

Using School of Ice Laboratory Tools for Undergraduate Climate Change Education

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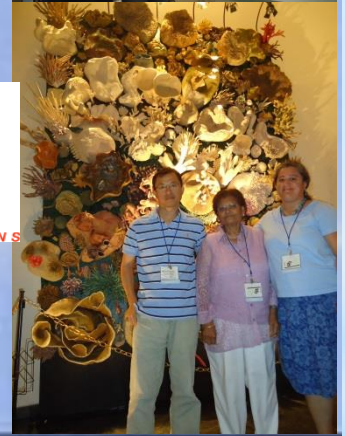


ICE DRILLING
PROGRAM OFFICE
CLIMATE EXPEDITIONS



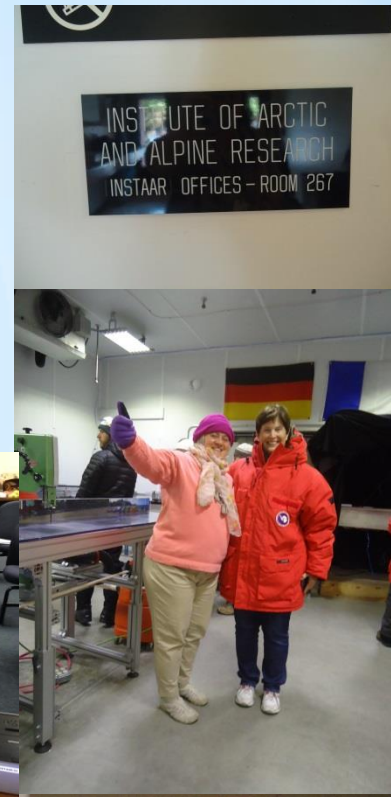
UNIVERSITY of
WASHINGTON

2017 American Meteorological Society
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Climatology Course

- * (MSI-ReACH Diversity Project - AMS Workshop 2013, Washington D.C., School of Ice Workshop and U.S. IDPO - 2015, Denver, Colorado and IODP Ocean Sediment Workshop 2016, College Park, TX)
- * Delaware State University Climatology(NTRS 303-01)
- * Fall 2014 # of Students = 12
- * Fall 2015 # of Students = 11
- * Fall 2016 # of Student = 9
- * Taught by Rose Ozbay
Laurieann Phalen (TA)



Lab-Centered Teaching

- * Lab-centered teaching is an integral part of the Climatology course taught at Delaware State University (DSU), which uses course materials developed by the American Meteorological Society (AMS) Education Program.
- * Laboratory activities become the centerpiece of the students' learning - allowing them to make real-world connections to material acquired during lecture, and implementing the concepts and skills learned through hands-on discovery.
- * Investigating the thermal expansion of water.



Goals and Target Audiences

- * **Goals** - Two lab hands-on activities focusing on ice cores, and one activity focusing on ice and sea level rise adapted from the AMS Diversity Project and School of Ice Workshop were taught to 12, 8, and 9 students in the Climatology course in the fall of 2014, 2015, and 2016, respectively.
- * The sea level rise activity will be used with the 16 students in the Introduction to Environmental Science course during the Spring 2017 semester.
- * **Target audience** includes students from both environmental sciences, natural resources and agricultural majors and other non-majors.



Ice Core Lab

Overview

A solid understanding of timescales is crucial for any climate change discussion; this lab allows students to study changes in Earth's atmospheric composition and temperature on millennial to orbital timescales. The Ice Core Lab is a fun hands-on supplement designed for the University of Washington in the High School Climate and Climate Change (ATMS 211) curriculum.

Focus Questions

1. How do we know about Earth's climate before the instrumental record?
2. What is a proxy?
3. What timescale do ice cores capture?
4. What caused the cyclic changes in past CO₂ and temperature?
5. What are the two main differences between natural CO₂ variability during the past 800,000 years and recent CO₂ levels recorded by modern instruments?

Learning Goals

Students should be able to...

UWHS Climate Science
Unit 3: Natural Variability:
Paleoclimate on Millennial Timescales
Ashley Maloney

Grade Level 9-12

Time Required

- 2 weeks Preparation
- 1 week to order/gather materials
- 3-6 hours to become familiar with data and plan
- 15 minutes/day for one week
- 1-3 hours Class Time
- 5 minute pre survey
- 0.5 - 1 hour lab introduction
- 10min proxy exercise
- 0.5 - 1 hours to gather data from ice cores, assemble class data, and plot in Excel
- 0.5 - 1 hour to plot extended record in Excel and examine trends
- 5 minute post survey

Materials Needed

- Reference textbook: Kump, L.R., Kastning, J.P., Cause GC: (2010) The Earth System. Pearson.
- To make ice cores
 - Freezer space for five 1ft tall tubes
 - Hacksaw or pipe-cutter to cut acrylic tube into 5 sections

SEA LEVEL: ON THE RISE

DESCRIPTION

Students will understand the relationship between climate change and sea-level rise. In the first activity, they will learn that heated water causes sea level to rise through a process called thermal expansion. They will also perform an experiment to learn that melting land-based ice contributes to greater sea-level rise than melting sea ice.

BACKGROUND

In general, as water gets warmer, it takes up more space. Each drop of water only expands by a little bit, but when you multiply this thermal expansion of water over the entire depth of the ocean, it all adds up and causes sea level to rise.

Sea level is also rising because melting glaciers on land are adding more water to the oceans. Glaciers are large sheets of snow and ice that are found on land all year long. They are found in the western United States, Alaska, the mountains of Europe and Asia, and many other parts of the world. The giant ice sheets on Greenland and Antarctica are also considered glaciers. Warmer temperatures cause glaciers to melt faster than they can accumulate new snow. As giant ice sheets and smaller glaciers melt, they add more water into the ocean, which causes sea level to rise.



TIME: 60 to 75 minutes

LEARNING OBJECTIVES:

Students will:

- Learn that heated water has more volume and will cause sea level to rise through a process called thermal expansion.
- Learn that ice formations on land will cause a rise in sea level when they melt, whereas ice formations on water will not cause a substantial rise in sea level when they melt.

Student Learning Outcomes

- * Making scientific observation
- * Improving critical thinking skills
- * Formulating research questions
- * Having hypothesis
- * Analyzing data
- * Interpreting graphs
- * Using claim evidence reasoning technique to discuss data
- * Draw conclusion
- * Provide Big Picture (Broader Impact)



Arctic Ice & Sea Level Rise Lab

- * This was the first lab activity in the Climatology class and was done after an introductory overview of Climate Change - cause & effects. This lab contained elements of the lab “Flooded! An Investigation of Sea-Level Rise in a Changing Climate”, and was adapted from Part 2 - Sea Level: On the Rise - EPA.
- * Students explored the relationship between climate change and sea-level rise, and performed an experiment to learn that melting land-based ice contributes to greater sea-level rise than melting sea ice.

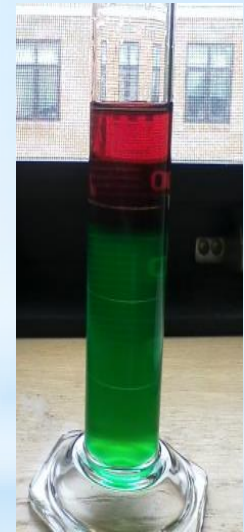


- * As an independent research extension activity students completed page 2 of the Climate Change Inquiry Lab; Melting Sea Ice and Sea Level Rise.
(http://pmm.nasa.gov/education/sites/default/files/lesson_plan_files/climate%20change%20inquiry/climate%20change%20inquiry%20sea%20level%20lab.pdf)

<p><i>developed by the</i></p> <h2 style="text-align: center;">Global Precipitation Measurement Mission</h2> <p>GPM.NASA.GOV / EDUCATION TWITTER.COM / NASA_RAIN FACEBOOK.COM / NASA_RAIN</p> <hr/> <p>Mountain of Ice: If the ice melts - http://www.pbslearningmedia.org/asset/ess05_int_ice_melt/</p> <p>How much would sea level rise if the Western Antarctic Ice Sheet melted? _____</p> <p>How much would sea level rise if the Eastern Antarctic Ice Sheet melted? _____</p> <p>Choose one of the regions: U.S. East Coast, Florida, Northern Europe, or Southeast Asia.</p> <p>What observations do you have about the differences between the three scenarios – Western Ice Sheet melting, Eastern Ice Sheet melting, and conditions 20,000 years ago?</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>Regions Vulnerable to Sea Level Rise - http://serc.carleton.edu/images/slides/cryosphere/areas_risks_from_sea.png</p> <p>According to the map, what areas of the world will be most threatened if sea level rises by a few meters?</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>	<p>Describe the consequences the United States may face if sea level rises by a few meters. Give specific examples of coastlines, cities, industries, and habitats that would be impacted. _____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>Extension: The plot only shows coastal areas that are at or near current sea level. There are also island nations at risk of entirely disappearing as a result of sea level rise. Do an Internet search to find at least one example. Then answer the following questions:</p> <ul style="list-style-type: none"> • What is the name of the island nation? _____ • What is the nation's average elevation? _____ • What is the nation's population? _____ • How soon does this nation expect to be affected by sea level rise? _____ <p>_____</p> <p>_____</p> <p><i>Adapted from EarthScience: Future of the Cryospheres,</i> http://serc.carleton.edu/esla/be/cryosphere/se.html</p> <p>http://gpm.nasa.gov/education/stmas/default/files/ta_son_n_plan_files/climate%20change%20inquiry/climate%20change%20inquiry%20sea%20level%20lab.pdf</p>
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Hands-on Lab Activities

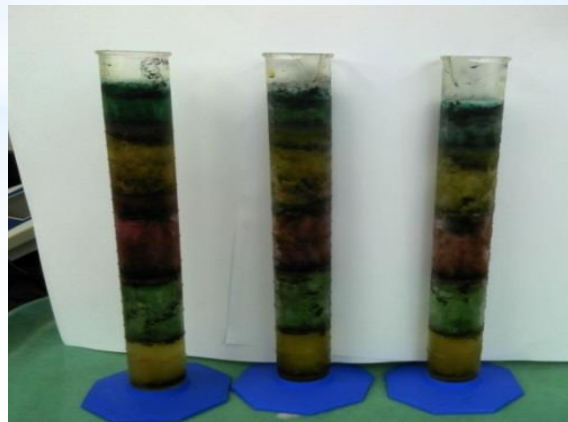
- * A hands-on activity was done with the students during the face-to-face session on density, temperature, salinity, and convection currents in order to facilitate a better understanding of The Great Ocean Conveyor, World Climate, and Climate Change.



- * Students performing density experiments (left), Egg sank in freshwater and floated in saltwater (middle), Freshwater layered on saltwater (right).

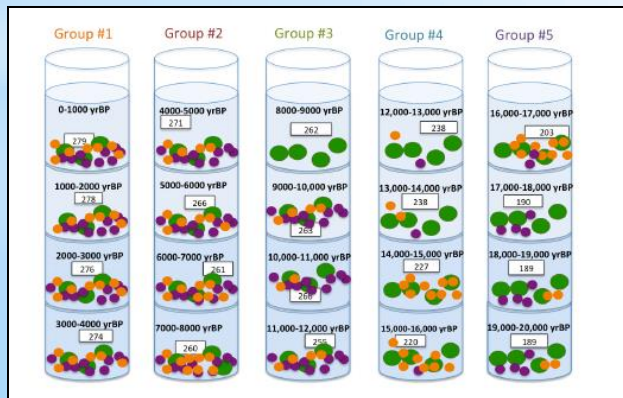
Ice Core Labs

- * The two ice-core labs focused on student learning about climate change from ice core data which was particularly relevant to the Climatology course, and taught in conjunction with one another.
- * The first lab activity, entitled Ice Core Research, was adapted from the laboratory “Exploring the History of Climate Change” - Wisconsin Department of Natural Resources-Climate Change: A Wisconsin Activity Guide.
- * In this activity, students discovered first-hand what historical information scientists can obtain about climate from ice cores by analyzing the pH and relative amount of particulates in each layer of a homemade ice core.



Ice Core Labs (cont.)

- * In the second lab, students built upon the knowledge gained from the first lab, and discovered how the deuterium/hydrogen isotope ratio, a paleoproxy for temperature in ice cores, can be used by scientists to gain temperature information about the past.
- * This activity was adapted from a hands-on Ice Core Lab and allowed students to participate in scientific practices such as collecting, processing, and interpreting temperature and CO₂ data.
- * Students dissected and analyzed layers of homemade ice cores containing various amounts of colored beads. These beads acted as a proxy for hydrogen isotope ratios present at the time when the layer was formed.



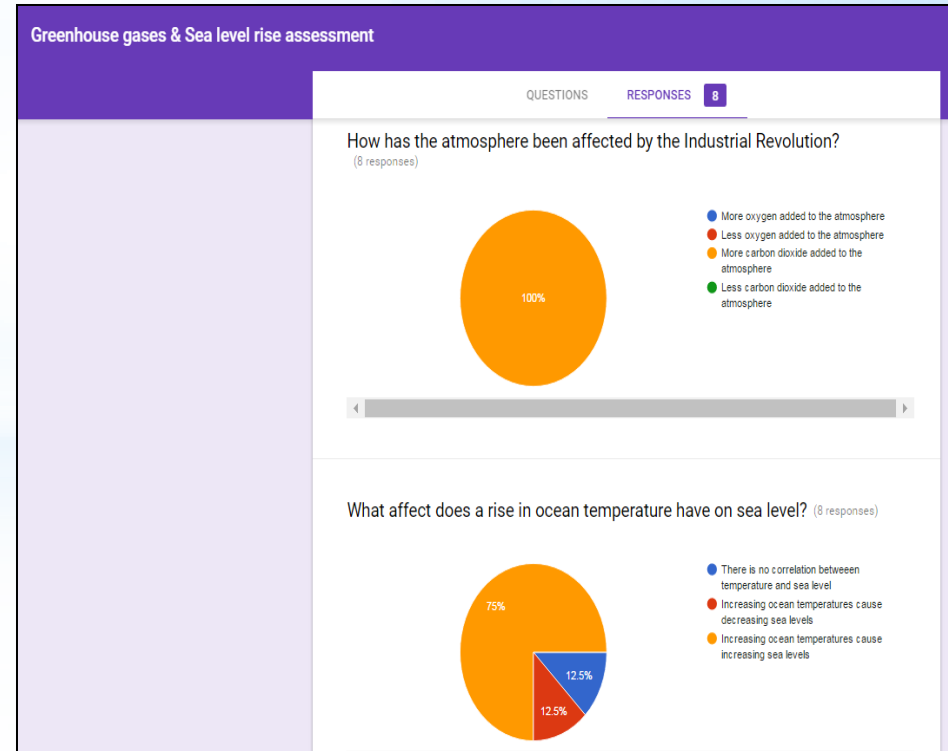
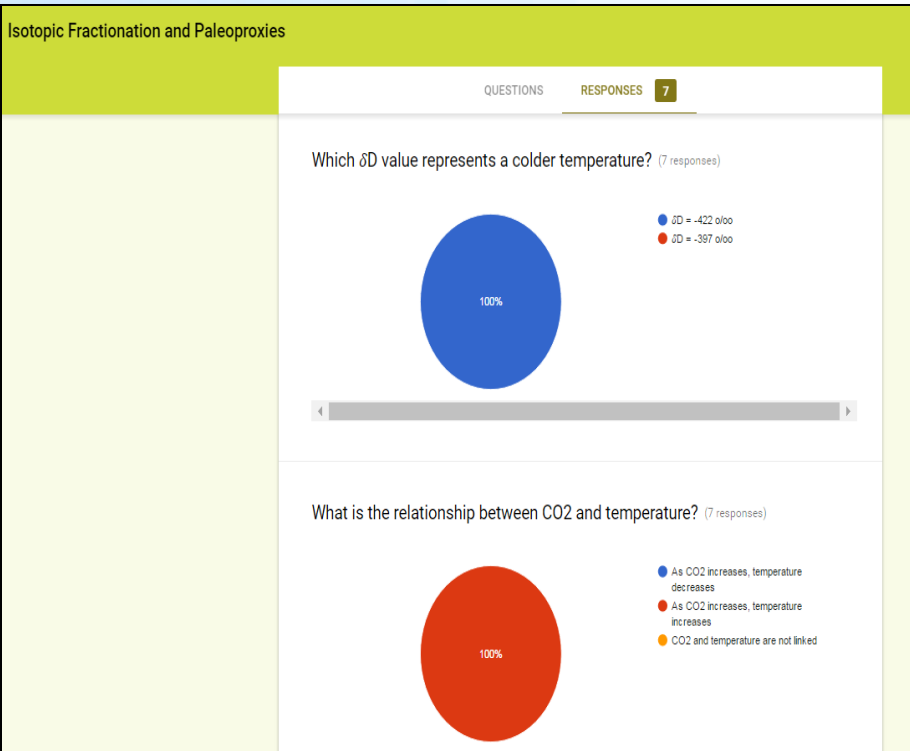
Assessments

- *To monitor students' knowledge and understanding of the materials covered in the class, assessments followed the lectures and laboratory activities, via google forms.

QUESTIONS	RESPONSES
<p>7</p> <h2>Isotopic Fractionation and Paleoproxies</h2> <p>Form description</p> <p>What is your name?</p> <p>Short answer text</p> <p>Isotopic fractionation is the enrichment of one isotope of an atom relative to another isotope of that same atom in a physical process - such as the hydrologic cycle. What is the difference between the 2 isotopes that makes isotopic fractionation occur?</p> <ul style="list-style-type: none"><input type="radio"/> Extra protons in the nucleus<input type="radio"/> Extra electrons in the nucleus<input type="radio"/> Extra neutrons in the nucleus <p>During periods of colder climate, where would you find the greatest amount of the heavy form of an atom?</p> <ul style="list-style-type: none"><input type="radio"/> In the water vapor that evaporated from the ocean<input type="radio"/> In the ocean	<p>8</p> <p>What affect does a rise in ocean temperature have on sea level?</p> <ul style="list-style-type: none"><input type="radio"/> There is no correlation between temperature and sea level<input type="radio"/> Increasing ocean temperatures cause decreasing sea levels<input type="radio"/> Increasing ocean temperatures cause increasing sea levels <p>Explain your answer to the previous question about temperature & sea level.</p> <p>Long answer text</p> <p>Melting sea ice has the potential to raise sea level by several meters</p> <ul style="list-style-type: none"><input type="radio"/> True<input type="radio"/> False <p>Explain your answer to the previous question about melting sea ice and sea level rise.</p>

Assessments

- * Assessments showed that these lab-centered teaching activities engaged students and enhanced their understanding of how historical ice core data are used to understand changes in the magnitude and rate of temperature changes, as well as the relationship between sea ice, land ice, and sea level rise.



Modifying the Labs - Ice Core 1

- * Rather than making the entire ice core in a polyethylene graduated cylinder, recycled water bottles were used to make each layer of the ice core.
- * This allowed students to access the layers in a more timely manner, and prevented the loss of some of the sediment from one layer to an adjacent layer. The bottles were later recycled.



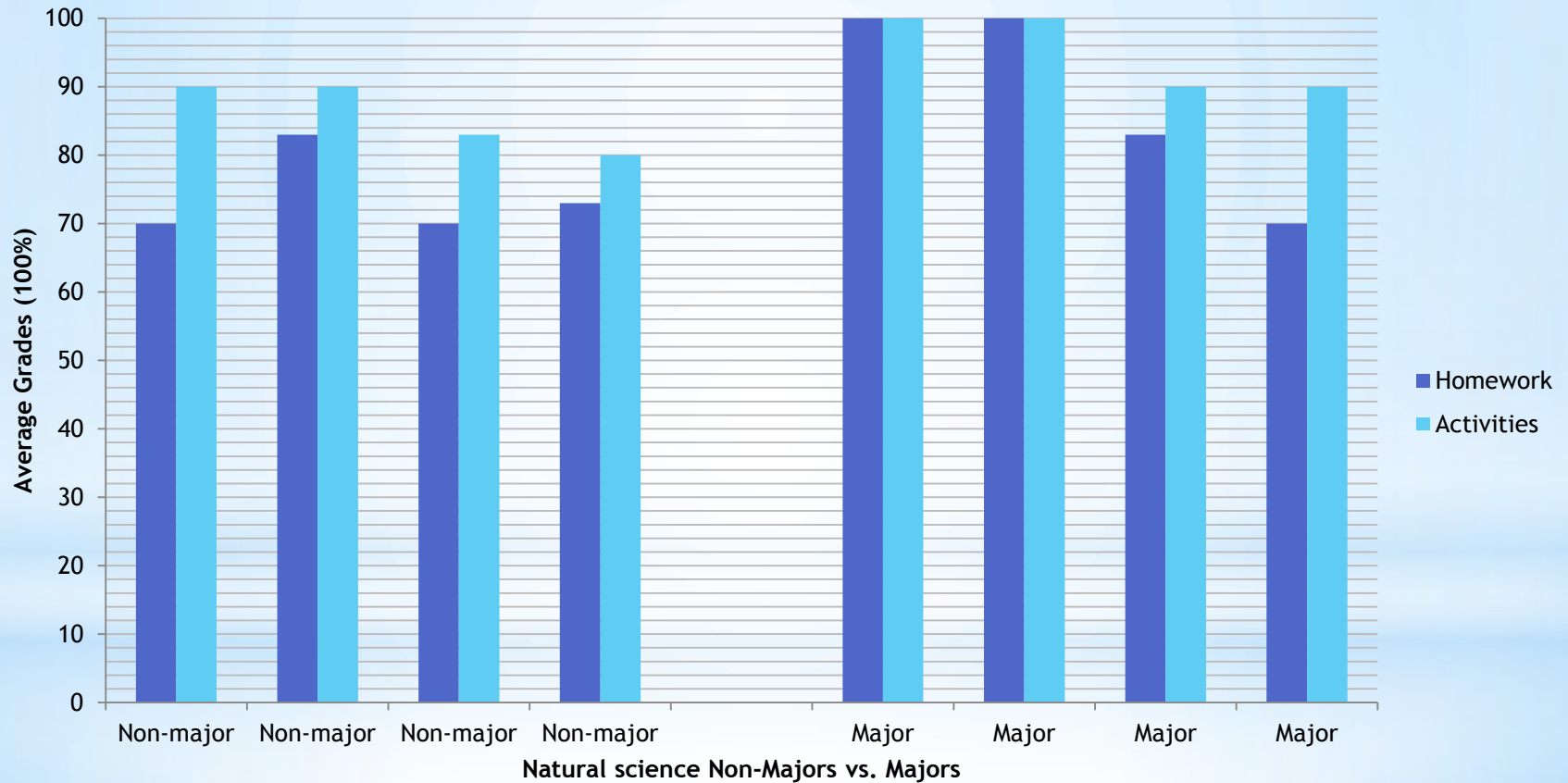
Modifying the Labs - Ice Core 2

- * Small pringles cans were used to form each of the layers for each ice core - this allowed the “layers” to be melted right in the can in order to collect the CO₂ and deuterium isotope data.



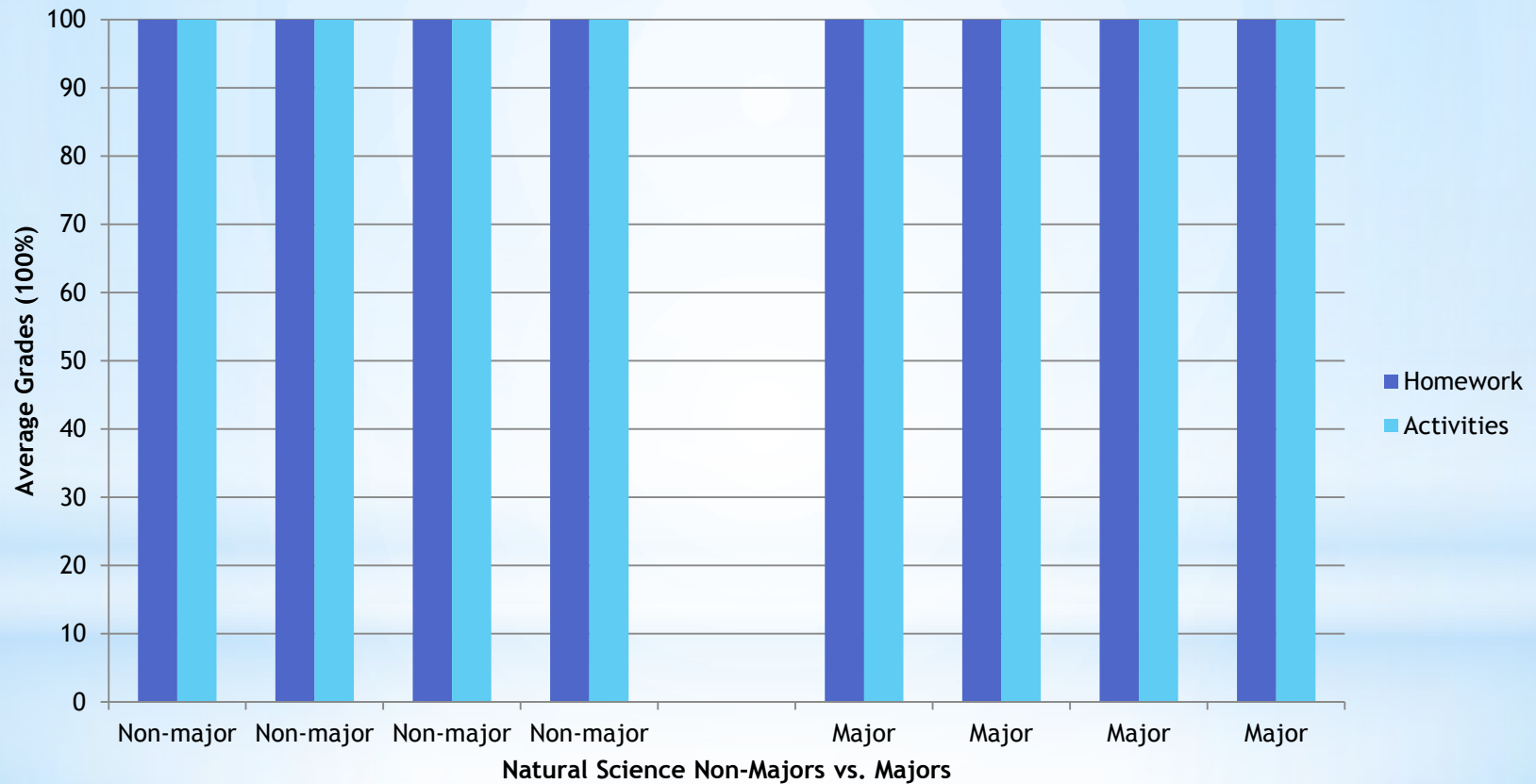
Climatology Class 2014

Homework & Activity Assessment Grades **Without** Hands-on Labs



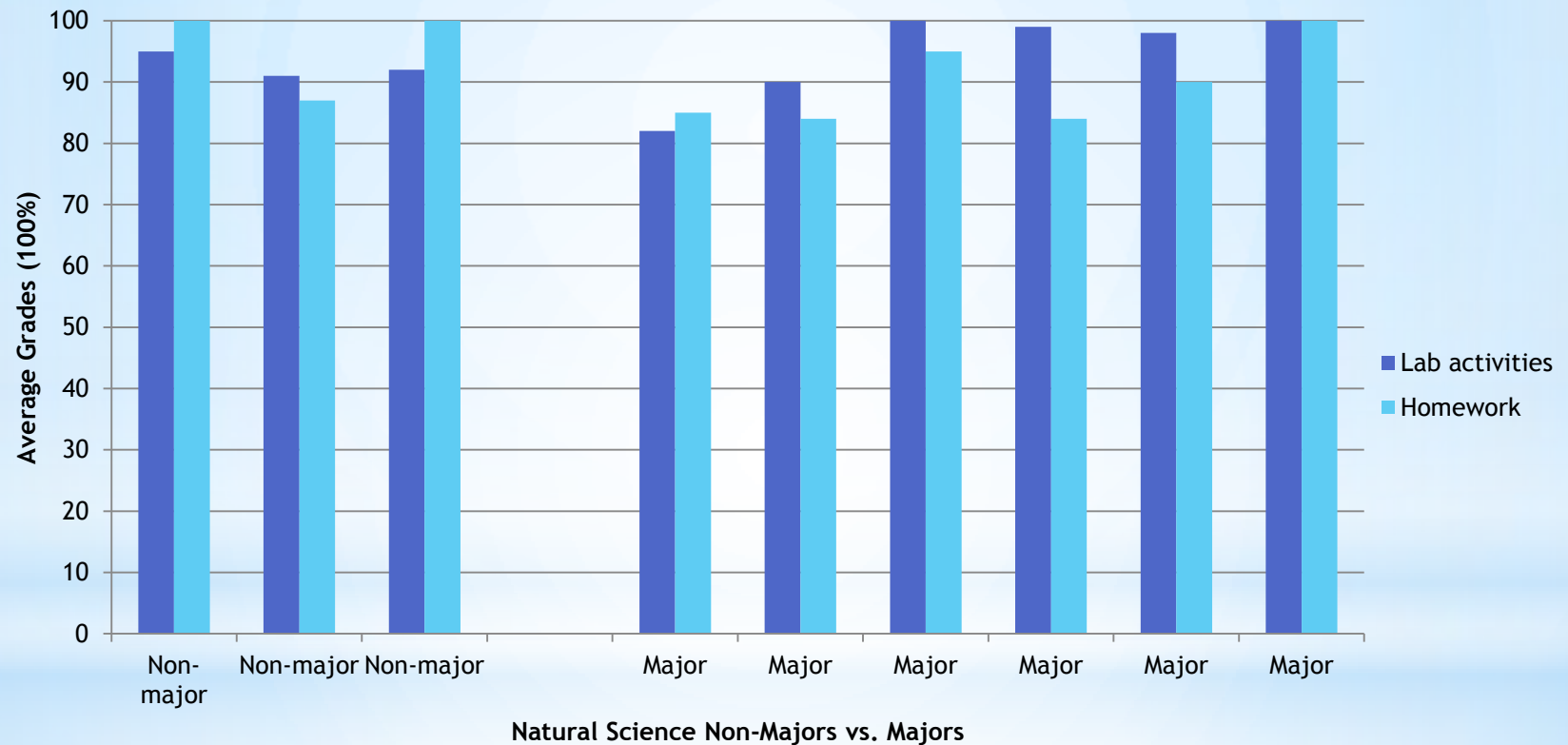
Climatology Class 2014

Homework & Activity Assessment Grades **With** Hands-on Labs



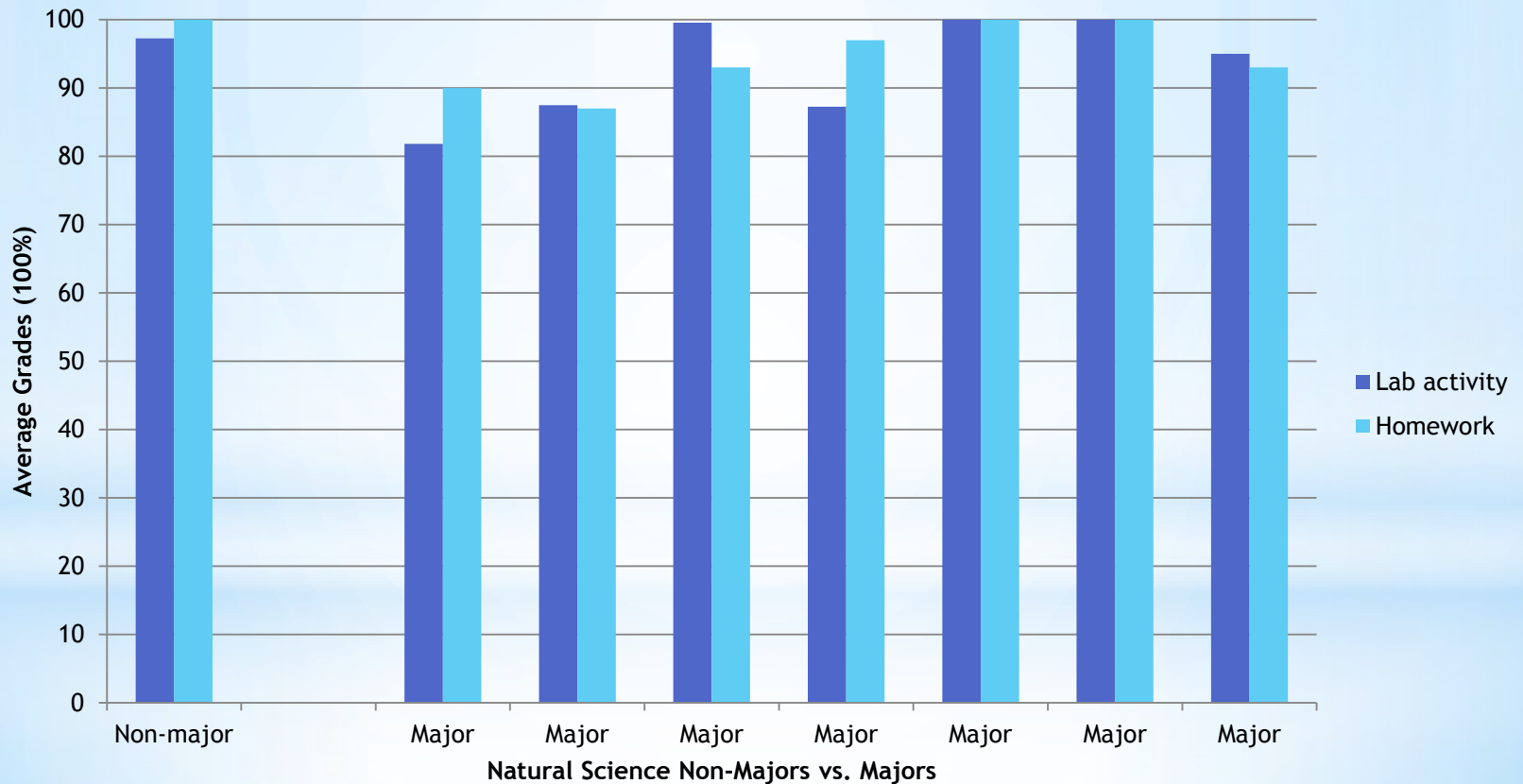
Climatology Class 2015

Homework & Activity Assessment Grades **With** Hands-on Labs



Climatology Class 2016

Homework & Activity Assessment Grades **With** Hands-on Labs



Successes

- * Student grades were primarily A's
- * Non-natural resource majors performed just as well, if not better than natural resource majors when hands-on labs were done.



Lessons learned...

- * Teaching Climatology is a complex subject - hybrid format for teaching the class was stressful to the students
- * Although all the students passed the course and received A's and B's, student learning were significantly different between natural resources majors and non- majors
- * By providing both lectures and hands-on practices to all students in the class, we were able to minimize these discrepancies in learning between the majors and non-majors
- * We were able to provide a better setting for discussion on local and regional emerging issues in the environment and climate change issues.



Next

- * We would like to focus students on decision making about campus-wide practices (i.e. recycling)
- * Have students to be advocates on various topics of their interest and partner with journalism students to publish opinion articles/produce a video
- * Campus-wide student symposium/workshop on sustainability and ethics
- * Encourage students to become the educators to the youth (informal - upper elementary aged students)
- * Find a funding source to allow students to attend an earth science or environmental symposium in the region



Challenges (Field trip - class time)



Previous Years

- * Baltimore Aquarium

- * University of Maryland College Park Sustainability Program

- * Climatology Class Group Picture



Acknowledgements

School of Ice Workshop for MSI Faculty
Deadline: February 12, 2017
Workshop Dates: June 25-29, 2017
Location: Dartmouth College, Hanover, NH

- * AMS
- * SOI Team
- * IODP Team
- * NCAR Team
- * FAMU and UF Teams
- * MADE-CLEAR Program Team
- * Northeast Climate HUB Team
- * Graduate Students, Melanie Fuoco and Nivette Perez-Perez
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United States Department of Agriculture
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