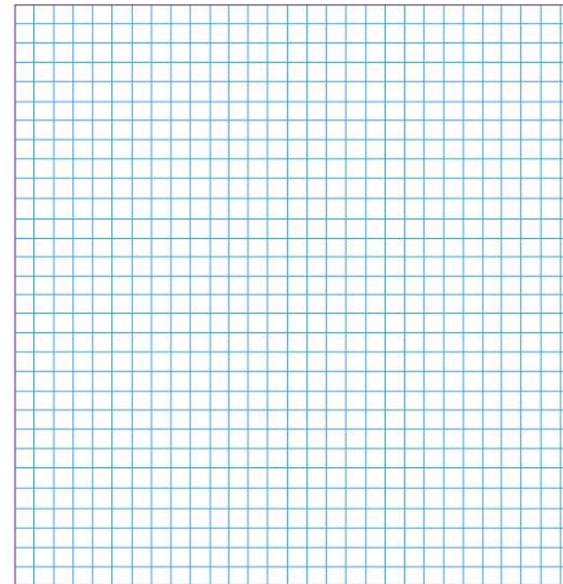
Range of numbers needed: _____

Scale: _____

Units of measurement: _____

Use the grid below to create a rough draft of the graph of your data:

Week seven





NASA and GLOBE Investigation



Step 24: Observation Data Sheet

Week seven

Step 24: Surface Temperature Measurement and Cloud Observation Data Sheet

School Name: _____ Study Site: _____

Observer Names: _____

Date: Year ____ Month ____ Day ____ Universal Time (hour:min): _____

Surface Temperature:
Site's overall surface condition (Check one): Wet Dry Snow

Sample	Temperature (°C)	Snow Depth (mm)
1		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm
2		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm
3		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm
4		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm

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)

Sketch the sky below:

Comments: _____

Week 7

NASA Langley Research Center 2016

Student Science Research Journal - 73

Week seven

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

Week 7

NASA Langley Research Center 2016

Student Science Research Journal - 74

Week seven

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

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: _____

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Step 25: Finalize Culminating Project and Present Results

week eight

Step 25: Surface Temperature Measurement and Cloud Observation Data Sheet

School Name: _____ Study Site: _____

Observer Names: _____

Date: Year ____ Month ____ Day ____ Universal Time (hour:min): _____

Surface Temperature:
Site's overall surface condition (Check one): Wet Dry Snow

Sample	Temperature (°C)	Snow Depth (mm)
1		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm
2		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm
3		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm
4		<input type="checkbox"/> Zero <input type="checkbox"/> Trace (<10 mm) <input type="checkbox"/> Measurable (>10 mm) ____ mm

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)

Sketch the sky below:

Comments: _____

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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

Alto cumulus

Low (in the sky):
(Check all types seen)

Stratus

Stratocumulus

Cumulus

Rain or snow producing clouds:
(Check all types seen)

Nimbostratus

Cumulonimbus

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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

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: _____

Week 8

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