MODEL RESEARCH INVESTIGATION

EXPEDITION EARTH AND BEYOND

STUDENT SCIENTIST GUIDEBOOK

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Student Scientist Guidebook

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EXPEDITION EARTH AND BEYOND

Student Scientist Guidebook

The *Expedition Earth and Beyond Student Scientist Guidebook* is designed to help student researchers model the process of science and conduct a research investigation. The *Table of Contents* listed below outlines the steps included in this guidebook.

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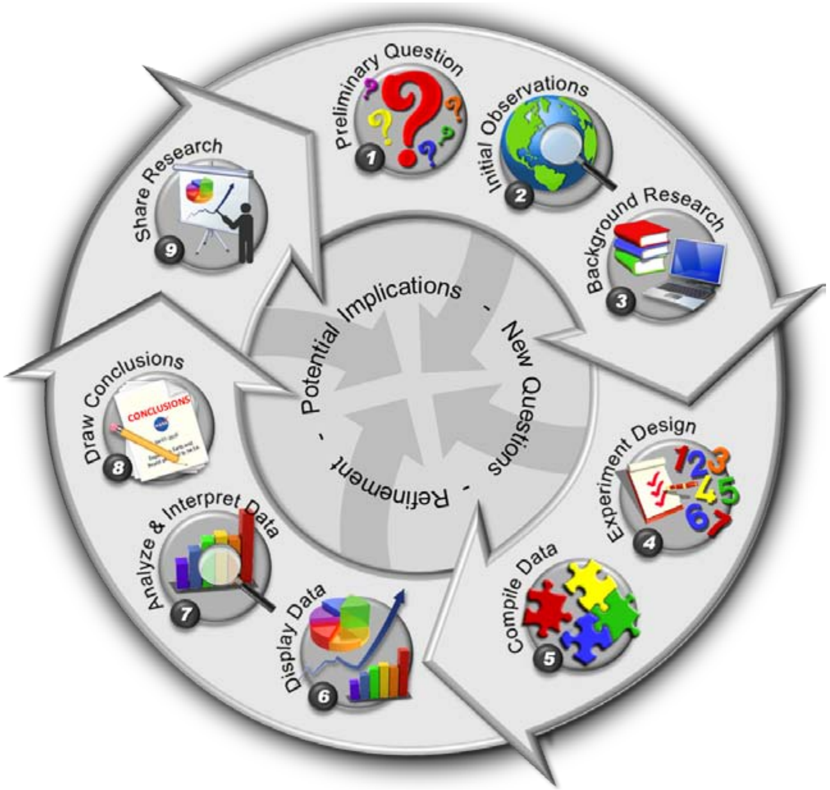
EXPEDITION EARTH AND BEYOND
Student Scientist Guidebook

GET ACTIVELY INVOLVED IN NASA EXPLORATION, DISCOVERY, AND THE PROCESS OF SCIENCE
As you begin your expedition of conducting research about Earth and/or a planetary comparison, it will be helpful to use the 9-step process of science as a guide. It is a good idea to take a look at each step of this process as a quick preview, to make sure you know what to expect as you get started with your investigation.

OVERVIEW OF THE PROCESS OF SCIENCE
The steps and activities in this *Student Scientist Guidebook* will provide strategies for you to use as you conduct your research investigation. This 9-step process models what scientists do as they conduct their own research.

The process of science is an iterative process. Throughout each step, your team should focus on your research question which you may refine and change more than once. As you gather background research, this will help you finalize your research question and decide on the methods (experiment design) your team will use to collect, display, and analyze data to help you draw conclusions about your research. Although your research should focus on something very specific, make sure you think about the bigger picture. This includes thinking about potential implications of your research -- how what you are researching may help you (or others) gain a better understanding of processes on Earth and/or other planetary bodies.



A model of the process of science

The nine steps in this iterative process of science are described below:

STEP 1: Preliminary Question All science begins with observations that lead to a question. This preliminary question evolves from your observations, ideas, or prior knowledge and curiosity you may have about a particular topic. This helps drive what you want to investigate.

STEP 2: Initial Observations You must make initial observations and formally log data to figure out what details or characteristics of a feature(s) you may be interested in investigating. These observations will help you refine your question and formulate an initial hypothesis.

STEP 3: Background Research Background research from books, scientific journals, magazines, the internet, or scientists is essential to help you understand what is already known about what you may be researching. It is important to keep track of sources you use as part of your research so you can cite them appropriately.

STEP 4: Experiment Design With your developing knowledge and observations, you will likely adjust and refine your preliminary question. Once you "finalize" your question, you must decide on a strategy to answer your question. This strategy includes a list of steps or methods to gather data consistently. This is called an experimental design.

STEP 5: Collect and Compile Data Collecting and compiling data is extremely important. You must make sure everyone is logging the same data and recording it consistently. Once team members have collected data, it needs to be compiled so all the data can be displayed and later analyzed. The more data you have, the better your conclusions.

STEP 6: Display Data Displaying your data helps you organize it. Data can be displayed in tables, in graphs, on maps, or even as annotated or captioned image illustrations. General observations of data displays help you think about general trends the data are showing.

STEP 7: Analyze & Interpret Data Using the knowledge you have gained, along with observations from your data displays, you will be able to analyze your data. This will help you interpret or make sense of what the data mean and how it applies to your question and hypothesis.

STEP 8: Draw Conclusions Once you have analyzed your data you will be able to draw conclusions. This includes answering your question as well as deciding if your hypothesis was supported or refuted.

STEP 9: Share Research Publishing or presenting your science research (even to your classmates) is an extremely important part of science. Sharing your discoveries will allow others to learn from and build on your previous research.

Your contributions to science and the implications of your research can help drive future work that needs to be done. Your research will likely spark new questions you or someone else may want to investigate. New knowledge helps drive new science. Science is ongoing and continual as shown in the model of the process of science on page 3.

As you conduct your investigation, be sure to always focus on your scientific question. This question must drive every aspect of your research as you go through the process of science.

BEGINNING THE PROCESS OF SCIENCE – CONDUCTING YOUR RESEARCH

STEP 1: Preliminary Question

Everyone observes and learns from personal experiences. Based on your experiences, in the space below, list what you may know about studying features on Earth with images taken from space.

You can see the difference between inhabited areas and natural areas because of regular shapes in inhabited areas.

You can tell the differences in the depth of water based on the color of the water. Light blue water is usually shallow. The darker the blue, the deeper the water. Brown, green, or yellow colors in the water are usually due to sediments and/or organic matter in the water.

When you use different lenses on the camera, you get very different views of the surface. Longer focal length lenses show small areas up close. Shorter focal length lenses show large areas in less detail.

Discuss the information you listed with your group. Based on your group discussion, fill out the table below. List three specific features you think would be interesting to study, the associated Earth System (biosphere, atmosphere, hydrosphere, or geo/lithosphere) and describe or list a specific aspect or characteristic of each listed feature.

Feature	Earth System	Describe or list a specific aspect or characteristic of this feature.
Volcano	Lithosphere	• Locations of most volcanoes • Lava flows • Volcano types
Glacier	Hydrosphere	• Features/characteristics of glaciers • Changes in glaciers • Glaciers of South America • Other places glaciers are found • Melting glaciers
Coastlines	Hydro/Lithosphere	• Beaches along coastlines • Shapes of coastlines

Preliminary Questions: Based on your group discussion, create a preliminary question for each feature of interest you listed. Be sure to focus your questions on a specific aspect or characteristic of that feature that can be observed in astronaut photographs.

Feature 1: __Volcanoes_______ Aspect/Characteristic of feature: __layers of lava flows________________________
Question:____

_________Is it possible to determine the age of lava flows using astronaut photography?____________________________

Feature 2: _Glaciers______ Aspect/Characteristic of feature: __melting ____

Question:_____Can you see evidence of glaciers melting in South America?_____________________________________

____

Feature 3: _Coastlines____________ Aspect/Characteristic of feature: ___shape of the coastline__________________

Question:_How do the shapes of coastlines on the east coast of the United States compare to the shapes of coastlines on the west coast?____

Discuss these questions and others created within your group. Combine your best ideas to decide on a preliminary research question your group will explore further. Factors that may help you decide are:

- Which question is most interesting to your group?
- Which question focuses on an aspect or characteristic that can be observed in astronaut photographs?
- Which question can be successfully investigated using astronaut photographs and other data?
- Which question may be important or have a potential implication or impact for you, your class, or society?

After your discussion, write your preliminary research question. What types of changes are occurring to the glaciers found in South America? (Our group changed the original question 2 because we did not want to make the assumption that the glaciers were already melting.) ____

STEP 2: Initial Observations

Now that you have a preliminary question, you need to start making and logging observations of astronaut photographs. Astronaut photos should be your initial source of data. These observations (which are part of data gathering), will help you formulate a hypothesis as you look for patterns or trends. While making observations, you may decide to refine your question. This is a natural part of the process of science.

As you conduct your investigation, it is important to focus on your question. Write your question in the space below.

Research Question: What types of changes are occurring to the glaciers found in South America?

As you work to complete Step 2 of the process of science, you will do the following: A) List sources where can you find astronaut photos, B) Consider what data and observations you will log, C) Create an initial data table, D) Log your initial observations, E) Formulate a hypothesis, and F) Discuss and debate the team research question.

A. FINDING ASTRONAUT PHOTOGRAPHS

Below is a list of two sources where you can find astronaut photos. As you find additional sources, add those to your list.

Source #1:

- Website name: Expedition Earth and Beyond Quick List of Images
- Website link: http://ares.jsc.nasa.gov/ares/eeab/atmosphere.cfm

Source #2:

- Website name: Gateway to Astronaut Photography of Earth
- Website link: http://eol.jsc.nasa.gov

Source #3: List an additional source you may use.

- Website name: ________NASA Earth Observatory____
- Website link: _http://earthobservatory.nasa.gov/____

Source #4: List an additional source you may use.

- Website name: ______The LANDSAT Program____
- Website link: _______http://landsat.gsfc.nasa.gov/____

Feel free to list other sources you want to explore.

B. CONSIDER WHAT DATA AND OBSERVATIONS TO LOG

Once you know where to find astronaut photos, you need to consider what specific information to log. Each image you observe has its own unique information referred to as metadata. The following statements are designed to help you consider what metadata and other information you may want to log.

Use the word bank provided to help fill in the blanks below. Some words specific to your research might **not** be included in the word bank.

image identification number	*cameras*	*longitude*	*date*	*quantitative*
notes/comments	*qualitative*	*lenses*	*latitude*	

1. The *image identification number* is a unique identifier for every image. Logging this information will allow each image to be searched for and viewed.

2. The center _______longitude ___________ and _______latitude__________ of an image will provide you with an exact location of that image on a map of Earth.

3. Based on your preliminary question, what specific feature(s) will you look for in each image? __glaciers_________

   List others if you are looking for more than one feature. _________________________, _________________________.

4. Describe specific aspects or characteristics of this feature you will be looking to observe in images. List as many as you feel are appropriate.

   Any types of changes to glaciers over time________ Size of the identifiable features on the surface of the glacier_

   Identifiable features on the surface of the glacier _ Length and width of the glacier_________________________

   ____ ____

5. If you decide to look at changes over time in an area, it would be important to record the ____________date_________ the image was acquired.

6. There have been different hand-held _________________cameras_________________ astronauts have used to take pictures. The most recent one is the Nikon D3.

7. Astronauts can use different _____________lenses________________ on their cameras to acquire images that cover different sized areas. Images taken with longer focal lengths cover less area on the ground but have more detail. Images taken with shorter focal lengths cover more area on the ground but show less detail.

8. Scientists make observations that fall into two categories. _____________Qualitative__________ observations are observations that focus on visual or descriptive characteristics noted about an image or data. ______Quantitative________ observations are observations that focus on numeric information such as mass, distance, area, etc. Both types of observations can be useful, depending on the research being conducted.

9. It can also be useful to log additional *notes/comments* about an image that may not be part of your formal observations. This can be a statement about the image you may want to refer to at a later time.

10. Is there any other data you feel is important to log for your research? List additional data below:

    __glacier name__________ _____country_____________ _______________________________

The answers to the above statements provide important data to consider logging as you make observations of images. As you decide on other data to log, think carefully to make sure you know how you will go about collecting that data. Think about what data you need that directly relates to your specific question.

C. CREATE AN INITIAL DATA TABLE

How do you organize all this information? The simple answer is to create a data table. A data table provides a structure for you to collect consistent data for all images you observe. This will later help you as you display your data and make observations, interpretations, and ultimately draw conclusions about your question.

Read the data table tips to help you organize your initial data table.

DATA TABLE TIPS: Before you create your data table, read these tips and look at the sample table provided. These tips will help you create and refine your data table as your project evolves.

1. Consider using your responses from Part B (fill-in-the-blank statements) as column headings for your data table.
2. Each column of your data table should log one piece of data. For example, latitude and longitude should each have their own column. Do not combine this data in one column.
3. Excel or any other spreadsheet program can only "understand" number **<u>or</u>** letter data for each field. As you title any column, be careful to include the appropriate "unit" so you can log your data as a number **or** letter only.
4. If you include a latitude column in your data table, it is recommended to title this column ***Latitude (N).*** This will allow you to log your latitudes as numbers in each cell of your spreadsheet. Be aware that the *Gateway to Astronaut Photography of Earth* website lists south latitudes as negative numbers. For example, an image located at 74 south would be written as (-74). Be sure you think about how you log your south latitudes, so you can be consistent when using astronaut photographs or data acquired from other websites.
5. If you include a longitude column in your data table, it is recommended to title this column **Longitude (E).** The *Gateway to Astronaut Photography of Earth* website lists west longitudes as negative numbers. For example, an image located at 36 west would be written as (-36). Be sure you think about how you log your west longitudes so you can be consistent when using astronaut photographs or data acquired from other websites.
6. If you are looking for a specific feature, you can name the feature in the column heading along with a **(Y or N).** Let's say, for example, you are studying sand dunes. You will obviously be looking for sand dunes in each image you observe. A suggested title heading would be **Sand Dunes (Y or N)**. This will indicate that the feature was in the image (Y) or the feature was not observed in the image (N). Be consistent with how you log your data. For example, either use "Y" or write out the whole word "Yes." Consistency is essential when logging data.

DATA TABLE TIPS (*continued):*

7. Depending on what specific observation you are looking for, you should consider creating a column heading that will allow you to log a consistent one or two word (or letter) observation or number as applicable. For example, if you are looking at sand dunes and want to know the type of sand dune identified, you can title the column heading **Sand Dune Type [Barchan (B), Longitudinal (L), Star (S), None (N/A) or Unsure (U)]**. As you log your data, you can include the letter or the name of the type of sand dune identified. Just be sure to log your information consistently.

8. You may consider logging the name of the country where an image you observed is located. In this case, title the column **Country.** When you log your data, be sure to log only the country. Do not include the city, state, or continent. If you want that data recorded, it should be listed as its own column of data.

9. It is recommended to have a column in your table titled **Qualitative Observations**. This column would include information that would likely contain more than a one or two word observation. You may decide to start by logging general qualitative (descriptive) information you think is important to note. As you further your research, you may look to add in specific qualitative observations related to the specific aspect of a feature you are researching. In this column you may also consider creating a sketch. You can include this column anywhere in your data table where it makes sense to the team.

10. You may also have a column in your table titled **Quantitative Observations**. For starters, this column may include a type of measurement information you may want to explore later. Be sure to include units of measure (*Example:* km) If your team decides to include measurement or other numeric data, this at least gives you a starting point for later consideration. If you eventually decide to gather more than one type of numeric data, each type of data should have its own column.

11. It's a good idea to have a column on your data table for **notes** or **comments**. This column provides an area for you to log additional comments you may want to refer to later. For example, you may note that a particular image would be good to include as an image illustration (which will be discussed later).

Look at the sample table provided for Sand Dunes on Earth. Take note of the column headings as well as the data listed in each column. This sample table includes actual information based on real imagery. Notice that some of the image identification numbers start with ISS and others with STS. This is based on whether the imagery was taken from the International Space Station (ISS) or one of the Space Shuttle missions (STS).

SAMPLE MASTER DATA TABLE - SAND DUNES ON EARTH

Image ID#	Latitude (N)	Longitude (E)	Sand Dunes (Y or N)	Sand Dune Type (B=Barchan; L = Longitudinal, C=Crescent; S=Star; N/A = none; U = Unsure)	Country	Date Acquired	Camera	Camera Focal Length (mm)	Qualitative Observations	Quantitative Observations	Notes/Comments
STS61A-43-78	16	(-4)	Y	L	Mali	11/2/85	Hasselblad	100	Series of long dunes seen around river and lake.	None at this time but could measure the distance between dune crests.	Earth From Space Image Collection image view has best image quality.
STS085-501-14	22.5	55	Y	L	Oman	8/?/1997	Linhof	250	Very visible dunes that run up against mountains; dunes are tannish/orangish in color; near water.	None at this time but could measure the distance between dune crests.	Great detail in this image.
ISS018-E-14770	24.5	12.1	Y	S	Lybia	12/20/08	NikonD2X	400	Image only shows dunes in great detail, no other context; dunes appear orangish in color.	None at this time but could measure the distance between dune crests.	
ISS017-E-8290	23.3	30.6	Y	C	Egypt	5/31/08	NikonD2X	800	Dunes seem to be moving along the land and are near body of water; dunes are tannish in color.	None at this time but could measure the distance between dune crests.	
ISS010-E-10124	29.4	4.4	Y	U	Algeria	12/11/04	Kodak DCS760C	400	Seems to be a combination of dune types that are hard to decipher; may have flat mesas between dunes.	None at this time but could measure the distance between dune crests.	

This sample table shows a log of data and observations for five different astronaut photographs. Your team's final master data table may look similar to this but will include data from many more images logged from all team members. Keep in mind, the data you log should be based on what is appropriate for your scientific question. Be sure to log all data consistently.

Discuss options for creating your initial data table with your group. On the blank *initial data table* provided, draw in lines as necessary and write in column headings to indicate what data you will collect.

Note: Choose only headings that fit your research investigation.

INITIAL DATA TABLE					
Image ID#		**Longitude (E)**	______ (Name of Feature) **(Y or N)**		**Notes/ Comments**

D. LOGGING INITIAL OBSERVATIONS

Once you have discussed and finalized your initial data table columns and headings, **re-create your data table on a separate piece of paper or using a spreadsheet**, so you can log your data neatly, clearly, and consistently. You are now ready to look at images and log data. Go to one of the sources listed and log observations from 5-10 images on your neatly drawn table.

See initial data table labeled "Initial Data Table 1 – Glaciers in South America" (page 14 Part D).

E. HYPOTHESIS DEVELOPMENT

Once you have made 5-10 initial observations, think about your question. Are you noticing any patterns or trends? You should be able to make an educated guess about how the processes related to the feature you are investigating may work. This educated guess about the answer to your question is called a hypothesis. A hypothesis should be formulated based on information and observations that can support it. Your hypothesis should also be testable. To help you formulate your hypothesis, complete the following:

1. What is your preliminary research question?__What types of changes are occurring to the glaciers found in South____

America?____

____

Initial Data Table 1 - Glaciers in South America

Image ID Number	Glacier Name	Date Image Was Taken (YYYYMMDD)	Latitude (N)	Longitude (E)	Country	Lens Size (mm)	Qualitative Observations
ISS022-E-073075	Upsala	20100225	-49.9	-73.3	Argentina	800	Moraine is apparent, glaciers feed into glaciers, lots of calving, some sides more than others.
ISS010-E-5807	Upsala	20041104	-50	-73	Argentina	180	Some calving, moraine evident, several glaciers joined into one.
ISS022-E-78363	Viedma	20100226	-49.5	-73	Argentina	800	Dark lateral streaks along the top of the glacier, terminus appears fairly straight across, cloud shadows appear over glacier, and ice appears separated by water from south fork glacier terminus – possibly calved off glacier.
ISS001-E-5108	Viedma	200012_	-49.5	-73	Argentina	400	Dark lateral streaks along the top of the glacier, terminus appears convex with outward bulge near the center, and cloud shadows appear over glacier.
ISS008-E-13260	Perito Moreno	20040127	-50.5	-73	Argentina	800	In this image the glacier is crushed against the side of the "island" completely. The two branches of Perito end at lakes. The lakes have very different colors. Why are the colors so different?
ISS015-E-19983	Perito Moreno	20070728	-50.5	-73	Argentina	800	Obvious evidence of calving at the terminus. There is actually a ring of material at the edge. Is this one feature or a series of icebergs linked together?
ISS014-E-14359	Chico	20070217	-49	-73	Argentina	180	Great overall view of the area. The general shape of the moraines can be seen in Chico. You can also see the terminus of the glacier and the muddy lake ending in a huge obstruction at the end of the valley.
ISS008-E-18428	Chico	20040312	-49	-73	Chile	370	Good view of the blockage seen at the end of the lake. After this barrier the color of the water changes from grey to blue.
ISS0014-E-10766	Grey	20061225	-51	-73	Chile	180	Great overall view of the area shows the grey color of Grey's runoff, while the glacier to the right has a blue color to the runoff.
ISS004-E-9281	Grey	20020401	-51	-73	Chile	180	Overall view of the area showing all of the glaciers.

2. Based on your current observations, what is your hypothesis (educated guess about the answer to your question)?

All glaciers in South America will be retreating. ____

____

3. What other knowledge do you have that directly supports this hypothesis? ____We have read information about___ climate change in class that talks about warming temperatures on Earth. This information would support our hypothesis that all these glaciers will be retreating. ____

F. DISCUSSION AND DEBATE OF TEAM RESEARCH QUESTION

At this point you have formulated a question, logged initial observations, and formulated a hypothesis. Depending on how your teacher has structured your class participation, other groups in your class will have done the same. It is now time to discuss and debate with your class to decide what question the class should focus on as a team. If you are working in mini research groups, you will need to decide what specific question to research. Use the information below as a guide to discuss and debate. Be sure to have a compelling argument to convince your teammates that your question is the best to focus on for the team investigation:

DISCUSSION AND DEBATE CONSIDERATIONS:

- **Preliminary Question:** Refine your question so it is focused on a very specific detail related to the feature you are interested in researching. Make sure that detail is visible in astronaut photos.
- **Data Collection Methods:** List the specific data needed to be collected/logged from each image observed to help you answer your question.
- **Other Comments:** Think about other comments you want to make to the class/group. Is this project easily doable? What makes this question interesting? Does it relate to something you are already studying in class? Are there important implications of your study for you, your class, or society?

Student Presentation Guide: Be sure you are prepared to convince the class or your research group that your preliminary research question should be the focus for the class research investigation.

REFINED PRELIMINARY QUESTION	What types of changes are occurring to the glaciers found in South America?
DATA COLLECTION METHODS **(Include a bulleted or numbered list)**	• Image ID # • Glacier Name • Date Image was Taken • Latitude • Longitude • Country • Lens Size • Qualitative Observations
OTHER COMMENTS	Researching this question will help to answer if the glaciers are shrinking. If the glaciers are shrinking, how much longer will they be around? We wonder how this will impact the water levels on Earth. We also think this might provide information related to climate change.

As each group/individual presents their information, take notes so you can think about which project would be best for the class to research as a team. At the end of all group presentations you will need to discuss, debate, and vote on which project should be the focus for the class or mini research group project.

After the discussion, debates, and voting process, list the final question the class/group has decided to research: ________ ___What types of changes are occurring to the glaciers found in South America?___________________________________

As a team, discuss the list of data you will need to collect and log from each image observed. Make sure everyone knows where to find each piece of data. It is also important to know why and how that data is essential to collect for your project.

Fill out the table below to help make sure everyone understands the importance of the data being collected as part of your research. (Use additional paper as necessary.)

Specific Data/Metadata You Will Log	Brief Explanation of Importance of this Data for Your Research
Image ID Number	This will allow us or anyone else to find this image again.
Glacier Name	This will allow us to keep our data organized as well as help us to refer back to the image. We can also research information on each glacier.
Date Image Was Taken	We will be able to compare images and look for changes over a period of time.
Latitude	This along with longitude will help us to identify the location of the image.
Longitude	This along with latitude will help us to identify the location of the image.
Country	We will be able to better understand the location of the feature we are studying.
Lens Size	This provides us with information about the camera lens that was used to capture the image. It gives us a rough idea of the level of detail in the image.
Qualitative Observations	This information will help us determine what features and characteristics can be seen in the image to further our study.

Remember the initial data table you created in Part D (page 14)? Everyone should create and use the same data table to log the information you included above. Remember, logging data consistently is extremely important. Take some time to create your team data table now.

If your proposed question was not selected as the question the team will focus on, do not feel bad. All team scientists need to learn to compromise, come to a consensus, and move forward together. You can always continue to research your interests on your own. You now have the chance to contribute to your team project and provide data that will help others understand more about our planet. Your team research is very important and can be shared with other students across the nation as well as with NASA scientists!

STEP 3: Background Research

Once you decide on a team research question, which may still get further refined, it is important to become familiar with what other scientists already know about the subject. Think about the specific feature that is the focus of your question. What Earth system is most closely related to your feature of interest (biosphere, atmosphere, hydrosphere, geo/lithosphere) and how is it related? These are sample questions to answer as you conduct your investigation. Conducting background research is an ongoing process. You should continually gain knowledge and become aware of information that already exists. Building on existing knowledge is an important part of the scientific process, so you can avoid "reinventing the wheel."

As you continue your research, it is essential to constantly remind yourself of your research question and hypothesis. This will allow you to gather background research related specifically to your investigation. List your question and hypothesis in the spaces provided:

Research Question: What types of changes are occurring to the glaciers found in South America?

Hypothesis: All glaciers in South America will be retreating.

Potential Sources for Background Research

As you conduct your background research, you must keep track of references you use to obtain facts, general information, figures, or images. When you log and post information or write up your results, you **must** cite your references. Any fact, figure, or image you use needs to be credited by referencing it in your text and also including the actual source in your reference or bibliography section. This allows readers to check your sources and gain confidence in your research and conclusions. It also gives credit to the person(s) who did the work you are now using. Citing resources appropriately is extremely important. ALL scientists do this!

The following four sources may be useful for your research:

1. Books: Books offer a wealth of information that has been written, reviewed, and published. These reliable sources of information are strongly recommended as you conduct your research.

2. Journal Articles/Magazines: Scientific journals or magazines offer some of the latest information and would be an excellent source for your research. Some journal articles may be written at a very high level, but they will give you insight into scientists' thinking today about a specific topic.

3. Electronic Sources (Internet): If you are using the internet as a source of information, you should be careful you are using reliable sources. NASA sites would be considered reliable as would most .edu or .gov sites. The internet should never be the sole source of your research, but it is a great place to start. Sites like Wikipedia (http://wikipedia.org) can be a great starting point but should not be the only internet source you use. Some of the information on Wikipedia may not be accurate.

4. Scientist/Science Expert: Communication or presentations given by a scientist are also great sources. For example, you may participate in a distance learning conference. If there is information that pertains to your investigation, you can use and include that information as part of your research.

For each type of reference or source, make sure you log the following information:

BOOK/JOURNAL/MAGAZINE	ELECTRONIC SOURCE (Internet)	SCIENTIST/SCIENCE EXPERT
a) Author Name(s) (Last name, first name)	a) Author Name(s) (if one exists)	a) Scientist Name (Last name, first name)
b) Name of Book/Journal/Magazine	b) Name of website	b) Affiliation (where scientist works)
c) Publisher	c) Publication date (if one is listed)	c) Date of conversation
d) Year of publication	d) Date(s) you accessed the site	d) Means of communication (Wiki, distance learning connection, personal communication)
e) Pages where information was obtained	e) Website address	e) Summary of information obtained
f) Summary of information obtained	f) Summary of information obtained	

Gather information from any of these sources. Include each of the details listed above in your bibliography, except for the summary information. The summary information helps you remember what details you obtained from that source for possible referencing later in your project.

To properly cite a written source within the text of your paper, presentation, or other document, you would include the author and year of publication in parenthesis after your cited information (*Example:* Graff, 2009). If there are multiple authors, you would indicate this by using *et al.* after the lead author's name (*Example:* Graff et al., 2009). For websites, you would include the website (*Example:* www.nasa.gov). To properly cite information from a scientist or science expert, you would include the scientist's name and indicate that it was personal communication (*Example:* Graff, personal communication, 2009).

Basic Background Research and Information

As you conduct your research, there is certain information you should consider. Your research should focus on a specific feature you can see in astronaut images of Earth. You should be able to tell others general information about that feature. This includes what the feature looks like in astronaut photographs. It may also include information about where you might find this type of feature on Earth and how it forms. It is also important, if you will do a planetary comparison, to include this same information about this feature on whatever planetary body you will investigate.

The following list of questions is provided to help guide some of your background research. This information may change, or you may update it as you learn more. There may be other information you feel is important to include as well. Add this information as appropriate. To provide additional information for your question, use additional paper as necessary.

1. IMPORTANT DEFINITIONS: Name and define the feature(s) you are studying as the focus of your research. Include other terms associated with your research that are important to understand.

- Glacier - a mass of freshwater ice that formed by accumulation of snowfall on land and flows slowly downhill in response to gravity
- Alpine or Valley Glacier - a glacier that forms in a mountain valley
- Crevasse - a deep crack or crevice in the ice of a glacier
- Iceberg - a large mass of ice detached from a glacier and floating in the sea or a lake
- Moraine – a mass or ridge of earth, rock, etc. deposited on the sides (lateral moraine), end (terminal moraine), or between (medial moraine) a glacier
- Valley – a broad area of low-lying land situated between hills or mountains and usually having a river or stream flowing along its bottom
- Calving – the breaking off of an ice mass from the parent glacier
- Terminus – the end of a glacier

2. EARTH SYSTEM INFORMATION: Explain basic information about this feature(s) including which Earth system it is related to (litho/geosphere, hydrosphere, atmosphere, or biosphere) and how it is related to that system.

   a. Although there is always an interaction between Earth's systems, which system is most closely related to the feature(s) you are studying? ___Glaciers are associated with the hydrosphere. ______________________

   b. What is the significance/importance/role of the feature within this Earth system?_____Glaciers hold large _______

   __quantities of fresh water.____

   ____

   ____

   c. If the feature you are researching, as part of your study, plays a major role in another Earth system, please explain.

   Glaciers also impact the geo/lithosphere by changing the appearance of the surface of the land as they move over it.

   ____

   ____

3. FORMATION PROCESS:

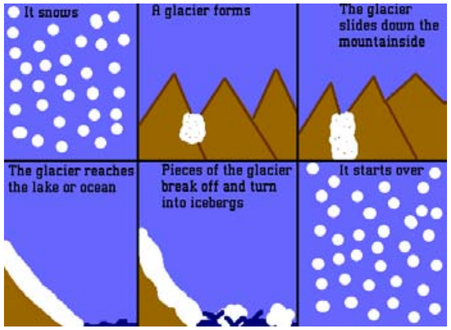
   a. Describe the process of how this feature is formed.

   Glaciers take hundreds of years to form. Snow builds up over time turning into layers of ice. The weight of the snow builds up year after year and compresses the layers together.____

   ____

   ____

b. Draw a sketch or diagram with labels to illustrate how this feature forms.



http://library.thinkquest.org/3876/glaciers.html

4. FEATURE DESCRIPTION OR CHARACTERISTICS:

a. What specific characteristics are used to identify this feature(s) in an image? A glacier is a large mass of ice and snow located in a mountainous area. It often has chunks of ice at the end of the glacier. Throughout the glacier, there may be visible lines or streaks.

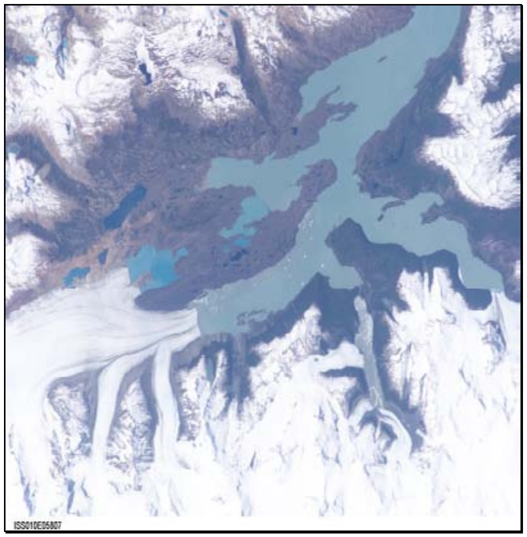
b. Are there any features that look similar to the feature(s) you are studying but are actually something else?

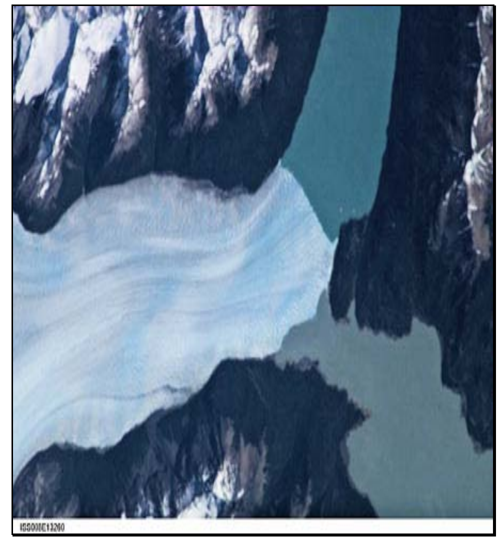
Pictures of snow on the ground can also be mistaken for glaciers.

c. How do you make sure you are not misidentifying this feature? To make sure you are identifying glaciers use the characteristics listed above.

5. ASTRONAUT IMAGES WITH THIS FEATURE: List the image identification numbers for at least three astronaut photographs that include the feature(s) you are investigating. Include a thumbnail image of each listed astronaut photograph or include a sketch of each image in the boxes below.

A.__________ISS010-E-5807 _______ B._________ISS022-E-78363________ C.____ISS008-E-13260__________





6. GEOGRAPHIC REGION OF FOCUS: What specific geographic region(s) on Earth will you focus on to observe this feature(s), and why? Regions can be continents, countries, latitude/longitude ranges, or some other geographic distinction.

Our geographic region of focus is South America. We seemed to have the easiest time finding large numbers of astronaut images of glaciers showing change over extended periods of time in this region.

7. PLANETARY COMPARISON: If you plan to conduct a planetary body comparison, what planetary body will you compare this feature to on Earth? Include an explanation as to why you selected this planetary body.

We would compare Earth to Mars. The European Space Agency's Mars Express released an image of Kasei Valles taken on February 25, 2005. The picture indicates the possibility of glacier activity.

Note: This student model will focus on the study of glaciers on Earth only, but students could do a planetary comparison later on as an extension.

If you plan to conduct a planetary body comparison, you should understand how this feature and related processes work on Earth first. At this point you may consider the possibility of doing comparative research but you are encouraged to complete your Earth-based research first.

Continue Logging Data and Making Additional Observations

As you continue with your research, making observations of images is also part of background information. The more observations you log, the more you will gain an understanding of how the process associated with your feature(s) may work. Use your team data table (discussed on page 17) to log all information agreed upon for every image you observe. At this point you should be making observations and logging data.

STEP 4: Experiment Design

By this time you have looked at many images that include the feature(s) you are researching. You should have also learned more about processes associated with this feature. As you learn more, refinements and changes to your question may occur. Before you move on, you should revisit your current research question. Decide if your question should be refined or even changed.

Once you finalize your question and hypothesis, the rest of your research should focus on answering your question and either supporting or refuting your listed hypothesis. This step in the process of science also involves formalizing your list of procedures or methods to conduct your experiment (experimental design).

Refining your question: List your current research question. Based on new knowledge you now have and observations you have made, discuss and refine this question as necessary. Once the team agrees upon the final refined research question, be sure to also refine your hypothesis. Include observations and knowledge that support this hypothesis.

Current Research Question	What types of changes are occurring to the glaciers found in South America?
Suggested Refined Research Question	What types of changes are occurring to the glaciers found in Argentina and Chile? Are the glaciers retreating, advancing, or staying the same? What types of changes are occurring to the five glaciers (Viedma, Upsala, Perito Moreno, Chico, and Grey) found in South America?
Final Refined Research Question (After discussing options with the class)	What types of changes are occurring to the five glaciers (Viedma, Upsala, Perito Moreno, Chico, and Grey) found in South America? ****Note: Some groups may further refine their question or may leave the question as originally written.****
Hypothesis (Include observations and other knowledge that support this hypothesis.)	All five glaciers will have visible and measureable evidence of retreat. We base this hypothesis on the images we have observed so far. We also base this on information we read in class that talks about warming temperatures and climate change on Earth.

EXPERIMENT DESIGN (METHODS)

It is important to make sure everyone is collecting the same data from each image and that the experimental design for collecting your data is consistent. Answer the following questions. Then discuss these questions as a team. It is important to make sure you and your teammates are consistent with your plan.

IMAGE DATA COLLECTION:

1. Name and describe the specific data set you will use as the primary source of image data for your research of Earth.

Our class decided we would use the Google Earth link within the Astronaut Photography of Earth Website (http://eol.jsc.nasa.gov/scripts/SSEOP/GoogleMapsQuery.pl) to locate glaciers that are in South America (Chile and Argentina). Once we did this, we were able to get a list of the glaciers.

2. List each specific piece of data you will log from each image you observe (see your team data table on page 17 for reference):

Image ID Number	Glacier Name	Qualitative Observations
Date Image Was Taken	Latitude	Longitude
Country	Lens Size	

3. How many images, at a minimum, will you observe overall in order to draw conclusions about your research? __15___

4. What specific geographic region(s) on Earth will you focus on to gather your data?______________________________

We will focus on the Patagonian Ice Fields in South America (Argentina and Chile).

OTHER DATA SETS:

1. What other data sets of Earth will you use, if any, to support your research of Earth? We will use Google Earth.______

2. Explain how you will use each of these other data sets to help support your research? We will use Google Earth to measure any changes in the glaciers based upon surrounding landmarks. ____

MEASUREMENTS:

If you are going to make measurements, list the procedure you will use to ensure all measurements are made in the same consistent manner. This may be a list of steps or instructions you will follow.

- We will find the glaciers we are studying in Google Earth.
- We will identify a permanent feature in Google Earth found near the end of the glacier as it appears in each of the astronaut photographs and measure the feature using Google Earth's measuring tool, and use that as a standard.
- If the images were taken using different focal length lenses, we will enlarge or shrink the image so that the size of the feature appears to be the same in each image.
- We will try to only use images that were taken as close to the nadir angle as possible.

SOURCES:

List each source you will use to gather data AND include bibliographical information (see information provided below). If there is specific information you need to elaborate on regarding how to navigate a website to retrieve your data/information, feel free to provide those details. Use additional paper, as necessary.

BOOK/JOURNAL/MAGAZINE	ELECTRONIC SOURCE (Internet)	SCIENTIST/SCIENCE EXPERT
a) Author Name(s) (Last name, first name) b) Name of Book/Journal/Magazine c) Publisher d) Year of publication e) Pages where information was obtained f) Summary of information obtained	a) Author/Organization (if available) b) Name of website c) Publication date (if one is listed) d) Date(s) you accessed the site e) Website address f) Summary of information obtained	a) Scientist Name (Last name, first name) b) Affiliation (where scientist works) c) Date of conversation d) Means of communication (Wiki, distance learning connection, personal communication) e) Summary of information obtained

Fill in the information below for each source you will use/have used for your research.

SOURCE #1

SOURCE TYPE (circle one): Book Journal Magazine Electronic Source Science Expert Other ____________

BIBLIOGRAPHICAL INFORMATION:

Author/Organization: Image Science and Analysis Laboratory, NASA-Johnson Space Center
Name of website: The Gateway to Astronaut Photography of Earth
Publication Date: January 10, 2011 – May 6, 2011
Date Accessed: January 10, 2011 – May 6, 2011 at least once a week
Website Address: http://eol.jsc.nasa.gov/

SUMMARY OF INFORMATION OBTAINED:

We obtained the astronaut photographs and metadata used for our research at this site. We also obtained background information from the captions written for many of the images.

SOURCE #2

SOURCE TYPE (circle one): Book Journal Magazine Electronic Source Science Expert Other ____________

BIBLIOGRAPHICAL INFORMATION:

Author/Organization: Google
Name of website: Google Earth
Publication Date: ©2011 Cnes/Spot Images, ©2011
Date Accessed: April 25, 2011 – May 6, 2011
Website Address: http://www.google.com/earth/index.html.

SUMMARY OF INFORMATION OBTAINED:

We used Google Earth to zoom into the region where the glaciers we were studying are located. We also used the Google Earth measurement tool to determine the approximate change to each glacier's terminus from one date to another. We were able to create our regional and continental maps using this website as well.

SOURCE #3

SOURCE TYPE (circle one): Book Journal Magazine Electronic Source Science Expert Other ____________

BIBLIOGRAPHICAL INFORMATION:
Author/Organization: BBC News
Name of website: BBC News
Publication Date: Not listed
Date Accessed: February 16, 2011
Website Address:
http://news.bbc.co.uk/2/shared/spl/hi/picture_gallery/05/sci_nat_how_the_world_is_changing/html/1.stm

SUMMARY OF INFORMATION OBTAINED:
This website provided us with information, data, and pictures taken of the Upsala Glacier. The data included measurements taken from various expeditions to the glacier. It stated that Argentina's Upsala Glacier was once the biggest in South America, but it is now disappearing at a rate of 200 meters per year.

SOURCE #4

SOURCE TYPE (circle one): Book Journal Magazine Electronic Source Science Expert Other ____________

BIBLIOGRAPHICAL INFORMATION:
Scientist Name: Runco, Susan
Affiliation: NASA Johnson Space Center
Date of conversation: February 14, 2011
Means of communication: personal communication

SUMMARY OF INFORMATION OBTAINED:
We discussed how astronaut photographs are continuing to be acquired to aid in the study of South American glaciers. Dr. Runco talked about how it has been noted that these glaciers appear to be changing over time.

As necessary, include additional sources of information or additional details retrieved from each source on a separate piece of paper. Note: See Additional Source Pages 1 and 2.

Additional Source Page 1

SOURCE #_5_

SOURCE TYPE (circle one): Book Journal Magazine Electronic Source Science Expert Other ____________

BIBLIOGRAPHICAL INFORMATION:

Author/Organization: PATAGONIA-ARGENTINA.COM
Name of website: PATAGONIA-ARGENTINA.COM
Publication Date: © 1999 - 2011 Patagonia-Argentina.com
Date Accessed: February 16, 2011
Website Address: http://www.patagonia-argentina.com/i/andina/glaciares/glaciarupsala.php

SUMMARY OF INFORMATION OBTAINED:

This website provided us with information, data, and pictures taken of the Upsala Glacier. The data included measurements taken from various expeditions. This site also stated that Argentina's Upsala Glacier was once the biggest in South America, but it is now disappearing at a rate of 200 meters per year.

SOURCE #__6__

SOURCE TYPE (circle one): Book Journal Magazine Electronic Source Science Expert Other ____________

BIBLIOGRAPHICAL INFORMATION:

Author/Organization: Extreme Ice Survey
Name of website: Extreme Ice Survey
Publication Date: © 2011 Extreme Ice Survey
Date Accessed: January 10, 2011 – February 11, 2011 at least twice a week
Website Address: http://www.extremeicesurvey.org/index.php

SUMMARY OF INFORMATION OBTAINED:

This website gave us background information about glaciers as well as detailed information about glaciers and climate change.

Additional Source Page 2

SOURCE #_7__

SOURCE TYPE (circle one): Book Journal Magazine Electronic Source Science Expert Other ____________

BIBLIOGRAPHICAL INFORMATION:

Author/Organization: Argentina Travel Guide
Name of website: All About AR: Argentina Travel Guide
Publication Date: © 2010 All About AR
Date Accessed: February 16, 2011
Website Address: http://www.allaboutar.com/ard_cala_perito_moreno.htm

SUMMARY OF INFORMATION OBTAINED:

This website provided us with information, data, and pictures taken of the Perito Moreno Glacier. The data included measurements taken from various expeditions. The site stated that the Perito Moreno Glacier is unique in a variety of facets, including its size, scientific significance, and accessibility. This site stated that the glacier is advancing.

SOURCE #_____

SOURCE TYPE (circle one): Book Journal Magazine Electronic Source Science Expert Other ____________

BIBLIOGRAPHICAL INFORMATION:

SUMMARY OF INFORMATION OBTAINED:

STEP 5: Collect and Compile Data

Once you have your experiment design in place, you will continue to collect and compile your data. You should have an overall goal for the number of images you want to observe. This number should be based on what your team believes is a suitable amount of observed images to draw conclusions about your question. Once you have all the data you planned to collect, you will want to compile the data from each team member into one master data table.

As you compile the data, make sure that you have a complete set of logged data for every image. You may have logged information from an image someone observed early in the process before the data table was finalized. If this is the case, be sure to go back and log any missing data. Once all the data is included on the master data table, clean up the data by making sure it is all recorded consistently. If you have a hand-written data table, consider recreating it using a spreadsheet (i.e., Microsoft Excel, Google Docs).

When you have your master data table with all your data compiled, you may decide there is additional image data you wish you had as part of your research. First, make sure the data relates to your research. Second, as an *Expedition Earth and Beyond* (EEAB) participating team, you have the opportunity to request new data. There are certain requirements for submitting a request for new data. They are:

- Only one *Data Request Form* per class can be submitted. Forms are available on the *EEAB* website.
- Only the teacher/adult facilitator can submit the *Data Request Form.*
- The *Data Request Form* includes a section to be filled out by the teacher and information that should be filled out by student team members.
- *If* your team submits a *Data Request Form,* you must realize it may take a month, semester, or more to acquire that image. Completing your team research should not depend on a new image. See the *Student Scientist Introduction* PowerPoint presentation for image acquisition factors.

After your *Data Request Form* has been submitted, the team should continue with their research. Remember, finishing your team research should not depend on a new image of Earth.

Submitting a *DATA REQUEST FORM* is OPTIONAL. Only one form can be submitted per class.

STEP 6: Display Data

Science research projects and investigations are strengthened by the data that provides evidence to support conclusions. Therefore, displaying your data is extremely important. Once you have finished collecting and compiling your data you will need to make sure you can list, organize, and display your data clearly. This will allow you to answer your question and support or refute your hypothesis.

With every aspect of your research, but especially as you get ready to display your data, it is important for you to focus on your research question and initial hypothesis. State these below.

Research Question:

What types of changes are occurring to the five glaciers (Viedma, Upsala, Perito Moreno, Chico, and Grey) found in South America?

Hypothesis:

All five glaciers will have visible and measureable evidence of retreat.

With your question and hypothesis in mind, there are three action items you should follow as you consider displaying your data. Each action item is described in more detail in the pages that follow.

DISPLAY DATA ACTION ITEMS:

A. **Discuss data display options:** Look at the four data display options described in this section (data table, graphs, maps, image illustrations), and decide which ones best apply to your research.

B. **Create your data displays:** Discuss and decide on a strategy for the team to have groups or individuals create your data displays.

C. **Make <u>observations</u> of the data:** Once you have your data displays created, it is important to make observations of the data. Any observations you make should simply indicate general patterns or trends you are noticing. **These observations should relate to your research question**. At this point you should not state any inferences about what the data means for your project.

A. DATA DISPLAY OPTIONS

All teams should have an organized master data table that includes the data collected and compiled by all team members. You should have already compiled your data into a master data table in Step 5 of your research. If you have not yet completed this, do so before you continue. This is essential for your team to have completed as you consider the data display options.

Consider the following four options to display your data. Discuss these as a team and decide which ones best apply to your research.

1) DATA TABLE

There are two aspects to consider with your master data table. The first is sorting your data. Sorting your master table will enable you to organize your data in different ways so you can more clearly look for patterns. If you created a spreadsheet of your master data table, this may allow you to easily sort data.

As a team, take a look at your master data table. With your science question in mind, think about how you may sort your data so you can make observations that relate to your question. Would it be useful to sort your data by latitude? Would it be useful to sort your table by region? Think about how you may sort your data and how that sorted data may be important for you to later draw conclusions. List your ideas below.

Data Sorting Ideas	Describe how this may help you later draw conclusions.
Latitude	Using latitude would be the most logical arrangement to see if there was a correlation between glacial change and distance from the equator.
Glacier Name and Date Image was taken (by glacier)	Using the glacier name and date image was taken would help to group the images by glacier. You could also order the images from oldest to newest so comparison over time can be done for each glacier.

The second aspect to consider is creating a new data table that includes a subset of the data you have collected along with additional information to further support your research. Look for specific pieces of information you may want to include in this new data table. Focus on particular details that will relate to your research question. The entire set of details included on the master data table is important, but sometimes a subset of the data can be useful.

Think about your research question, and decide if you should create a new data table(s). If so, list 1-3 sets of data that you will use in a new data table in the chart below. Include a list of the data table headings and how this may help you later draw conclusions.

Data Table Headings	Describe how this may help you later draw conclusions.
1. Glacier Name, Latitude, Longitude, Image 1 Date, Image 1 ID#, Image 2 Date, Image 2 ID#, Visible Changes, Approximate Amount of Change, Additional Observations/Comments	Using these data table headings, we can focus on images of specific glaciers on two different dates and record the amount of change measured using Google Earth. By noting the visible changes, we can tell if the glaciers are retreating, advancing, not changing, or if we are not sure.
2.	
3.	

2) GRAPHS

Scientists often use graphs or charts to represent and communicate their information visually. If the information you gathered needs to be organized or it is difficult to see clearly, graphs may be your answer. Graphs can help you show relationships, highlight patterns, or make comparisons. How do you choose the type of graph to best represent your data? First, decide if the data you collected is categorical or numerical. Categorical data classifies information by topics or words. For example, a scientist might look at ten images and classify by the different types of sand dunes. Numerical data is data that is given in numbers. This is sometimes referred to as quantitative data. An example of numerical data would be if a scientist wanted to record the elevation of ten mountains.

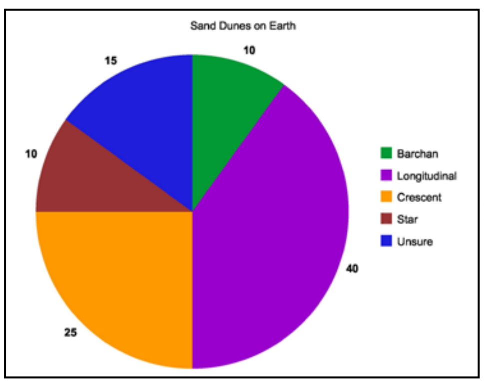
Type of graphs used to represent categorical data

A. PIE GRAPHS: These graphs are circular charts divided into pieces or sectors that show proportion. For example, if you did a study on the types of sand dunes, you might create a pie chart that is divided into pieces that represent the different types of sand dunes that you observed in all your images. This would allow you to calculate and visualize what percent of different types of sand dunes were observed compared to all the images you observed as a whole.

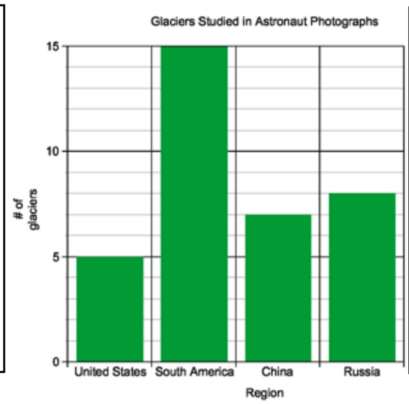
B. BAR GRAPHS: This type of graph uses bars to show the frequency of data. The higher the bar, the greater the frequency. One example might be to count the number of glaciers in particular regions of the world. The bars' heights would indicate that amount of glaciers counted for a particular region. Bars would be labeled by the region. The bars on a bar graph should not touch one another.

C. PICTOGRAPH: This type of graph uses symbols to show the frequency of data. You assign a symbol or picture to represent a certain amount of a particular type of feature. For example, let's say you are studying plankton blooms and the amount of area they cover. You may assign a star to represent 10 square kilometers of plankton bloom. If you had 10 stars on your pictograph for a certain region that would indicate that there were 100 square kilometers of plankton bloom. For example, 10 stars times 10 square kilometers (what each star represents) = 100 square kilometers of plankton bloom.

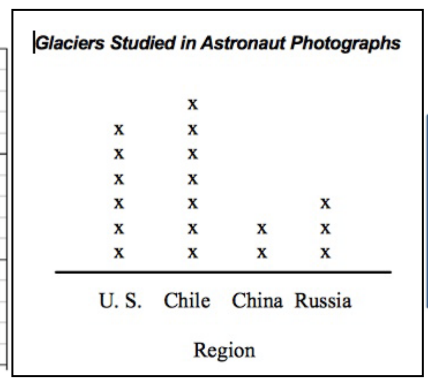
D. LINE PLOT: A line plot is very similar to a bar graph and a pictograph. This type of graph also shows frequency of data along a number line. However, instead of seeing bars or symbols, you see x's.



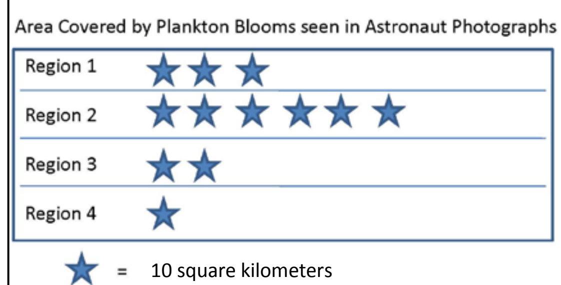
Pie Chart



Bar Graph



Line Plot



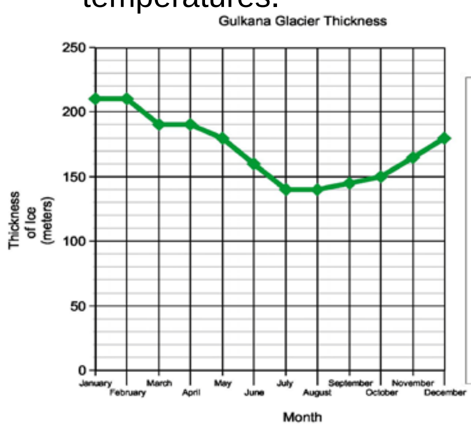
Pictograph

Type of graphs used to represent numerical data

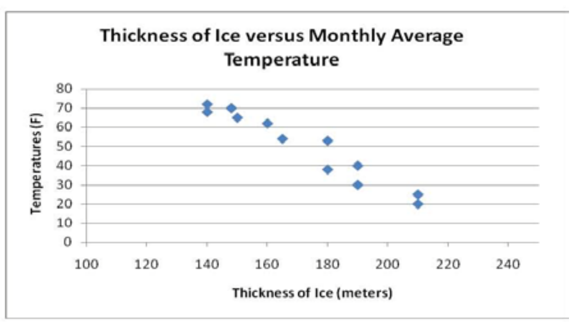
A. LINE GRAPH: A line graph plots data that continues or is continuous. Suppose you are studying glaciers to see if the thickness of a glacier is changing over time. If you obtain the thickness of a glacier each month, you can plot that data over time. These data points can then be connected showing changes in glacier thickness over time. (Note: You cannot obtain ice thickness from astronaut photographs.)

B. SCATTER PLOTS: Scatter plots show correlation of data. The data points are not connected with a line. They basically indicate if one type of data impacts or influences another type of data collected for the same feature or process. Let's think again about an example related to glaciers. Suppose you are trying to determine if temperature impacts or influences a glacier's thickness. A scatter plot will allow you to look at potential correlations of this data by plotting temperature against ice thickness. For example, does ice thickness go up as temperatures goes down? Sometimes a trend line or a line of best fit is used in scatter plots to help indicate correlation.

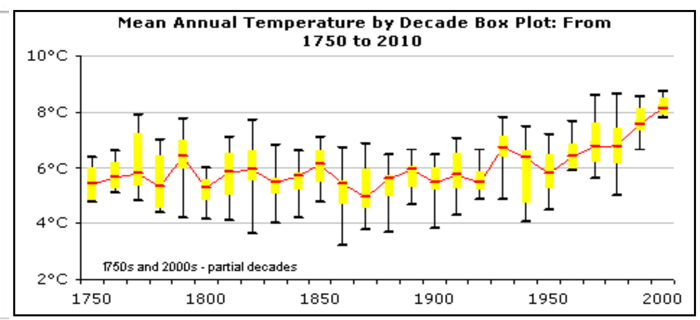
C. BOX AND WHISKER PLOTS: Box and whisker plots help you analyze large amounts of numerical data which help visualize statistical variation. If you had a set of numerical data, you would organize the data from least to greatest, find the median (middle number), and the upper and lower quartile medians. You box these two quartile medians and extend whiskers (lines) to the greatest and least pieces of data. If a scientist was interested in knowing what size lens the majority of astronaut photographs are taken with over a series of missions, he/she may use a box and whisker plot to show this. In addition to the main data of interest (the median lens size per mission), the box and whisker plot also provides information on the smallest and largest lens sizes used per mission, giving you a more complete picture of the range of data values. The example below shows a box and whisker plot of mean annual temperatures.



Line Graph



Scatter Plot



Box and Whisker Plot

Other types of graphs can also be used to represent data. You can use a number of internet mathematical resources to learn more about various types, and what they look like. Many sites allow you to enter data and create your own graph and print it out. One example site you may consider using is: http://nces.ed.gov/nceskids/createagraph/default.aspx. You can also put data into spreadsheet programs like Excel to create graphs. It is important to remember that not all data collections are best represented by graphs, and other types of analysis may be more effective.

As a team, discuss the different types of graphs and decide what is appropriate for your research. Create a list of at least three possible graphs you can create below, as appropriate. Be sure to include the following: 1) Type of data you will graph, 2) Type of graph that best represents that data, 3) Describe what you will graph, and 4) Explain how the graph will be relevant for your research.

POTENTIAL GRAPH TO DISPLAY DATA	
Type of data you will you graph (circle one)	Categorical data **Numerical Data**
Type of graph (circle one)	Pie Graph **Bar Graph** Pictograph Line Plot Line Graph Scatter Plot Box and Whisker Plot Other______________________
Describe what you will graph.	We would graph the change in length for the glacier on the X-axis vs. the latitude on the Y-axis. The Y axis would be at the center of the grid instead of the left edge. There would be negative values to the left of the Y-axis to indicate retreat, and positive values to the right of the Y-axis to indicate growth. The bars would extend parallel to the X-axis.
How will this graph be relevant for your research?	The graph would give a great picture of change in length at a particular latitude. We would be looking for a relationship with the location and length of the bars as we went toward or away from the Equator.

Note: It is alright to have just one graph or no graph for data. Remember we don't make graphs just to make them. If a graph is made, it must provide support to help answer the question being asked!

POTENTIAL GRAPH TO DISPLAY DATA	
Type of data you will you graph (circle one)	Categorical data Numerical Data
Type of graph (circle one)	Pie Graph Bar Graph Pictograph Line Plot Line Graph Scatter Plot Box and Whisker Plot Other______________________
Describe what you will graph.	
How will this graph be relevant for your research?	

POTENTIAL GRAPH TO DISPLAY DATA	
Type of data you will you graph (circle one)	Categorical data Numerical Data
Type of graph (circle one)	Pie Graph Bar Graph Pictograph Line Plot Line Graph Scatter Plot Box and Whisker Plot Other______________________
Describe what you will graph.	
How will this graph be relevant for your research?	

3) MAPS

Plotting data on a map can be very useful. This allows others to see where you observed images. Plotting data on a map provides a geographic context to what you are studying. An astronaut photograph covers a limited surface area of the Earth. Being able to see a more global or regional context of the location of images observed can be very useful.

North America

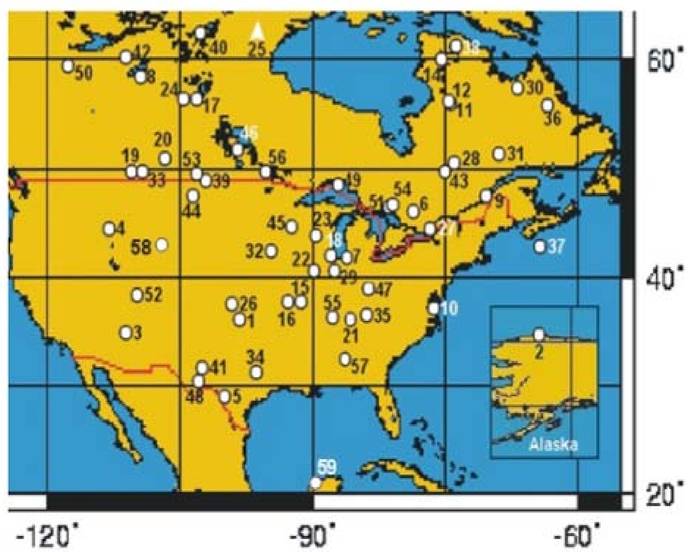


Image Credit: Earth Impact Database: http://www.unb.ca/passc/ImpactDatabase/NAmerica.html

World Impact Structures Sorted according to Location

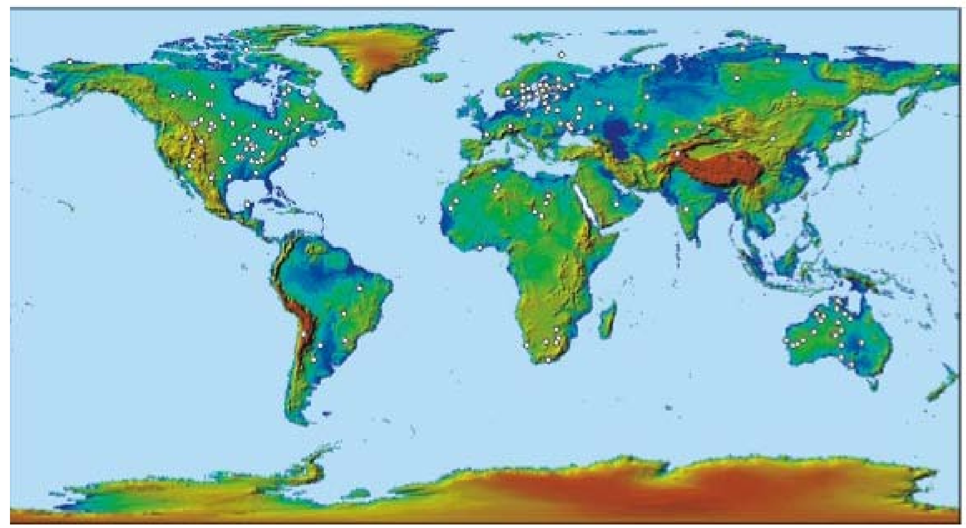


Image Credit: Earth Impact Database: http://www.unb.ca/passc/ImpactDatabase/CILocSort.html

Two examples of data plotted on a map. Map on the left illustrates a regional context and view of impact craters (North America). Map on the right illustrates a global context or view of impact craters.

You should consider what type of map (global or regional) would best apply to your research. These maps were acquired from the Earth Impact Database. You can use any "blank" map (Google Earth, for example) that is appropriate for your research and plot your points accordingly. For example, you can use a world map and plot points indicating images you viewed as part of your research.

Based on the data your team has logged, create a list of one or two possible ways to plot your data on a map. Be sure to explain what the map will show related to your research. Discuss this as a class and be sure to create the map(s) your team decides will be most useful.

POTENTIAL MAP TO DISPLAY DATA			
Describe what information you will plot on a map.	We would plot the location of each of the glaciers including latitude and longitude.		
Type of map (circle one)	Global Map	**Regional Map**	Other ____________________
How will this plotted data be helpful and relevant for your research?	The plotted data will show geographical context for each of the South American glaciers we investigated.		

POTENTIAL MAP TO DISPLAY DATA			
Describe what information you will plot on a map.	We would outline the Patagonia Region where the glaciers we are studying are located.		
Type of map (circle one)	Global Map	Regional Map	Other _**Continental Map**______
How will this plotted data be helpful and relevant for your research?	The outlined region will show the glaciers' geographical context within South America.		

4) IMAGE ILLUSTRATIONS

Image illustrations can be very important as part of your research. These illustrations will not only indicate to others that you can correctly identify features, but it will help others better understand characteristics of images you may describe. You may decide to show image illustrations for one of the following uses:

- Feature Focus: Label, annotate, or write captions for images that focus on and illustrate the feature(s) you may be studying.
- Image Comparisons: Label, annotate, or write captions for images that illustrate similarities or differences of features.
    - Images of the same location taken on different dates
    - Feature(s) in different locations so you can highlight certain visible characteristics
- Interrelated Features: Label, annotate, or write captions for images to show interrelated features connected to your research.

It is important to include an image caption to provide an explanation of what each image illustration is showing. The illustrations should directly relate to your research.

The information above was obtained at http://eol.jsc.nasa.gov/ and from Dr. Kamlesh Lulla, NASA JSC.

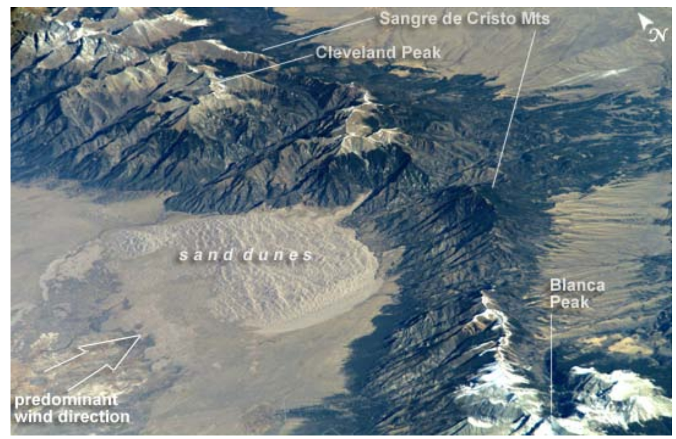


Image courtesy of the Image Science & Analysis Laboratory, NASA JSC: ISS016-E-6986

Examples of image illustrations: The set of images on the left is comparing the same location on two different dates. This would be considered an "Image Comparison." If you showed just one of these images to focus on the feature without making a comparison, that would be considered a "Feature Focus." The illustration on the right is an annotated (labeled) image showing "Interrelated Features" (sand dunes, mountains, wind direction).

List possible ways to use image illustrations to help describe features you are studying as part of your research. Be as detailed as possible. As a class, discuss your options and decide what feature illustration(s), if any, will be most useful.

POTENTIAL IMAGE ILLUSTRATIONS	
FEATURE FOCUS	Describe Your Plan and Use of Images for a Feature Focus.
IMAGE COMPARISONS	Describe Your Plan and Use of Images for Image Comparisons. We have three different types of image comparisons: 1. Image collage of the Upsala Glacier taken over time to look for changes in the terminus. 2. Image pairs of the five glaciers with reference line to show changes in the location of the terminus. 3. Image pairs of the five glaciers with measurements made with Google Earth to show the approximate amount of retreat.
INTERRELATED FEATURES	Describe your Plan and Use of Images to Illustrate Interrelated Features.

B. CREATE DATA DISPLAYS

Now that you are aware of 4 different ways to display your data, you should now create these data displays. As a team, discuss each data display option and decide the following:

1) What data displays should be created? Discuss organizing your data table(s), graphs, maps, and image illustration options.
2) Decide which team members will create which data displays.
3) Create the data displays.

Once your data displays are created, you will make observations of each display. Observations look at general trends or patterns. You will think about what those observations mean with respect to your research question as you analyze and interpret your data (Step 7).

Master Data Table - Glaciers in South America

Image ID Number	Glacier Name	Date Image Was Taken (YYYYMMDD)	Latitude (N)	Longitude (E)	Country	Lens Size (mm)	Qualitative Observations
ISS022-E-073075	Upsala	20100225	-49.9	-73.3	Argentina	800 mm	Moraine is apparent, glaciers feed into glaciers, lots of calving, some sides more than others.
ISS015-E-31043	Upsala	20070928	-49.9	-73	Argentina	400 mm	Some calving, moraine evident, diagonal terminus.
ISS010-E-5807	Upsala	20041104	-50	-73	Argentina	180 mm	Some calving, moraine evident, several glaciers joined into one.
ISS022-E-78363	Viedma	20100226	-49.5	-73	Argentina	800 mm	Dark lateral streaks along the top of the glacier, terminus appears fairly straŝŐŚƚ across, cloud shadows appear over glacier, and ice appears separated by water from south fork glacier terminus – possibly calved off glacier.
ISS004-E-9717	Viedma	20020408	-49.5	-73	Argentina	800 mm	Dark lateral streaks along the top of the glacier, terminus appears convex with outward bulge near the center but concave near the sides, perhaps indicationg calving, and possible calving along side fork terminus.
ISS001-E-5108	Viedma	200012_	-49.5	-73	Argentina	400 mm	Dark lateral streaks along the top of the glacier, terminus appears convex with outward bulge near the center, and cloud shadows appear over glacier.
ISS008-E-13260	Perito Moreno	20040127	-50.5	-73	Argentina	800 mm	In this image the glacier is crushed against the side of the "island" completely. The two branches of Perito end at lakes. The lakes have very different colors. Why are the colors so different?
ISS006-E-40731	Perito Moreno	20030326	-50.5	-73	Argentina	800 mm	Perito is possibly completely separated from the "island" at the side of the cliff. Evidence of calving can be seen.
ISS001-E-6370	Perito Moreno	2001	-50.5	-73	Argentina	800 mm	Many crevasses can be seen at the terminus. There also are numerous shapes that look like ripples or dunes on the left side of the glacier. Great blue color can be seen.
ISS015-E-19983	Perito Moreno	20070728	-50.5	-73	Argentina	800 mm	Obvious evidence of calving at the terminus. There is actually a ring of material at the edge. Is this one feature or a series of icebergs linked together?
ISS018-E-40451	Perito Moreno	20090314	-50.5	-73	Argentina	800 mm	Great details in the "island." Also you can see the ring of material again in greater detail.

Master Data Table - Glaciers in South America (continued)

Image ID Number	Glacier Name	Date Image Was Taken	Latitude (N)	Longitude (E)	Country	Lens Size (mm)	Qualitative Observations
ISS014-E-14359	Chico	20070217	-49	-73	Argentina	180 mm	Great overall view of the area. The general shape of the moraines can be seen in Chico. You can also see the terminus of the glacier and the muddy lake ending in a huge obstruction at the end of the valley.
ISS007-E-5752	Chico	20030519	-49	-73	Argentina	400 mm	Detailed image of the surface of Chico showing the unusual pointed shapes of the moraine. You can actually see the flow pattern of the glacier.
ISS004-E-9238	Chico-	2002----	-49	-73	Argentina	35 mm	The terminus of the glacier ends in something that looks like a spear point. It models the same shape of the moraines seen in the glacier. Great overall view of the area.
ISS004-E-7175	Chico-	20020206	-49	-73	Chile	800 mm	Highly detailed view of the moraine. Unfortunately it doesn't show the end of the glacier, but it is still a valuable image.
ISS008-E-18428	Chico-	20040312	-49	-73	Chile	370 mm	Good view of the blockage seen at the end of the lake. After this barrier the color of the water changes from grey to blue.
ISS014-E-14369	Chico-	20070217	-49	-73	Chile	180 mm	Another great overall view of the area. The difference in color between the Chico terminus lake and the rest of the water is striking The grey color must be from material being deposited by Chico.
ISS016-E-12167	Chico-	20071123	-49	-73	Chile	180 mm	Great overall view of the area. The general shape of the moraines can be seen in Chico. You can also see the terminus of the glacier
ISS018-E-19606	Chico-	Unknown	-49	-73	Chile	800 mm	Fantastic view in the terminal moraine of Chico. The shape of the spear head feature is great!
ISS018-E-39935	Grey	20090312	-49	-73	Chile	180 mm	Poor image. Only shows the general three-pronged shape of the terminus, and the blue color of the ice.
ISS0014-E-10766	Grey	20061225	-51	-73	Chile	180 mm	Great overall view of the area shows the grey color of Grey's runoff, while the glacier to the right has a blue color to the runoff.
ISS0010-E-12288	Grey	20050103	-51	-73	Chile	180 mm	Many different colors in the various bodies of water ranging from grey to very deep blue.
ISS0010-E-5811	Grey	20041104	-51	-73	Chile	180 mm	Difference in the colors of the bodies of water is striking.
ISS004-E-9281	Grey	20020401	-51	-73	Chile	180 mm	Overall view of the area showing all of the glaciers.

C. MAKE OBSERVATIONS: Use the tables below to record your observations of each data display. Discuss as a team.
Note: Make additional copies of the Observation Table as needed.

OBSERVATION TABLE				
Title of Data Display	Master Data Table – Glaciers in South America			
Type of Data Display (circle one)	**Data Table**	Graph	Map	Image Illustration
Summarize what the data display is illustrating.	This table is showing the following pieces of information: image ID number, name of glacier, date image was taken, latitude and longitude, country, lens size, and qualitative observations.			
List 1-3 general observations or trends of what the data display is showing.				
Observation #1: We have data for at least 3 images of each glacier.				
Observation #2: All glaciers are located within a degree of each other both in latitude and longitude.				
Observation #3: Images were taken with a variety of lens sizes ranging from 180 mm to 800 mm.				

OBSERVATION TABLE				
Title of Data Display	Glacier Data Table			
Type of Data Display (circle one)	**Data Table**	Graph	Map	Image Illustration
Summarize what the data display is illustrating.	The table is showing the following pieces of information: name of the glacier, latitude and longitude, dates of the first and final images, identification numbers of the first and final images, visible changes in the glacier, amount of the change, comments.			

List 1-3 general observations or trends of what the data display is showing.

Observation #1:

Except for Perito Moreno Glacier, all of the glaciers retreated during the periods measured. In all cases that retreat was at least 300 meters to as much as 500 meters.

Observation #2:

All glaciers are located within a degree of each other both in latitude and longitude.

Observation #3:

Some, but not all of the glaciers, show evidence of calving.

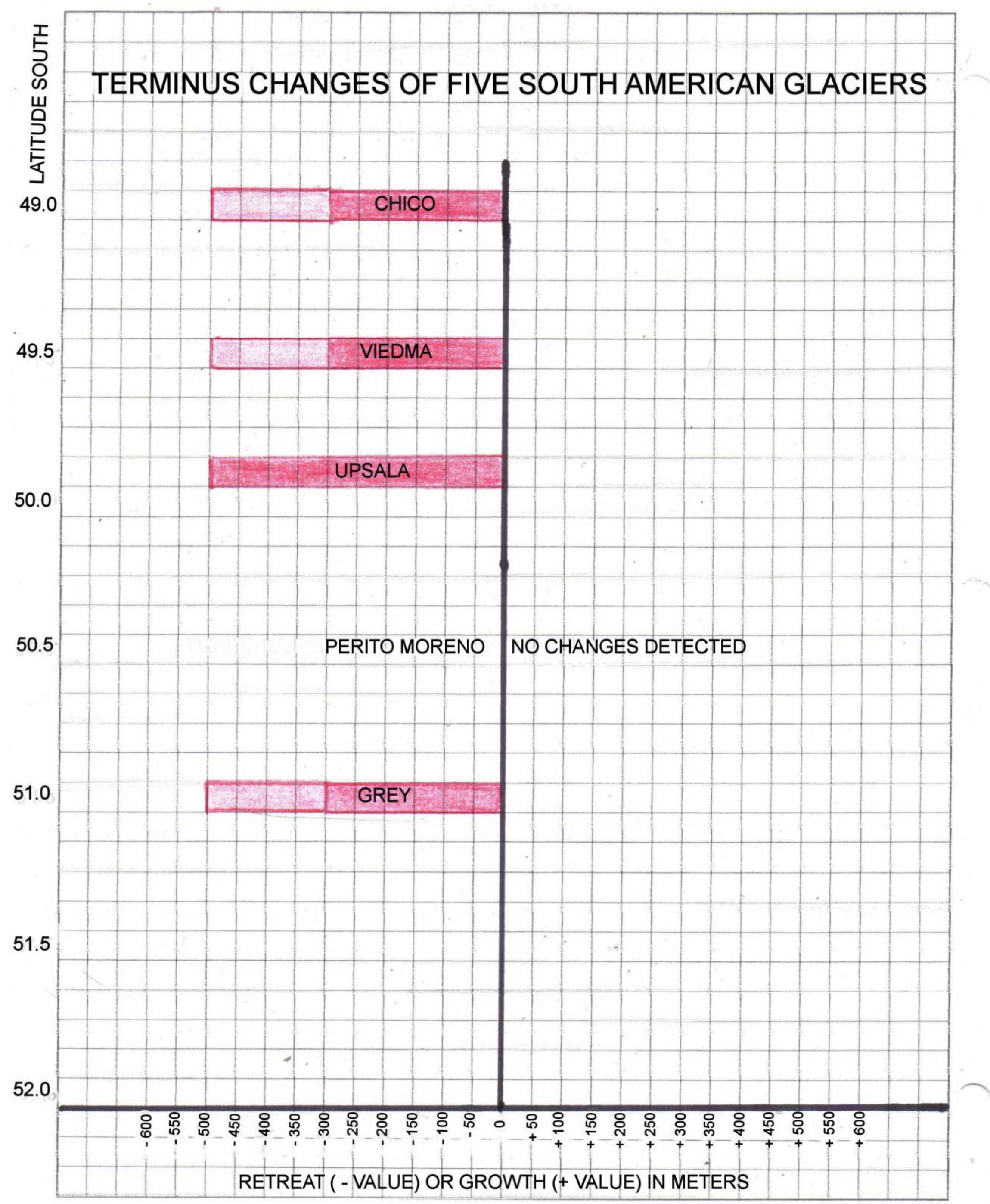
Glacier Data Table									
Glacier Name	**Latitude (N)**	**Longitude (E)**	**First Image Date**	**First Image ID #**	**Second Image Date**	**Second Image ID #**	**Visible Changes** (Retreat, Advance, No Change, Not Sure)	**Approximate Amount of Change (in meters)**	**Additional Observations or Comments**
Upsala	-49.9	-73.3	2004 November	ISS010-E-5807	2010 February	ISS022-E-073075	Retreat	500	Significant calving was observed in the 2010 image.
Viedma	-49.5	-73	2002 April	ISS004-E-9717	2010 February	ISS022-E-78363	Retreat	300-500	The terminus appeared quite convex in the 2002 image but nearly straight across in the 2010 image.
Perito Moreno	-50.5	-73	2001	ISS001-E-6370	2009 March	ISS018-E-4051	Little if any change observed	None	The terminus of the glacier appears unchanged during the time interval of between astronaut images.
Chico	-49	-73	2003 May	ISS007-E-5752	2007 February	ISS014-E-14369	Retreat	300-500	The terminus in the 2007 image appears less defined and perhaps showing evidence of calving.
Grey	-51	-73	2004 November	ISS010-E-5811	2010 February	ISS022-E-66553	Retreat	300-500	The left branch of the terminus appears to have receded, while the remainder of the terminus seems unchanged.

**South latitudes should be written as negative numbers if the column heading is written as Latitude(N). See Data Table Tip #4 from the Student Scientist Guidebook pg11.

**West longitudes should be written as negative numbers if the column heading is written as Longitude(E). See Data Table Tip #5 from the Student Scientist Guidebook pg11.

OBSERVATION TABLE				
Title of Data Display	Terminus Changes of Five South American Glaciers			
Type of Data Display (circle one)	Data Table	**Graph**	Map	Image Illustration
Summarize what the data display is illustrating.	This data display is comparing changes in the terminus (retreat or growth) of five South American glaciers. Changes to these glaciers were measured using landmarks in the images and the Google Earth measurement tool.			
List 1-3 general observations or trends of what the data display is showing.				
Observation #1: Three of the five glaciers show a retreat range of 300 – 500 meters of the terminus.				
Observation #2: The Perito Moreno Glacier does not appear to have any changes to its terminus.				
Observation #3: One of the glaciers, Upsala, shows a certain retreat of 500 meters of change to its terminus while three glaciers had an uncertain range of change.				
Observation #4: None of the glaciers showed growth.				

Note: See Extra Observation Tables.


TERMINUS CHANGES OF FIVE SOUTH AMERICAN GLACIERS
LATITUDE SOUTH
49.0
49.5
50.0
50.5
51.0
51.5
52.0
CHICO
VIEDMA
UPSALA
PERITO MORENO
NO CHANGES DETECTED
GREY
- 600
- 550
- 500
- 450
- 400
- 350
- 300
- 250
- 200
- 150
- 100
- 50
0
+ 50
+ 100
+ 150
+ 200
+ 250
+ 300
+ 350
+ 400
+ 450
+ 500
+ 550
+ 600
RETREAT (- VALUE) OR GROWTH (+ VALUE) IN METERS

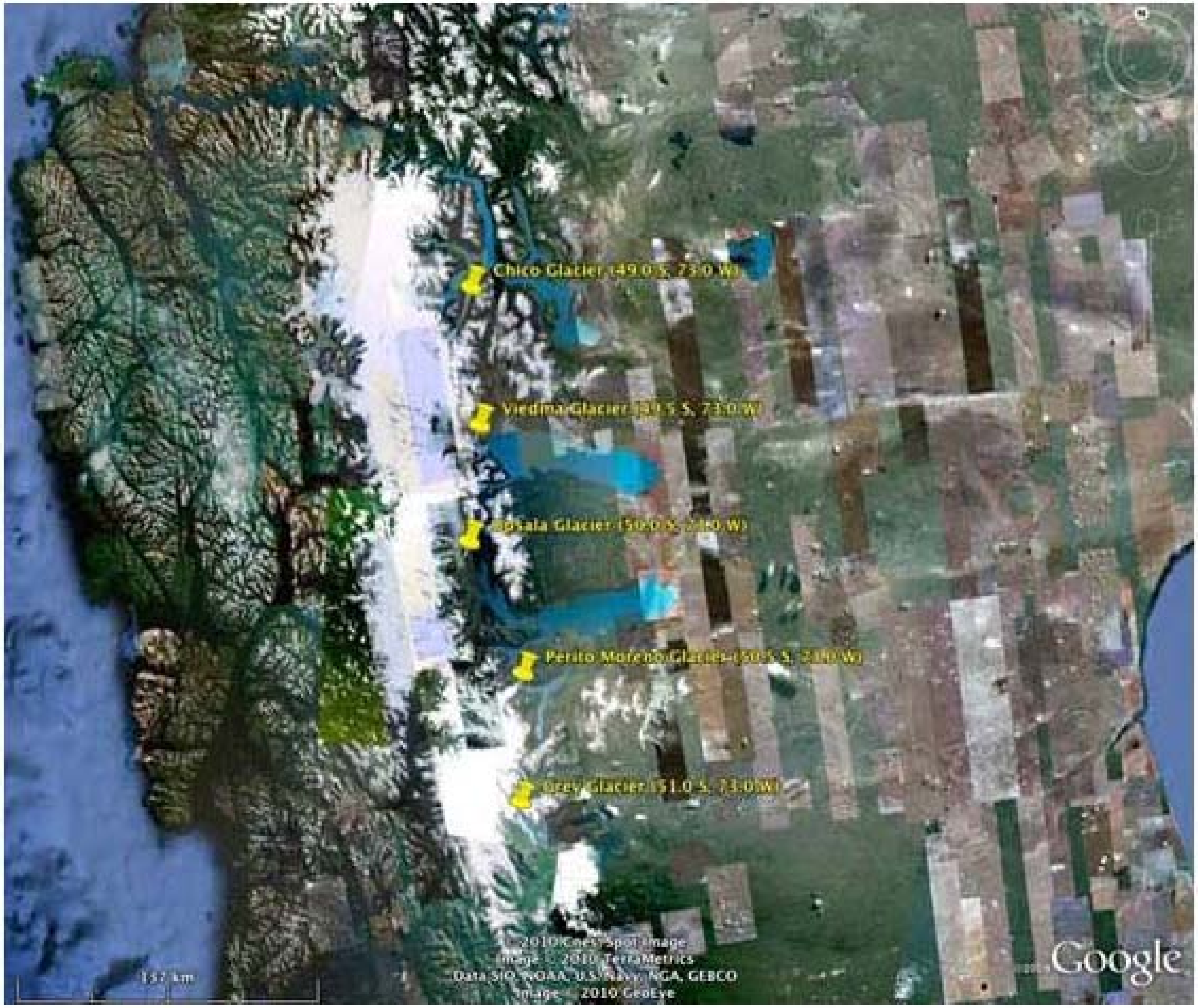
OBSERVATION TABLE				
Title of Data Display	Continental Map of Glaciers We Investigated			
Type of Data Display (circle one)	Data Table	Graph	**Map**	Image Illustration
Summarize what the data display is illustrating.	This map shows the area of South America where the five glaciers that we researched are located.			
List 1-3 general <u>observations</u> or trends of what the data display is showing.				
Observation #1: The glaciers are all located in the narrow southern portion of the South American continent.				
Observation #2: There appears to be a nearly continuous line of glaciers in the boxed in area on the map.				
Observation #3: The glaciers are located near the border between Chile and Argentina.				

Continental Map of Glaciers We Investigated

Map outlining the Patagonia region of South America where glaciers being studied as part of our research are found.
Image source: Google maps

OBSERVATION TABLE				
Title of Data Display	Regional Map of Glaciers We Investigated			
Type of Data Display (circle one)	Data Table	Graph	**Map**	Image Illustration
Summarize what the data display is illustrating.	This map uses labeled markers from Google Earth to show the exact locations and geographic coordinates of the five glaciers that we researched.			
List 1-3 general observations or trends of what the data display is showing.				
Observation #1: All five glaciers are located near the same line of longitude.				
Observation #2: The five glaciers are approximately 0.5 degrees of latitude apart from each other.				
Observation #3: The five glaciers are located along a mountainous region containing numerous other glaciers.				

Regional Map of Glaciers We Investigated



Map indicating the location (lat/lon) of the 5 glaciers being studied in detail using astronaut photographs for our research.
Image source: Google maps

Extra Observation Tables

OBSERVATION TABLE				
Title of Data Display	Upsala Glacier, Argentina			
Type of Data Display (circle one)	Data Table	Graph	Map	**Image Illustration**
Summarize what the data display is illustrating.	This data display is showing multiple images of Upsala Glacier in the same orientation over a period of time showing potential changes to the terminus.			

List 1-3 general observations or trends of what the data display is showing.
Note: You may wish to include your thought process as to how you made your observation.

Observation #1:
We observed calving of the three images. The 2004 and the 2007 images have some calving. The 2010 image has substantially more calving evident than the previous two.

Observation #2:
There is a significant change in the location and shape of the terminus from 2004 to 2010.

We used a landmark to the East of the glacier to line up the terminus of the glacier. The landmark looks like a lake formed by part of the glacier to the north. It looks like a face with a nose and chin on the right (East) with a hanging goatee. We will line the terminus up with this goatee in each picture. In 2004, the goatee and the terminus lined up and formed a horizontal line between the two. In the 2007 image, the glacier has receded north of this goatee line. In the 2010 image the terminus is well north of the goatee line and now is actually above the chin level.

Observation #3:
On both shorelines, the glacier has receded.

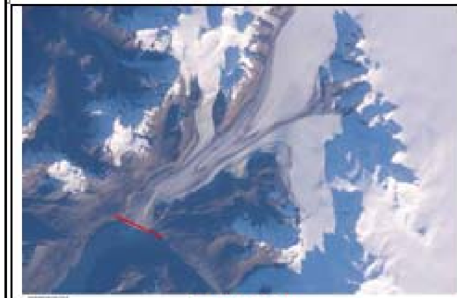
In the 2004 image the terminus is fairly straight across with a chunk out of the eastern side. The 2007 image has a terminus that is almost at a diagonal from the lower left to upper right. The 2010 image has a terminus that is not straight. There are two parts that elongate into the water body.

Upsala Glacier, Argentina

OBSERVATION TABLE	
Title of Data Display	Glacial Movement
Type of Data Display (circle one)	Data Table Graph Map **Image Illustration**
Summarize what the data display is illustrating.	This data display includes 5 sets of images. Each set contains two images of the same glacier taken on different dates. A red line is drawn at the same location in each set of images to help determine any change in the location of the terminus.
List 1-3 general observations or trends of what the data display is showing.	
Observation #1: All of the glaciers show an obvious retreat except for Perito Moreno.	
Observation #2: Chico Glacier appears to be the “dirtiest” of all the glaciers making it the most difficult glacier to interpret.	
Observation #3: Upsala appears to be the glacier showing the clearest indication of retreat.	

Glacial Movement

CHICO GLACIER 49.0S, 73.0W



MAY 2003

FEBRUARY 2007

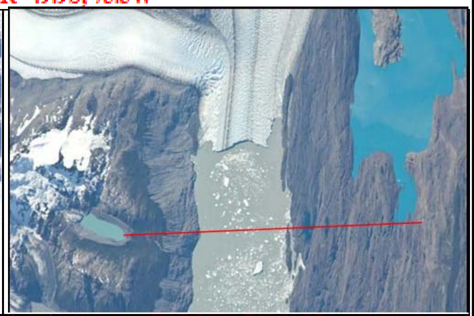
VIEDMA GLACIER 49.5S, 73.0W

APRIL 2002

FEBRUARY 2010

UPSALA GLACIER 49.9S, 73.3W

NOVEMBER 2004



FEBRUARY 2010

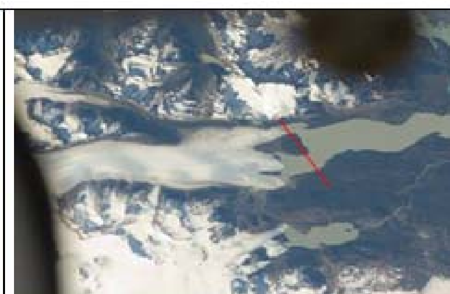
PERITO MORENO GLACIER 50.5S, 73.0W

2001

JULY 2007

GREY GLACIER 51.0S, 73.0W

NOVEMBER 2004

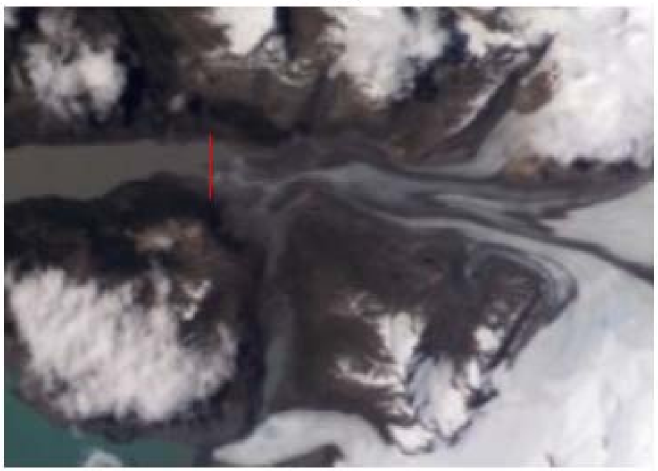


FEBRUARY 2010

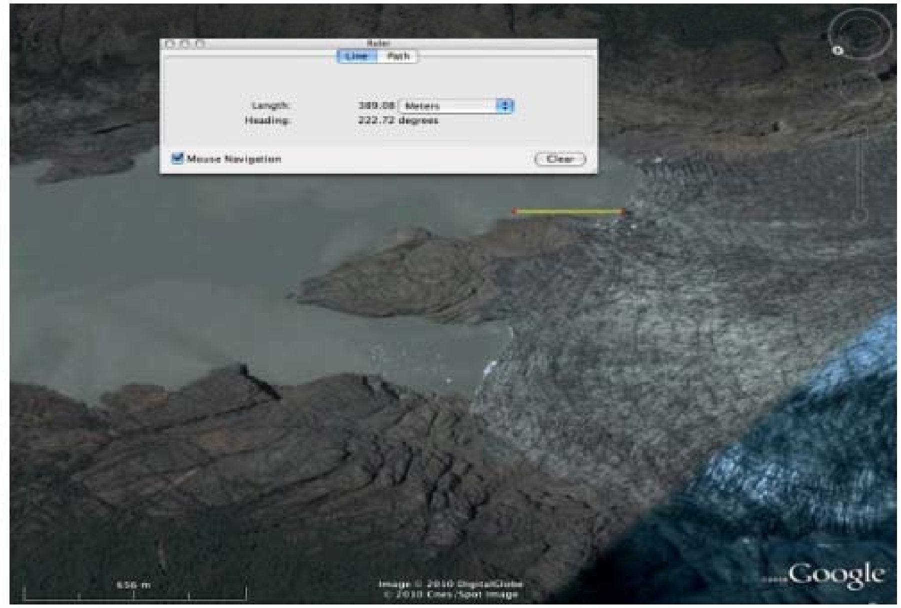
Title of Data Display	Chico Glacier – 2003 to 2007
Type of Data Display (circle one)	Data Table Graph Map **Image Illustration**
Summarize what the data display is illustrating.	The image on the right shows how the Google Earth measurement tool was used to determine a known distance based on a nearby landmark. The two images on the left show the glacier with a red reference line indicating change over time.
List 1-3 general observations or trends of what the data display is showing. *Note: You may wish to include your thought process as to how you made your observation.*	
Observation #1: There appears to be a recession of the terminus of the Chico Glacier between 300 – 500 meters when comparing astronaut images taken from 2003 to 2007. *Our team discussed the conflicting views of what the image was showing and had to look at a high resolution image to support our finding that the glacier was in fact retreating. You may have to look at a high resolution image to better determine the location of the terminus or the feature you are studying.*	
Observation #2: The February 2007 image appears to show less ice or melting ice. This made it more challenging to locate the terminus.	
Observation #3: The ice looks dirty, particularly in the February 2007 image.	

Chico Glacier - 2003 to 2007

Chico - May 2003



Chico - Feb 2007



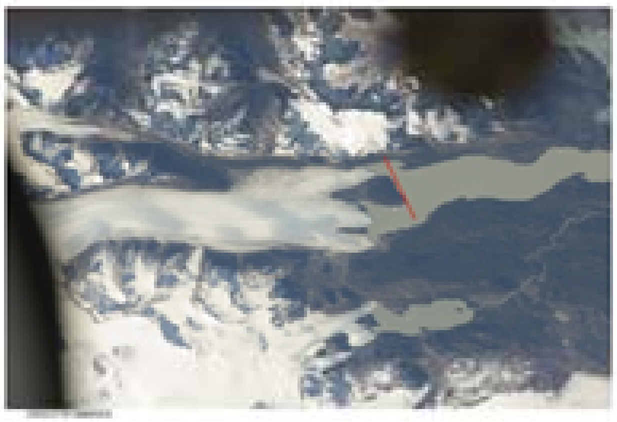
The image above shows how the Google Earth measuring tool was used to determine a known distance based on a nearby landmark, allowing us to estimate the change in the length of the glacier.

When comparing astronaut images taken from 2003 to 2007, there appears to be a recession of the terminus of the Chico Glacier between 300-500 meters.

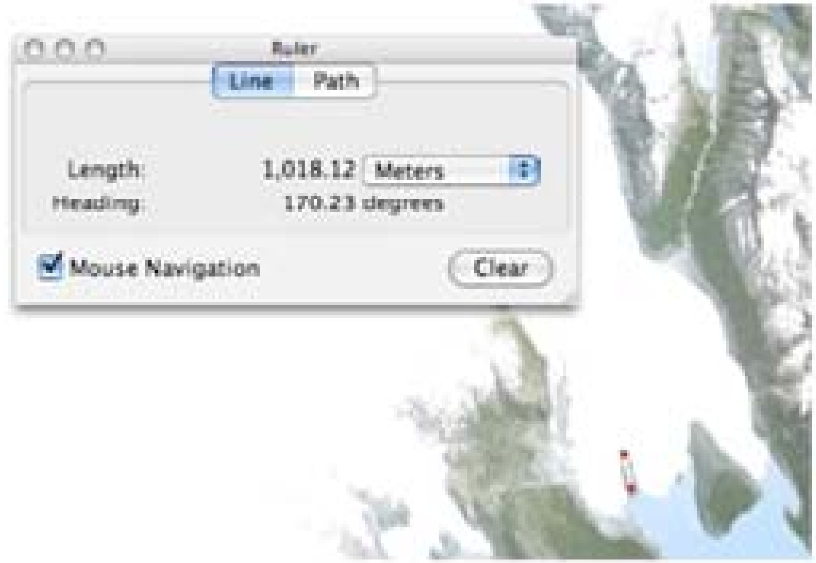
OBSERVATION TABLE	
Title of Data Display	Grey Glacier – 2004 to 2010
Type of Data Display (circle one)	Data Table Graph Map **Image Illustration**
Summarize what the data display is illustrating.	The image on the right shows how the Google Earth measurement tool was used to determine a known distance based on a nearby landmark. The two images on the left show the glacier with a red reference line indicating change over time.
List 1-3 general observations or trends of what the data display is showing. ***Note: You may wish to include your thought process as to how you made your observation.***	
Observation #1: The terminus of Grey Glacier looks like a 3-tined fork. Two of the tines wrap around a triangular island, creating a perfect environment for measurement.	
Observation #2: Using the island as a guide, we could see a retreat between 2004 and 2010. *In 2004 the top of the tine of the fork was at the broad end of the island. In 2010 there was a very visible distance between the end of that tine and the broad end of the island.*	
Observation #3:	

Grey Glacier - 2004 to 2010

Grey - Nov 2004



Grey - Feb 2010

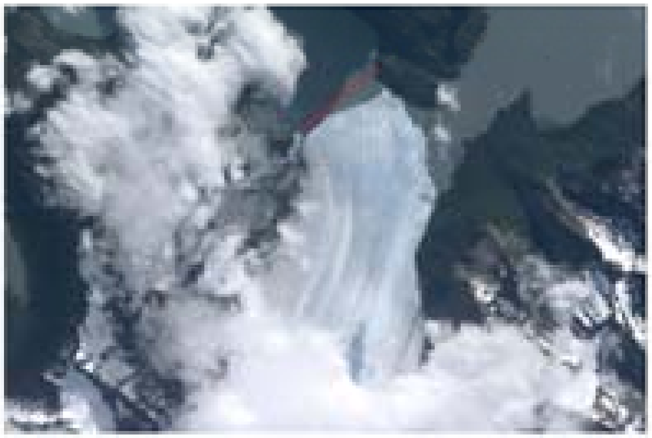


The image above shows how the Google Earth measuring tool was used to determine a known distance based on a nearby landmark, allowing us to estimate the change in the length of the glacier.

When comparing astronaut images taken from 2004 to 2010, there appears to be a recession of the terminus of the Grey Glacier between 300-500 meters.

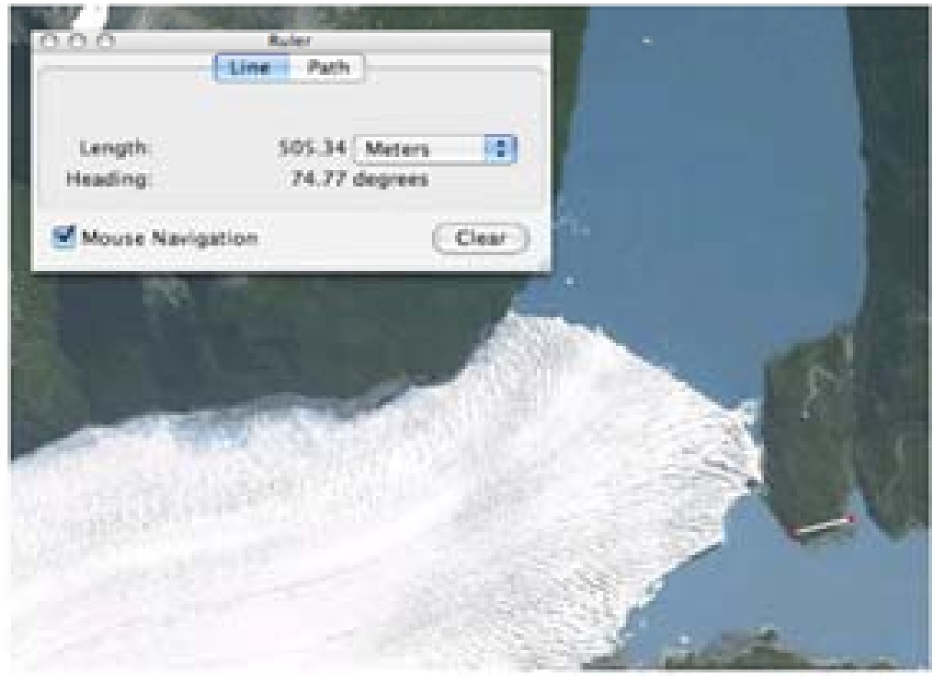
OBSERVATION TABLE	
Title of Data Display	Perito Moreno – 2001 to 2009
Type of Data Display (circle one)	Data Table Graph Map **Image Illustration**
Summarize what the data display is illustrating.	The image on the right shows how the Google Earth measurement tool was used to determine a known distance based on a nearby landmark. The two images on the left show the glacier with a red reference line indicating change over time.
List 1-3 general observations or trends of what the data display is showing.	
Observation #1: The terminus of Perito Moreno Glacier came in contact with a large rock outcrop that was located at the junction of two bodies of water. This created an excellent landmark for making our measurements.	
Observation #2: Between 2001 and 2009 there is no visible change in the glacier's location with relation to that rock outcrop. We can only assume that the glacier neither retreated nor advanced.	
Observation #3:	

Perito Moreno Glacier - 2001 to 2009



Perito Moreno - 2001

Perito Moreno - Mar 2009

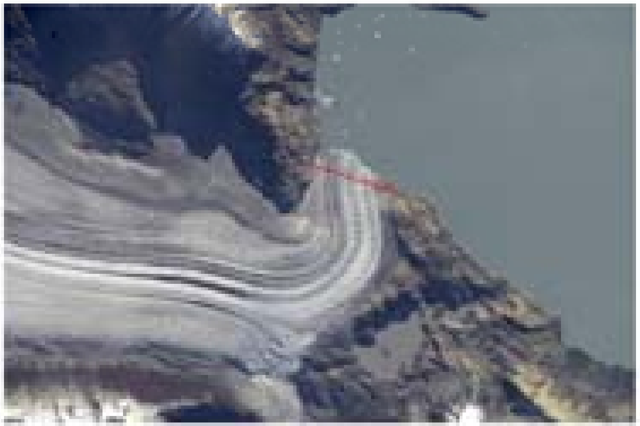


The image above shows how the Google Earth measuring tool was used to determine a known distance based on a nearby landmark, allowing us to estimate the change in the length of the glacier.

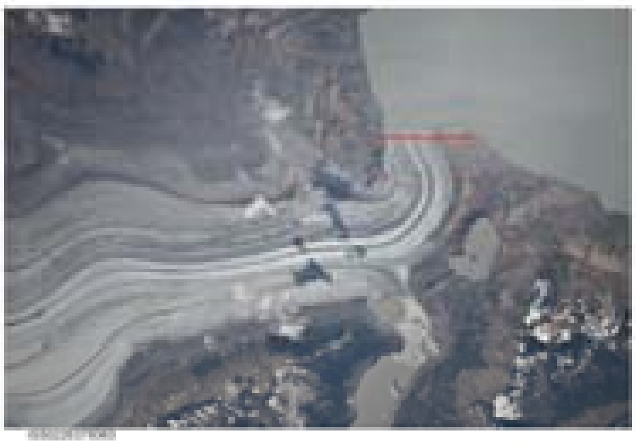
When comparing astronaut images taken from 2001 to 2009, there appears to be little, if any, recession of the terminus of the Perito Moreno Glacier.

OBSERVATION TABLE				
Title of Data Display	Viedma Glacier – 2002 to 2010			
Type of Data Display (circle one)	Data Table	Graph	Map	**Image Illustration**
Summarize what the data display is illustrating.	The image on the right shows how the Google Earth measurement tool was used to determine a known distance based on a nearby landmark. The two images on the left show the glacier with a red reference line indicating change over time.			
List 1-3 general observations or trends of what the data display is showing.				
Observation #1: Both images show almost the exact same area and landscape, making comparisons easier.				
Observation #2: We used the relatively straight end of one valley wall where the glacier empties into the lake as a landmark for measuring change.				
Observation #3: The terminus of Viedma Glacier extended far beyond the valley wall in 2002 but was parallel to it in 2010.				

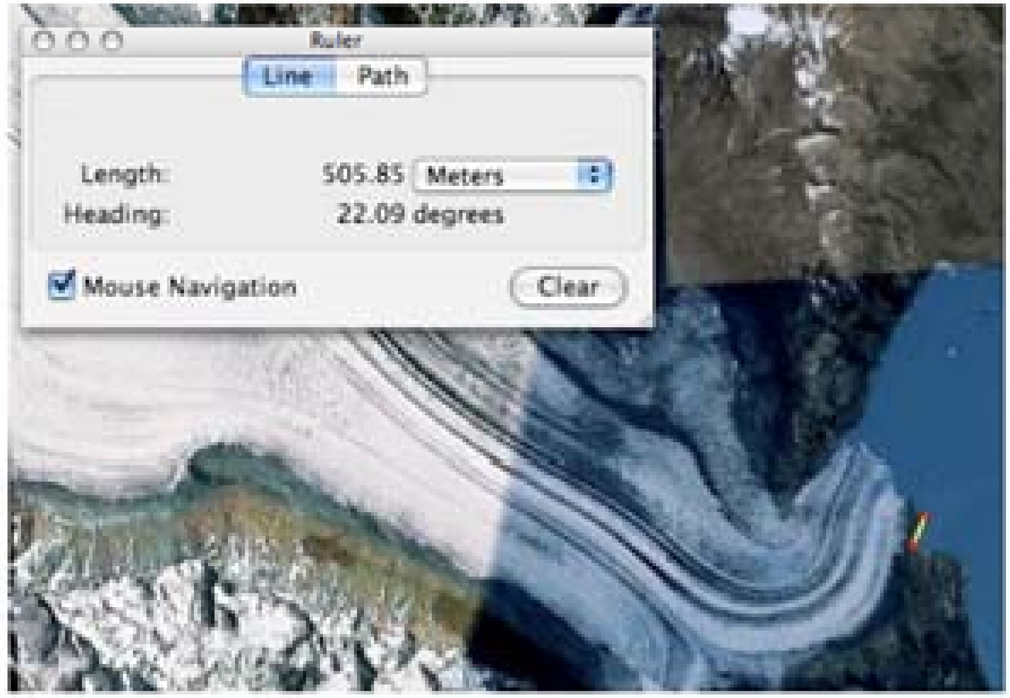
Viedma Glacier - 2002 to 2010



Viedma - Apr 2002



Viedma - Feb 2010

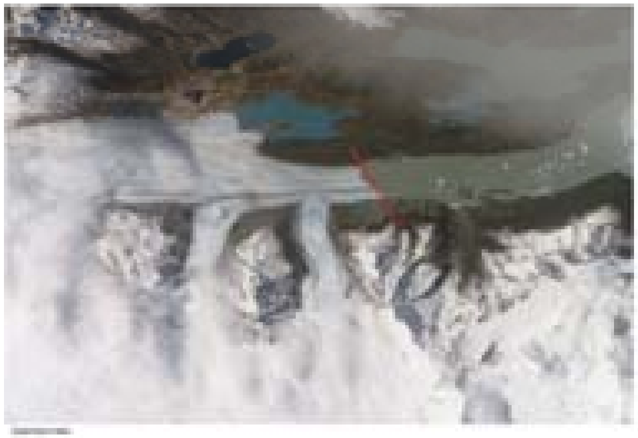


The image above shows how the Google Earth measuring tool was used to determine a known distance based on a nearby landmark, allowing us to estimate the change in the length of the glacier.

When comparing astronaut images taken from 2002 to 2010, there appears to be a recession of the terminus of the Viedma Glacier between 300-500 meters.

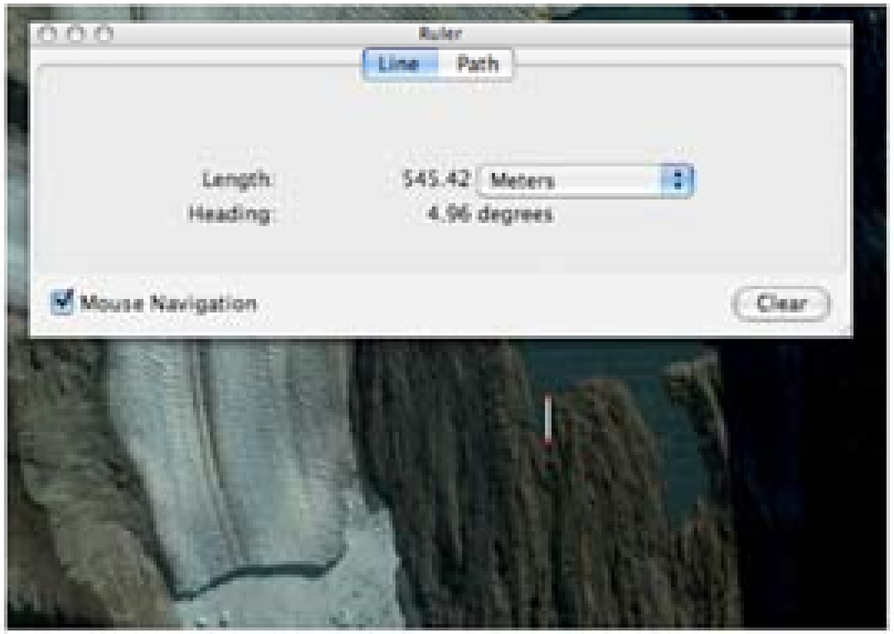
OBSERVATION TABLE	
Title of Data Display	Upsala Glacier - 2004 to 2010
Type of Data Display (circle one)	Data Table Graph Map **Image Illustration**
Summarize what the data display is illustrating.	The image on the right shows how the Google Earth measurement tool was used to determine a known distance based on a nearby landmark. The two images on the left show the glacier with a red reference line indicating change over time.
List 1-3 general <u>observations</u> or trends of what the data display is showing.	
Observation #1: The major landmark in the Upsala Glacier images is a large lake located beside the glacier. The irregular shape of the lake creates several great landmarks for making our measurements.	
Observation #2: In the 2004 and 2010 images you can see numerous ice chunks floating near the terminus of the glacier.	
Observation #3: Using an indentation in the lake as a guide, we can see a retreat in the terminus of Upsala Glacier.	

Upsala Glacier - 2004 to 2010



Upsala - Nov 2004

Upsala - Feb 2010



The image above shows how the Google Earth measuring tool was used to determine a known distance based on a nearby landmark, allowing us to estimate the change in the length of the glacier.

When comparing astronaut images taken from 2004 to 2010, there appears to be a recession of the terminus of the Upsala Glacier that is roughly 500 meters.

STEP 7: Analyze & Interpret Data

Now that you have your data displayed and have made observations of those displays, you are ready to do one of the most important steps of your research – analyze and interpret your data. Analysis and interpretation of data are done by thinking about how specific observations and acquired knowledge directly relate to your question. Your goal is to be able to draw conclusions about your research with supporting evidence.

As with all steps of your research, when you analyze your data, focus on your research question and hypothesis.

Research Question:

What types of changes are occurring to the five glaciers (Viedma, Upsala, Perito Moreno, Chico, and Grey) found in South America?

Hypothesis:

All five glaciers will have visible and measureable evidence of retreat.

To help you analyze and interpret your data, fill out the information in the table provided. Include the following:

- **Specific Observations from Data Display:** Examine the observations your team made of each data display. Think about observations that provide information related specifically to your question. You do not need to list every observation or even observations from every data display you created. List those observations that specifically relate to your question.
- **Interpretation(s) of What Observation Means With Respect To Your Question:** Describe how you think each listed observation can be interpreted. This means consider how the observation relates to your specific question.
- **Evidence That Supports Your Interpretation:** In the third column, list additional evidence that supports the interpretation of your observation. This can be specific evidence from other data displays or from background knowledge you gained throughout your research. Use additional paper as necessary to further discuss your observations and interpretations.

ANALYSIS AND INTERPRETATION OF DATA		
Specific Observation from Data Display	**Interpretation(s) of What Observation Means with Respect to Your Question**	**Evidence That Supports Your Interpretation** (from specific data displays and/or background knowledge)
1. Except for the Perito Moreno Glacier, all of the glaciers retreated during the periods measured. In all cases that retreat was at least 300 meters to as much as 500 meters. *[Glacier Data Table: Observation #1.]*	Almost all South American glaciers we studied seem to be retreating.	Data from our data table, image illustrations, measurements made, and our graph all support that most of the five South American glaciers we studied are retreating. Information from the Argentina Travel Guide website also stated that the Perito Moreno Glacier was advancing. The BBC and the PATAGONIA-ARGENTINA.COM sites both stated that the Upsala Glacier was retreating.
2. The Perito Moreno Glacier does not appear to have any changes to its terminus. *[Terminus Changes of Five South American Glaciers: Observation #2.]*	At least one of the five South American glaciers we studied, specifically Perito Moreno, is not changing. This leaves open the possibility that other glaciers in South America may not be changing as well.	Data from our data table, image illustrations, measurements made, and our graph all support that at least one of the five South American glaciers we studied is not changing.
3. None of the five glaciers we studied showed growth. *[Terminus Changes of Five South American Glaciers: Observation #2.]*	The cause of no growth could be based on climate changes in the region over time. This could be telling us that there is less precipitation or warming in the region.	Our background research (Extreme Ice Survey) provided information connecting climate change with glacial retreat.
4. All five glaciers are located near the same line of longitude and are approximately 0.5 degrees of latitude apart from each other. *[Regional Map of Glaciers We Investigated: Observation #1, 2]*	There may be a localized effect causing four of the five glaciers in our study to show evidence of retreat. The Perito Moreno Glacier, which showed no signs of retreat, may have another variable affecting it.	Our *Continental and Regional Maps of Glaciers* show this localized area of glaciers we studied as well as the larger region with additional glaciers. Additionally, our data table and internet sources provide supporting evidence for the retreat of four glaciers in this localized area except for Perito Moreno.

ANALYSIS AND INTERPRETATION OF DATA		
Specific Observation from Data Display	**Interpretation(s) of What Observation Means with Respect to Your Question**	**Evidence That Supports Your Interpretation** (from specific data displays and/or background knowledge)
5. The five glaciers are located along a mountainous region containing numerous other glaciers. *[Regional Map of Glaciers We Investigated: Observation #3]*	Since 4 out of the 5 glaciers we studied in this area showed visible signs of retreat, there may be a decreasing amount of snow fall or warming temperatures in this mountainous/regional area. If this is the case, in the future we could see additional evidence of retreat to the five glaciers we studied and potentially others in the region.	Our background research from the Extreme Ice Survey website states that global surface temperatures have increased over the last 100 years and are projected to continue to rise. Warming temperatures would contribute to the continual retreat or melting of glaciers.
6. There is a significant change in the location and shape of the terminus from 2004 to 2010. *[Upsala Glacier, Argentina: Observation #2]*	There is definite visible evidence of retreat of the Upsala Glacier observed in astronaut photographs. This visible evidence of retreat could probably be detected in other glaciers in the area. The Upsala Glacier could be retreating more than other glaciers in the region.	The measurements made using Google Earth show that the Upsala Glacier had the largest amount of visible retreat. Information read on websites also indicated that the Upsala Glacier was once the largest glacier in Argentina but has been showing signs of retreat.
7.		
8.		

Considering potential errors, inaccuracies, or limitations of your data is another important part of this step in the process of science. Stating these challenges up front helps others know you were aware of these aspects and took them into consideration as you stated your final conclusions.

Suppose your question was, "What is the average length of sand dunes?" If you were only able to measure the lengths of one type of sand dune in only one desert, is that enough data for you to conclude that your average length is accurate for *all* dunes? What if the resolution of the images you viewed made it difficult to measure dune length with confidence? Perhaps the data you focused on did not allow you to obtain the information and/or measurements you needed to answer your question. These would be considered potential errors, inaccuracies, or limitations of your data that should be thought about as you draw your conclusions. An acknowledgement of the limitations you list could help future research related to your question.

Consideration of Issues, Potential Errors, or Limitations of Your Research	
Potential errors or inaccuracies	Some of the images were also taken with different focal length lenses and from different angles, so there could be an error in our measurements due to varying perspectives. ***Note to teacher: You may wish to remind students that no measurement is exact.***
Potential misinterpretations	We did our best to identify and measure changes to glaciers using visible landmarks in images. We may have misinterpreted some landmarks or views of the glacier terminus due to shadows, clouds, or glacial moraines.
Limitations of data	Limitation 1: We investigated a very small number of glaciers over a limited geographical region. Limitation 2: As we searched for astronaut photographs of each glacier, we found it difficult to find images taken in the same month of different years. It was also impossible to compare glaciers over the exact same time span. The time spans varied from 4 to 8 years.
Other	Limited class time was an additional challenge.

STEP 8: Draw Conclusions

You have done all your research, displayed and analyzed your data, and considered any potential errors, misinterpretations, or limitations. You are now ready to draw conclusions about your question and hypothesis. This is an essential part of your investigation, as it allows you to synthesize your overall research and state your results. It also allows others to conduct future research related to your question.

1. State your research question. What types of changes are occurring to the five glaciers (Viedma, Upsala, Perito Moreno, Chico, and Grey) found in South America?

Based on your research and analysis of data, what do you conclude is the answer to your question? Summarize your supporting evidence.

Four out of the five glaciers we investigated were retreating. This was supported by the analysis of quantitative measurements obtained through Google Earth and the qualitative observations noted in our image illustrations. Background information obtained from various websites provided us with additional supporting evidence.

2. State your hypothesis: All five glaciers will have visible and measureable evidence of retreat.

Based on your research and analysis of data, was your hypothesis supported or refuted? Summarize pertinent evidence.

This hypothesis was refuted. However, four out of the five glaciers we studied showed visible and measurable evidence of retreat. This was supported by the analysis of quantitative measurements obtained through Google Earth.

3. List at least one new question, or explain what future research could be conducted, sparked by your investigation.

For future research we would consider investigating more of the glaciers in this area to see if they are also retreating.

4. Who would you like to acknowledge for helping you complete your investigation? This may include your teacher, mentor, parent, or anyone else that helped you or provided support throughout your investigation. We would like to acknowledge our teachers and our mentor for their help and support during our research. We would also like to thank NASA for the opportunity to request that an astronaut take a new image of Earth. This will allow us to further support our exploration and research of planet Earth.

5. Reflect on your research and think about how you might have been able to improve your investigation. List those ideas below. If we were to do this research again, it might be better to look at a greater number of glaciers in this area. The more glaciers we analyze, the more confident we could be in drawing conclusions about the overall trend in changes occurring to glaciers in this region. We could have also looked at data from sources that could provide additional evidence to support or negate the changes to these glaciers that we were seeing from astronaut photos. This would allow us to know if our findings from measurements we made using Google Earth were reliable or potentially questionable, helping us to strengthen our overall conclusions. Lastly, it would have been better to use the exact span of time for each glacier comparison to have a consistent set of data to compare.

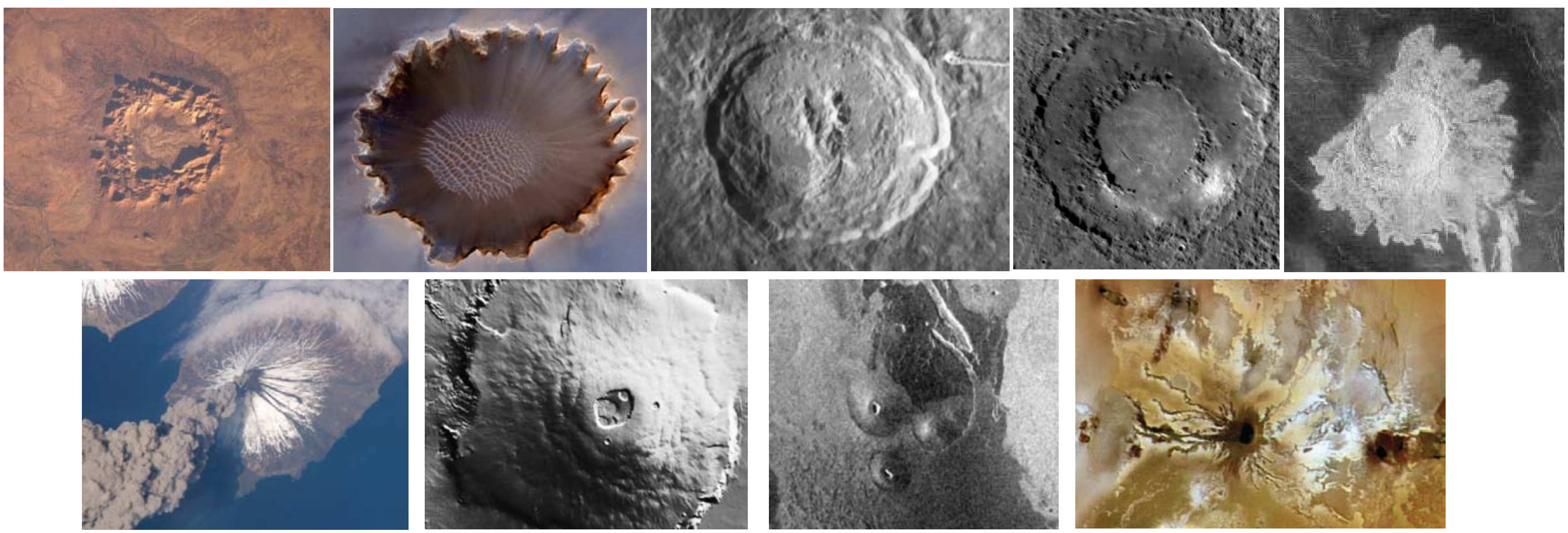
THE BEYOND

Now that you have a better understanding of the system and feature(s) you have studied on Earth, you may decide to conduct a planetary body comparison. Earth is a unique planet. The interrelated Earth system science model might not necessarily apply to other bodies in our Solar System. Your teacher can use activities, such as the *Blue Marble Matches* to help you get a sense of how to conduct planetary comparisons. You are not required to conduct such an investigation. It may, however, provide interesting connections to what you have already studied on Earth.

If you decide to conduct a planetary body comparison, other terrestrial bodies you may consider researching are:

-Mars	-Earth's Moon	-Mercury
-Venus	-Asteroids	-Moons of Jupiter (Io, Ganymede, Callisto, Europa)

These are a few examples of other worlds NASA is currently investigating. There are other planets in our solar system and other solar systems being explored. Comparative planetology is how researchers use what is known about Earth to better understand other planetary bodies in our Solar System. Consider conducting a planetary comparison investigation and take your research out of this world…and beyond!



Impact craters (top row) and volcanoes (bottom row) on Earth and other planetary bodies in our Solar System.

STEP 9: Share Research

One of the final steps of research is sharing it with others. Professional scientists go through a process of having their written papers formally evaluated by peers (other scientists in the same or related fields). This is called peer review. Every published scientist must have his/her work peer reviewed. This gives scientists the chance to acknowledge, question, or learn from each other's results, procedures, or conclusions. It is somewhat like a system of checks and balances. Professional scientists also present their results and conclusions to their peers at conferences. This can be considered a type of peer review, although not as formal. Science is about new ideas, new discoveries, and building on prior knowledge. If you don't share what you have researched, no one can build on or learn from your ideas.

Peer review can take place right in your classroom. By sharing your research with your teacher and other students in your school, you are participating in a type of peer review. As you assemble your findings, you should anticipate sharing your research with others using any one (or more) of the options listed below.

SHARING RESEARCH OPTIONS:

1. <u>EEAB Team Workspace Wiki:</u> If you have not already logged your team research on the wiki, you may consider doing so. This will allow you to share your research showing the 9 steps in the process of science.

2. <u>Scientific Paper:</u> Scientists who wish to publish their findings do so by writing a cohesive scientific paper or journal article. This technical paper includes titled sections that discuss the details of your research. Sections generally included are as follows: Abstract, Introduction, Background, Experiment Design, Data, Data Analysis/Discussion, and Conclusion. This type of technical writing is very valuable for you to experience.

3. <u>PowerPoint Presentation:</u> PowerPoint slides should be organized to show the progression of your research as written on your Team Workspace Wiki or your scientific paper. Your presentation cannot, and should not, include all the text you included on your wiki or in your scientific paper. A PowerPoint presentation should include a summary of the most important parts of each step of your research. The content of the slides should include a mixture of short bullets of information, images, and data displays that you can expand upon verbally during your presentation. Scientists typically use this format when presenting their research at conferences.

As part of the *Expedition Earth and Beyond* Program, you have the opportunity to share your research and results by participating in a Virtual Team Results Presentation. These presentations will allow you to present your team's results to scientists and NASA personnel as well as other students across the nation. If you are going to present your research live, you will need to have your research ready to present as a PowerPoint presentation. These virtual presentations will take place when a team is ready and will be run in a similar way to professional science conferences. Generally scientists meet in person at conferences. Since participants in *EEAB* will be from all over the country, these conferences will be held virtually. At professional conferences, scientist presentations are limited to about 15 minutes. This is followed by 5-10 minutes for questions or comments. *EEAB* will follow this same model. Keep this in mind as you put together your presentation and practice it. Professional scientists and other student scientists will look forward to hearing about your research. You will be building on a body of knowledge that will continue to grow as you and other students participate in *Expedition Earth and Beyond*.

EXPEDITION EARTH AND BEYOND – STEPPING INTO YOUR FUTURE

As you finish your *Expedition Earth and Beyond* investigation, you will have gained insight into the authentic process of science. Science doesn't just start and end. Each new discovery we make brings forth new questions and future work to be investigated. That is the true nature of science.

In the future, whether you decide to become a scientist, engineer, or take any other career path, you will have developed and refined some very important skills throughout your participation in this project.

IMPORTANT SKILLS GAINED THROUGHOUT YOUR PARTICIPATION:

- Critical thinking skills: Critical thinking is an essential skill for scientists, engineers, and you. Any time you have a question you want to answer or a problem you want to solve, you use critical thinking skills. Sometimes you need to be creative with how you go about attacking a problem. Critical thinking also allows you to evaluate the validity of statements and correctness of results presented by others. Your critical thinking and problem solving skills should have grown as you have participated in Expedition Earth and Beyond.

- Discussion and Debate Skills: These skills are extremely important no matter what you do. Being able to convince others that your opinion is the "right" (or most valid) opinion, is a very good skill to have. Scientific discussions and debate are similar to arguments. The difference is, you need to back up your opinions with facts and observations based on real data. Discussion and debate should also never be taken personally. Everyone's opinion should be valued, and debating professionally is always recommended.

IMPORTANT SKILLS GAINED THROUGHOUT YOUR PARTICIPATION (*continued*):

- Writing skills: Whether you posted on a wiki or put your final findings together in an outline or a cohesive scientific paper, one of the key items to keep in mind is the need to be clear and concise. This is important for any paper you write. Additionally, it is very important to learn how to appropriately cite references. Most papers you write in school or in your career will require this.

- Team work skills: No matter what line of work you are in, learning to function as a team is essential. There is always compromise that needs to take place when you work as a team. Learning to compromise and being open to different opinions is extremely important. Every aspect of life requires team work on one level or another.

- Presentation skills: Whether you debate a point of view or give a formal presentation, you are practicing presentation skills. If you can present your ideas clearly and with self-assurance, people will have confidence in what you are presenting. You will also more easily convince people to agree with your point of view. Presenting with confidence comes with experience. The more you present, the easier it becomes.

- STEM Careers: Science, Technology, Engineering and Mathematics (STEM) offer exciting career opportunities. These careers can have a major impact on the lives of everyone on our planet. They are such inter-connected fields that it is very difficult to participate in one area without touching on an aspect of the others. As you pursue a career for yourself in the future, one of the most important aspects to consider is what you would enjoy doing for the rest of your life.

Your participation in *Expedition Earth and Beyond* has provided you with an authentic experience in the process of science and the exploration of our Earth and possibly beyond. As we continue to explore our Earth and solar system, we hope you continue your journey of exploration both personally and professionally.