AGAP Antarctic Research Project

Visualizing Data – Learning About Antarctica From RADAR Data?

Teacher Version (answers italicized)

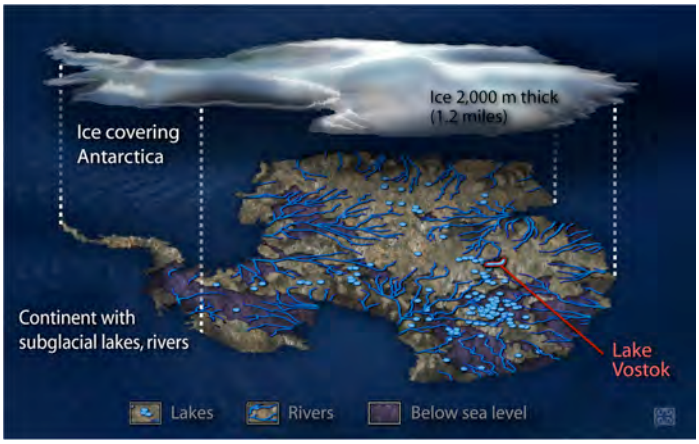


Image of Subglacial Lake network courtesy of NSF

Ice Sheet: A large glacier that covers the land. Antarctica and Greenland have the last two on Earth.

VOCABULARY:

Glacier: A body of ice that lasts all year and slowly flows across the land surface under the influence of gravity.

Calving: A section of ice called an iceberg that breaks off a glacier or ice shelf

Graticule: In discussing maps this command displays or creates a grid of lines that represent the Earth's latitude and longitude.

Ice Shelf: A thick section of floating ice along the edge of a continent. Forms from a continental glacier flowing into the sea.

Background: Using Radar to Locate Antarctic Subglacial Lakes

Antarctic ice is not just a blanket of frozen snow. It has floating shelves of ice and lakes of water under the ice! Twenty-five years ago no one would have believed that there could be lakes underneath glaciers. Today we know there are 200 or more of them in Antarctica. We know this **not** because we have actually seen the water…but because we have learned how to use radar to recognize their 'signature' in the ice sheet surface!

In this activity we will learn: 1) How lakes form under ice; 2) What role these lakes can play in the movement of the ice; 3) How to locate the lakes using radar images.

How can there be lakes under ice? At the base of the glacier the heat from the core of the Earth (geothermal heat) provides warmth from below, while the glacier sitting above is like a blanket holding in the heat. The trapped heat causes melting at the base of the ice sheet with water collecting wherever there is a pocket or depression forming lakes. Try this yourself. Use your warm hand as the Earth's core. Place an ice cube in your hand and watch as it melts from the bottom due to the warm contact. Look at your hand. It has pockets and crevices like the Earth surface does, and the water pools and collects in these depressions just like the lakes under the ice.

Lakes Effect Ice Sheets: In the 1990s scientists thought subglacial lakes were isolated from one another, each like a small underwater museum. Today we know that subglacial lakes are connected in a network under the ice through a maze of plumbing (see image above). These connections can cause them to rapidly drain or fill, as water can move from one lake into another. The movement of water between lakes can be sudden, like pulling the plug in a bathtub. This rapid shifting of water contributes to the surging of ice streams flowing in the glaciers, speeding more ice towards the continental edges to meet the ocean.

Warming ocean water causes more glacial melting with large chunks ***calving*** or breaking off into the ocean. Glacial ice has been melting and calving for years, but what is different today is that sections of the ice that have been locked to the land holding the ice back as they remain frozen hard, have started to melt and break away. The result? As these "stoppers" melt

away from the land they will release into the ocean large amounts of ice that they have been holding back. **What is the effect of adding more continental ice into the ocean?** ***Check out our "Climate Change: Why do the poles matter?" activity to see for yourself.***

TEACHER SETUP INFORMATION:

Visualizing Data Can Be Adapted to Multiple Grade Levels

Elementary School (grades 3-5): As a teacher directed group activity students complete sections I and II of the activity. They will learn about images as sources of information, how to identify different geographic features of Antarctica, and how to identify glacial features in the dataset. This can be done with a Smart Board or projecting the teacher's computer for the class.

Middle School: Match student in pairs with a computer between them. Begin part I as a group discussion before using the computer. Once the computers are in use after locating the website the teacher can let the students complete part one with their partners. Ask the students to stop when they have completed part I. As a group begin Part II by initializing the MOA. Then have the students spend some time familiarizing themselves with the navigation tools. When all students are comfortable working in MOA complete Part II working together as a class. Move from question to question allowing students to work in pairs, but ensuring that all students are managing to complete each section. Depending on how the students are doing with Part II you can either move on to Part III as student pairs are comfortable, or if your student group is finding movement in the data difficult, it might make more sense to continue working as a class.

High School: Depending on your student group you may wish to work on this project as a class activity (see the Middle School group discussion above), or let the students work independently in pairs or alone.

Alignment to National Science Standards:
Concepts & Processes – Evidence, Models & Explanation; Constancy change measurement,
Standard A: Science as Inquiry: Abilities necessary to do scientific inquiry; understandings about scientific inquiry
Standards B – Physical Science: Motions & Forces; Transfer of Energy
Standard D: Earth & Science: Structure of the Earth System
Standard E: Science & Technology: Technology; Understandings about science
Standard F: Science & Personal & Social Perspective: Natural Hazards; Science & Technology in Society
Standard G: History and Nature of Science: Science as a human endeavor

Materials Needed:

- Computer with internet connection for the class, or one for each student team (depending on set up)
- Copies of the activity for each team of students
- A globe

ACTIVITY

Part I – Science is about Data

1. What is Data? When you think about data in science and math what comes to mind? List some examples of data you have used:

Definitions for Data are widespread – data can be defined as:
Information used for calculating, discussing, reasoning…can include items representing facts, text, number series, graphics, images, sound, video…

2. Many individuals think of data as a series of numbers that provide measurements. Can data be an image or a picture? Explain your answer.

Yes – there are many types of scientific data - images, pictures, maps can all be data.

3. Go to **http://planet.sr.unh.edu/MOA/**
The image you are looking at is an example of data called the *Mosaic Image of Antarctica* (MOA). What can the name tell you about this data?

In art the term mosaic refers to pictures or designs that are created through setting small colored pieces into a surface. In imagery it is a composite picture made of putting together one image from many photographs. The MOA is created by the MODIS instrument (Moderate-Resolution Imaging Spectroradiometer), capturing data in 36 spectral bands at varying wavelengths and resolutions. There are 2 NASA instruments that image the entire Earth every 1 to 2 days. They collect data on large-scale global dynamics like cloud cover, radiation, and processes occurring in the oceans, land & atmosphere. The mosaic you see has been crafted from over 260 different images of data stacked from 4 to 38 images deep. The original MOA data was acquired between 20 November 2003 and 29 February 2004.

1. 4. Using the "MOA" data set we will explore some of the features of Antarctica. In front of you is an image of Antarctica. . If you were asked to describe what you see when you look at this image, in a sentence what would you say?

   Answers will vary.

5.There are several very noticeable features. Let's look at a couple that will help us learn a little more about Antarctica.

   • First if you were describing the overall surface of the continent you might have said it looks smooth and somewhat glassy. That is because most of the continent is covered by ice or continental glaciers that form large ice sheets.

   • Look at the area on the left of the image as you face it. One noticeable feature is a peninsula that extends off the far left side of the image that looks like a handle. You can use this peninsular handle to orient yourself to the continent. This handle is on the West coast of Antarctica.

How does this piece of Antarctica relate to the rest of the globe? *If you were to travel west out to the very tip of the peninsular handle and kept going you would end up in the continent of South America.*

   • Look at the bottom of the continental image, and move your eyes towards

the center where you will see a second prominent feature – a black and white strip of what seems to be a rough texture starting at the bottom of the continent and making a curved line extending about half way up the image. This strip is the Transantarctic Mountains (TAM), a large range of mountains that runs through the middle of the Antarctic continent separating West Antarctica from East Antarctica.

What you are seeing is the shadow relief image created by their height. These mountains are an important geographic and geologic feature in Antarctica. Geographically the mountains form a natural separation between West and East Antarctica, and geologically they provide a divide between two very different geologic times - with the lithosphere (Earth's crust) in East Antarctica being from the oldest time in Earth history, Archean-Proterozoic time up to 2500 mya, while the lithosphere in West Antarctica is from a much more recent time - the Paleozoic-Mesozoic – only as old as 540 mya!

PART II – Navigating & Identifying

Let's click on the initialize button and start exploring.
(See the separate instruction sheet on navigation before you begin this section).
We will use the smaller map over the control buttons as our 'control map' – clicking on this map will move you to a new location on the map. You will see where you have moved by the outlined red box on the map.

1. First we want to explore floating **ice shelves** so we will recognize what reflected ice looks like as it floats over water, rather than when it rests on land. Ice shelves are pieces of glacier that rest in the ocean, while ice sheets rest on the land. Zoom in on the map at the very bottom edge of the continent. Focus just to where the glacier rests west of the TAM. This area is an ice shelf.

Write a sentence to describe the surface of the ice here.
Answers will vary but it should say something like smooth butter or glue etc.

Does it seem smooth and flattened like the frosting on a cake? This smooth texture is what ice looks like as it floats on water. This area is called the Ross Ice Shelf. You can check this using the controls. On the right column click on 'glacier' and then click 'refresh'. You should see several names pop up in yellow – "Ross Ice Shelf" will be the one closest to the sea. (If you don't see the names try zooming in and hit refresh again)

Ice shelves are large flat sections of ice along the edge of a continent that form as a continental glacier flowing out into the sea. Glaciers and ice sheets are constantly moving, and continental ice sheets flow outwards from their thickest point. The Ross Ice Shelf is an example of the edge of the Antarctic ice sheet that has flowed out into the Ross Sea.

1. 2. Let's look for more floating ice. Move to the area that is on the top edge of the Antarctic image (remember use the small image to move in). Focus in on the section of ice that is in a U shape that is formed between the peninsular 'handle' that extends off the continent on the west and the rest of the continent to the right (East). Does this area look smooth and flattened like the Ross Ice Shelf? If you have the 'glacier names' choice highlighted you will see that this area holds the Ronne & the Filchner ice shelves. Again these ice shelves are the edges of the ice sheet that is floating over the Weddell Sea. We

have looked at two different ice shelves. Now that you know what they look like and where you would likely find them, see if you can find others. ***List the names of two additional glaciers*** and whether you found them on the West or the East side of the continent.

There are ice shelves around the perimeter of the Antarctic continent that the students can choose from. Be sure they use the peninsula to help recall West Antarctica from East Antarctica.

3. Scientists explore data sets just like this to better define known features and to locate new or previously unnoticed features in the topography. One item that can be visualized using this type of data is **subglacial lakes**. These are the lakes mentioned in the **Background Section**, that form underneath the glaciers from geothermal heat (heat that radiates up from the center of the Earth) warming the bottom of the ice sheet, combined with the heat trapping of the overlying ice sheet, creating enough energy to melt the ice. Because glacial ice floats over these lakes, radar images of subglacial lakes look like the floating ice-shelves we just looked at.

   Let's locate one together in the data. First, on the left side of the control board select the highest resolution image provided - '**moa_uhc**' - which stands for ultra high contrast. Once you have hit refresh you will have very starkly detailed topography. It is easier to spot lakes in this setting, so leave your image selection on this setting for the rest of the activity

   On the right side of the controls select '**graticule**'. This will add the latitude and longitude lines onto the map. If you click close to what looks like the center of Antarctica on the control map you will see a central star-like image where all the longitude lines come together. This is the South Pole – the origin of the longitudinal lines at this end of the globe. We will follow longitude 105° as it goes out to the East. Move out until you are on longitude 105° between latitude that shows as -75° and -80°. (Note: Latitudes south of the equator and longitudes west of the prime meridian are negative numbers). ***Write a sentence to describe what you see:***

   Answers will vary but should describe a kidney bean or oval shaped image with a flat surface and slight elevation at the edges.

4. What you are seeing is the smooth area of ice floating over a subglacial lake. On the top edge you will see a trough like depression where the ice disconnects from the underlying bedrock as it moves over water, and on the bottom edge you will see a ridge where the ice reconnects with the bedrock. This smooth surface, with a ridge/trough boundary is characteristic of subglacial lakes.

To verify that it is a subglacial lake on the right side of the control panel select a second button (leave graticule selected). Select 'Lakes'. You will need to be zoomed in close before you will see the name appear. **What lake is this?**

(Vostok Lake)

How does this piece of Antarctica relate to the rest of the globe? *If you were to travel east from this large subglacial lake to the edge of the Antarctic*

continent, continuing out into the ocean, if you kept going you would just skim along the Western edge of Australia.

PART III Identification & Analysis

1. In this same area of the continent are at least two other subglacial lakes that can be identified. These lakes are more recently located so they are not labeled in the data set. Locate them using the same techniques you have just used to find Lake Vostok. Look for smooth surfaces, and the ridge/trough boundaries. **Identify them by noting their latitude and longitude.**

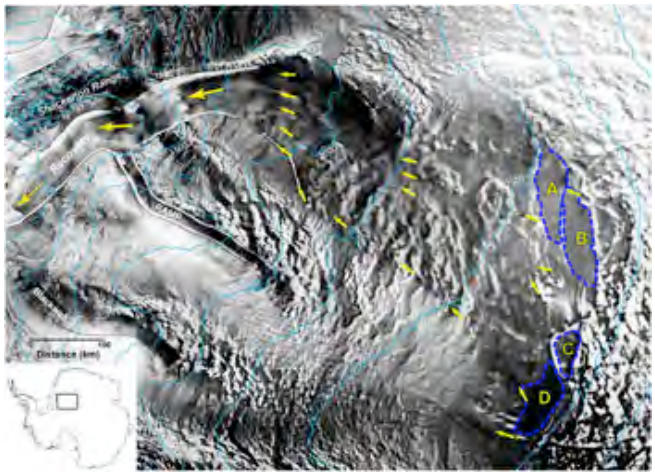
There are two lakes identifiable in the image - 90°E Lake, named because it is located along 90°E longitude between -78° and -77° latitude, and just above this is a smaller lake that falls along -78° latitude between 90°and 85° longitude. This lake is called Sovetskaya Lake.

2. Remember that ice sheets are always slowly moving, flowing outward from their thickest point. Recently scientists have determined that subglacial lakes can actually accelerate the movement of ice sheets by adding water to their base and lubricating them. This is like adding wax to the underside of a sled. Amazingly you can actually see the ice flowing by zooming in over some of the ice sheets. We will try this next.

Lets go to a new section of the map by The Recovery Ice Stream. Use your small map over the control panel to get a general idea of the location. We want to navigate to the upper half of the Antarctica continent, East of the Ronne & Filchner ice shelves we located earlier, and just East of the uppermost extension of the TAM. Place your cursor in this general area and lets zoom in. You want to focus on the ice between 20° and 15° longitude and -84° and -83° latitude. Let your eyes travel west and north (upward) and see the blurred and wavy line that streams out like a comet tail. That is the ice streaming towards the edge of the continent where it might become part of the ice shelf ending up over the sea. Scientists estimate that each year the Recovery Ice Stream deposits close to 35 billion tons of ice into the ocean ***As ice from the continent moves into the water what effect do you think it will have?***

Ice over land (continental ice) does not contribute to sea level rise, but once it is added to the ocean it will.

3. At the top of The Recovery Ice Stream, an 800 km river of moving ice, a group of 4 subglacial lakes has been located – The Recovery Lakes. These lakes are feeding the ice stream, sending new contributions of ice towards the coastline. This contribution can have an impact on sea level rise. These lakes are not as easy to see as the other subglacial lakes we have looked at but see if you can find them using the clues we have used before. They are clustered together and all located from 25° and 15° longitude and -85° and -82° latitude. (Hint – these lakes are shifted 90° in relation to the ones we looked at earlier.)



The lakes are outlined in the image above and labeled A, B, C, D. These are very challenging images to locate so if your students are having difficulty with this piece of the activity you might want to just show them this image or locate the lakes as a class.

How does this piece of Antarctica relate to the rest of the globe? *Travel along the 25° longitude line away from the South Pole and continue to what we have called the 'top' edge of the continent. If you move out over the ocean the first continent you will reach is South America.*

4. Subglacial lakes speed the movement of ice sheets. In this data you can see the ice streaming and lakes at the onset of the ice stream. Scientists don't really know how the lakes speed up the ice flow. Two theories are:

a. Maybe the lakes are slowly leaking out at the basins they rest in and this greases the bottom of the ice sheet.
b. Maybe the water in the lake warms up the bottom of the ice sheet as it slowly moves across. This warming may lubricate the ice sheet enough to speed it up.

Do you think one of these might be the answer?
OR do you have another theory?
Defend your favorite hypothesis and what additional information we would need to know to support it. (What data do you think would need to be collected?)

Remember your hypothesis might be the right answer!

Take a vote as to who thinks (a) or (b) makes more sense. If there are alternative hypotheses share them. We don't know the answers so creative thinking is a valuable part of the process.

Activity Data Source

Haran, T., J. Bohlander, T. Scambos, and M. Fahnestock compilers. 2005. *MODIS mosaic of Antarctica (MOA) image map*. Boulder, CO, USA: National Snow and Ice Data Center. Digital media.

For More Information:
http://earthobservatory.nasa.gov/Study/MOA/