What do we already know, or think we know, about climate & Antarctica? - Teacher Guide

Setting the Stage

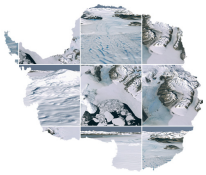
Students will participate in a chalk talk to elicit initial ideas about climate and Antarctica and the types of data scientists collect. Students will then explore images of Antarctica and make initial noticings and wonderings about what they're seeing. Students will be introduced to important vocabulary through matching terms to components or features of a satellite image. Students will then synthesize their initial ideas about how satellite imagery can help us understand climate change in Antarctica.

Photo Credit: Meltwater on the ice shelf near the McMurdo research station, Antarctica. Nicholas Bayou / UNAVCO

Lesson Overview

- *Part 1 – (20 minutes) Climate and Antarctica Chalk Talk*
  Students will rotate through six posters and answer questions about climate and Antarctica designed to elicit existing ideas.
- *Part 2 – (25 minutes) Introduction to Satellite Imagery*
  Students will look at a variety of satellite images and fill out a table of what they notice (observations) and wonder (inferences).
- *Part 3 – (15 minutes) Interpreting Satellite Imagery*
  Students will match components of the imagery to specific vocabulary terms used in interpreting satellite imagery.

These materials were developed by Meghan Mosher, Penny Rodrick-Williams, Allen Pope, Anna Ruth Halberstadt, Luke Trusel, and Mahsa Moussavi in collaboration with CIRES Education & Outreach at CU Boulder. Funded by NSF OPP Award #1643715.



Instructional Overview	
Grade Level	High School
Instructional Time	60 minutes
Standards Alignment	**NGSS:** ● **PS4.C: Information Technologies and Instrumentation:** Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. ● **Analyzing and Interpreting Data** ● **Patterns**
Driving Questions	● Is ice in Antarctica melting? How do we know? ● What tools do scientists use to answer these questions?
Anchoring Phenomenon	● Climate change and environmental feedback loops are causing Antarctic ice to melt, which is causing dramatic local and global impacts.

Learning Goals	● Students will be able to…
	  ● Use new vocabulary to describe Antarctic climate and environmental processes, in particular surface hydrology
	  ● Begin to interpret satellite imagery of the Antarctic ice sheet

Materials	❑ Poster sheets or group whiteboards ❑ Markers ❑ Student handouts ❑ Satellite image sets ❑ Card sort sets ❑ Computers
Material Preparation	❑ If not using computers: print out one set of satellite images per group and one set of cards for the card sort per individual or group ❑ Print out students handouts (1 per student)
Instructional Strategies	● Part 1: Chalk Talk http://www.rcsthinkfromthemiddle.com/chalk-talk.html ● Part 2: Notice (Observe) / Wonder (Infer) Table ● Part 3: Card Sort & Scaffolded Notes

CC BY NC

	Web Links for Lesson Resources
Part 1	• None
Part 2	• A writeup and explanation of one of the images that the students investigate: NASA EO - Widespread Melt on the George VI Ice Shelf https://earthobservatory.nasa.gov/images/146189/widespread-melt-on-the-george-vi-ice-shelf
Part 3	• Satellite images • On-the-ground photos

Part 1

Climate and Antarctica Chalk Talk (20 minutes)

Driving Question: What do we already know, or think we know, about climate and Antarctica?

Start the class with a rapid Chalk Talk protocol intended to record students' existing ideas about climate and Antarctica. Using large pieces of poster paper or white boards, create six questions to post around the room. Questions to use:

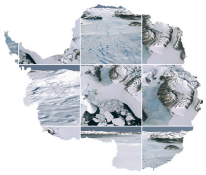
- What is weather? What is climate? What is the difference?
- What controls weather patterns on Earth?
- What do you know about Antarctica?
- Why is Antarctica so important in studying weather and climate?
- What kinds of data do we collect to understand Antarctica?
- How does data we are collecting in Antarctica connect to understanding our local environment?

1. Ask students to spend approximately 10 minutes total moving from poster to poster and writing down their answers to each question. They should spend approximately 1 minute per poster. If they see something they agree or disagree with already written, they must elaborate on it, modify it, or otherwise explain their agreement/disagreement (they can't just say, "I agree"). It is okay at this point for students to have misconceptions, most of these will be addressed in the following lessons.

2. As students speed around the room, read what they are writing to assess and interpret their initial thoughts about climate and use this information to inform your instruction.

3. Next, gather students as a class to summarize their responses for approximately 5 minutes. Then, take 5 more minutes to go over the core information - 10 minutes total for wrap-up.

CC BY NC

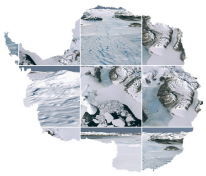


Part 2
Introduction to Satellite Imagery (25 minutes)
Driving Question: What data do scientists currently use to study (ice melt in) Antarctica?

Divide the class into small groups (at least 4), and give each group a set of satellite images. To keep groups small, multiple groups can receive the same set of imagery. Each set features one region in Antarctica, with 4 multispectral (i.e., visible) satellite images and one radar image (the greyscale ones).

- Images are chosen to highlight the difference in Antarctica of each season.
- You might be interested in the naming of the files - you can read more about that here for the multispectral data and here for the radar data - but it includes information about the sensor, location, date, and processing.
- You might need to remind students that Antarctica is in the Southern hemisphere and so the seasons are not at the same time as in the Northern hemisphere.
- Multispectral sensors are “passive” - like a camera without a flash. This makes these images relatively intuitive to interpret. Radar images, on the other hand, are “active” - they send out a signal and record what comes back. That’s why the radar images can be collected in the winter when it is dark - as well as through clouds (because of the wavelength they use)!
- The radar images depict how the radar energy emitted by the satellite interacts with the ground—both at the surface and at some depth below the surface. Where there’s a strong reflection, the image appears bright, and where there’s a weak reflection the image appears dark. The strength of this reflection is called ‘backscatter’. Many processes impact the backscatter, but in general, rough surfaces (like rocks or jagged ice) have high backscatter, whereas smooth surfaces (like calm water) have low backscatter. Over ice sheets, if there’s a very dry and deep snowpack, the image will appear dark because the radar signal penetrates several meters into the dry snowpack and little radar signal escapes back to the satellite. In an area that has a lot of frozen or re-frozen water at the surface or within the snowpack, backscatter can be quite high. And perhaps most useful for studying melting over ice sheets is a decrease in backscatter that occurs when the surface of the ice sheet is melting. The decrease in backscatter during melt is because liquid water absorbs the radar signal, leading to little radar energy making its way back to the satellite. Using this radar signal, we can determine whether the surface of an ice sheet is melting or frozen.
- Images were chosen to be spaced out by at least a month, but it depended on when data were available (a combination of the overflight by the satellite, having non-cloudy weather, and there being enough light (for the multispectral images)).
- Things that the students might observe include:
    - Lakes, streams, rocks, clouds, blue ice, snow/firn, maybe even a penguin colony

CC BY NC



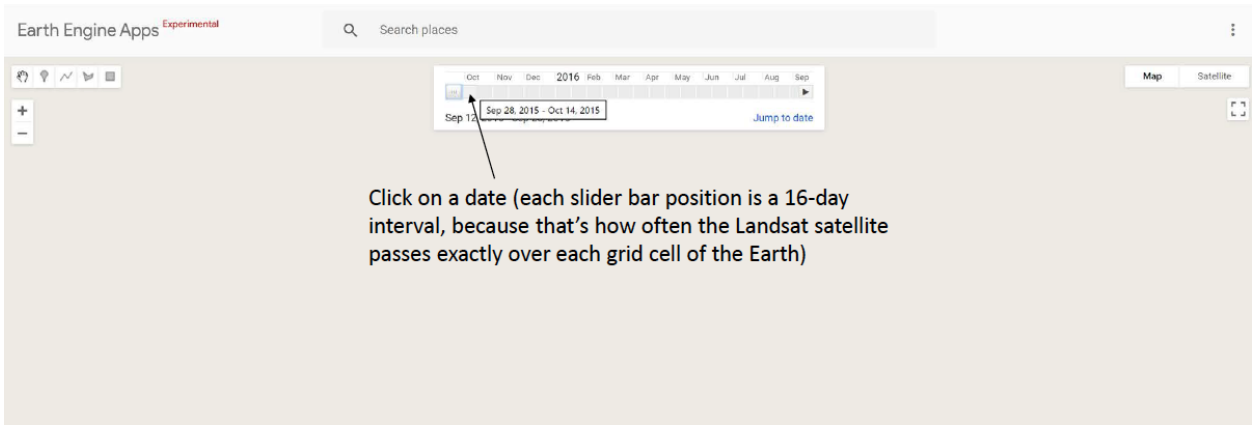
    - Land ice, sea ice, crevasses, rifts, leads, outcrops / nunataks, and open ocean
    - The amount of light (being related to season)
    - That radar images have different bright/dark areas and NO clouds, and how these areas compare to what they observe in the multispectral images.
- You might ask leading questions to invite students to hypothesize what the color changes mean in the context of a seasonal cycle, why some areas change more than others, and other similar questions about things you notice.

Students will be asked to fill out an observation chart, or something similar to start thinking about patterns:

Notice (Observe)	Wonder (Infer)

Once students have analyzed the stack of 4 images, here is an app developed within Earth Engine:
https://sleuthyruthie.users.earthengine.app/view/images-through-time
...where they can investigate these same areas they were presented with above, but across multiple years instead of just one! You can zoom in and out to find all 4 areas around Antarctica. (Note that Landsat 8 imagery, which you are looking at, is only available from 2013 to the present.)

CC BY NC



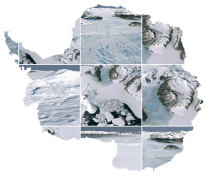
For time management, it is suggested to use 5 minutes to fill in the chart, 5 minutes to share observations and questions with the class, and 10 minutes to work with groups/partners in checking out the app!

Part 3
Interpreting Satellite Imagery (15 minutes)
Driving Question: What can satellite imagery tell us about climate and Antarctica?

In order to think about these questions, we need some vocabulary. Therefore, in this section, students will match components of satellite imagery and regular photos with specific vocabulary terms.

The terminology and imagery are in the accompanying Card Sort Set. If you like, you can cut out the term and imagery cards so that students can physically rearrange and match them up on their desks. Full size images are also available here: satellite images and on-the-ground photos. Here is some context about why particular terms were chosen to be included:

- Understanding the difference between land ice and sea ice is important for sea level rise implications. Same goes for ice shelves (which are already floating - and so don't contribute more to SLR themselves, but when removed can cause more of the land ice behind them to flow into the ocean!).
- Understanding these terms is important for the role these pieces play in environmental, regional, and global systems. They are also important habitats - what lives on land ice is not the same as what lives on sea ice!



Card Sort Answer Key

Term	Definition (a-i)	Photograph (A-I)	Satellite Image Feature (1-9)
Land Ice	**h**	**E**	**9**
Sea Ice	**a**	**G**	**7**
Ice Sheet	**e**	**C**	**4**
Ice Shelf	**i**	**D**	**1**
Supraglacial Lake	**b**	**I**	**5**
Supraglacial Stream	**d**	**F**	**8**
Firn	**f**	**B**	**6**
Blue Ice / Glacial Ice	**c**	**A**	**3**
Nunatak (or outcrop)	**g**	**H**	**2**

Summary Question:

- What can the satellite images tell us about Antarctica?
- Depending on the timing of your class period, this would be a great opportunity to bring in a scientist for a short presentation and Question/Answer session, or if that isn't possible then a pre-recorded video about work being done in Antarctica.

CC BY NC