

## Lesson 3: Antarctic Life & Albedo

### Driving Question(s):

- How do penguins both influence their environment and are influenced by their environment?
- How do we know what is happening to penguin populations in Antarctica?

Word Bank	
Albedo	
Remote Sensing	

### Part 1: How do penguins impact their environment?

In the last lesson, we ended in a place asking how penguins are impacted by a changing environment. We know this from mapping penguin colonies using satellites. In this lesson you'll see how penguins also influence their surrounding environment, and will use real satellite data to estimate the number of penguins within a colony.

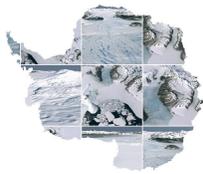
Take a look at the following pictures of a penguin rookery (a breeding colony) from the ground (pictures 1-2) and from a satellite's view (picture 3). Then, take a few minutes to think about the following prompt and discuss your thoughts with a partner:

- *How do you think penguins might impact their environments?*



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.





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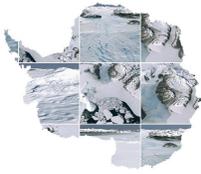
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## Part 2: What is albedo and how is it important?

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Now that we know that penguins leave an imprint on their surroundings by darkening the surface, let's explore the physical basis (i.e., what is the scientific term for this, and why is it important when both mapping penguins and thinking about how snow and ice melt?).

When penguins poop, they darken the snow, causing **albedo** to drop. Albedo is simply how reflective something is. Surfaces that reflect a higher proportion of incoming light have a higher albedo, which also means they absorb less of the sun's light.

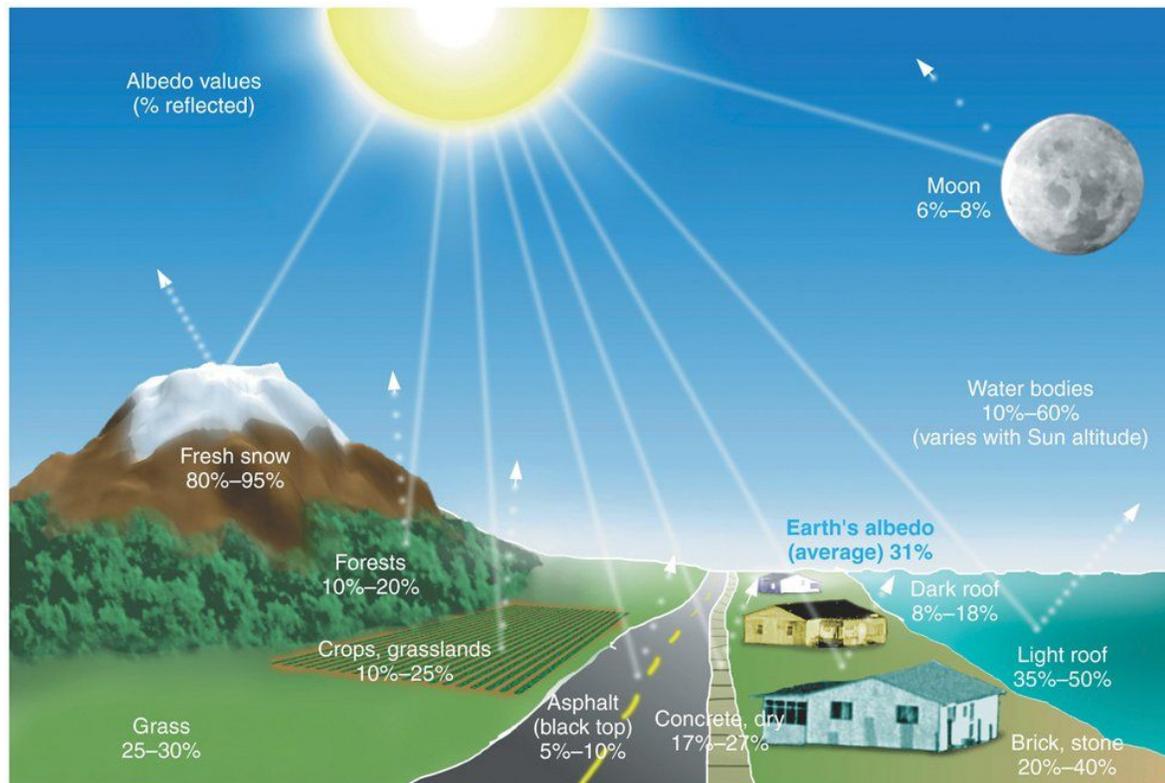


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Different surfaces have different albedos, which impacts how much of the Sun's energy they absorb -- and as a result -- how much they warm up during sunny conditions.



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### Part 3: Science of mapping penguins from space

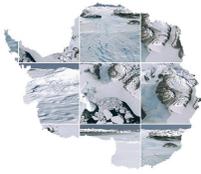
In this part, we'll learn how scientists can estimate penguin sizes from space, and your teacher will introduce some important concepts. Take a quick look at the following satellite photo and speculate how scientists would estimate the number of penguins within a colony. Consider the following questions:

- What would you want to measure in the satellite image to estimate the number of penguins?
- What do you think the general relationship is between the low albedo area and number of penguins?
- Beyond just having satellite images, what else would you need to estimate the number of penguins?



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#### Part 4: Satellite-based mapping exercise

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Now we're going to map penguins using satellite data!

1. In your group, each with your own computer, open up this [Google Earth Engine application](#). This application allows you to calculate the area of a penguin colony from different images representing different dates. Image dates can be selected by clicking 'Layers' and only selecting the date of interest. There are multiple dates, which allow you to track areas and estimate penguin population size over time.



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2. Have a Google Sheets (<https://sheets.google.com>) or Excel spreadsheet to keep track of your group's results. One member of your group should be assigned the task of creating and compiling the data from your group.
3. Start with the oldest image and familiarize yourself with how to calculate an area of by clicking "Measure Area" and then clicking around in the image.
4. You, along with each member in your group, will then calculate areas for the first image. Once each of you have finished, compare your numbers. Are they similar? Are they different? If they're very different, you'll want to recalculate until you can come up with similar answers. You may wish to discuss among your group what criteria they used to select the area of penguins vs. no-penguins, as this determination is subjective!
5. Go through each image together as a group and report your numbers to the member who is compiling your measurements in Google Sheets. Their spreadsheet may look something like this:

Image date	Student 1 Area	Student 2 Area	Student 3 Area	Average Area
Date 1				
Date 2				
...				

### Part 5: Calculating penguin colony size over time

As a class now, each group will report their "best estimate" average areas to the instructor who will tabulate these values to calculate a class average area for each image as well as the standard deviation for each image, which indicates how much variation in the areas exists among the different groups.

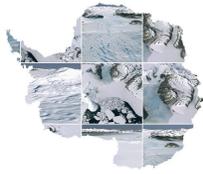
Using the quantitative relationship between penguin colony area and penguin counts that your teacher introduced in part 3, your teacher will also calculate the penguin counts for each image and plot these versus time.

Analyze what the plotted results show.



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- Is there a trend in penguin populations over time? What might this signify?
- Are there images with particularly large standard deviations? Why might this be?

Also consider how the mapping of penguins might be improved. Think about the following questions:

- How subjective (user-determined) is the area of the penguin colony? Is it always easy to distinguish what is part of the penguin colony versus outside of it?
- Can you think of different satellite characteristics that could improve detection of penguins? What could be done to improve the understanding of penguins over time?

Lastly, you'll be asked to think about the big picture.

- Since penguins need the sea ice, how could climate change impact penguin colony size?
- If the ocean is changing, what is happening to the food sources that penguins rely on and that we learned in lesson 2?
- How are climate changes leading to ecosystem change?
- How would a change in sea or land ice affect albedo of the polar regions?



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