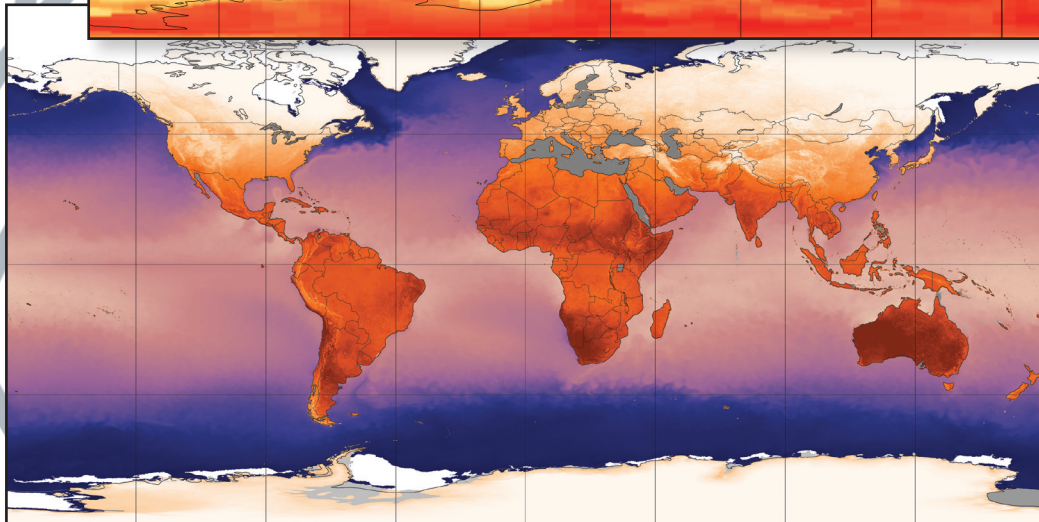
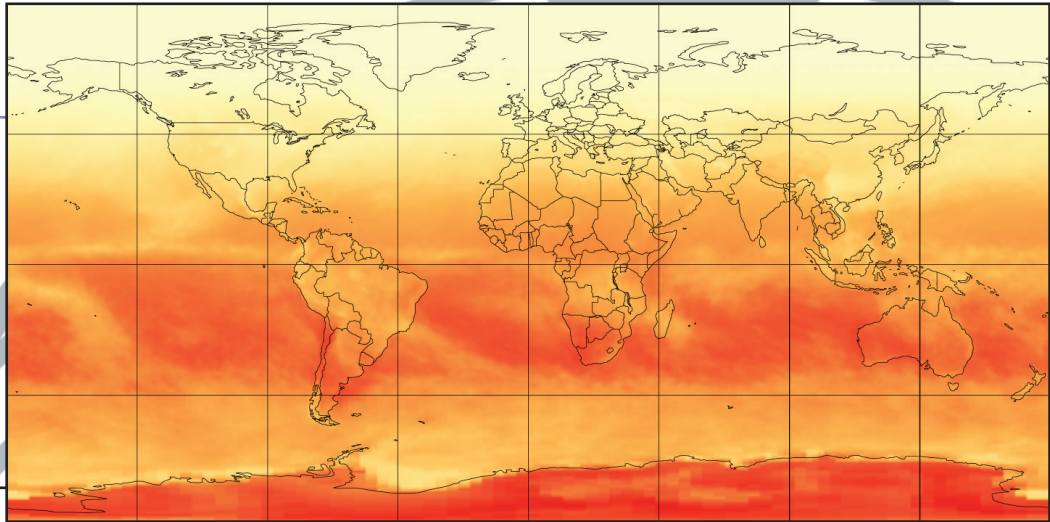




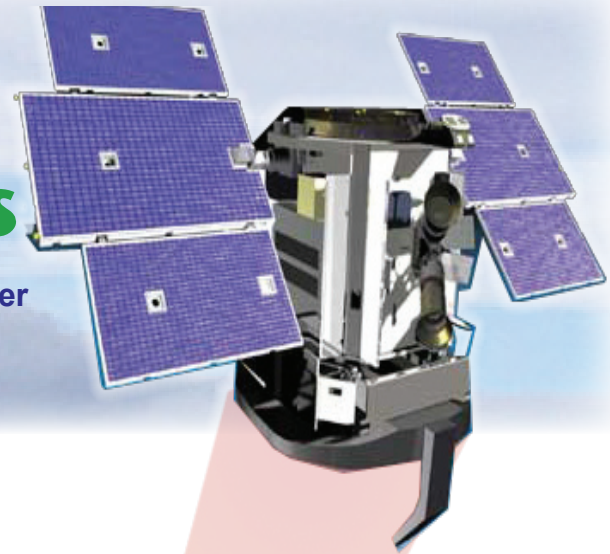
The **GLOBE** Earth System Poster Learning Activities



Activities to accompany the GLOBE Earth System Poster
"Exploring Connections in Year 2007"

Earth as a System Learning Activities

Activities to accompany the GLOBE Earth System Poster
“Exploring Connections in Year 2007”



Overview

The processes comprising the Earth's environment are interconnected. Understanding how these connections operate on a global scale is to understand the Earth as a system. Understanding the Earth as a system requires a quantitative exploration of the connections among various parts of the system. These processes take place in and between the atmosphere, oceans, fresh water, ice, soil, and living components. These processes also include energy from the Sun, and the gases and particles that enter the atmosphere and oceans from both natural and anthropogenic, or human-caused, sources.

The activities in this guide will help students understand variations in environmental parameters by examining connections among different phenomena measured on local, regional and global scales. As students look at the connections between environmental data, they will see that the environment is the result of the interplay among many processes that take place on varying time and spatial scales. They will also understand that environmental processes are not bound by oceans, mountains, or country delineations—they are truly global in scope.

The latest version of the GLOBE Earth System Poster—Exploring Connections in Year 2007 and this accompanying activity guide will serve as a way to introduce the importance of Earth system connections to a new generation of students around the world.

Sincerely,
The GLOBE Program





Purpose:

To identify global patterns and connections in environmental data contained in the GLOBE Earth Systems Poster and to develop an understanding of the interactions within the Earth system.

Overview:

Images displaying global environmental data through the course of 2007 are compared in order to understand how the Earth works as a system. Extension activities connect the Earth System Poster to external web sites (e.g., NASA, NOAA, NSIDC, and SERC).

Student Outcomes:

Science Concepts

Earth and Space Science

- Students will be able to explore the concepts of Earth as a System.
- Students will be able to find patterns and connections between and among maps containing different environmental data.
- Students will understand the relationship between time and space in regard to global environmental data.

Scientific Inquiry Abilities:

- Discover, analyze, and interpret patterns in a graphic display of data.
- Conduct an analysis of mapped data.
- Develop descriptions and explanations using evidence.
- Communicate observations and explanations.

Level:

Secondary (Note: teachers of higher primary grades may also find some of these activities useful and applicable).

Time:

Two to three class periods for Activities 1 through 5 plus Assessments (Extension Activities will require additional time)

Materials & Tools:

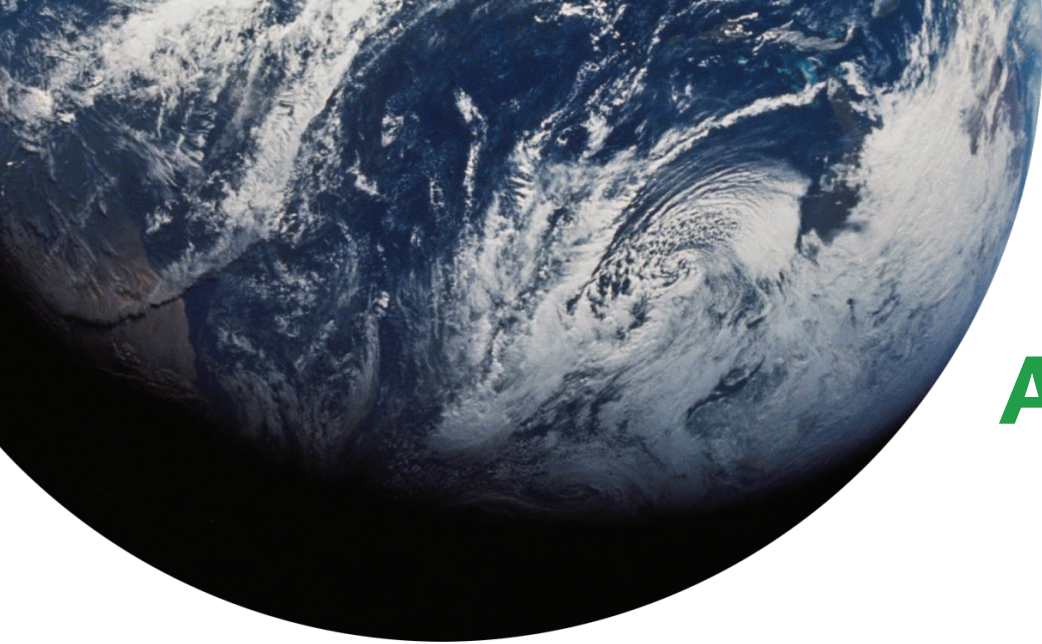
- One “GLOBE Earth System Poster for year 2007.” The poster, individual images (for individual downloading and printing) as well as the complete set of activities to accompany the Earth System poster can be found on the GLOBE Web site at <www.globe.gov/page?earth_system>.
- Internet connection is required for Extension Activities
- Scissors

Preparation:

Cut the GLOBE Earth System Poster into:

- The 36 global images: 6 – Insolation; 6 – Surface Temperature; 6 – Cloud Fraction; 6 – Precipitation; 6 – Aerosol Optical Thickness; 6 – Biosphere
- The 6 labels (Insolation, Surface Temperature, Cloud Fraction, Precipitation, Aerosol Optical Thickness, Biosphere)
- The 6 Month labels (January, March, May, July, September, November)

Or print out individual images from the GLOBE Web site (see url above). Lamination of images can ensure long-term use.



Activities

1 Exploring Single Images

Goals:

Students will observe images individually, looking for available information (data displayed, unit of measure, range of values, etc.) then for any patterns noticeable within the image.

Procedures:

1. Arrange students into six groups (preferably no more than six students per group).
2. Provide each student with one global image corresponding to the variable labels as shown in the table below (e.g., each student in Group One receives a global image of Insolation, each student in Group Two receives a global image of Surface Temperature, etc.):

Group	Variable Label
One	Insolation
Two	Surface Temperature
Three	Cloud Fraction
Four	Precipitation
Five	Aerosols
Six	Biosphere

3. Ask students to study and interpret their images for available information.
4. Have groups designate a spokesperson, to report observations from the members of the group.
5. Ask the six groups, one at a time, to share with the entire class the information provided on their images. Use the following guiding questions:
 - What variable did you examine and what is the range of values shown on the scale bars?
 - Where in the world do you find the highest and lowest values (the extremes) of the data in your images? Why do these locations experience the extremes and not other locations?
 - Are any patterns in the data noticeable? Are patterns different on different continents? Different over water than over land? Explain these patterns.

2 Exploring Annual Changes

Goals:

Students will observe images as a group, looking for any changes that are occurring throughout the year.

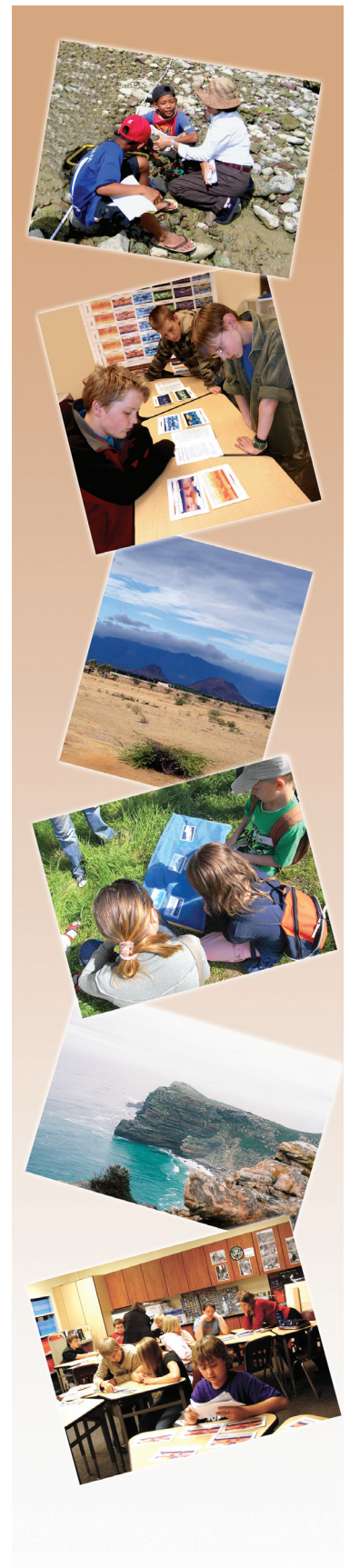
Procedures:

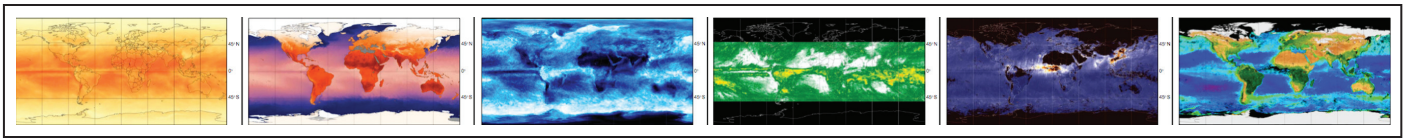
1. Distribute all global images per variable to groups designated in Activity 1 (e.g., all six Insolation images to Group One; all six Surface Temperature images to Group Two, etc).
2. Have groups arrange their images in chronological order, beginning with January.
3. Ask groups to identify annual cycles for their variable. Use the following guiding questions:
 - What changes do you see through the year? What explanations can you suggest for these patterns?
 - Choose a location or region. During which months do the extreme highs and lows occur? What explanations can you suggest for the timing of those extremes?
 - Which regions experience both the extreme highs and lows? Which regions don't experience the extremes? Why do you think this happens?
 - What differences, if any, do you find between the year's variations over the oceans versus the year's variations over the continents?
 - Are there regions that remain relatively unchanged over the year? Why do you think this happens?

[Teaching Hint: if students have trouble locating significant changes have them focus their attention on one location on the image throughout the year.]

4. After several minutes, ask the groups to share with the entire class their discoveries of patterns and their interpretation of those patterns.

*Understanding the **Earth** as a system requires a quantitative exploration of the **connections** among various parts of the system.*





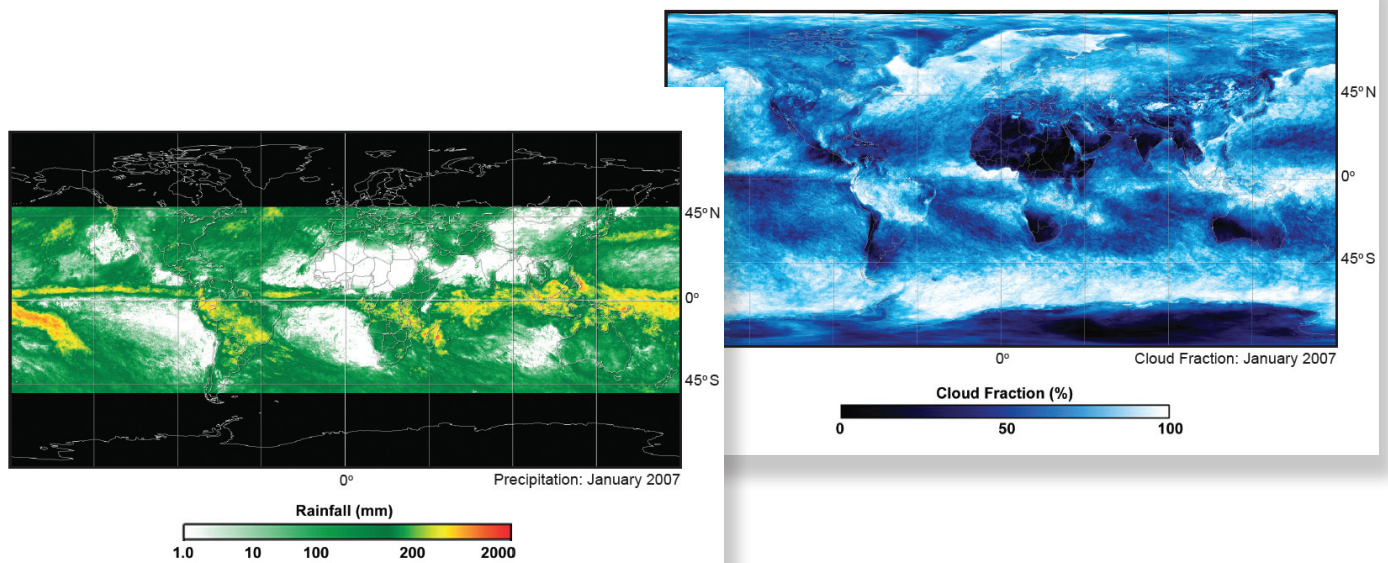
3 Exploring Relationships Between Two Variables

Goals:

Students will observe images from two variables, looking for possible relationships that are occurring throughout the year.

Procedures:

1. Instruct groups to come together in the following pairs:
 - Group One (Insolation) with Group Two (Surface Temperature)
 - Group Three (Cloud Fraction) with Group Four (Precipitation)
 - Group Five (Aerosols) with Group Six (Biosphere)
2. Have groups arrange their images in chronological order.
3. Have groups line their images next to each other (January next to January, etc.).
4. Ask groups to identify the relationships and associations between the variables. Use the following guiding questions:
 - What relationship do you see between insolation and surface temperature? Cloud fraction and precipitation? Aerosols and Biosphere?
 - Do the relationships appear to be directly or inversely proportional? Explain.
5. After several minutes, ask groups to share with the entire class the relationships they have identified between the two variables. Have them also share the methods they used to identify these relationships.



4 Exploring Relationships Among Variables for a Particular Month

Goals:

Students will observe images from all six variables for one month, looking for possible relationships that are occurring between or among variables for their particular month.

Procedures:

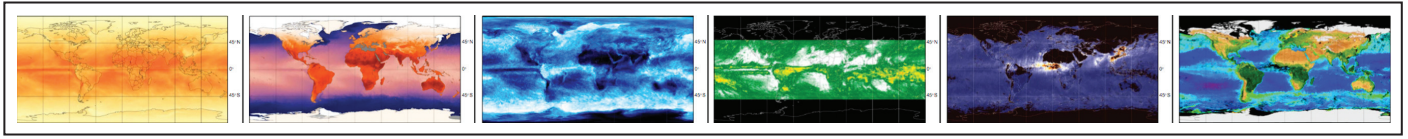
1. Collect all images from the groups.
2. Ask students to reform their six original groups (See Activity 1, Step 1).
3. Distribute the Month labels to each group as shown in the following table:

Group	Month Label
One	January
Two	March
Three	May
Four	July
Five	September
Six	November

4. Redistribute the images to groups according to month. Each group will have images for all six variables for a single month.
5. Ask students to identify relationships among data for each month. Use the following guiding questions:
 - Which regions experience the extreme highs and lows for each variable?
 - Which regions don't experience the extremes? Why do you think this occurs?
 - What differences, if any, do you find between variations of variables over the oceans versus variations in variables over the continents?
 - What amounts of insolation, surface temperature, cloud fraction, precipitation and aerosols characterize the world's most vegetated regions for a particular month? Where is the greatest concentration of aerosols originating from and how would you characterize that particular environment based on the six images?
6. After several minutes, ask groups to share with the entire class their discoveries of relationships and their interpretations of them.

*As students look at the **connections** between and among environmental data, they will see that the **environment** is the result of the interplay among many **processes** that take place on varying time and spatial scales.*





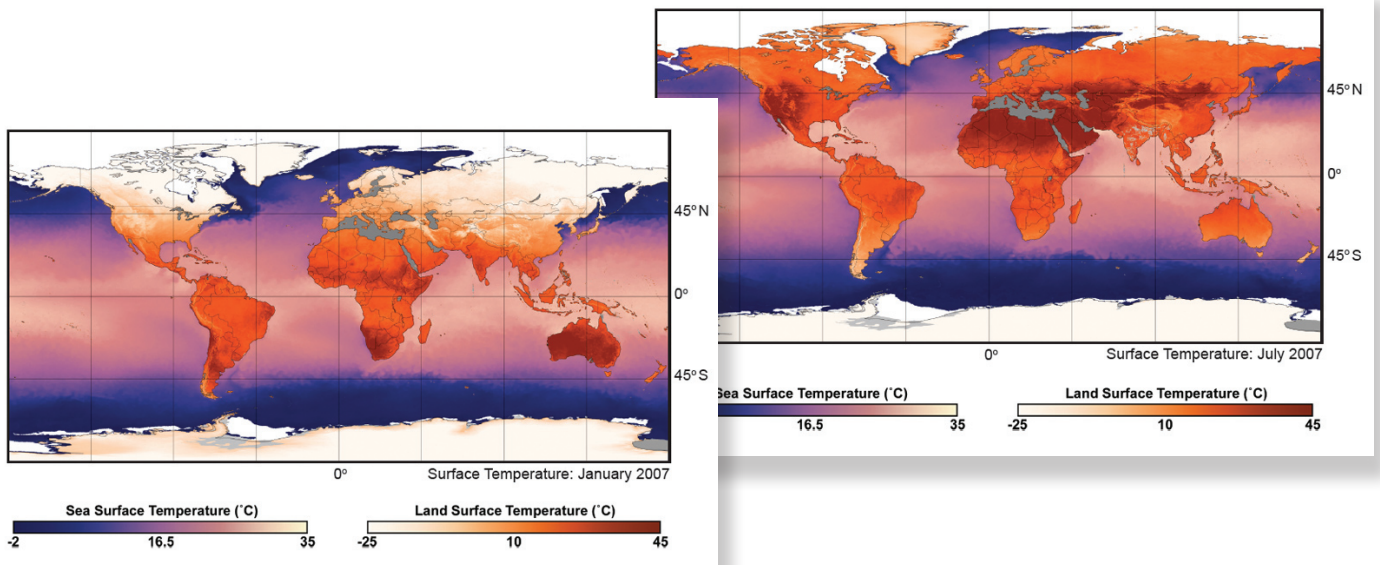
5 Exploring Relationships Among Variables Six Months Apart

Goals:

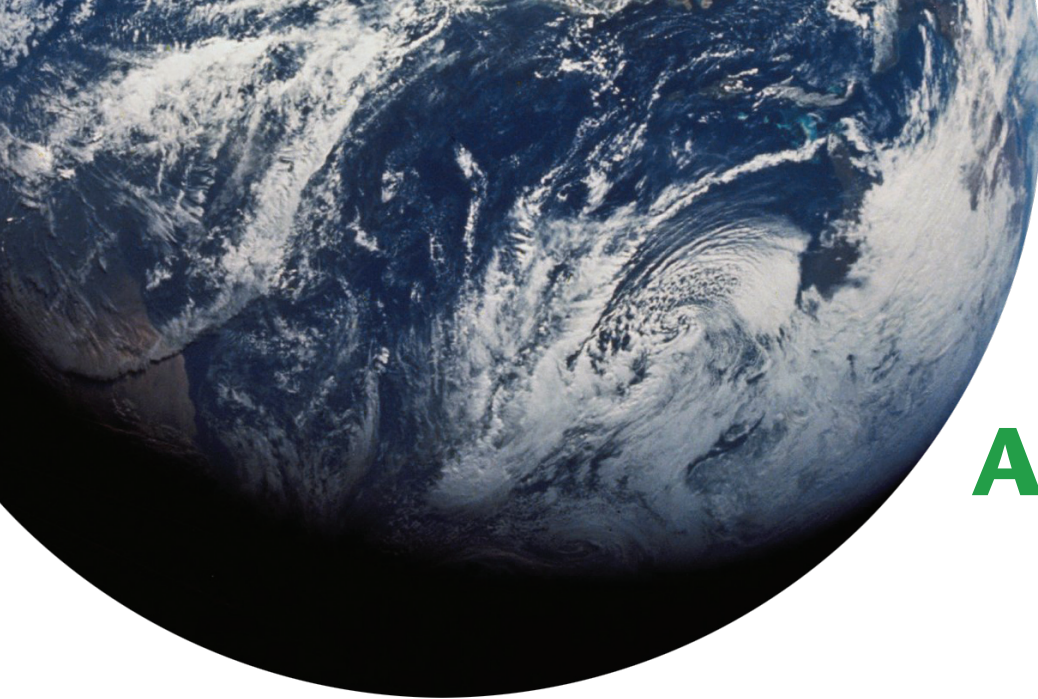
Students will observe images from all six variables for two months, six months apart, looking for relationships and/or changes that are occurring among variables.

Procedures:

- Instruct the groups formed in Activity 4 to come together in the following pairs:
 - Group One (January) with Group Four (July).
 - Group Two (March) with Group Five (September).
 - Group Three (May) with Group Six (November).
- Have groups line their global images next to each other by variable (Insolation January next to Insolation July, Surface Temperature January next to Surface Temperature July, etc.).
- Ask students to identify the changes that occur in the six variables between the six-month period. Use the following guiding questions:
 - Which variables change the most over the six-month period? Which variables change the least? Why do you think this happens?
 - Do you see any relationships among the variables that you didn't see previously?
- After several minutes, ask groups to share with the entire class the relationships they have identified among the variables. Have them also share the methods they used to identify these relationships.







Assessments

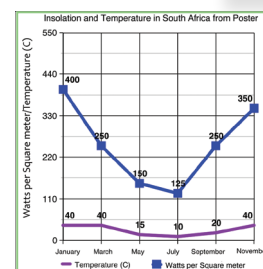
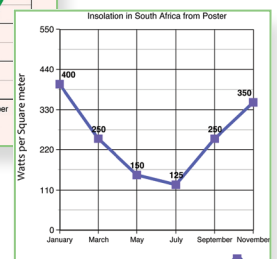
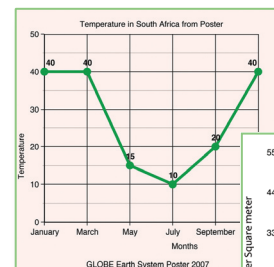
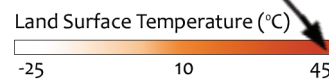
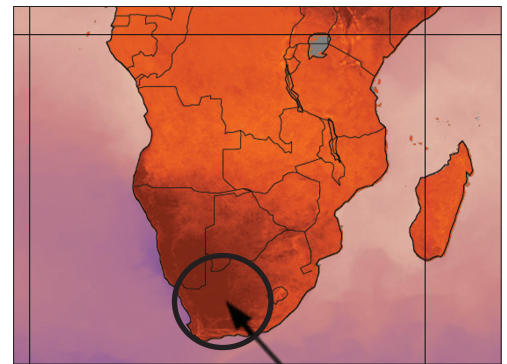
1 Graphing Data from the Poster

Goals:

Students will use the color bars and associated units displayed in the images to estimate the values displayed throughout the year, graph these values and look for patterns. Students will then add a variable to look for possible relationships.

Procedures:

1. Have students choose a variable (e.g. Surface Temperature) and arrange the six images in chronological order.
2. Determine a location to follow the data throughout the year (e.g. Southwestern South Africa).
3. Have students estimate the land surface temperature at the determined location based on color on the image and the approximate value on the color bar (See image at right).
4. Have students estimate values for Southwestern South Africa for all six images.
5. Have students graph approximated data for images on either graph paper or using graphing software (Example graphs were generated using *Create A Graph*, available at <http://nces.ed.gov/nceskids/createagraph>).
6. Have students do a similar data estimation for another variable (e.g. Insolation) and combine the graphs. Can students see a possible relationship? Do these graphs support the observations made in Activities 2 and 3?
7. Have students choose another location in another part of the world to collect data on these two variables. Do students see a similar pattern or relationship? What additional information or data might be useful to consider?



2 Sequencing Annual Changes in a Variable

Goals:

Students will attempt to organize images (per variable) in chronological order based on observing image details (not including date) in order to determine which variables follow a yearly cycle.

Procedures:

1. Cover the dates on the global images.
2. Distribute the images (in random order) by variable to groups of students.
3. Ask students to arrange the images in order.
4. After several minutes, ask students to explain with the rest of the class how they placed the images in chronological order without knowing the dates.
5. Have students uncover the dates on the images to check their order. Have them discuss the difficulty or ease of arranging the images for the different variables. Which variables were easiest to arrange in chronological order? What clues in the images helped? Which variables were the most difficult? Why?

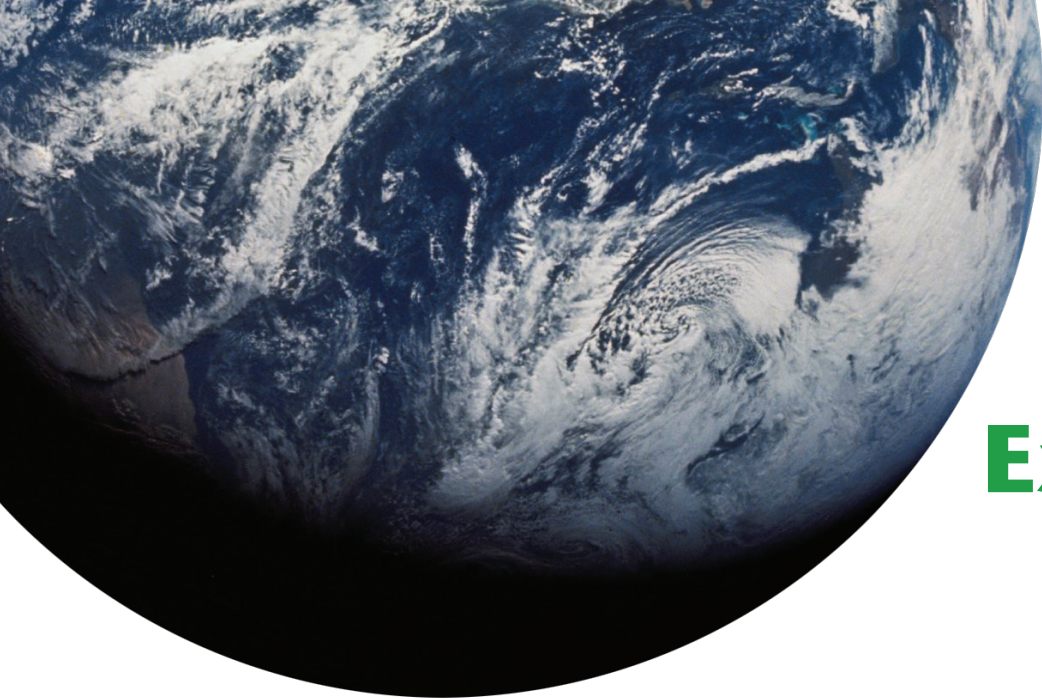
3 Applying the Data

Goals:

Students will observe images from all six variables at six months apart, answering hypothetical questions, building on prior knowledge.

Procedures:

1. Have students look at variables that are six months apart (or sorted as in the uncut GLOBE Earth System Poster).
2. Ask them to use the images or the poster to answer the following questions:
 - Notice that cloud fraction values over the equatorial region of Africa are quite high throughout the year (>50%.) Also notice that precipitation is high as are vegetation (NDVI) values. What type of environment might this be? If cloud fraction values were decreased to less than 25%, what environmental changes would you expect for this region? ***[Teaching Hint: have students refer to global biome maps.]*** Would you expect high precipitation values (e.g. >200 mm) to exist under low cloud fraction? What additional information might be useful in making these statements? ***[Teaching Hint: guide students to understand the role of geography in precipitation, as in rain shadow.]*** What about a similar reduction in the Amazon region of South America? What effects would these changes have on the vegetation (NDVI)? Why would you expect these changes? ***[Teaching Hint: students should begin to understand how to connect ideas to form scientific questions or hypotheses. The point is not that they know what changes will occur but rather that they are using constructed knowledge to form questions or hypotheses.]***
 - Follow the pattern visible in the Biosphere images. How are the patterns in the ocean (Chlorophyll Concentration) similar to the patterns on land (Vegetation)? What time of year does it seem like the Earth is the “greenest”? How do the other five variables influence changes in biomass? Explain.
3. Have students choose a location where they (as groups) would like to go on vacation (since this is hypothetical, any place on Earth is possible).
 - What is the best month to visit that location? Why? What activities would they be engaged in? What types of clothing would they need to pack?
 - If you were only able to go on vacation during the month of May, where would be the best location for your trip? Answer the same question for the other five months available.
4. Have students justify their answers by referencing the specific variables and months that helped them formulate their responses.



Extensions

1 Exploring Further Relationships – Aerosols

Goals:

Students will explore aerosols information and compare aerosols and biosphere images as well as aerosols images with active fires images (on the NEO Web site).

Procedures:

1. Have students explore Aerosols Information Page (page 22) to help them discover answers to the following questions about aerosols and aerosol optical thickness:
 - What are aerosols? Where do they come from?
 - What role do aerosols play in the Earth system?
2. Ask students to name some natural sources of aerosols. List these on a chalkboard or white board. Ask students to name anthropogenic sources of aerosols, those resulting from human activities. Create a different list of these on the chalkboard or white board.
3. Have students examine aerosols images. Ask them to report what they observe; the group that examined the aerosols images in Activities 1 and 2 (Exploring Single Images and Exploring Annual Changes, respectively) could also report their findings to the class.
4. Have students find an area on the aerosols images that is black during all months **[Teaching Hint: suggest that they use North Africa (Sahara Desert) and/or the Arabian Peninsula as examples if necessary.]** Why would these areas be black in all images? What is constant during all months for these regions? **[Teaching Hint: ask leading questions, such as what biome exists in these areas, if students are stuck. And if they know the biome they may be able to determine the surface cover. Students should find that these areas have mostly sand. Albedo (reflectance) of sand is high therefore these areas appear black.]** Some students hopefully have identified Greenland as an area that is always black in these images. **[Teaching Hint: ask students again about the biome and surface cover to help them.]** What surface cover commonalities exist between Greenland and other Northern latitudes during January, March and December? **[Teaching Hint: the answer is snow and/or ice. Similar to deserts, areas with snow and ice have a high albedo, or reflectance, therefore these areas appear black. This is a limitation of the satellite instrument.]**

5. Have students examine biosphere images. Ask students what they think the black areas in the images could be. Have them refer to the aerosols images to assist in their responses. Do students notice that some, but not all, aerosols show up as black areas in the biosphere images? Why might this occur? After students have provided some answers, have them refer to their list of natural and anthropogenic sources. Ask them if all aerosols are the same.
6. Have students visit the NASA Earth Observations (NEO) Web site <<http://neo.sci.gsfc.nasa.gov>>. “Blue Marble: Next Generation” is the default image. Have students click on the “Land” tab under the image. Notice that there are several possible selections; have students click on “Active Fires (MODIS)”. The default image will be the latest available. Have students look for active fires images that correspond to the aerosols images on the poster, clicking on the month they wish to see and then clicking on “View”. Notice that continent/country outlines are not overlaid. However, some basic continent identification should be possible.
7. Have students compare active fires, aerosols and biosphere images. Are there aerosols on the images when and/or where there are no fires? Do these aerosols show up on the biosphere images? If yes, what types of aerosols might these be? **[Teaching Hint: the answer is aerosols not produced by fire, such as sand or dust.]** Have students read the article, “Africa to Atlantic, Dust to Dust,” at: <www.gsfc.nasa.gov/feature/2004/0116dust.html>.

GLOBE students can also collect aerosol data as a way of understanding aerosols in their local environment (See: www.globe.gov/tctg/aerosol.pdf?sectionId=9).



2 Polar Studies

Part 1 - Exploring Relationships Between Insolation and Surface Temperature

Goals:

Students will compare changes in Insolation images with changes in Surface Temperature images.

Procedures:

1. Have students arrange both Insolation and Surface Temperature images in chronological order, so that both variables are next to each other for each month (January Insolation next to January Surface Temperature, etc).
 - Ask students to identify the visible relationships between insolation and surface temperature; how might other variables affect this relationship? [Provide other variable images to students if they wish to compare them]
 - Have students sketch their best estimates of the annual temperature cycle from Arctic and Antarctic areas based on images of Surface Temperature.
2. After several minutes, ask students to share with the entire class the relationships they have identified between the two variables and the methods they used to identify these relationships. Have students present their Arctic and Antarctic graphs and the methodologies used to develop them.

Part 2 - Using Data and Images to Understand Albedo

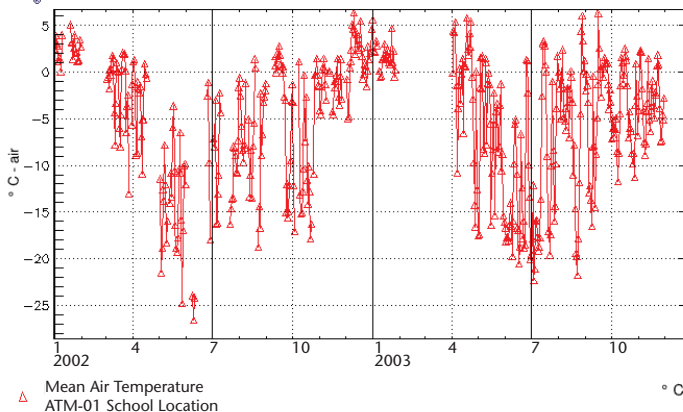
Goals:

Students will look at data from the Arctic and Antarctic, looking for similarities and differences. Students will explore albedo and its affects on arctic sea ice.

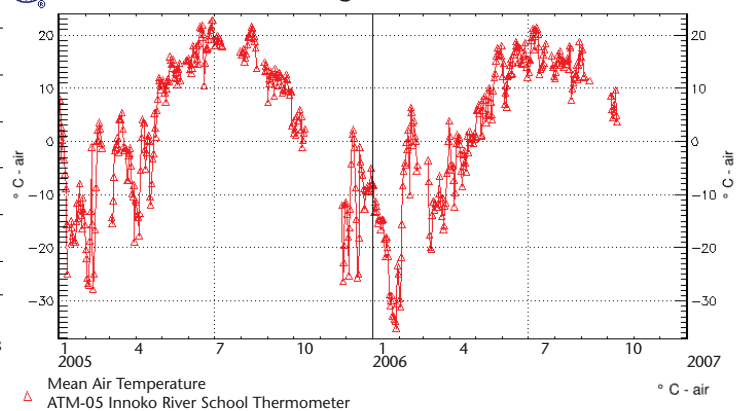
Procedures:

1. Have students compare the following two graphs (See Appendix B for large graphs and instructions)
2. Have students compare the highs and lows in the graphed data with their sketched graphs. How are they similar and/or different?

 Escuela Provincial No. 38 Julio Argentina Roca, GLOBE school in Antarctica



 Innoko River School - Shageluk, Alaska



- Have students explore patterns in these data; students should see inverse, or opposite, patterns in atmospheric temperature data (e.g., Antarctic is colder in July while Arctic is warmer in July, etc).
- Have students discuss processes behind the patterns in these data (e.g., seasonal patterns connected to solar energy and angle of the Sun throughout the year).
- Ask students what they think happens to sea ice during these different seasons in these two areas? Which area (Antarctica or Arctic) do they think has more sea ice?
- Have students read the Pew Center article, "The Science Behind the Shrinking Arctic Ice Cap", and study Figures 1 and 2 (See: www.pewclimate.org/impacts/icecap for article); what does this mean for Arctic Sea Ice?
- Have students visit the National Snow and Ice Data Center Sea Ice Web page: <http://nsidc.org/seaice> and click on "Processes".
- Have students click on "Albedo" and read the text; look at the images on the right of the web page (see Figure 3);
- Have students click on "Environment" then click on the "Trends" sub-link (within Environment) and read the article;
- Have students click on the "Sea Ice Index" link near end of article;

Graphs Illustrating Arctic Sea Ice Decline September 2007

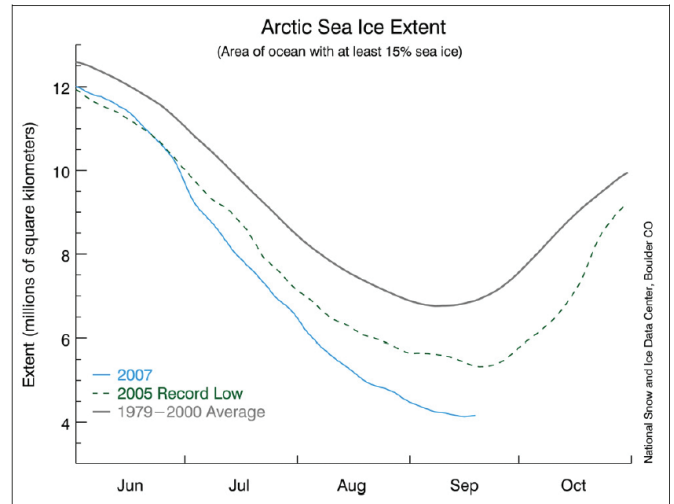


Figure 1. Time series of daily Arctic sea ice extent for 2007 compared to 2005 and the average for years 1979 to 2000.

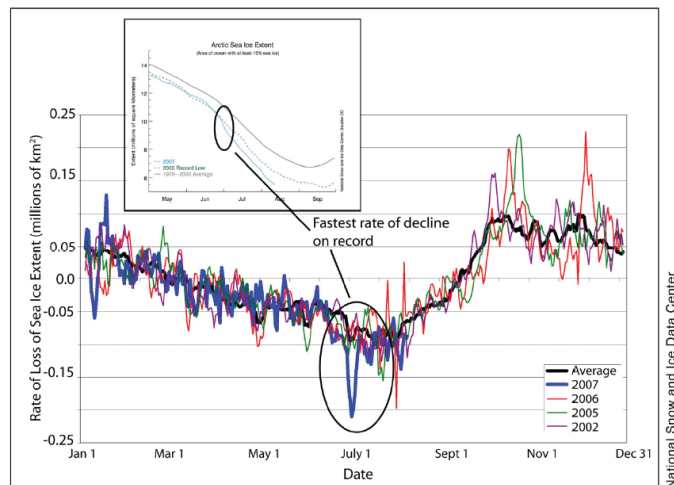
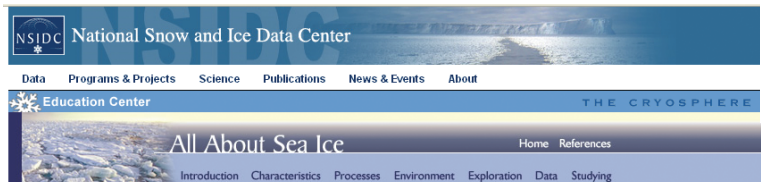


Figure 2. Rate of sea ice loss in 2007 compared to recent record-breaking years.



Processes: Thermodynamics: Albedo

Thermodynamics Albedo is a non-dimensional, unitless quantity that indicates how well a surface reflects solar energy. Albedo (α) varies between 0 and 1. Albedo commonly refers to the "whiteness" of a surface, with 0 meaning black and 1 meaning white. A value of 0 means the surface is a "perfect absorber" that absorbs all incoming energy. Absorbed solar energy can be used to heat the surface or, when sea ice is present, melt the surface. A value of 1 means the surface is a "perfect reflector" that reflects all incoming energy.

- Growth**
- Albedo**
- Melt**
- Cycle**

Dynamics

- Circulation**

Sea ice has a much higher albedo compared to other earth surfaces, such as the surrounding ocean. A typical ocean albedo is approximately 0.06, while bare sea ice varies from approximately 0.5 to 0.7. This means that the ocean reflects only 6 percent of the incoming solar radiation and absorbs the rest, while sea ice reflects 50 to 70 percent of the incoming energy. The sea ice absorbs less solar energy and keeps the surface cooler.

Snow has an even higher albedo than sea ice, and so thick sea ice covered with snow reflects as much as 90 percent of the incoming solar radiation. This serves to insulate the sea ice, maintaining cold temperatures and delaying ice melt in the summer. After the snow does begin to melt, and because shallow melt ponds have an albedo of approximately 0.2 to 0.4, the surface albedo drops to about 0.75. As melt ponds grow and deepen, the surface albedo can drop to 0.15. As a result, melt ponds are associated with higher energy absorption and a more rapid ice melt.

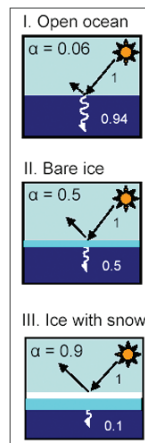


Figure 3, Albedo in the Polar Regions.

11. Have students click on “Browse Image Spreadsheet Tool (BIST)” on the bottom left of the page under “Browse, Compare, and Animate Images”;
12. Have students Click on “Sea Ice Index: Extent, Concentration, and Concentration Anomalies”
13. Have students change the top set of controls to be as follows (See Figure 4):
 - a. Change “Scale” (in the Control Panel box) to 75% (A in Figure 4).
 - b. Click on the first Month dropdown menu and change it to Feb (B in Figure 4).
 - c. Click on the first Map dropdown menu and change it to Sea Ice Conc (C in Figure 4).
 - d. Click on the second Month dropdown menu and change it to Aug (D in Figure 4).
 - e. Click on the top Year dropdown menu and change it to 1987 (E in Figure 4).
 - f. Click on the bottom Year dropdown menu and change it to 2007 (F in Figure 4).
 - g. Click on the Refresh button (G in Figure 4).

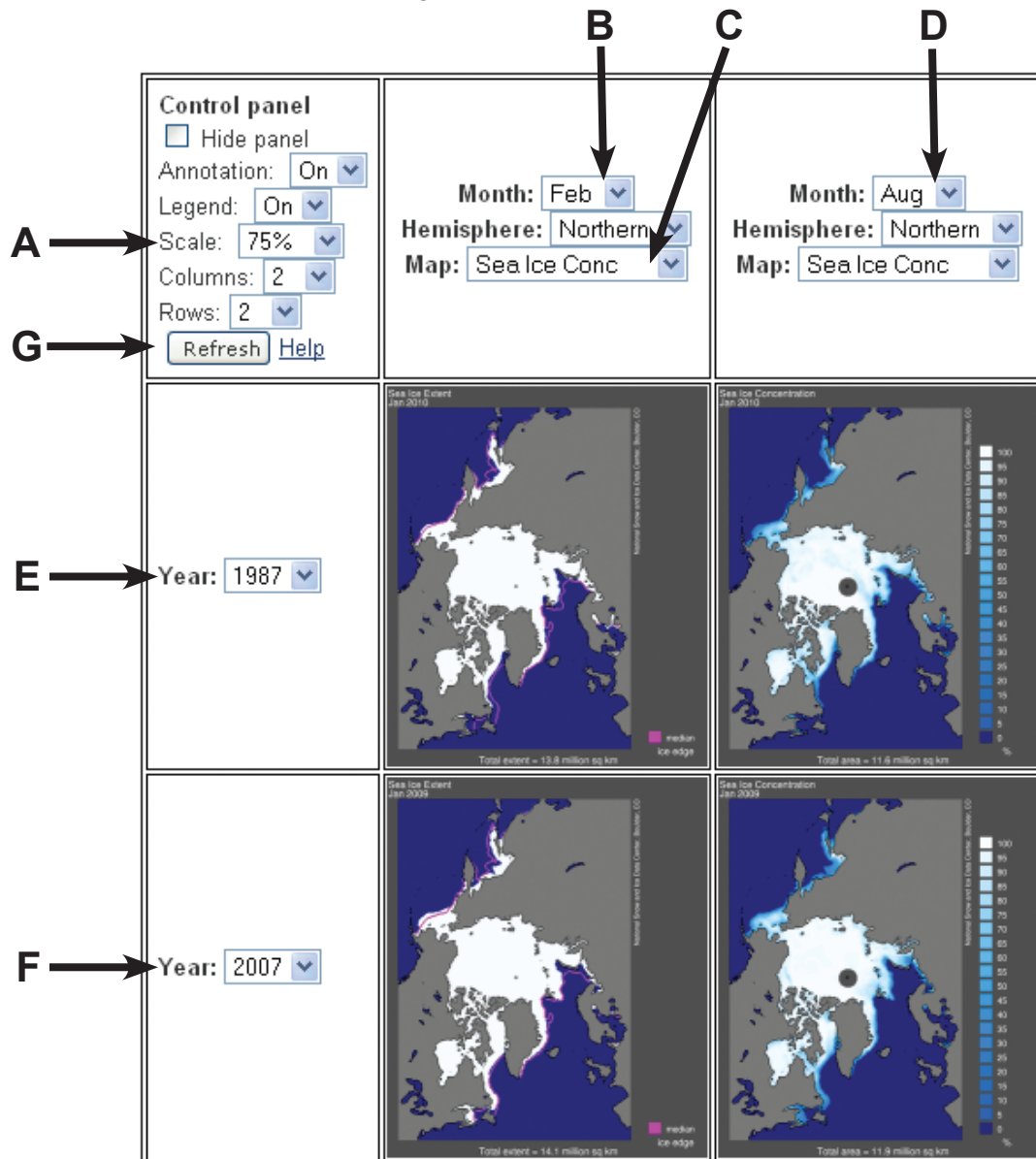


Figure 4, Changing control panel parameters for Sea Ice Concentrations in the Arctic

14. Students should see the following set of images (Figure 5).

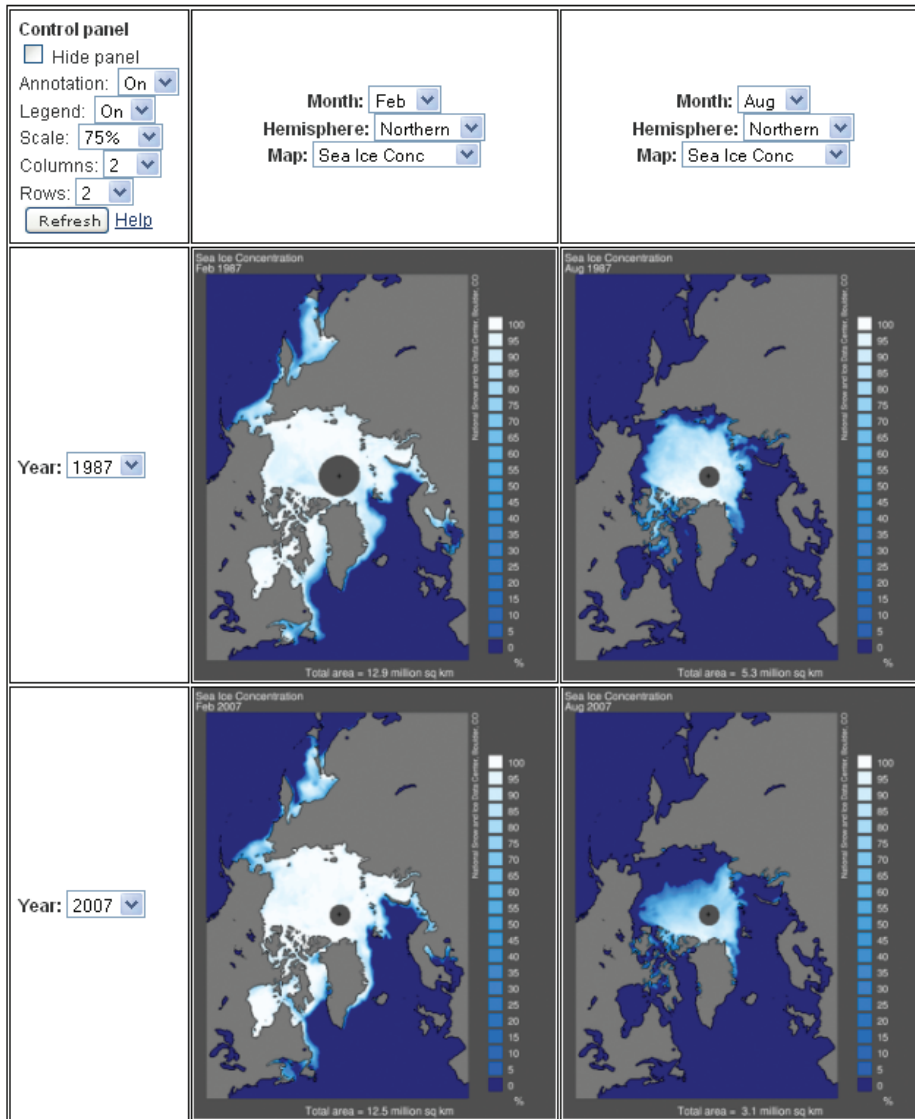


Figure 5, Changes in Arctic Sea Ice Concentration from 1987 to 2007.

- Have students interpret the images. Make sure they notice the “total area” at the bottom of each image. Also make sure that the students compare February to February and August to August. Student should notice drastic area loss in February, 2007. Students should understand how such changes affect the albedo and how changes in the surface (from sea ice to melt water) can create a feedback loop of melting and lowering of the albedo. Have students construct a relationship between images from the Earth as a System poster, data from GLOBE schools (primarily in Alaska), article from Pew Climate Center, and information from National Snow and Ice Data Center. What do the poster images and other information have in common? Can students summarize these ideas? Involve the Language Arts and Technology instructors in order to facilitate a science-writing assignment including images and references to help younger students understand the issues surrounding Arctic sea ice.

Further Studies:

Air and sea surface temperature (SST) values can be downloaded from the NCEP/NOAA Reanalysis Fields. Please note that these download may not function with all browsers (they have been tested using Firefox and Internet Explorer). Long-term averages and anomalies for the year of interest can be estimated. Plots of the region of interest can be constructed at: www.cdc.noaa.gov/cgi-bin/data/composites/printpage.pl (See Figure 6 for screen capture of Web page showing fields completed).

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Monthly/Seasonal Climate Composites

Plot seasonal composites (averages) of the mean or anomalies (mean - total mean) of variables from the NCEP reanalysis and other datasets. NCEP data is available from Jan 1948 to Jan 2010.

What variable? Level?

Beginning month of season: Ending month:

Enter years for composites (from 1 to 16): For seasons that span a year (e.g. DJF), please enter year of the LAST month.

To subtract one set of values from another, use a minus sign (-) before the years that are to be subtracted.

OR Enter range of years: to (optional minus to)

OR List of year: Enter filename:

OR Years from values in Time Series:

If CUSTOM Time Series:

Value to composite on:

Type of comparison:

Lag: Plot composites for months before or after dates chosen

Color? Shading:

Plot type? Mean Anomaly Long Term Mean

Scale plot size (%) Plot contour labels? No Yes

Reverse colorbar? No Yes

Override default contour interval? Interval: Range: low high

Map projection

If CUSTOM projection:
Lowest lat: (-90 to 90) Highest lat:
Western-most longitude (0 to 360): Eastern-most longitude:
CUSTOM projection:

Choose height range if CROSSECTION:
Lower level Upper level

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Earth System Research Laboratory | Physical Sciences Division
<http://www.esrl.noaa.gov/psd/cgi-bin/data/composites/printpage.pl>

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Figure 6. Web page at NCEP/NOAA with changes to default values.

- Students should make the following changes to the default selections (letters below correspond to letters and arrows on Figure 6):
 - Change “Geopotential Height” to “NOAA OI SST”.
 - Change “1000mb” to “Surface”.
 - Change “Jan” and “Jan” to “Mar” and “Mar”.
 - Enter “2007” and “2007”.
 - All other selections leave as default; Click on “Create Plot”.
- Students should see image similar to Figure 7.

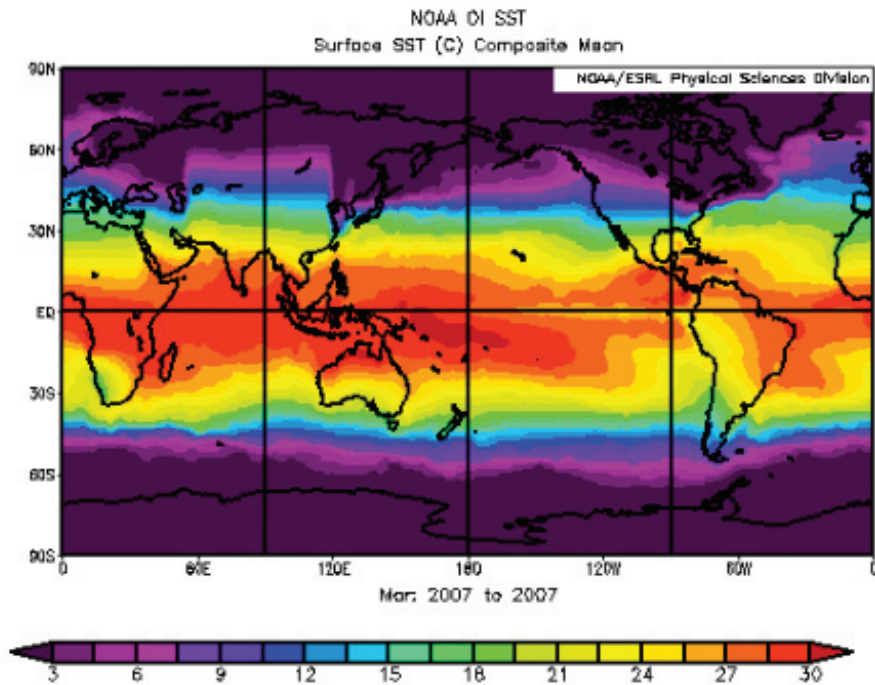


Figure 7. Mean Sea Surface Temperature, March 2007

3. Have students explore the image noting sea surface temperature patterns; how do temperatures in the polar regions relate to lower latitudes?
4. Have students click on the Back button.
5. Have students change “Mar” and “Mar” to “Sep” and “Sep”; Click on “Create Plot”.
6. Students should see image similar to Figure 8.

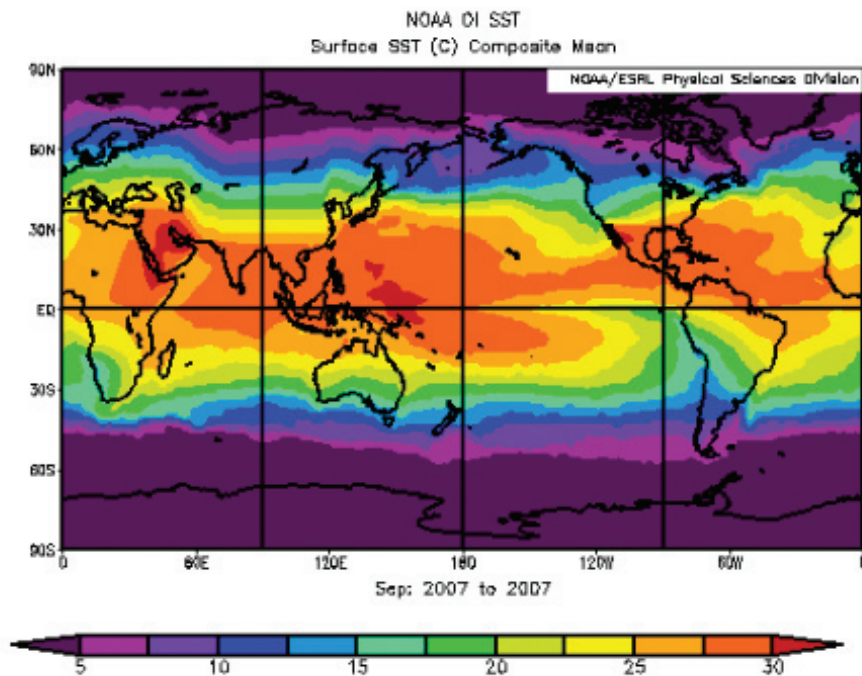


Figure 8. Mean Sea Surface Temperature, September 2007

7. Have students explore the image noting sea surface temperature patterns; how do temperatures in the polar regions relate to lower latitudes? What differences can they observe between the previous image (March 2007) and this image (September 2007)? Do students see that the two images have slightly different temperature scales? How would they use this information in their analysis of the visualizations?

8. Have students click on the Back button.
9. Have students change “Sep” and “Sep” back to “Mar” and “Mar”; have students change Map Projection “ALL” to “Northern Hemisphere” (see letter f on Figure 5); Click on “Create Plot”.
10. Students should see image similar to Figure 9.
11. Have students explore the image noting sea surface temperature patterns; What is occurring in the Arctic?

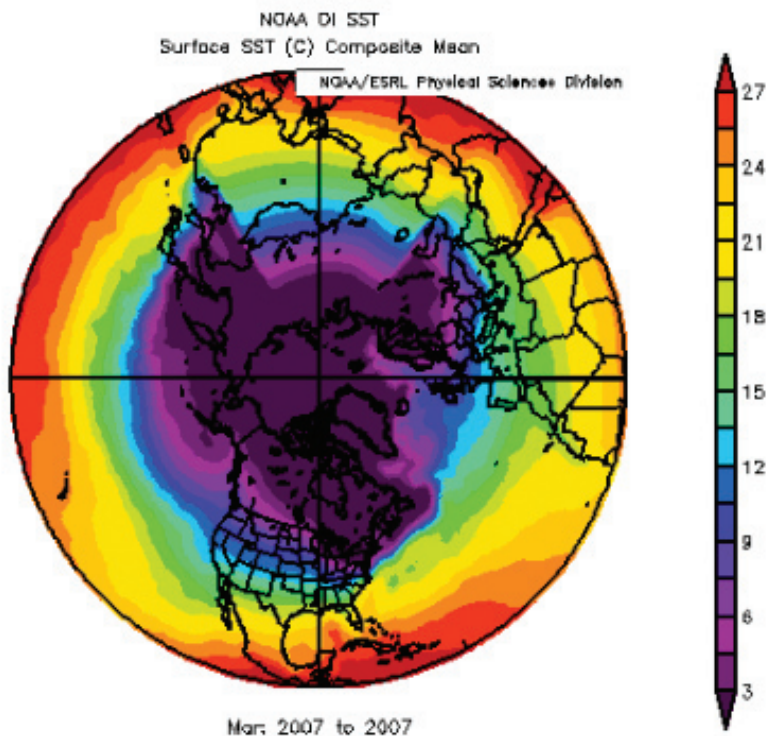


Figure 9. Mean Sea Surface Temperatures, Northern Hemisphere, March 2007

12. Have students click on the Back button.
13. Have students change “Mar” and “Mar” to “Sep” and “Sep”; Click on “Create Plot”.
14. Students should see image similar to Figure 10.
15. Have students explore the image noting sea surface temperature patterns; how do temperatures in the Arctic Region relate to lower latitudes? What differences can they observe between the previous image (March 2007) and this image (September 2007)? (Remind students that the two images have slightly different temperature scales) Are these images easier or more difficult to evaluate than the images in Figures 6 and 7?

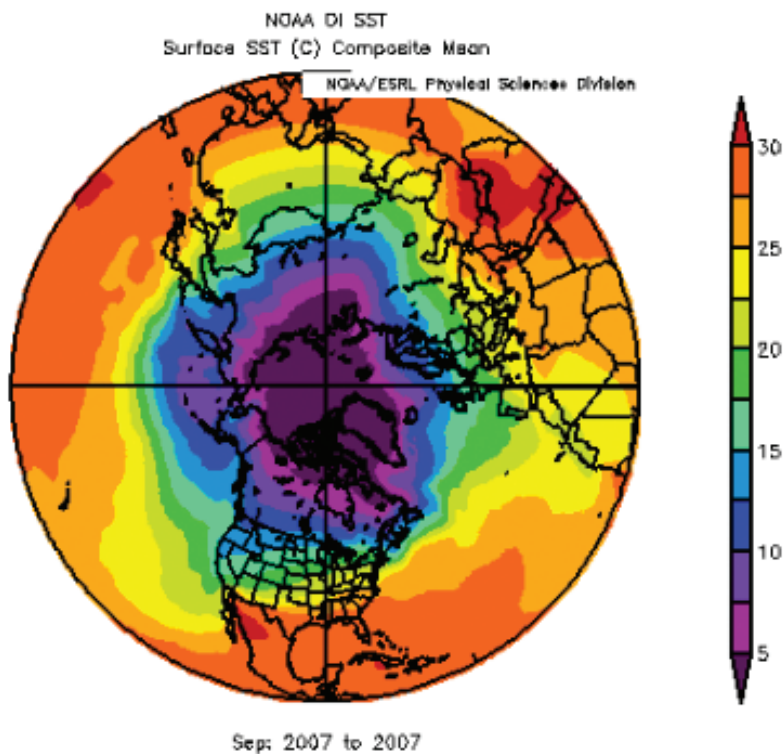


Figure 10. Mean Sea Surface Temperatures, Northern Hemisphere, September 2007

Part 3 - Exploring Time Series Plots

Goals:

Students will explore Time Series Plots and raw data to aid in their understanding of the role of sea surface temperature increases on arctic ice melt. This activity builds on the knowledge gained in Using Data and Images to Understand Albedo. Note: these instructions apply to the current NOAA Earth System Research Laboratory Web site.

Procedures:

1. Have students go to the NOAA Earth System Research Laboratory Web page at: www.cdc.noaa.gov/Timeseries
2. Select “NCEP/NCAR Reanalysis monthly means” (A in Figure 10) and click on the “Go to Selection Options” button (B in Figure 10).

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NOAA Earth System Research Laboratory
Physical Sciences Division

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Timeseries Extraction Information

In order to help ensure that this web analysis page remains available, we would greatly appreciate feedback on its use, particularly in the classroom, for presentations or for research. Mail to (esrl.psd.data@noaa.gov).

Which Dataset?

Dataset Name	Time Range	Information
<input checked="" type="radio"/> NCEP/NCAR Reanalysis monthly means	1948-Jan 2010	INFO
<input type="radio"/> NCEP/DOE AMIP-II Reanalysis monthly means	1979-2007	INFO
<input type="radio"/> Interpolated OLR	1974-Feb 29 2008	INFO
<input type="radio"/> US Climate Division: temperature, precipitation and Palmer Drought Severity Index (PDSI)	1895-Jan 2010	INFO
<input type="radio"/> Kaplan SST	1856-Jan 2006	INFO
<input type="radio"/> U of Delaware Precipitation	1856-2006	INFO

A → **B**

Figure 11. Web page at NCEP/NOAA for creating Time series plots

3. Students should make the following changes to the default selections (See Figure 12):
 - a. Change “Geopotential Height” to “SST”;
 - b. Change “1000mb” to “Surface”;
 - c. Change Latitude from “0” to “0” to “75” to “85”;
 - d. Change Longitude from “0” to “0” to “140” to “200”;
 - e. Click the “Seasonal average” radio button;
 - f. Change First Month of season to Jan (January), the second month to Mar (March);
 - g. There are two methods of plotting these data:
 - i. Selecting “Raw data values” and placing them into a spreadsheet tool, or
 - ii. Selecting “Plot data” and allowing the Web site to plot these data;
 - h. Click on “Create Timeseries”;
 - i. If you choose the “Plot data” your students should see an image such as in Graph 3.

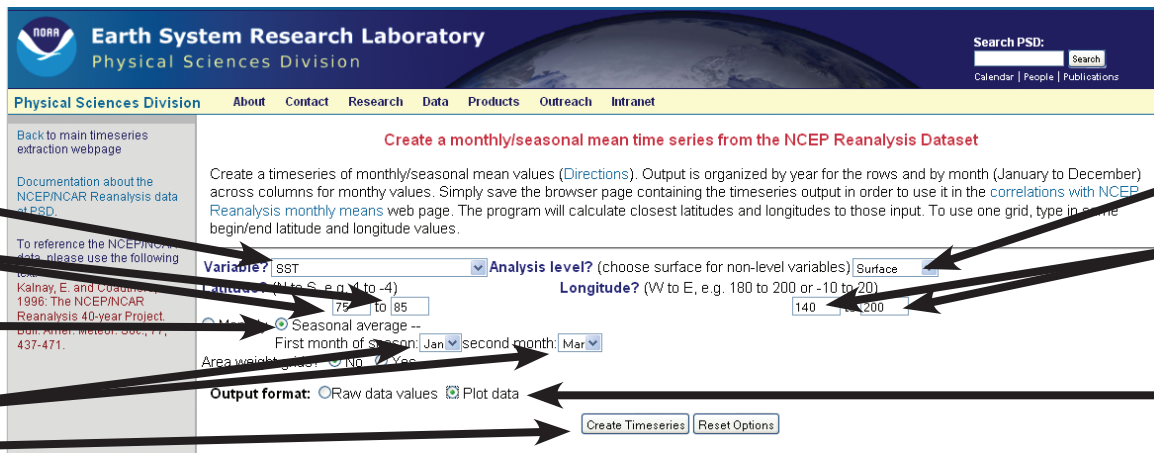
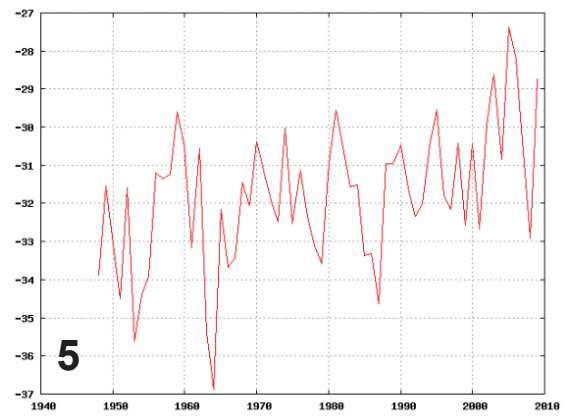
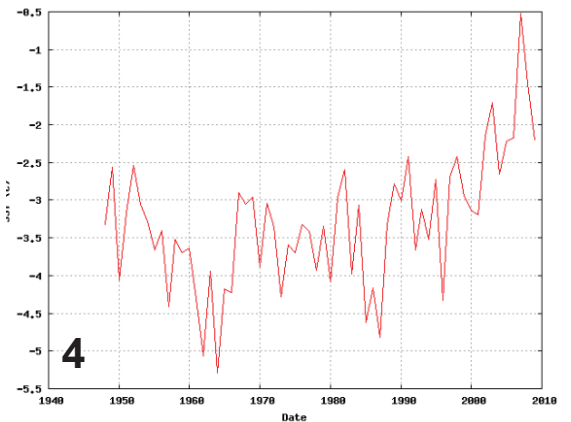
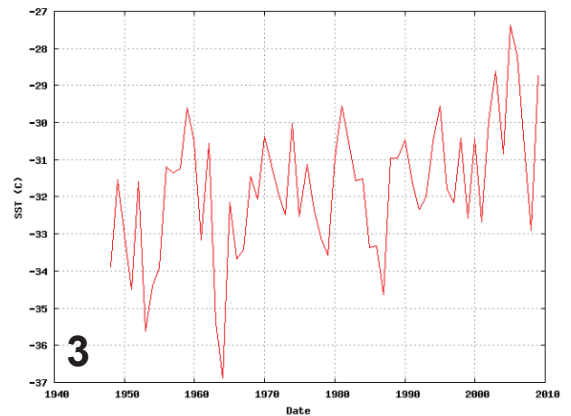


Figure 12. Web page at NCEP/NOAA with changes to default values

4. Have students explore Graph 3; what is the trend of the data?
5. Have students click on the Back button (values should remain as changed);
6. Have students change First Month of season to Jul (July), the second month to Sep (September);
7. If you choose the "Plot data" your students should see an image such as in Graph 4.
8. Have students compare graphs from January-March with July-September. What differences do they notice (Ensure that they notice the different scales for sea surface temperature). Which month of the three-month July-September season do they think would be warmest? Have the students discuss their hypotheses.
9. Have students click on the Back button;
10. Have the students change both first month and second month to Sep;
11. If you choose the "Plot data" your students should see an image such as in Graph 5.
12. Ask students why they think September sea surface temperatures would be warmer than July or August?

Two applicable learning activities, located in the GLOBE Teacher's Guide (www.globe.gov/tctg/tgtoc.jsp), may help students understand warming and cooling time of land versus water:

- a. Land, Water, Air (Atmosphere Chapter)
- b. Seasonal Change on Land and Water (Seasons and Phenology Chapter)



Graphs 3, 4 and 5. Time series of average seasonal (January to March - 3; July to September - 4; and September to September - 5) Sea Surface Temperature from 1948 to 2007

Part 4 - Using Data to Understand Polar Changes

Goals:

Students will analyze regions of sea ice using data and ImageJ software.

Procedures:

1. Have students go to the “Whither Arctic Sea Ice?” Earth Exploration Toolbook (EET) chapter (<http://serc.carleton.edu/eet/seaice/index.html>) and download sea ice data from NSIDC (<http://nsidc.org>; see exact url for data download in the EET chapter). A good example is the large amount of open water in the western Arctic during the 2007 summer season (June – October).
2. Albedo is estimated based on standard reference albedos for sea ice in varying months (June, July = 0.7; August = 0.6, September = 0.5) and for ocean (albedo = 0.08). The “effective albedo” can be an area-weighted estimate based on the proportion of ice and water in a given region. The albedo estimate can be very crude or more realistic based on real data.
3. Based on the “effective albedo” from the amount of sea ice and water, along with the incoming solar energy, estimated from The GLOBE Earth System Poster (or the online images), students can estimate how much energy is absorbed and compare an anomalous event, such as summer 2007, with normal conditions or other years.

Plotting data with ImageJ software: Plots can be made that compare solar energy and surface area of ice to water by month. An example plot is shown below in Figure 13.

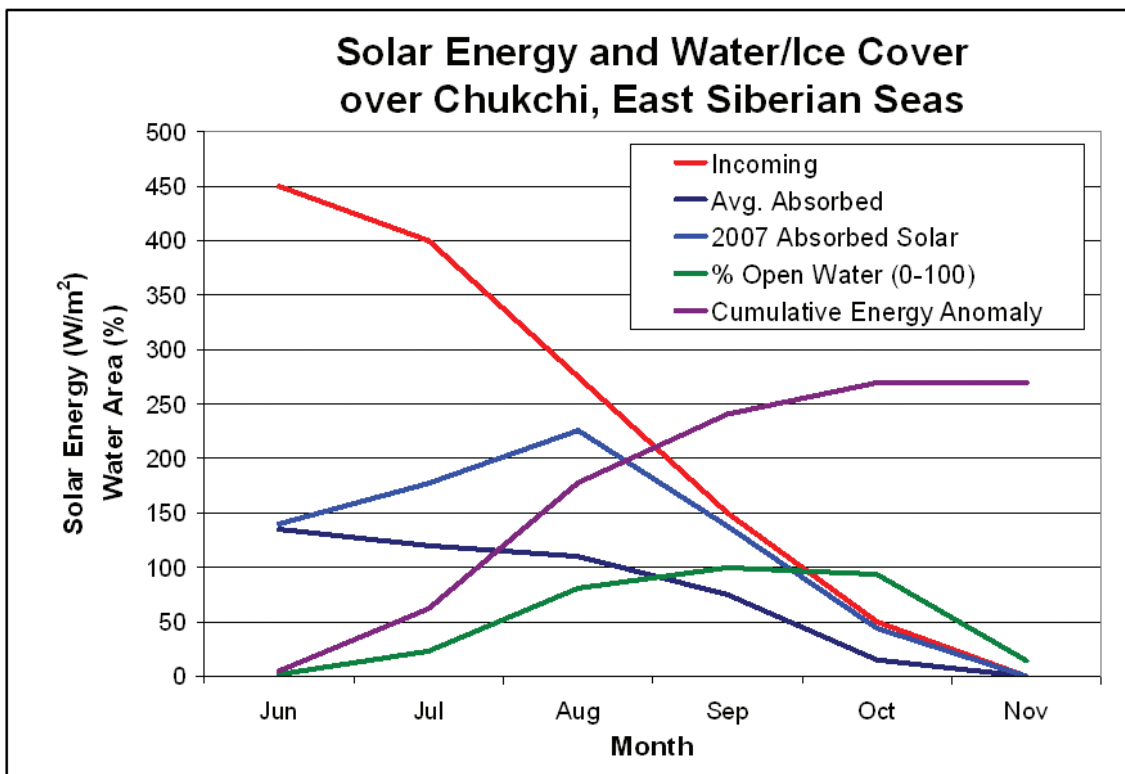


Figure 13. Changes in Solar Energy and Water/Ice Cover percentages

Further Studies:

1. Visit <http://nsidc.org/seaice/environment/index.html>
Explore the “*Indigenous People*” and “*Wildlife*” tabs;
2. Visit the International Polar Year Web site: www.ipy.org

Aerosols Information Page

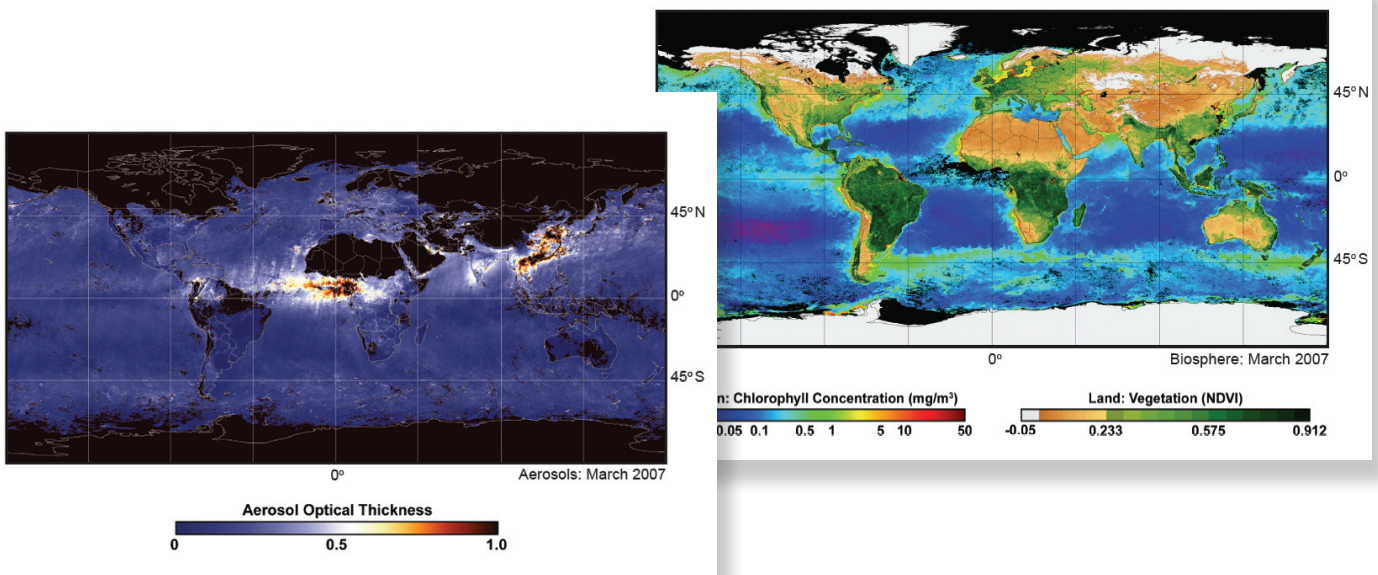
The atmosphere is made up of molecules of gas as well as small solid and liquid particles suspended in the air, called aerosols. Some aerosols are naturally produced from volcanoes, sea spray, sand, or wind-driven erosion of surface soil. Some aerosols are the result of human activity, such as dust from agricultural activities, smoke from burning plants and fossil fuels and smog due primarily to vehicle emissions. Small water droplets and ice crystals are also considered aerosols.

Most aerosols are in the troposphere, but large volcanic eruptions can send aerosols and trace gases much higher into the stratosphere, sometimes cooling surface air temperatures around the world for years at a time. Aerosols in the stratosphere may remain for years while in the troposphere, precipitation and interactions with Earth's surface usually remove aerosols in usually less than two weeks.

While aerosols are too small to see individually, when combined in the atmosphere they make the sky look hazy or dirty. Orange or red-orange skies at sunrise or sunset can also indicate aerosols in the atmosphere – between the viewer and the horizon.

Aerosols also influence Earth's weather and climate; they affect the amount of sunlight reaching the planet's surface by reflecting and absorbing light. Burning of biomass, wood and other plant material, causes an increase in local aerosol concentrations that can affect weather regionally. Aerosols are also very mobile, carried by the wind and therefore able to cross oceans and mountain ranges. Dust storms in Northern Africa often cross the Atlantic Ocean depositing dust and other particulates as far West as the Caribbean Sea and the Gulf of Mexico.

For more information, see the NASA TERRA Aerosols Fact Sheet at:
<http://terra.nasa.gov/FactSheets/Aerosols>



Additional On-line Resources

Visit other GLOBE Earth System Poster resources (including the 1997 GLOBE Earth System Poster, activities and online animations of all 12 months) at:

www.globe.gov/page?earth_system.

Visit the NASA Earth Observations (NEO) Web site to explore other fascinating satellite images at:

<http://neo.sci.gsfc.nasa.gov>.

Visit the NASA Earth Observatory Web site for additional images, references, mission information, experiments at: <http://earthobservatory.nasa.gov>;

the Image Composite Editor (ICE) for advanced image processing and data analysis at:

http://earthobservatory.nasa.gov/Laboratory/ICE/ice_intro.html.

Visit the NASA IMAGERS Web site and Teacher's Guide on IMAGERS – Unit II: Remote Sensing to explore remote sensing and satellite imagery at:

<http://science.hq.nasa.gov/kids/imagers/teachersite/RSi.htm>.

Visit the NASA Goddard Institute for Space Studies for a lesson on Studying Clouds from Space at:

<http://icp.giss.nasa.gov/education/cloudintro/page6.html>.

For additional information on Earth system topics, visit the GLOBE Teacher's Guide specifically the Earth as a System chapter at:

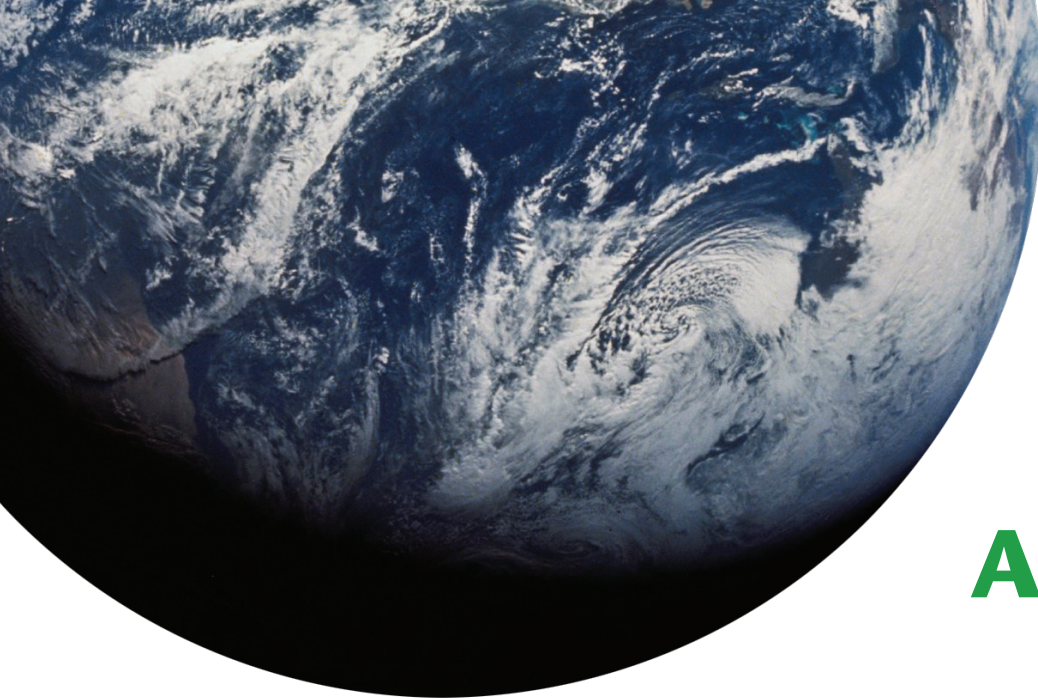
www.globe.gov/tctg/tgtoc.jsp.

Additional information on Sea Surface Temperature can be found at:

www.csc.noaa.gov/crs/cohab/hurricane/sst.htm.

Cloud Fraction information can be found at the Earth Observatory Web site:

http://earthobservatory.nasa.gov/Observatory/Datasets/cldfrc.isccp_c2.html.



Appendix

A - Information on the Earth System Data and Imagery

Insolation

Insolation (incoming solar radiation) is the rate of incoming sunlight reaching the Earth's surface measured in Watts per square meter (W/m^2). The amount of solar energy reaching the Earth's surface varies due to air molecules, cloud and aerosols. These images are derived from measurements of radiant energy escaping the top of Earth's atmosphere by the CERES instrument aboard NASA's Terra and Aqua satellites.

Credit and contact information:

Imagery by Jesse Allen, NEO Team, based on FLASHFlux data produced using CERES observations combined with MODIS measurements. Data provided by the FLASHFlux team, NASA Langley Research Center.

MODIS: Moderate Resolution Imaging Spectroradiometer (<http://modis.gsfc.nasa.gov>)

FLASHFlux: Fast Longwave And SHortwave Radiative Fluxes (<http://flashflux.larc.nasa.gov>)

CERES: Clouds and Earth's Radiant Energy System (<http://science.larc.nasa.gov/ceres>)

NEO: NASA Earth Observations (<http://neo.sci.gsfc.nasa.gov>)

Surface Temperature

Surface Temperature images are a compilation of Land Surface Temperature (LST) and Sea Surface Temperature (SST) images measured in degrees Celsius ($^{\circ}C$). LST is measured by MODIS (Moderate Resolution Imaging Spectroradiometer) aboard NASA's TERRA satellite, while SST is measured by AMSR-E (Advanced Microwave Radiometer for EOS) aboard NASA's Aqua satellite. AMSR-E's analysis product is able to merge data from AMSR-E (which has microwave ability to see through cloud cover), MODIS (which has higher spatial resolution, but cannot measure through clouds), and TMI.

Credit and contact information:

LST images by Reto Stockli, NEO Team, using data provided by the MODIS Land Science Team; SST images by Jesse Allen, NEO Team, and using SST data from the (AMSR-E), courtesy Dr. Chelle Gentemann, RemSS.

MODIS: Moderate Resolution Imaging Spectroradiometer (<http://modis.gsfc.nasa.gov>)

AMSR-E: Advanced Microwave Radiometer for EOS (www.ghcc.msfc.nasa.gov/AMSR)

TMI: TRMM Microwave Imager (<http://trmm.gsfc.nasa.gov/>) RemSS: Remote Sensing Systems (www.remss.com)

NEO: NASA Earth Observations (<http://neo.sci.gsfc.nasa.gov>)

Cloud Fraction

Cloud fraction is the portion of Earth's surface covered by cloud relative to the portion of Earth not covered by cloud expressed in a percentage (%). Cloud fraction is measured using MODIS (Moderate Resolution Imaging Spectroradiometer) aboard NASA's Terra and Aqua satellites. MODIS collects information in pixels with resolution of one square kilometer. Scientists count the number of pixels that are cloudy in a 25-square-kilometer area and dividing that number by 25.

Credit and contact information:

Images by Reto Stockli, NEO Team, using data provided by the MODIS Atmosphere Science Team.

MODIS: Moderate Resolution Imaging Spectroradiometer (<http://modis.gsfc.nasa.gov>)

NEO: NASA Earth Observations (<http://neo.sci.gsfc.nasa.gov>)

Total Rainfall

Total Rainfall is derived from data collected by the Precipitation Radar instrument aboard the Tropical Rainfall Measuring Mission (TRMM) measured in millimeters (mm). TRMM is a joint mission sponsored by NASA and the Japanese Space Agency (JAXA). TRMM's orbit is near the equator, so its field of view is limited to Earth's tropical and sub-tropical regions--between 35 degrees North and South Latitude; therefore, TRMM cannot measure rainfall at high latitudes or in Earth's Polar Regions.

Credit and contact information:

TRMM images provided by NASA Goddard Earth Sciences DISC, based on data from NASA and the Japanese Space Agency

(JAXA). TRMM: Tropical Rainfall Monitoring Mission (<http://trmm.gsfc.nasa.gov>)

NEO: NASA Earth Observations (<http://neo.sci.gsfc.nasa.gov>)

Aerosols

Aerosols are small solid and liquid particles suspended in the air. Aerosol Optical Thickness (AOT) is determined by the amount of visible and near-infra-red light reflected back into space by particles in the atmosphere – or a measure of how much light these airborne particles prevent from traveling through the atmosphere to the surface of the Earth. Aerosols data includes optical thickness and size distribution of aerosols over most of the globe on a daily basis. This information is used to study aerosol climatology, to monitor the sources and sinks of specific aerosol types (such as industrial/urban aerosols and biomass burning aerosols), to serve as inputs for climate modeling and detection of the finger prints of anthropogenic climate change, and to perform atmospheric corrections of remotely-sensed surface reflectance over the land. Aerosols are measured using MODIS (Moderate Resolution Imaging Spectroradiometer) aboard NASA's Terra satellite.

Credit and contact information:

Images by Reto Stockli, NEO Team, using data provided by the MODIS Atmosphere Science Team.

MODIS: Moderate Resolution Imaging Spectroradiometer (<http://modis.gsfc.nasa.gov>)

NEO: NASA Earth Observations (<http://neo.sci.gsfc.nasa.gov>)

Biosphere

Biosphere images are composed of Chlorophyll Concentration and NDVI (Normalized Difference Vegetation Index) images. Chlorophyll α (alpha) is a pigment found in phytoplankton (tiny aquatic organisms). Its concentration, measured in milligrams per cubic meter (mg/m^3) is used as an index of phytoplankton biomass and, is a key input to primary productivity models. MODIS, aboard NASA's Aqua satellite, measures chlorophyll α daily over the entire planet. NDVI images show a global measure of the "greenness" of vegetation (ranging from - 0.1, low vegetation, to 0.9, maximum detectable vegetation) across Earth's landscapes for a given composite period. These images are accurate measures of vegetation activity (chlorophyll concentration) at the land surface. NDVI images were made using data collected by the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Terra satellite. As plants, both aquatic and terrestrial, grow they take in carbon dioxide during photosynthesis.

Credit and contact information:

Chlorophyll Concentration images by OceanColor Web, G. Feldman and N. Kuring; NDVI images by Reto Stockli, NEO Team, using data provided by the MODIS Atmosphere Science Team.

MODIS: Moderate Resolution Imaging Spectroradiometer (<http://modis.gsfc.nasa.gov>)

NEO: NASA Earth Observations (<http://neo.sci.gsfc.nasa.gov>)

B - Creating Graphs of Data in Polar Regions

GLOBE school on Antarctica

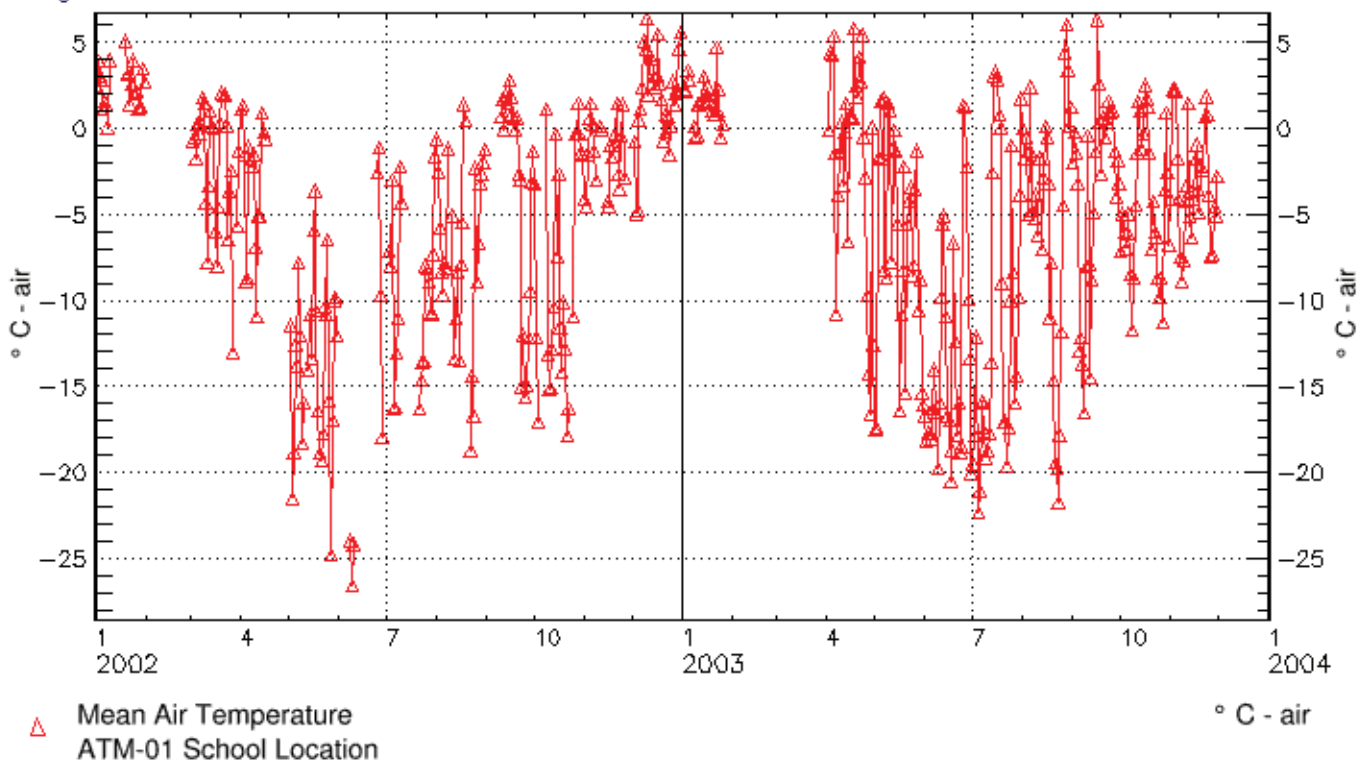
Procedures:

1. From the GLOBE Home Page, www.globe.gov, place your mouse cursor over *For Students*; move the cursor down to highlight *Maps and Graphs*; move the cursor over to highlight *Graphs*; click on *Graphs*.
2. Highlight *AR - Argentina* from the Country list under *School Location Country Search*.
3. Scroll down until you see the *NUMBER OF DATA REPORTS* section. Type 3000 in the first box under *Find schools that have submitted at least:*
4. Click on the *Total* box and select *All Atmospheric Data* and click on *Go*.
5. Place a checkmark by *Escuela Provincial No. 38 Julio Argentina Roca, a GLOBE school in Esperanza, Antarctica, hosted by Argentina*, by clicking in the square next to the school name and click on *Go* in the green box next to "Make a Graph" above the table of schools.
6. Scroll down below the graph until you see *Graph Data and Display Selection*. Change the **Dates** as follows: Year: *2002*; Month: *01*; Day: *01* through Year: *2004*; Month: *01*; Day: *01*.
7. Under the *Datasets (choose up to 6)* option, click on *Mean Temperature*. Click on *Redraw*.

The resulting graph should appear as below:



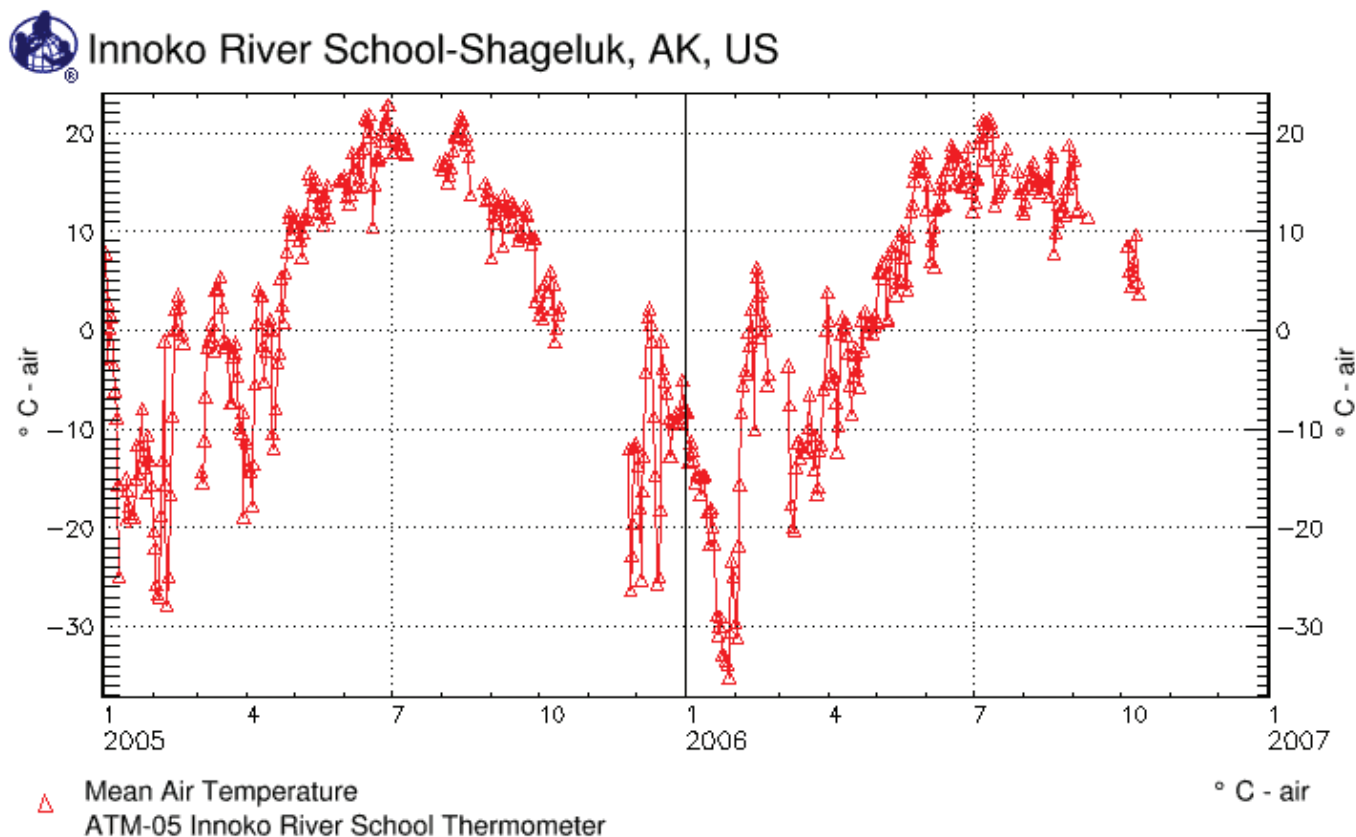
Escuela Provincial No. 38 Julio Argentina Roca, a GLOBE school in Espe



GLOBE school in Alaska

Procedures:

1. From the GLOBE Home Page, www.globe.gov, place your mouse cursor over For Students; move the cursor down to highlight Maps and Graphs; move the cursor over to highlight Graphs; click on Graphs.
2. Highlight US – United States of America from the Country list under School Location Country Search. Click on State/Province Search*
3. Highlight US AK – Alaska from the State/Province list under School Location State/Province Search.
4. Scroll down until you see the NUMBER OF DATA REPORTS section. Type 3000 in the first box under Find schools that have submitted at least:
5. Click on the Total box and select All Atmospheric Data and click on Go.
6. Place a checkmark by Innoko River School, Shageluk, AK, by clicking in the square next to the school name and click on Go in the green box next to “Make a Graph” above the table of schools.
7. Scroll down below the graph until you see Graph Data and Display Selection. Change the **Dates** as follows: Year: 2005; Month: 01; Day: 01 through Year: 2007; Month: 01; Day: 01.
8. Under the Datasets (choose up to 6) option, click on Mean Temperature. Click on Redraw.
The resulting graph should appear as below:



For additional activities using GLOBE Data, see Understanding GLOBE Student Data at:
<http://viz.globe.gov/globe/en/docs/UnderstandingGLOBEStudentData.pdf>

Acknowledgements

This guide and the accompanying poster are the result of collaboration by many people. The GLOBE Program Office would like to thank all those who have been involved in the development of the GLOBE Earth System Poster and Guide. First, to our many colleagues and friends at NGDC (National Geophysical Data Center), who created the first poster in 1997 and used 1987 satellite and model data. The original poster soon had an accompanying set of activities, developed by our colleagues and friends at TERC, to assist teachers in Earth system education. This early poster and activity set has helped hundreds of thousands of students around the world to better understand Earth system connections.

The GLOBE Program Office initiated discussions on the feasibility of a new Earth System poster in 2007. The development team began with input from GLOBE's international community of partners, educators, and scientists on how to improve an already exceptional product. Soon, Mr. Frank Niepold, at the NOAA Climate Program Office and a long-time GLOBE teacher, trainer and supporter, joined the discussion, bringing with him Mr. David Herring, also at the NOAA Climate Program Office. NASA's Earth Observations Web site became a focal point in our collective search for images to populate the new poster and Mr. Jesse Allen and Mr. Kevin Ward, of NASA Earth Observations, soon joined the collaborative team. Dr. Walter Meier, at the National Snow and Ice Data Center, contributed to the Sea Ice extension activities.

A special thank you is due the NASA science teams, satellite engineers and Principle Investigators (PIs), who designed the data-gathering instruments, followed by the computer scientists who then turned these data into the incredible images available on the NEO Web site and used on the GLOBE Earth System Poster. This product is truly a collaborative effort and appreciation is extended to all those involved.

The satellite imagery displayed in the GLOBE Earth System poster can be visualized (as well as various other satellite and model imagery) on a two-meter diameter sphere, known as Science On a Sphere (SOS). For more information, including SOS locations worldwide, visit <http://sos.noaa.gov>. Attending a Science On a Sphere presentation following or preceding an exploration of the Earth System poster activities may engage students in better understanding of Earth system processes.

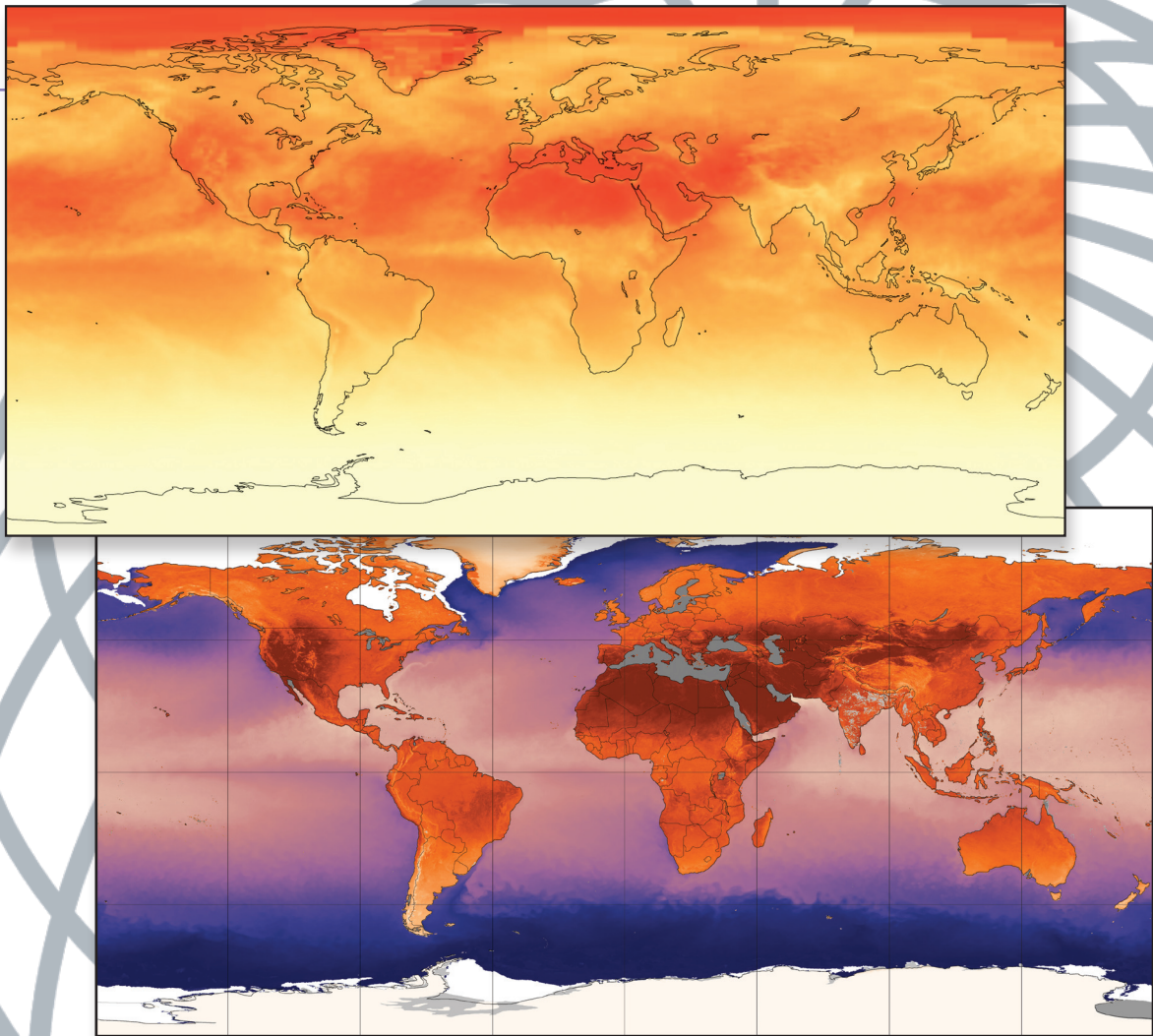
Much appreciation is also extended to the NASA SMD Earth Science Education Product reviewers, other informal reviewers and to Ms. Melinda Merrill, the 6th and 7th grade science teacher at Estes Park School in Estes Park, Colorado, for allowing us to photograph her students engaged in these activities.





The **GLOBE** Program

GLOBE (Global Learning and Observations to Benefit the Environment) is a worldwide hands-on, primary and secondary school-based science and education program. GLOBE's vision promotes and supports student, teacher and scientist collaboration on inquiry-based investigation of the environment and the Earth system. The Earth System Poster was jointly developed by NASA Earth Observations (NEO), NOAA Climate Program Office and the GLOBE Program Office.



www.globe.gov

