

Overview of the Albedo Learning Sequence

Focus: What is albedo and how is it impacted by environmental variables, such as land cover, seasonality, and snow?

Rationale: In order to engage students in the science of climate change it is important to make the learning experience authentic and grounded in the students' experience and environment. The Albedo Learning Sequence begins with an introduction to albedo and how it relates to climate. Once students are familiar with the concept of albedo, they use online tools to explore interactions between albedo and other environmental variables (snow, land cover type, seasonality, etc.) at their location and other locations that they find interesting. The Learning Sequence culminates with an inquiry-based project in which students develop their own research questions and hypotheses use the tools and knowledge they have acquired to conduct an investigation and analyze their results.

Part 1. Read a brief introduction to albedo and complete thought questions.*

- What is albedo and how does it relate to climate?

Part 2. Use the Carbon Mapper tool to explore albedo, land cover, and seasons. Answer questions based on your location and another location of your choosing.

- How does albedo change over the seasons in different land cover classes?

Part 3. Use provided data to explore the interactions between albedo, snow depth, and land cover.*

- How does albedo change in response to changes in snow depth and land cover?

Part 4. Using the tools available on the Student Climate Data website, conduct your own investigation to explore interactions between albedo, land cover, and/or seasonality by posing a research question, developing a hypothesis, and analyzing your results.

Part 5. Conduct an advanced exploration of albedo and other environmental factors by downloading and analyzing data available online that has a finer spatial and temporal resolution. This is appropriate for upper-level students as a capstone or long-term project.

* Can be completed as a homework assignment

Optional: After students are familiar with the concept of albedo, start the Albedo Learning Sequence by taking laboratory measurements. See the Student Climate Data Albedo Laboratory Activities webpage for more information and links to activities such as: *Wintertime Albedo Measurements*, using infrared laser thermometers, or the UAF Arctic Climate Modeling Program's *Albedo Lab*.

Part 1. What is Albedo?

Guiding question:

- What is albedo and how does it relate to climate?

Definitions:

- Albedo = The fraction of incoming solar radiation (sunlight) that is reflected back into space. Albedo values range from 0 to 1, and because they are expressed as fractions, they do not have units.
- Feedback Loop = When the result of an event influences the occurrence of that same event in the future.
 - Positive Feedback = Factors that result from a process and, in turn, amplify or enhance that same process (e.g. a snowball rolling down a hill). Positive feedbacks are destabilizing and can often be destructive to ecosystems.
 - Negative Feedback = Factors that result from a process and, in turn, reduce that same process (e.g. thermostat control). Negative feedbacks generally resist change and keep a system stable.

Materials (1 per student):

- Pencil
- *Introduction To Albedo* handout

Estimated Time: 30 minutes

What to Do and How to Do It:

1. INTRODUCTION: Briefly introduce the concept of albedo to the students.
2. Students read the *Introduction To Albedo* and answer the thought questions provided. This can be completed as a homework assignment.
3. Discuss questions students have on the reading and their answers to the thought questions. Talk about differences between satellite data and ground measurements (both in temporal and spatial scale).

Part 2. Albedo, Seasons, and Land Cover

Guiding question:

- How does albedo change over the seasons in different land cover classes?

Definitions:

- Land Cover Class = a broad classification system of land cover (the physical material on the surface of the Earth). For more information on the particular land cover classification system used by MODIS, see: <http://www.igbp.net>.
- MODIS = The MODerate resolution Imaging Spectroradiometer is a scientific instrument launched by NASA that captures data in 36 spectral bands. It images the entire Earth every 1 to 2 days. For more information see: <http://modis.gsfc.nasa.gov/>

Materials (1 per student or student pair):

- Computer with access to the Internet
- Pencil
- *Land Cover Class Slideshow* or *Definitions* (ppt or pdf available on Student Climate Data website)
- *Changes in Seasonal Albedo with Land Cover Class* handout (Structured or Guided option)

Estimated Time: 1.5 hrs

What to Do and How to Do It:

1. INTRODUCTION: Use the *Land Cover Class Slideshow* or *Definitions* to introduce the concept of land cover classes, and explore the specific classes that are used by the MODIS instrument. Provide a brief background of the MODIS instrument (for a general description of what satellites do, see: http://www.nasa.gov/audience/forstudents/5-8/features/what-is-a-satellite-58.html#_I6bLxdUmg). Revisit the importance of satellite data (long-term measurements and global coverage).
2. Instructor poses the guiding question (**How does albedo change over the seasons in different land cover classes?**) and solicits students' ideas on what information/data they would need to answer that question.
3. Navigate to Carbon Mapper using the instructions on the *Changes in Seasonal Albedo with Land Cover Class* handout.
4. Instructor provides a brief tour of the Carbon Mapper
5. Students continue to follow instructions on the *Changes in Seasonal Albedo with Land Cover Class* handout to find seasonal albedo for locations with different land cover classes.
6. WRAP-UP: Answer any questions students have regarding the activity or concepts.

Part 3. Albedo, Snow, and Land Cover

Guiding question:

- How does albedo change over the seasons in different land cover classes?

Materials (1 per student or student pair):

- Pencil
- *Interactions between Albedo, Snow and Land Cover* handout

Estimated Time: 30 - 45 minutes

What to Do and How to Do It:

1. INTRODUCTION: Ask students, based on their prior knowledge of albedo, land cover, and seasonality, how they think snow would affect the albedo of a landscape? Would this depend on the land cover class? How? Depending on students' familiarity with reading graphs, a review of the components of a graph, and how to interpret graphical figures, may be necessary.
2. Students complete the *Interactions between Albedo, Snow and Land Cover* handout. This can be completed as a homework assignment.
3. WRAP-UP: Discuss any questions students have. In pairs, or as a class, have students share the research questions they developed, and what information they would need to answer those questions.

Part 4. Albedo Investigation

Guiding question:

- Determined by the student.

Materials (1 per student or student pair):

- Computer with access to the Internet
- Pencil
- *Albedo Investigation* document (Structured or Guided Option)

Estimated Time: 1.5 hrs

What to Do and How to Do It:

1. INTRODUCTION: Briefly discuss how to formulate a research question and a hypothesis, and describe the difference between the two. Discuss the scientific process (i.e. the GLOBE Model for Student Scientific Research in the *Planning Guide for Scientific Research*) and the importance of flexibility when conducting a scientific investigation (i.e. as you go, you may have to change directions, or re-define your research question based on what tools and resources are available).
2. Students spend 5 -10 minutes exploring the Student Climate Data resources and/or Google maps to identify/ narrow down their research question. Some useful resources include: the Carbon Mapper, the Single Site Albedo Data tool, the Biome resources, and Google maps. If necessary, the instructor can give a brief tour of the Student Climate Data Data Tools page to point out the location of useful resources.
3. In the Structured experience, students use the *Albedo Investigation* handout to record their research question and hypothesis, and find and record the appropriate data needed to answer their question in the provided data tables. The Guided experience provides the opportunity for students to design their own data tables and/or graphs.
4. Instructor supports the more open inquiry process (refining question to conducting investigation) by circulating among groups and encouraging students to pursue researchable questions (e.g., those that can be answered with the available resources and tools).
5. Students use chart paper to report research question, major findings (in words and graphs), and future research questions.
6. WRAP-UP: Student groups share findings with classmates using the chart paper as a mini-poster.

Part 5. Advanced Albedo Investigation

****Note:** This is appropriate for upper-level students as a capstone or long-term project in place of the Guided Albedo Investigation. Requires experience with Excel or another spreadsheet tool.

Guiding question:

- Determined by the student.

Materials (per student, student pair, or student group):

- Science notebook
- Pencil
- Computer with access to the Internet and Excel

Estimated Time: Varies

1. **INTRODUCTION:** Briefly discuss how to formulate a research question and a hypothesis, and describe the difference between the two. Discuss the scientific process (i.e. the GLOBE Model for Student Scientific Research in the *Planning Guide for Scientific Research*) and the importance of flexibility when conducting a scientific investigation (i.e. as you go, you may have to change directions, or re-define your research question based on what tools and resources are available).

2. *Students use the Planning Guide for Scientific Research* and resources available on the Student Climate Data Advanced Albedo Investigation webpage to plan and carry out a self-designed scientific investigation.

3. Students synthesize their results (in written, graphical, and/or presentation format). See the Communicating Findings and Results webpage (available from the Teacher Resources tab) for guidelines, examples, and rubrics.