Arctic Sea Ice Extent

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Integrating the Mathematics of Planet Earth 2013 in the College Mathematics Curriculum

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Abstract

Arctic Sea Ice Extent: A Qualitative Literacy Project and an Entry Point for Environmental Mathematics

We present a group project based on Arctic Sea Ice Extent data for 1979 to the present obtained from the National Snow and Ice Data Center. This project offers an easy entry for integrating environmental mathematical modeling into lower division courses in a significant way. The topical nature of Arctic Sea Ice Extent, especially given the current historically low September minimum value, ties current events, the environment, and mathematical modeling together in powerful ways. Student teams can use their simple models to predict the first ice-free summer for the Arctic Ocean. Students’ project reports were also used as a quantitative literacy assessment for precalculus students and for the course; results of the projects use in class will be discussed.
1 Background
Melting arctic sea ice and the Greenland ice cap have been in the news. The data gives strong evidence of the impacts of climate change.

2 Student Project
Easily available data allows us to bring environmental mathematics into the classroom at multiple levels.

3 First Results
An environmental data project was used in precalculus to introduce and reinforce:
- Discovering trends in data sets
- Mathematical modeling
- Environmental mathematics
National Snow and Ice Data Center (NSIDC)

**NSIDC:** The NSIDC is housed at the U of Colorado, Boulder. The Center conducts programs in the Arctic and Antarctic, has partnerships with NASA, NOAA, and maintains archives of data, historical notes, “journals, books, maps, photographs, prints, and expedition notebooks.”

**History:** Established at U of CO in 1982 and merged with the World Data Center for Glaciology.

**Today:** The Center produces Daily Image Updates for Arctic Sea Ice Extent.

*Sources:* NSIDC and Mathematics of Planet Earth 2013
The Arctic Sea Ice Extent Project

**Background**

European explorer’s, with Cabot’s 1497 attempt to sail to the Orient from England, searched for the Northwest Passage, a route through the Arctic Ocean along the coast of Canada. See Figure 1. The Norwegian explorer Amundsen was the first to complete the journey, though it took from 1903 to 1906. In 1957, the U.S. Coast Guard Cutter Arctos became the first U.S. vessel to circumnavigate the continent, a 22,000 mile trek.

The problem is the Arctic Ocean is covered by a sea ice pack nearly all the time—the passage is closed. Since the beginning of the Industrial Revolution, global temperature averages have risen overall causing more of the ice pack to melt in the summer, which leaves more ocean open. Ice is very reflective; giving the arctic region a high albedo, ice reflects up to 70% of the sun’s energy. The ocean is darker, reflecting only 6% of the sun’s energy, so as the ice pack retreats, the area’s albedo gets lower. More energy is absorbed by ocean water than by sea ice increasing the temperature, causing more ice to melt leading to more open water, creating a positive feedback loop.

NASA’s National Snow and Ice Data Center, U. C., Boulder. (http://nsidc.org/arcticseaicenews/)

Figure 1: Arctic Ice

**Project**

Determine the overall trend in the average monthly sea ice extent using the data given in Table 1.

1. List the month _______ your group is assigned.
2. Use NSIDC’s Arctic Sea Ice Extent Averages data given in Table 1 for your assigned month to derive a linear function giving the overall trend of the average sea ice extent.
3. Plot the linear functions and your data on the same graph.
5. Explain why the slope of the linear function describes the trend of your data. What is the trend as a percentage?
6. Is the trend you found reasonable? Why or why not?

**Extra for Experts** Explore quadratic models of the data.

**Report Requirements**

Your report must include:

1. Your project team members’ names.
2. Your linear model and predictions for 2013 and 2014 with a justification of its appropriateness.
3. A graph showing your model with the data points.
4. A discussion of the trend you calculated and whether or not it reasonably describes the data.

You may produce your final report as your choice of:
- a standard paper (in pdf format; not doc, docs, .txt)
- a slide show (Impress, Keynote, PowerPoint, or pdf)
- a video of your team presenting to a group of classmates in Quicktime or Windows Media format, mpeg, mp3, mov, wav, or avi

Upload your report file to our AsULearn class web site.

**Table 1: MONTHLY ARCTIC SEA ICE EXTENT AVERAGES (million square km.)**

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<tbody>
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<td>12.00</td>
<td>12.31</td>
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**Figure 2: Average September Arctic Sea Ice Extent, 1979 to 2012**

All images courtesy of NASA and the National Snow and Ice Data Center, U. C., Boulder. (http://nsidc.org/arcticseaicenews/)
First Results

Student Reports

Initial Results Summary:

• Student teams easily discovered the linear fit’s slope as a trend indicator.

• Students had difficulty writing their analysis. Most assimilated the obvious trend, but had trouble relating the trend to reality. Some resisted making the connection.

• Unsurprisingly, most students’ effort was directly related to their perception of the project as a graded assignment versus a course assessment.
For the Curious...

**Linear Fit**

\[ S_L = 163.28 - 0.0782x \]
\[ S_L(2013) = 5.78 \]
\[ S_L(2014) = 5.70 \]

**Quadratic Fit**

\[ S_Q = -11152 + 11.263x - 0.00284x^2 \]
\[ S_Q(2013) = 5.18 \]
\[ S_Q(2014) = 5.00 \]
Links to the Project and Data

<table>
<thead>
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<th>Links</th>
<th>Description</th>
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<td>QR code links to the student project handout (.pdf)</td>
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<tr>
<td>QR code links to the sea ice extent data spreadsheet (.xlsx)</td>
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<td>QR code links to me (.vcf)</td>
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- Project Handout URL
- Data Spreadsheet URL
- My Contact Info