LESSON 5: WHEREFORE ART THOU, ALBEDO?
Investigating Ice-Albedo Feedback

TEACHER BACKGROUND
Overview:
Earth's albedo is the fraction of incoming radiation (sunlight) that is reflected into space. The Earth has an average albedo, which describes how much sunlight is reflected on average for the whole planet and the whole year. That value is about 0.3. The Earth also has a local albedo, which determines how much of the Sun's light is reflected from a particular place at a particular time. The local albedo depends on the particular local surface, which can change seasonally as vegetation changes. It also depends on more rapidly changing things such as snow and clouds.

For reference, the values of albedo range from 0.0 to 1.0, where a value of 0.0 is for a surface that absorbs all radiation (reflects 0 percent) that strikes its surface, and a value of 1.0 represents a surface that reflects 100 percent of the radiation that strikes it.

Fresh snow has an albedo ranging from 0.75 to 0.90.
Dry dark soil has an albedo of approximately 0.13.
Open ocean has an albedo of approximately 0.10.

How fast the planet warms in response to adding greenhouse gases to the atmosphere depends in part on climate feedbacks. These natural processes can amplify/hasten the warming (a positive climate feedback) or counteract some warming (a negative climate feedback). How snow and ice respond to warming and the resultant impact on surface albedo is an important positive climate feedback. As the climate warms, snow and ice melt, the earth's surface becomes less reflective (especially if sea ice melts, revealing open ocean, which is very dark), more solar energy is absorbed by the earth's surface rather than being reflected back to space, causing the temperature to increase and the cycle to continue.

Preparation:
- Color copies of Monthly Snow-Ice Amounts
- Copies of Monthly Snow-Ice Amounts Data Worksheet per pair of students
- Sign up for a free Teacher's Domain account—must have in order to do EXPLORE.

Helpful Hints:
- Plan in advance for computer use—whether in through the lab or mobile cart.
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ENGAGE

Student Groupings: Pairs
Time: 15-20 min.

Essential Questions:
A. What considerations should be given to weather and climate when analyzing the maps?
B. What is the relationship between Earth’s energy budget and the two TOA All-Sky Net Flux maps?

Directions:
1. Examine the two NASA satellite data maps. The maps show TOA All-Sky Net Flux for March 2010 and September 2010.
2. As students analyze the maps ask them to record similarities and differences between the maps in their science notebook. Have students use the Essential Questions as a guide during analysis.
3. Discuss responses in class.
4. Homework: Read about the relationship between snow cover and net radiation on NASA’s Earth Observatory. Utilize Rubric for Reading Extensions, found on page 11 of this document, to assess for a grade.

*NOTE* You want to relate these maps to Earth’s energy budget, found in “Prerequisite Knowledge”

EXPLORE

Student Groupings: Individual or Pairs
Time: 45 min.

Essential Questions:
C. What is meant by the term albedo?
D. How does albedo affect the behavior of solar radiation reaching Earth’s surface?
E. Why would you expect Greenland to have a higher albedo than its surrounding areas?
F. What role would seasonality have on Earth’s albedo and how does the Earth’s albedo change over the course of a year?
G. How do soot particles in the atmosphere affect incoming solar radiation? How might an increase or decrease in the number of particles change the intensity of solar radiation reaching Earth’s surface?

STUDENT OBJECTIVES

Students will -
- Utilize NASA satellite data.
- Understand the connection between snow-ice cover and trends in albedo.
- Hypothesize causes related to long term albedo.
- Hypothesize causes related to long term albedo trends.
- Differentiate between seasonal and human induced differences in Earth’s albedo

MATERIALS
- Science notebook
- Computer with internet access

VOCABULARY

Albedo, flux, total all-sky net flux (see Engage-Essential Question B), energy budget

LESSON LINKS can be found under Web References unless otherwise noted.
- TOA All-Sky Net Flux-found as a pdf. in the Lesson 5 folder.
- Teacher’s Domain Snow-Ice Albedo
- Links to reading extensions are found at the conclusion of the lesson
### Explore Continued

#### Directions:
1. Students need access to a computer with internet. Be sure to schedule time for the computer lab or check out the mobel lab cart. If 1:1 or 2:1 computer access is not possible then show and share with the entire class.
2. 2 ways to show Teacher’s Domain-Earth’s Albedo and Global Warming:
   a. If you have a Teacher’s Domain account (it is free) in the search type “Earth’s Albedo”. Download the video to your folder and make the folder public if not already. This way students can be given a link and go straight to the content.
   b. Follow the link under “Lesson Links” to the folder I have made public.
3. Answer Essential Questions which come directly from Teacher’s Domain associated with this media piece.

### Explain

#### Student Grouping: Pairs

#### Time: 45 min

#### Essential Questions:
H. How has snow/ice coverage changed over time for Northern Chukchi Sea? Explain how you know?
I. How has snow/ice coverage changed over time for Beaufort Sea? Explain how you know?
J. How has snow/ice coverage changed over time for Northwestern Passages? Explain how you know?
K. What are limitations to this process for looking at change over time in snow/ice amounts?
L. Explain how changes in snow/ice amounts could affect the earth system, specifically wildlife and coastal communities.

#### Directions:
1. Students now have a basic knowledge of albedo. Students will now examine an Arctic region that expands north, east and just west of Alaska and calculate percent change.
2. Pass out the ISCCP Satellite – Monthly Snow/Ice Amount Maps. Have your students label the following bodies of water using a reference sources; Chukchi Sea, Beaufort Sea, and Northwestern Passages.
3. Students will make observations about the maps. Their focus should be on change over time. Observations should be noted in science notebook.
4. Monthly Snow/Ice Amount-Change Over Time data sheet, found on pages 13 and 14 of this document, will be used by students to calculate percent change over time.
5. Answer Essential Questions on the bottom of the data sheet.

### Elaborate

#### Student Groupings: Individual

#### Time: Could be done as homework or 45 min. in class

#### Directions:
1. Students will choose one of the following articles to read and report on using the Rubric for Assessing Reading Extensions, found on page 11. Instructions are included for students to utilize.
   Read A: Artic Ice is Younger, Thinner, and Disappearing
   Read B: Not-So-Permafrost Could Release as Much Heat-Trapping Pollution as Deforestation
   Read C: ESA Protection for Ice-Dependent Arctic Seals Improperly Delayed
   Read D: Arctic Sea Ice Melt 2nd Greatest Ever Seen

### Evaluate

#### Student Groupings: Individual

#### Time: 20-30 min.

#### Directions:
1. Choose one of the following assessments or allow your students to choose one of the following:
   a. Concept Quiz-found on pages 5-7 of this document
   b. Essay-found on page 8 of this document
   c. Justified True/False Statements-found on pages 9 and 10 of this document
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Web References

Energy Budget Explanation
http://mynasadata.larc.nasa.gov/Radiation_Explanation.html

Energy Budget Diagram

Flux
http://mynasadata.larc.nasa.gov/glossary.php?word=flux

Definition for TOA All-Sky Net Flux
http://mynasadata.larc.nasa.gov/glossary.php?&letter=T

Teacher's Domain
http://www.teachersdomain.org/

Teacher's Domain: Earth’s Albedo and Global Warming-Public Folder
http://www.teachersdomain.org/folder/view/1548034/

Calculating Percent Change
http://www.econport.org/content/handbook/Elasticity/Calculating-Percentage-Change.html

Reading: NASA’s Earth Observatory-The Relationship between Snow Cover and Net Radiation
http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MOD10C1_M_SNOW&d2=CERES_NETFLUX_M

Read: Arctic Is Younger, Thinner and Disappearing
http://news.discovery.com/earth/arctic-ice-is-younger-thinner-and-disappearing.html#mkcpgn=rssnws1

Read: Not-So-Permafrost Could Release as Much Heat-Trapping Pollution as Deforestation
http://switchboard.nrdc.org/blogs/dlashof/not_so_permafrost_could_releas.html

Read: Endangered Species Act Protection for Ice-Dependent Arctic Seals Improperly Delayed

Read: Arctic Ice Melt 2nd Greatest Ever Seen
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Name: ________________________________ Date: _____________

Science Concept Quiz
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Which statement is true using the evidence from the graph above?

A. All polar bear populations will die within 10 years.
B. Arctic ice extent has gradually increased from the 1950’s to present.
C. Monthly sea ice extent increases as annual sea ice extent decreases.
D. There has been a steady decline in sea ice extent starting around 1980.

______ points out of 20

I. Answer
  A. O  B. O  C. O  D. O

______ points out of 15

II. What is the main concept behind the question?
1. Defining Variables
2. Drawing Conclusions
3. Glacial Decline and Wildlife
4. Interpreting Graphs

______ points out of 25

III. Provide the reasoning for choosing your answer in part II.
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_____ points out of 40

IV. Why are the other responses in part I not the best answer choice?

1.

2.

3.

4.

Use the rest of this page if more room is needed to fully communicate your thoughts.
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TEACHER ANSWER KEY
1. D

2. 4

3. Answers will vary. D. Interpreting graphs is the best answer because if I can’t read the graph I am unable to answer questions related to the graph.

4. Answers will vary.

   A. Although reports suggest the polar bear populations are in danger this graph does not analyze the decline in those populations.

   B. The graph shows the opposite, arctic sea ice extent has gradually decreased since the 1950’s.

   C. The monthly and annual lines do not run in opposite directions. Both monthly and annual lines are directly correlated and show gradual decrease over time.

   D. This is the correct answer. According to the graph sea ice extent has been gradually decrease since around 1980.
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Using evidence from your work with this lesson explain ice-albedo feedback. What can be learned from studying data collected over time related to ice-albedo feedback?

What Is the Expectation?
Use new lesson knowledge or student readings to support your position
Visual representations if applicable
Key vocabulary
Evidence of on grade level spelling and grammar usage
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**Justified True or False Statements**

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*Justified True or False Statements* provide a set of claims or statements that are examined by you. You are meant to draw on evidence from what you have learned to analyze the validity of the statements, and then describe the reasoning used to decide whether each claim is true or false.

*NOTE* Please use grade appropriate spelling and grammar.

<table>
<thead>
<tr>
<th>STATEMENT</th>
<th>T</th>
<th>F</th>
<th>WHY I THINK SO…</th>
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<tbody>
<tr>
<td>1. Earth’s energy budget and the ice-albedo feedback loop are unrelated.</td>
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<td>2. Wildlife is negatively affected by declining ice amounts.</td>
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<tr>
<td>3. More radiation is reflected from the deep ocean waters than from snow and ice covered areas.</td>
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</table>

Use this space to include more evidence to support your claim and or to draw a model if applicable.
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GRADING RUBRIC
Assign a score of 0-3 based on the following criteria:
- Level 0 (17 pts.) = answered T or F correctly or incorrectly/no explanation
- Level 1 (23.3 pts.) = answered T or F correctly/cursory explanation
- Level 2 (28 pts.) = answered T or F correctly/deeper explanation
- Level 3 (33.3 pts.) = answered T or F correctly/complex explanation

TEACHER ANSWER KEY
Answers will vary.
1. False—Earth’s energy budget and ice-albedo feedback loop are directly related. How snow and ice behave as a part of the Earth system tells us if the Earth’s budget is in sync or out of whack. When more energy is absorbed into our Earth system via the hydrosphere and atmosphere our overall climate temperatures increase. Part of this increase in temperature is due to the fact that there is less snow and ice coverage and therefore the sun’s radiation is absorbed into open waters and land masses that are no longer covered with snow and ice.

2. True—Wildlife is negatively impacted by losses in snow and ice because several species such as polar bears and seals depend on snow and ice coverage for shelter, breeding, and hunting.

3. False—More radiation is reflected from snow and ice covered areas than from open waters and uncovered land masses. White reflects the sun’s radiation while the deep dark color of open waters absorbs the sun’s radiation. *NOTE* Students may draw a model of the ice-albedo feedback and/or Earth’s energy budget.
Using Student Reading Extensions as an Assessment Tool

DIRECTIONS

REQUIREMENTS

1. Using the Student Reading Resources or articles that you allow students to use related to the topic; write a summary meeting the following guidelines.
   a. Half to whole page
   b. Double spaced
   c. 12pt font size
   d. Times New Roman font

2. Do not print out the article. At the end of your summary write an endnote with the correct bibliographic information (http://www.easybib.com/) for your article.

ARTICLE SUMMARY FORMAT

1. Name, date, class, and period

2. Paragraph #1-Introduction
   a. What is the title of the article (should be in quotes or italics)?
   b. Who is the author?
   c. What source or publication did the article come from?
   d. What is the date of the article?
   e. Write one to two sentences about what the article is about

3. Paragraph #2-Summary (Abstract) of Article
   a. Give a summary of the article; what is the article about?
   b. If necessary, you can write more than one paragraph summarizing the article

4. Paragraph #3-What did you think of the article (critique)
   a. Do you agree or disagree with the author(s)?
   b. Did it support or change your opinion of the topic; if not, why or if so, how?
   c. Did the writer demonstrate that he/she did sufficient research?
   d. What would you have added to enhance the article?

5. Paragraph #4-Conclusion
   What are your reasons for choosing your particular article and how does it relate to what we are studying now?
# Article Summary Rubric

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<th>3</th>
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<tr>
<td>Requirements</td>
<td>All written requirements completed accurately and turned in on time.</td>
<td>4 of the 6 requirements were met.</td>
<td>3 of the 6 requirements were met.</td>
<td>Only 1 or 2 requirements met.</td>
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<tr>
<td>Spelling, Grammar, and Punctuation</td>
<td>There are no spelling, grammar, or punctuation errors in the summary. RUN SPELL CHECK BEFORE PRINTING!</td>
<td>There are no more than 2 spelling, grammar, or punctuation errors in the summary.</td>
<td>There are 3-4 spelling, grammar, and punctuation errors in the summary.</td>
<td>The summary has 5 or more spelling, grammar, and punctuation errors in the summary.</td>
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<tr>
<td>Summary of Article</td>
<td>The summary covers all the main points of the article.</td>
<td>The summary covers all but one of the main points of the article.</td>
<td>The summary covers all but 2 of the main points of the article.</td>
<td>The article is not well summarized. Most main points are missing.</td>
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<td>Critique</td>
<td>All four questions under “Critique” are answered clearly and completely.</td>
<td>Three questions under “Critique” are answered clearly and completely.</td>
<td>Two questions under “Critique” are answered clearly and completely.</td>
<td>One or none of the questions under “critique are answered.</td>
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<tr>
<td>Overall Paragraph Construction</td>
<td>All paragraphs include introductory sentence, explanations or details, and concluding sentence.</td>
<td>Most paragraphs include introductory sentence, explanations or details, and concluding sentence.</td>
<td>Paragraphs included related information, but were typically not constructed well.</td>
<td>Paragraphing structure was not clear, and sentences were not typically related within the paragraphs.</td>
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Self Assessment: ___________Grade Equivalent: ___________
Teacher Assessment: ___________Grade Equivalent: ___________

Student and or teacher comments:
NAME:  
DATE:  

Monthly Snow/Ice Amount-Percent Change Data Sheet

Please label all your maps as follows...

*NOTE* Percentage equals the amount of snow/ice that is in the box. These are estimates only.

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Percent change from 1994 to 2008 4A-4L = __________
Percent change from 1994 to 2008 3A-3L = __________
Percent change from 1994 to 2008 2A-2L = __________
Percent change from 1994 to 2008 1A-1L = __________
Total, all map percent change 1994-2008 = __________

**Essential Questions:**

**Answer in your science notebook.**

A. How has snow/ice coverage changed over time for Northern Chukchi Sea? Explain how you know?
B. How has snow/ice coverage changed over time for Beaufort Sea? Explain how you know?
C. How has snow/ice coverage changed over time for Northwestern Passages? Explain how you know?
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