Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE

ACTIVITY III: ROSETTA: DECODING THE MYSTERIES OF THE ROSS ICE SHELF

Ice Shelves play a critical role in Antarctica, serving as a buffer between the ocean and the continental ice sheet covering the land.

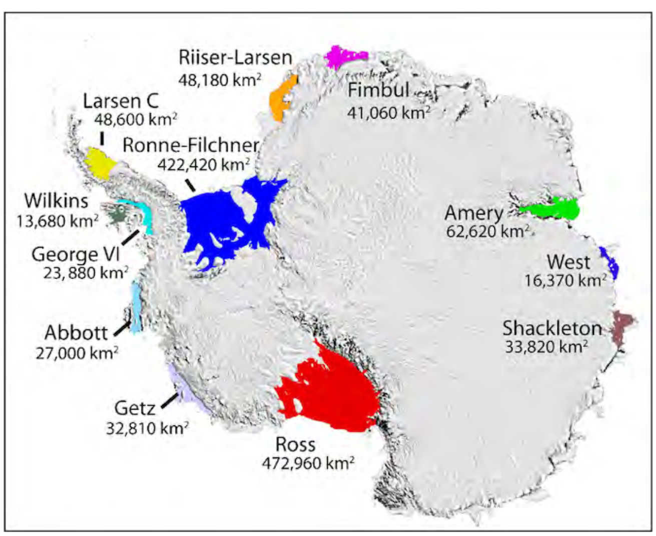
The Ross Ice Shelf: In this third activity focused on Antarctic Ice Shelves we take a look at the Ross Ice Shelf. The largest of the Antarctic ice shelves. Ross is a massive apron of ice stretching to an area of 487,000 sq. kms (188,000 sq. mi.). You will measure the ice yourself using radar data to see just how thick the ice is at the shelf front.

This incredible block of ice, about the size of California, is being fed a constant flow of ice from glaciers draining in from both the East and West Antarctic Ice Sheets. You will track some of the ice as it moves across the shelf, calculating its age.

The Ross Ice Shelf plays a critical role in stabilizing the Antarctic ice sheet, buttressing the ice that is constantly moving over the land surface. But just how stable is it? We will turn to some models to help answer this question.

Activity Goals:
In this activity you will:

- Consider the importance of the scale of ice shelves in the overall ice cover in Antarctica
- Use data from the Ross Ice Shelf ROSETTA Project to determine ice shelf thickness (http://www.ldeo.columbia.edu/rosetta)
- You will use data to track packets of ice from Mulock glacier as it enters the ice shelf until it melts away
- Consider two models on the stability of the Ross Ice Shelf under different global conditions.



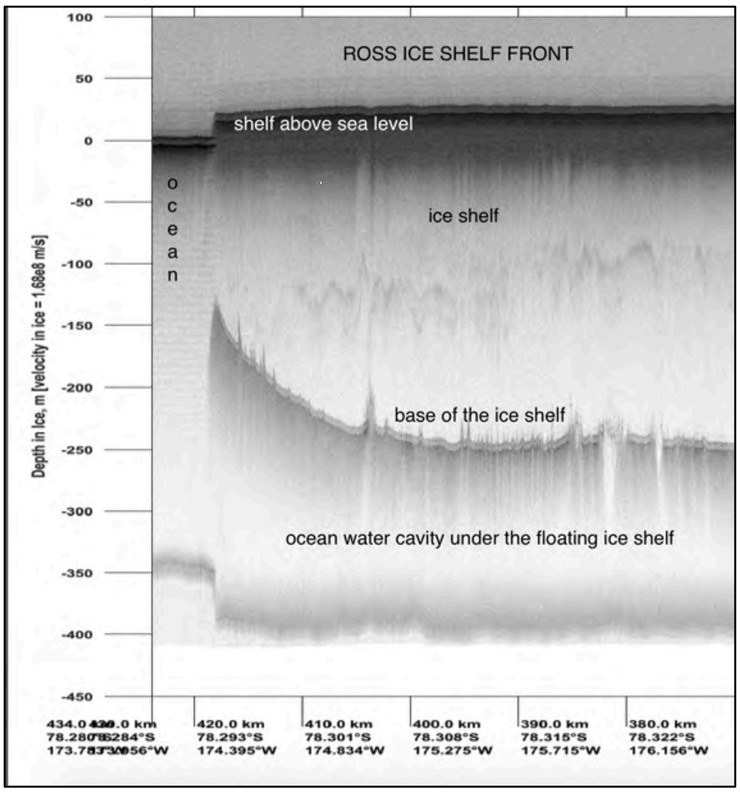
How Big Is Big? There are approximately 45 ice shelves surrounding the Antarctic continent covering almost half the coastline. They represent an area of ~1.5 million km^2. This is close to 10 percent of the total ice that covers Antarctica. Recall from activity #1 that white Ice cover is reflective, called albedo. High albedo sends a lot of the sun's energy back into space.

About a dozen of the ice shelves are considered major shelves, with the largest being the California-sized blocks of ice called the Ross Ice Shelf and the Filchner-Ronne across from it. These two shelves fill the bays that sit at the intersection of East and West Antarctica.

Circle the largest and the smallest of the dozen largest ice shelves. What is the difference in scale between these two ice shelves? __________

Overall ice shelf size is important and hints at the stability of the shelf. But there can be other factors that influence the life of an ice shelf. We will consider this later in this activity.

Section 1. Measuring Ice Shelf thickness: Ice shelves are weakened by melting at the base resulting from warming ocean water below, and melt at the surface from warming atmosphere above. A thick ice shelf has more buffering from these processes. The image to the left is from radar imaging through the ice at the front of the Ross Ice Shelf. Radar, like an x-ray, is a black and white image that can require training to interpret. We added labels to help.



- The far left and under the ice shelf is the Southern Ocean.
- The dark layer on the top of the image is the surface of the ocean on the left and then steps up to the surface of the ice shelf.
- The base of the ice shelf has been labeled.
- The Y axis is meters of elevation above and below sea level.
- The X axis is distance in kilometers.

A) Start by calculating the elevation of the ice shelf. The part of the ice shelf that is visible to the human eye is that small part sitting above the ocean. Use the scale on the Y axis and estimate approximately how high the ice shelf sits above the water_________.

B) Ice shelves, like icebergs, are mainly below the waterline. This is a result of the difference in density between ice and ocean water. The density of water is 1.0 g/ml. When water freezes into ice the water molecules spread apart and it becomes lighter with a density of 0.92 g/ml. Because of the salt, ocean water has a little higher density than freshwater (1.03 g/ml). Because the densities of ice and ocean water are so close in value, ice floats very "low" in the water, with a large percent of the ice below the waterline.

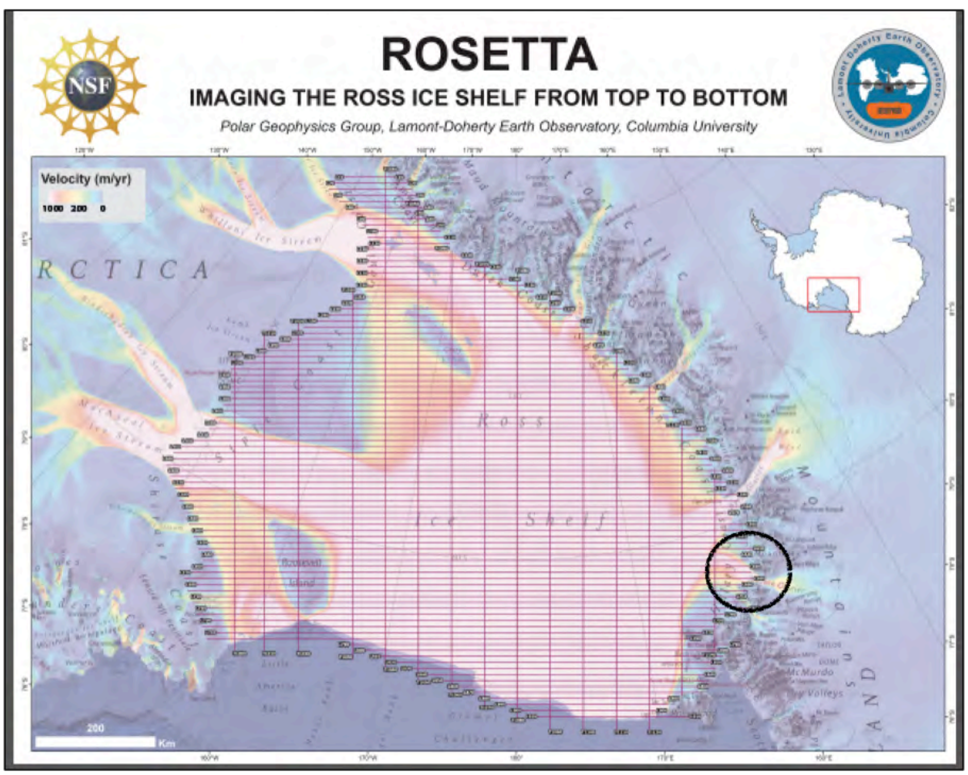
What percent of the ice shelf would we expect to find below the water surface? ________

C) Since the majority of the shelf is only visible using instruments we will use the measurements from our radar to see what percent of the Ross Ice Shelf is below the water. Our radar measurements tell us that the shelf gets thicker as you move further away from the front of the ice shelf where the water has been melting the ice at the base. Estimate the ice shelf thickness at each of the kilometer markings starting at the ocean edge (left) and moving back towards the Antarctic continent (right).

Kilometer Reading	Ice Shelf Thickness below the surface in meters	Ice Shelf Thickness above the surface (Question #2)	% Submerged
420 km			
410 km			
400 km			
390 km			
380 km			

Check to see how your calculations match the density principle. What was your average percent submerged?________

Fast Fact: You calculated thicknesses at the front of the ice shelf. You might be surprised to learn that at its thickest, back away from the floating edge where it is frozen to the ground below, the shelf is close to 1200 m (~4000 ft.) thick! That is a lot of ice!



Section 2. The image above is the Ross Ice Shelf. The dense grid of lines is the ROSETTA project planning tool focused on collecting a complete series of radar data by flying back and forth both N-S and E-W in order to make a grid of data on ice shelf thickness. The data

will help us to better determine areas where thinning may occur. This activity will work with some of the data collected during the flights. Look at Mulock glacier circled above, where ice is streaming along the southeast edge of the ice shelf. Ice is constantly moving into the ice shelf from a series of glaciers all around it. Ice from Mulock glacier flows in and hooks down along the edge of the shelf at ~ 125 meters a year or 1.25 km every 10 years.

A) Using the series of images provided by your teacher you will track this ice over 80 kms as it moves across the shelf. You will be calculating approximate ice thickness of the glacier input into the iceshelf as it moves through each of 5 areas, as well as calculating ~how long the ice has been on the shelf given the rate of flow provided above and distance covered.

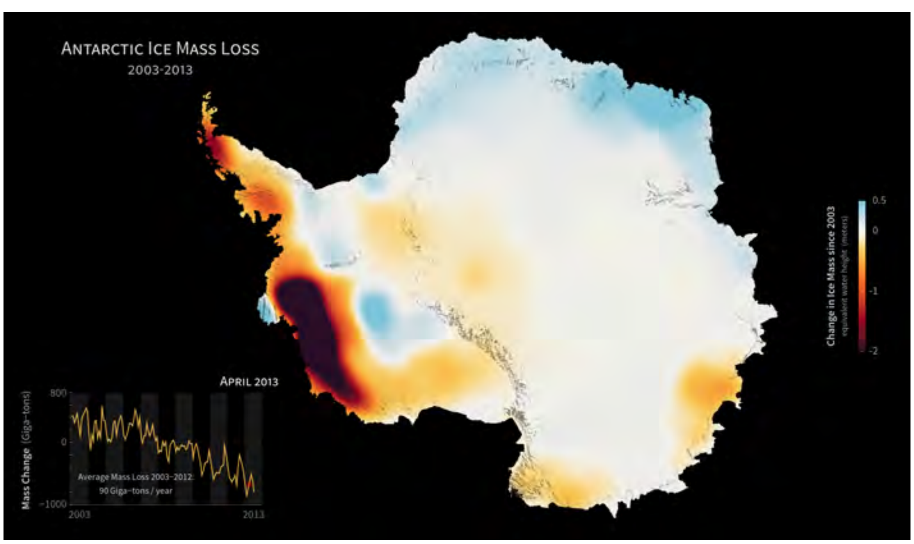
Kilometer of the reading	**Thickness of the ice**	**Time the Ice has been traveling on the shelf**
Kilometer 790		
Kilometer 800		
Kilometer 830		
Kilometer 850		
Kilometer 870		

B) Based on your analysis, what happens to the ice as it moves?

C) How many years does it take for the ice from Mulock's glacier to be almost fully melted away at the base?

Section 3. Stability of the ice shelf: If size equals stability the Ross Ice Shelf should be very stable. However it is important to consider the location of the ice shelf, and the stability of the glaciers feeding it. Ross ice shelf becomes vulnerable because of its neighbors. Ross depends on ice from both the West and the East Antarctic ice sheets and without constant inflow of ice a warming atmosphere and warming ocean will wear away at the ice shelf.

A) Satellite Data: Consider this satellite data collected by NASA's GRACE satellites showing ice loss in West Antarctica over a 10 year period (2003-2013). The image shows large amounts of ice loss in West Antarctica that extends over to the Ross Ice Shelf.



Why is West Antarctica losing so much ice? West Antarctica has large sections of land pushed down below sea level. Sitting lower than much of East

Antarctica, the ice is more exposed to warming ocean water. One hypothesis is that warm water is moving up over the continental shelf weakening the ice where is it frozen to the ground. Several science journal articles have noted that we have passed the 'tipping point' and we can no longer stop the melt of this area. But have we passes it?

B) Models: Two different sets of models have been developed from a team of scientists (DeConto and Pollard). The models are based on two of the International Panel on Climate Change (IPCC) scenarios, RCP 2.6 and RCP 8.5. Scenario RCP 2.6 presumes the global annual Greenhouse Gas (GHG) emissions peak by 2020 and decline substantially after that. Scenario RCP 8.5 presumes the global annual GHG emissions continue to rise throughout the century.

Run the models.
If the West Antarctic ice sheet collapses global sea level will rise over 6 meters (~21 ft.). Changes are necessary if we want to protect the future.

C) Action Now!
Not everyone sees the need to respond since the big changes don't happen until the end of the century and later. We need the help of people who understand that not acting is extremely harmful. Consider how we can start creating change locally and communicating to others by what we do.

Using the space below or on a separate sheet:

1. Work with a group of students and identify at least **five** changes students your age can make to reduce GHG emissions.
2. Identify at least **three** ways that you and your friends can share this information with other students.
3. Identify opportunities that you have to communicate to businesses, corporations and community leaders about changes that can be made both through your actions and through direct communications.

1. ____
____
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____
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2. ____
____
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3. ____
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