



EarthLabs

Earth Systems Investigations and EarthLabs: Inquiry Investigations of Earth System Science and Climate Change



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With
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from



Educational Resources Addressing Climate Science and Earth System Science

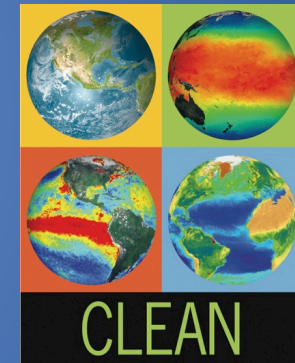
Earth Exploration Toolkit

- <http://serc.carleton.edu/eet>



Climate Literacy and Energy Awareness Network (CLEAN)

- <http://cleanet.org>



EarthLabs

- Teachers Guide
<http://serc.carleton.edu/earthlabs>
- Student Guide
- <http://serc.carleton.edu/eslabs>



The Earth Exploration Toolbook (EET)

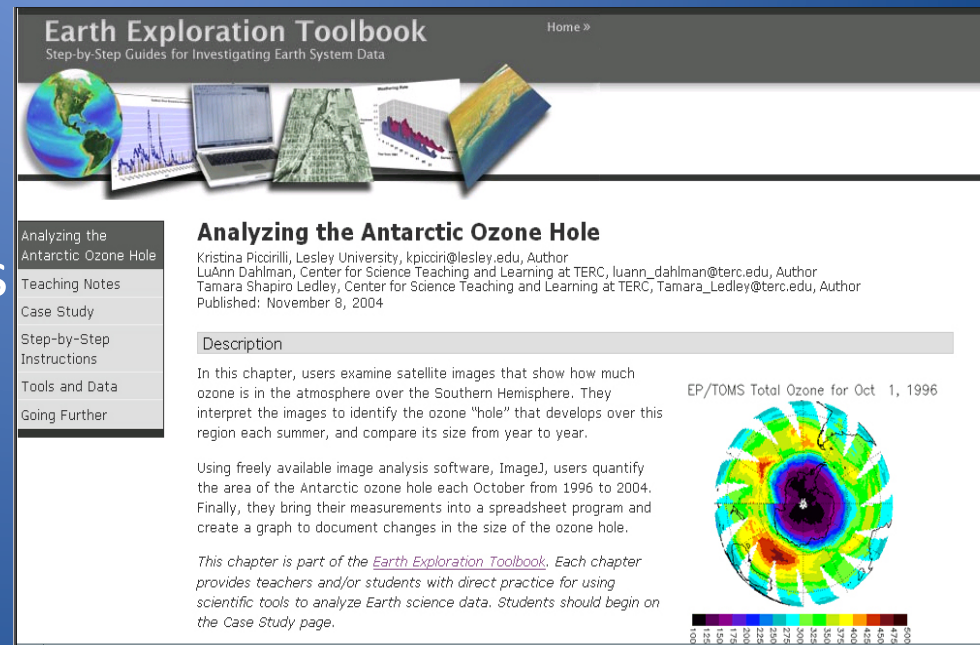
<http://serc.carleton.edu/eet>

- The **EET** is a collection of computer based activities that feature Earth science datasets and data analysis tools.
- **EET** chapters provide step-by-step instructions for accessing and analyzing data to explore issues or concepts in Earth system science.
- 44 EET chapters

Ledley et al, Science, vol 333, no 6051, pp1838-1839, 2011

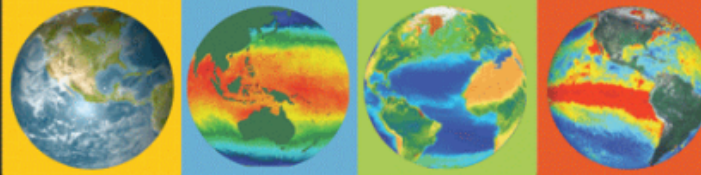


The screenshot shows the homepage of the Earth Exploration Toolbook. At the top, the title "Earth Exploration Toolbook" is displayed with the subtitle "Step-by-Step Guides for Investigating Earth System Data". A navigation bar includes a "Home" link. Below the title, there is a banner image showing various Earth science data visualizations like a globe, a line graph, a map, and a 3D surface plot. On the left, a sidebar menu lists: "Earth Exploration Toolbook", "How can I use the EET?", "Chapters in the EET", "EET Professional Development", "The EET Team", and "About EET". The main content area features a "Welcome to the Earth Exploration Toolbook!" message. To the right of the welcome message, there is a box titled "Awarded Science Magazine's Science Prize for Online Resources in Education (SPORE), September 30, 2011" with a link to the "AAAS Press Release". Next to this is the "Science Education Prizes" logo. Further right is a "Related Links" section with a link to "Using Data in the Classroom: Teaching with Data, Models, and Simulations". Below the welcome message, there is a photo of a person using a computer, captioned "Photo by Keith Weller, ARS/USDA". A section titled "What is the Earth Exploration Toolbook?" explains that it is a collection of online Earth system science activities. Another section states that within the context of a case study, each chapter guides users through a step-by-step process.



The screenshot shows a specific chapter page titled "Analyzing the Antarctic Ozone Hole". The header is identical to the homepage. The sidebar menu now includes: "Analyzing the Antarctic Ozone Hole", "Teaching Notes", "Case Study", "Step-by-Step Instructions", "Tools and Data", and "Going Further". The main content area has a title "Analyzing the Antarctic Ozone Hole" followed by the authors: Kristina Piccirilli, Lesley University, kpiccir@lesley.edu, Author; LuAnn Dahlman, Center for Science Teaching and Learning at TERC, luann_dahlman@terc.edu, Author; and Tamara Shapiro Ledley, Center for Science Teaching and Learning at TERC, Tamara_Ledley@terc.edu, Author. The publication date is November 8, 2004. A "Description" section explains that users will examine satellite images to identify the ozone "hole" and compare its size over time. It also mentions using ImageJ software to quantify the area of the ozone hole and creating a graph. A "This chapter is part of the Earth Exploration Toolbook..." note is at the bottom. On the right, there is a circular satellite image of the Antarctic region showing ozone levels, with a color scale legend below it ranging from 0.00 to 5.00. The caption for the image is "EP/TOMS Total Ozone for Oct 1, 1996".

CLEAN



CLIMATE LITERACY & ENERGY AWARENESS NETWORK

<http://cleanet.org>

Collection of Climate and Energy Educational Resources

A collection of 600+ free, ready-to-use resources rigorously reviewed by educators and scientists.

Suitable for secondary through higher education classrooms.

[Explore the Collection »](#)

Featured Resources from our Collection



Ice Core Secrets Could Reveal Answers to Global Warming

This video features research conducted at University of Colorado's Institute of Arctic and Alpine Research, which studies isotopes of hydrogen trapped in ice cores to understand climate changes in the past.

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Collection of Educational Resources

Guidance in Teaching Climate and Energy

CLEAN Network


About CLEAN



Guidance in Teaching Climate and Energy Science

Background information, pedagogic approaches, links to relevant educational resources in the CLEAN collection.

News

 The CLEAN Collection is now aligned with NGSS!

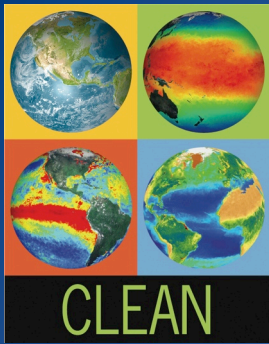


CLEAN Network

A community of professionals committed to improving climate and energy literacy.

[About the CLEAN Project](#)

[CLEAN Review Process](#)



Climate Literacy and Energy Awareness Network (CLEAN)

<http://cleanet.org>

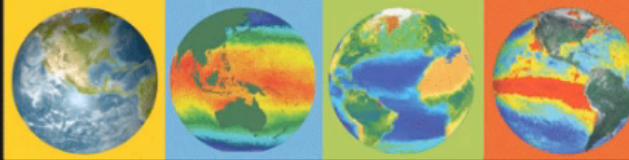
- >645 climate and energy resources
 - Activities, videos, and more
 - Grades 6-16
 - Reviewed for scientific accuracy, effectiveness, and relevance by scientists and educators
 - Collection of educational resources in the Climate section www.climate.gov
- Won 2014 Webby Award in the Education Category

Gold et.al, Journal of Geoscience Education

The screenshot shows the NOAA Climate.gov website. The header includes the NOAA logo and the text "Climate.gov science & information for a climate-smart nation". A search bar is located in the top right. The main navigation bar includes links for "News & Features", "Maps & Data", "Teaching Climate" (which is highlighted), "About", "Contact", "FAQs", "Site Map", and "What's New?". Below the navigation bar, there are several tabs for "Reviewed resources for teaching about climate and energy", including "Climate Systems", "Causes of Climate Change", "Measuring & Modeling Climate", "Climate Impacts", "Human Responses to Climate", and "Nature of Climate Science". The "Teaching Climate" section is active, showing "Featured Resources" with a list of 1, 2, 3, and 4 items. The first featured resource is a large image of Earth with a green leaf graphic and the text "#TEACH4CLIMATE". To the right of this image is a section titled "#Teach4Climate Back to School 2016 Campaign" with a description of the campaign and a "read more" link. Below the featured resources, there are two columns: "Teaching Climate Literacy" and "Professional Development". The "Teaching Climate Literacy" column shows a book cover for "Climate and Energy: Bridging Learning to Know and Learning to Do" with a "Read more" link. The "Professional Development" column shows a "Climate Change Education: Bridging Learning to Know and Learning to Do" event with a "View event" link. A "Search" section is located on the right side of the page, with a search bar, a "Grade Level" dropdown menu, and a "Find Resources" button. At the bottom right, it says "Reviewed learning activities from cleanet.org".

CLEAN Resources: Tagged with the NGSS

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Climate and Energy Educational Resources

Teaching Climate and Energy Science
CLEAN Network
About CLEAN

Mauna Loa CO2 Collection Data

<http://www.ctenergyeducation.com/lesson.htm?id=7gb7b019>

Connecticut Energy Education

[Jump to this Activity »](#)



Students examine data from Mauna Loa to learn about CO2 in the atmosphere. The students also examine how atmospheric CO2 changes through the seasonal cycle, by location on Earth, and over about 40 years and more specifically over 15 years. Students graph data in both the Northern and Southern Hemisphere and draw conclusions about hemispherical differences in CO2 release and uptake.

Activity takes about one to two class periods.

[Learn more about Teaching Climate Literacy and Energy Awareness»](#)



See how this Activity supports the Next Generation Science Standards»

Middle School: 1 Performance Expectation, 1 Disciplinary Core Idea, 5 Cross Cutting Concepts, 7 Science and Engineering Practices

High School: 1 Performance Expectation, 1 Disciplinary Core Idea, 5 Cross Cutting Concepts, 9 Science and Engineering Practices

Notes From Our Reviewers The CLEAN collection is hand-picked and rigorously reviewed for scientific accuracy and classroom effectiveness. Read what our review team had to say about this resource below or learn more about how [CLEAN reviews teaching materials](#)
[Teaching Tips](#) | [Science](#) | [Pedagogy](#) | [Technical Details](#)

Teaching Tips

- Read the student worksheet first, which has a more constrained dataset for graphing. Educators' guide contains a more extensive dataset that the educator can give to more advanced students.
- Younger students may require additional scaffolding for graphing and analyzing the graphs.
- We suggest that educator look for the most up-to-date Keeling Curve. Suggested link: http://www.esrl.noaa.gov/qmd/ccag/trends/#mlo_full.
- Educator should be prepared to explain to students that the volcanic gases are not affecting the measurements, which is an often-cited argument that climate change deniers use to discredit these CO2 measurements.

Topics

Greenhouse Effect
See more on this topic.

Atmospheric Circulation
See more on this topic.

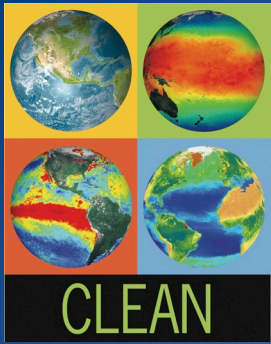
Carbon Cycle
See more on this topic.

Greenhouse Gases
See more on this topic.

Seasonal Variability
See more on this topic.

Greenhouse Gas Emissions
See more on this topic.

Measurements and Observations



Earth Systems Investigations

New in July 2016

- Suggested learning paths that integrate reviewed CLEAN resources into a 3-dimensional learning sequence.
- Three Dimensions
 - Science and Engineering Practices
 - Disciplinary Core Ideas
 - Crosscutting Concepts

Earth Systems Investigation Template Built on the Science and Engineering Practices

Step 1. Define the investigation and gather background Information

1. Asking Questions & Defining Problems

8a. Obtaining Information

Step 2. Plan an approach to conduct the investigation

2a. Developing Models

3a. Planning Investigations

8b. Evaluating Information

Step 3. Conduct the Investigation

2b. Using Models

3b. Carrying Out Investigations

4. Analyzing & Interpreting Data

8b. Evaluating Information

5. Using Mathematics & Computational Thinking

Step 4. Construct the outcome of the investigation and communicate to others

6. Constructing Explanations & Designing Solutions

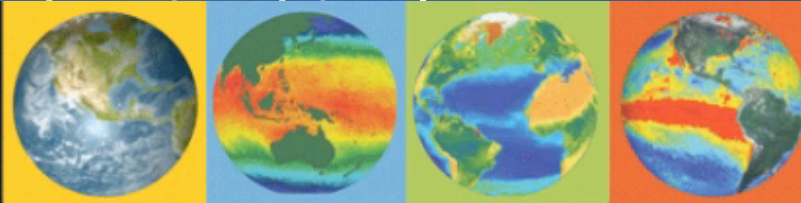
7. Engaging in Argument from Evidence

8c. Communicating Information

NGSS Science & Engineering Practices

- 1. Asking questions and defining problems
- 2. Developing and using models
- 3. Planning and carrying out investigations
- 4. Analyzing and interpreting data
- 5. Using mathematics and computational thinking
- 6. Constructing explanations and designing solutions
- 7. Engaging in argument from evidence
- 8. Obtaining, evaluating, & communicating information

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CLIMATE LITERACY & ENERGY AWARENESS NETWORK

CLEAN > Teaching Climate and Energy Science > Earth Systems Investigations > Ecosystems and Carbon Cycle

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Climate and Energy
Educational Resources

Teaching Climate and
Energy Science

Teaching Climate
Science

Teaching Energy
Science

Earth Systems
Investigations

Carbon Cycle

Ecosystem

Educator Guide

Investigation
Steps

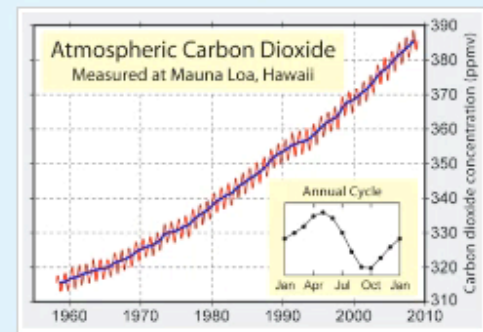
Going Further

CLEAN Network

About CLEAN

Ecosystem's Role in the Carbon Cycle

Users of this Earth Science Investigation Plan engage with twelve resources in a four-step learning sequence to investigate the role of the ecosystem in cycling of carbon dioxide among the hydrosphere, atmosphere, geosphere, and biosphere. Through the course of the guided investigation users view short video clips, download, graph and analyze CO₂ data, and work with interactive modeling online resources.



Mauna Loa Graph



[Next Page »](#)

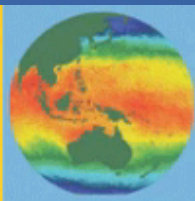


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CLIMATE LITERACY & ENERGY AWARENESS NETWORK

CLEAN > Teaching Climate and Energy Science > Earth Systems Investigations > Ecosystems and Carbon Cycle

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Teaching Energy
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Earth Systems
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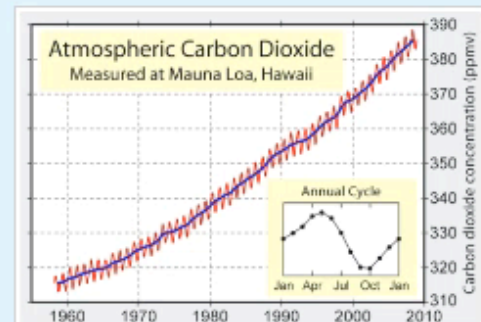
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Mauna Loa Graph



Next Page »



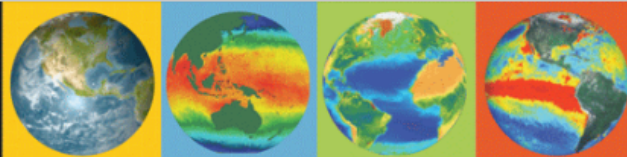
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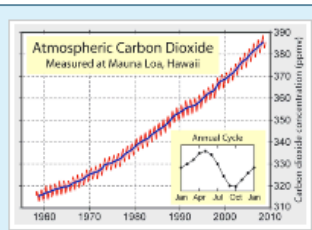
Going Further

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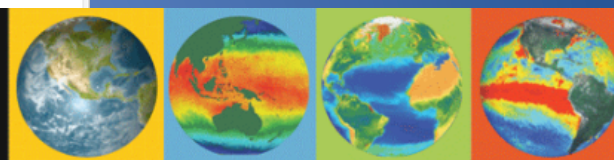
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CLIMATE LITERACY & ENERGY AWARENESS NETWORK

CLEAN > Teaching Climate and Energy Science > Earth Systems Investigations > Carbon Cycle

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CLEAN Network

About CLEAN

Carbon Cycle

Users of this Earth Science Investigation engage with eight CLEAN, NASA, and NOAA resources in a four-step learning sequence to investigate cycling of carbon dioxide among the hydrosphere, atmosphere, geosphere, and biosphere. Through the course of the guided investigation users view short video clips, analyze CO₂ data, do hands-on experiments, and work with several interactive models. In the final step, students do a summative performance assessment to communicate their results and conclusions using interactive and physical models to illustrate the cycling of carbon in Earth systems. They use an interactive online resource to produce a single carbon pathway and then combine their results on a large poster in their classroom to construct a visual model of the carbon cycle.



carbon cycle diagram



EarthLabs Climate Modules

<http://serc.carleton.edu/earthlabs/index.html>

EarthLabs

Climate and the Biosphere

Climate and the Carbon Cycle

Climate and the Cryosphere

Climate Detectives

Corals

Drought

Earth System Science

Lab 1: Think Globally, Act Locally

Lab 2: Drawing Local Connections

Lab 3: Discovering Local Data

Lab 4: A Bird's Eye View: Exploring Your Region

Lab 5: It's All Connected: Global

Earth System Science

Why study Earth System Science?

Beginning to perceive Earth as a system can begin with something as simple as when we first feel warmth from sunshine or get wet standing in the rain. However, truly understanding Earth as a system—Earth System Science—requires a quantitative exploration of the connections among all parts of the system: air, water, and life.

EarthLabs

Climate and the Biosphere

Lab 1: Climate, Weather, and Trees

Lab 2: Climate and Earth's Energy Balance

Lab 3: Climatology Basics

Lab 4: Climate Patterns and Life

Lab 5: Extreme Weather

Lab 6: Trees and Paleoclimate

Lab 7: Future of the Forest

Climate Glossary

Climate Resources

Climate References

Climate and the Carbon Cycle

Climate and the Cryosphere

EarthLabs

Climate and the Biosphere

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Climate Detectives

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Drought

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Lab 5: It's All Connected: Global

Climate and the Cryosphere: Unit Overview

Educator Pages »

Why study the cryosphere?

Snowman in Alabama. Photo taken by Melinda Shelton; image source: Flickr.

Snow and ice are everywhere. Many different kinds of snow and ice, including sea ice, lake and river ice, snow cover, glaciers, ice caps and sheets, and frozen ground, make up the **cryosphere** (a word derived from kryos, the Greek word for cold)—the places on Earth where water exists in solid form. Although most of Earth's frozen water is found near the poles.

EarthLabs

Climate and the Biosphere

Climate and the Carbon Cycle

Climate Detectives

Corals

Drought

Earth System Science

Lab 1: Think Globally, Act Locally

Lab 2: Drawing Local Connections

Lab 3: Discovering Local Data

Lab 4: A Bird's Eye View: Exploring Your Region

Lab 5: It's All Connected: Global

Climate and the Carbon Cycle: Unit Overview

Educator Pages »

Why study Earth's climate history?

Earth has experienced a number of ice ages in the past 800,000 years. Source: USGS

Earth's climate has changed, sometimes dramatically, in the past. If you had lived on the island of Manhattan about 20,000 years ago, you would have found yourself living during an ice age. You would see nothing but an expanse of ice as you pitched your tent on a 4,000-foot thick slab of ice that covers the island and extends for miles in all directions. But what does it matter? Why is it important to understand Earth's climate history?

EarthLabs

Climate and the Biosphere

Climate and the Carbon Cycle

Climate Detectives

Corals

Drought

Earth System Science

Lab 1: Think Globally, Act Locally

Lab 2: Drawing Local Connections

Lab 3: Discovering Local Data

Lab 4: A Bird's Eye View: Exploring Your Region

Lab 5: It's All Connected: Global

Why Study the Carbon Cycle?

Educator Pages »

Why study the carbon cycle?

Carbon is everywhere, in the oceans, in the atmosphere, in the soil, and in living organisms. It is a key element of life and plays a central role in Earth's climate system.

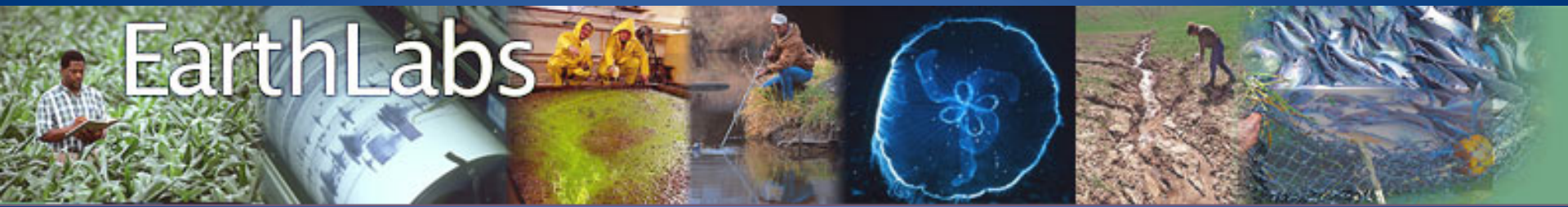
NOTE TO USERS: This module is still under development. Content has not yet been finalized for classroom use.

Project Components

Curriculum Development Professional Development
Educational Research on Student Learning

Ellins et al, Journal of Geoscience Education, vol 62, No. 3, pp307-318, Sept 2014

McNeal et al, Journal of Geoscience Education, vol 62, No. 4, pp560-577, Nov 2014



- 9 Modules comprised of 5-9 labs each in Earth and climate science
- Modules illustrate sequences for learning science concepts through data analysis and hands-on experiments.
- Use satellite imagery, numerical data, and computer visualization software to explore Earth system processes
- Include the use and development of quantitative skills that enable students to evaluate scientific results for themselves.

EarthLabs



- Time requirement: 12 – 14 hours
- Each module uses a variety of instructional strategies
 - readings
 - videos, animations
 - interactive visualizations
 - hands-on lab investigations
 - data analysis
 - classroom discussions

<http://serc.carleton.edu/earthlabs/index.html>

EarthLabs

About EarthLabs

Topics and Labs

Climate and the
Cryosphere

Climate and the
Biosphere

Climate and the
Carbon Cycle

Climate
Detectives

Corals

Drought

Earth System
Science

Fisheries

Hurricanes

EarthLabs for Educators
About This Project
The EarthLabs Team
The Labs
Climate Series Intro
Climate and the Cryosphere
Climate and the Biosphere
Climate and the Carbon Cycle
Climate Detectives
Corals
Drought
Earth System Science
Fisheries
Hurricanes

EarthLabs

Earth science is emerging as a demanding high-school science course that prepares learners for college admissions and informed citizenship. Long perceived as a low-level science subject without a lab component, it now challenges and inspires students by leveraging visualization technologies and orbital and aerial perspectives to present Earth's components, including human activities, as a single interacting system. Earth science classes integrate physics, chemistry, and biology to introduce students to a rich body of concepts and knowledge with which to understand the world around them and pressing environmental, social, and economic issues.

EarthLabs supports this transformation by providing a model for environmental science labs. EarthLabs offer the laboratory component to a capstone high-school science course that prepares students for college placement.

EarthLabs units offer sequences for learning science concepts through data analysis. Using satellite imagery, numerical data, computer simulations, and hands-on experiments that illustrate processes of our Earth system.



EarthLabs

About EarthLabs

Topics and Labs

Climate and the Cryosphere

Climate and the Biosphere

Climate and the Carbon Cycle

Climate Detectives

Corals

Drought

Earth System Science

Fisheries

Hurricanes

EarthLabs

Earth and environmental science classes are changing. Long perceived as low-level courses with little to engage or challenge students, they are becoming vital, rich, invigorating courses. As more humans recognize that our planet's resources are being stressed, these classes are receiving more interest and they are being taught as true laboratory science courses.

In keeping with this transformation, the EarthLabs project provides a national model for rigorous, engaging Earth and environmental lab science courses. Four units illustrate a sequence for learning science concepts through data analysis activities, satellite imagery and computer visualizations, and hands-on experiments that illustrate processes of our Earth system.




EarthLabs
website has
2 Parts

Teacher Guide: <http://serc.carleton.edu/earthlabs>
Student Portal: <http://serc.carleton.edu/eslabs>

EarthLabs Topics

Brief Overview of Each Module



EarthLabs

for Educators and Policy Makers

a National Model for
Earth Science Lab Courses

[EarthLabs for Educators](#) > The Labs

EarthLabs for Educators

- About This Project
- The Labs**
 - Climate Series Intro
 - Climate and the Cryosphere
 - Climate and the Biosphere
 - Climate and the Carbon Cycle
 - Climate Detectives
 - Corals
 - Drought
 - Earth System Science
 - Fisheries
 - Hurricanes
- Partners
- EarthLabs for Students

EarthLabs Topics

EarthLabs presently includes eight modules. The sequence of labs in each module represent active learning experiences that are meant to be a part of integrated instructional units.

Climate and the Cryosphere

The cryosphere, which includes all of Earth's snow and ice, is highly variable on time scales ranging from days to hundreds of thousands of years. Changes in the cryosphere influence environmental conditions like air temperature, sea level, ocean currents, storm patterns, and ultimately Earth's climate. What can the cryosphere teach us about past, present, and future changes in Earth's climate?.

Climate and the Biosphere

Climate results from a complex set of interactions between the Sun and multiple components of the Earth system, interactions that we can't always see and that many poorly understand. What is the relationship between climate and the biosphere, and how does a change in one influence the other?

Climate and the Carbon Cycle

Carbon is essential to life as we know it. It is a component of our DNA and of the foods we eat, and its presence in the atmosphere (in the form of carbon dioxide) helps shape our planet's climate. As we alter the amount of carbon dioxide in the atmosphere through the burning of fossil fuels, how do we change the planet's carbon cycle and everything that is linked to that cycle, including climate?

Corals: Rainforests of the sea

Coral reefs are often compared to rainforests for the vast biodiversity they support, and to old growth forests for the longevity of their ecological communities. Now, forty percent of Earth's coral reefs are in critical condition or already degraded beyond recovery. Learn more about why these amazing marine animals are so important to our planet.

Drought: Dealing with a dry spell

Educator's Information Page

Educator's Information Page

EarthLabs Climate Introduction



[EarthLabs for Educators](#) > [Climate Series Intro](#)

EarthLabs for Educators

Climate Series Intro

Climate and the Cryosphere

Climate and the Biosphere

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Partners

Preparing to Teach a Climate EarthLabs Module

Introduction

Studies about weather and climate and the ways in which they shape life on Earth have long had a place in the school curriculum. Today, as we struggle to understand the surprisingly new ways in which weather and climate are influencing our lives, the need for an informed citizenry is greater than ever. The most recent set of three EarthLabs climate modules will play a key role in helping students deepen their understanding of how our climate system works. Like their EarthLabs Climate Series predecessors (Drought; Hurricanes), the new modules address weather and climate not simply as atmospheric processes, but in the context of the interconnected Earth system, which includes the planet's oceans, landmasses, biosphere, and cryosphere (Earth's frozen places), as well as the atmosphere.

Although the main focus of the three new climate modules is climate literacy, it is impossible to ignore climate change when one looks seriously at climate data, something that students will do in all three of the new modules.

A brief introduction to each of the new modules (below) is followed by some classroom implementation suggestions and short science background notes that apply to all three modules.

► [Show Climate and the Cryosphere](#)

► [Show Climate and the Biosphere](#)

► [Show Climate and the Carbon Cycle](#)

In the Classroom

Student Prerequisite Knowledge: The Earth System

All students should read [Earth System: The Basics](#) (Microsoft Word 2007 (.docx) 151kB Jun6 12) before starting one of the Climate modules. It is short

http://serc.carleton.edu/earthlabs/climate_intro/index.html



EarthLabs

for Educators and Policy Makers

a National Model for
Earth Science Lab Courses

[EarthLabs for Educators](#) > [Climate and the Cryosphere](#) > [Lab Overviews](#)

EarthLabs for Educators

[Climate Series Intro](#)

[Climate and the Cryosphere](#)

[Lab Overviews](#)

[Lab 1: Getting to Know the Cryosphere](#)

[Lab 2: Earth's Frozen Oceans](#)

[Lab 3: Land Ice](#)

[Lab 4: Climate History & the Cryosphere](#)

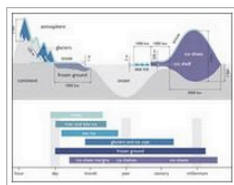
[Lab 5: Evidence of Recent Change](#)

[Lab 6: Future of the Cryosphere](#)

[Climate and the Biosphere](#)

[Climate and the Carbon Cycle](#)

Climate and the Cryosphere: Lab Overviews

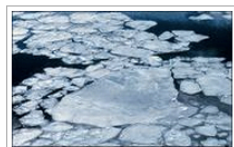


1. Getting to Know the Cryosphere

In Part A of this lab, students will learn about the different components that make up the cryosphere and where they can be found on Earth. In Part B, they will be introduced to some of the ways climate and the cryosphere influence one another, as well as how and why scientists study changes in our planet's snow and ice. In Part C, students will learn about some of the ways that humans, plants, and animals are connected to and affected by the cryosphere.

Tools Needed: Internet browser

[► Show me materials needed for this lab](#)



2. Earth's Frozen Oceans

In Part A of this activity, students will learn about the different components that make up the cryosphere and where they can be found on Earth. In Part B, they will be introduced to some of the ways climate and the cryosphere influence one another, as well as how and why scientists study changes in our planet's snow and ice. In Part C, students will learn about some of the ways that humans, plants, and animals are connected to and affected by the cryosphere.

Tools Needed: Internet browser, RealPlayer media player

[► Show me materials needed for this lab](#)



3. Land Ice

In the first part of this lab, students will learn about the different components that make up the cryosphere and where they can be found on Earth. In Part B, they will be introduced to some of the ways climate and the cryosphere influence one another, as well as how and why scientists study changes in our planet's snow and ice. In Part C, students will learn about some of the ways that humans, plants, and animals are connected to and affected by the cryosphere.

EarthLabs
for Educators and Policy Makers

a National Model for
Earth Science Lab Courses

[EarthLabs for Educators](#) > [Climate and the Cryosphere](#) > [Lab Overviews](#)

EarthLabs for Educators

[Climate Series Intro](#)

[Climate and the Cryosphere](#)

[Lab Overviews](#)

[Lab 1: Getting to Know the Cryosphere](#)

[Lab 2: Earth's Frozen Oceans](#)

[Lab 3: Land Ice](#)

[Lab 4: Climate History & the Cryosphere](#)

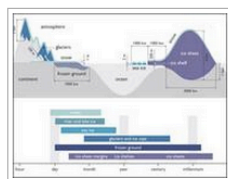
[Lab 5: Evidence of Recent Change](#)

[Lab 6: Future of the Cryosphere](#)

[Climate and the Biosphere](#)

[Climate and the Carbon Cycle](#)

Climate and the Cryosphere: Lab Overviews



1. Getting to Know the Cryosphere

In Part A of this lab, students will learn about the different components that make up the cryosphere and where they can be found on Earth. In Part B, they will be introduced to some of the ways climate and the cryosphere influence one another, as well as how and why scientists study changes in our planet's snow and ice. In Part C, students will learn about some of the ways that humans, plants, and animals are connected to and affected by the cryosphere.

Tools Needed: Internet browser, Media player plugin such as QuickTime

[▼ Hide](#)

- light source
- 4 plastic containers (plastic shoe boxes work well)
- snow or shaved ice
- dirt or soil
- gravel
- sand
- light meter or probe
- printed [image of Antarctic sea ice](#)
- two thermometers

Lab 1: Getting to Know the Cryosphere

The lab activity described here was developed by Erin Bardar of TERC for the EarthLabs project.

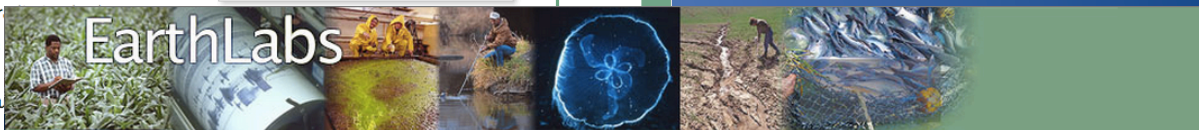
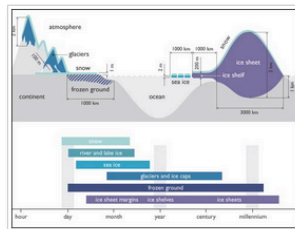
Summary and Learning Objectives

In Part A of this lab, students will learn about the different components that make up the cryosphere and where they can be found on Earth. In Part B, they will be introduced to some of the ways climate and the cryosphere influence one another, as well as how and why scientists study changes in our planet's snow and ice. In Part C, students will learn about some of the ways that humans, plants, and animals are connected to and affected by the cryosphere.

After completing this investigation, students will be able to:

- list the major components of the cryosphere
- identify where snow and ice are found on Earth
- explain the role of albedo in balancing Earth's radiation budget
- give at least 3 examples of how the cryosphere affects Earth
- explain why scientists use the cryosphere to study climate change

[Open the Student Lab »](#)



EarthLabs > Climate and the Cryosphere > Lab 1: Getting to Know the Cryosphere

Overview and Teaching Materials

Detailed overview of what students will do in each lab activity, including a list of materials and a list of activities.

[► Read more](#)

Printable Materials

Download and print files needed for each lab activity, including a list of materials and a list of activities.

EarthLabs

Climate and the
Biosphere

Climate and the
Carbon Cycle

Climate and the
Cryosphere

Lab Overviews

Lab 1: Getting
to Know the
Cryosphere

1A:
Introduction to
the
Cryosphere
1B: Why We
Study the
Cryosphere
1C: The
Changing
Cryosphere

Lab 2: Earth's
Frozen Oceans

Lab 3: Land Ice

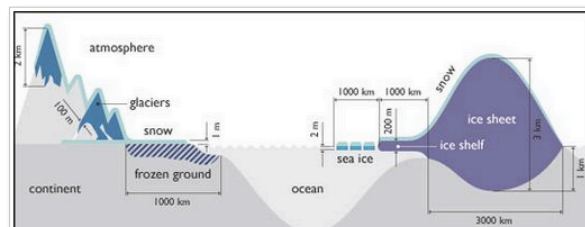
Lab 4: Climate

Getting to Know the Cryosphere

Introduction

The Earth's surface contains many forms of snow and ice, including sea ice, lake and river ice, snow cover, glaciers, ice caps and sheets, and frozen ground. Together, these features are known as the **cryosphere**. Snow and ice are a vital part of the global climate system because they influence air temperatures, sea levels, ocean currents, and storm patterns all over the world. Life on Earth depends on the cryosphere for many different things. In Arctic regions, sea ice provides a home for animals like seals and polar bears, feeding and breeding areas for a variety of migrating species, and hunting grounds for local communities. Much of the world depends on the cryosphere for fresh drinking water, while others use it for recreation—without the cryosphere, there would be no skiing, sledding, or snowball fights!

Although concentrated in the polar regions, parts of the cryosphere can be found at nearly all latitudes, which make them useful indicators of global climate and climate change. Different parts of the cryosphere change on different timescales ranging from less than a day to more than a millennium, as shown in the figure below. Scientists keep a close watch on the cryosphere and patterns in how the cryosphere changes over time to find important clues about the health of our planet.



Keeping track of What You Learn

In these pages, you'll find two kinds of questions.

- **Checking In** questions are intended to keep you focused on key concepts. They allow you to check if the material is making sense. These questions are often accompanied by hints or answers to let you know if you are on the right track.
- **Stop and Think** questions are intended to help your teacher assess your understanding of the key concepts and skills. These questions require you to pull some concepts together or apply your knowledge in a new situation.

Your teacher will let you know which questions you should answer and turn in.

Checking In

- During which months does soil moisture at 10 cm remain basically steady?
- During which months does soil moisture at 10 cm change quite frequently?
- What change do you notice as you compare soil moisture for 1998 with 1999?

Stop and Think

- 1:** Do air temperature and soil moisture at 10 cm follow the same pattern? Why or why not?
- 2:** What does this graph show about the interconnection between air temperature and soil moisture at 10 cm?

Explore the Climate and the Cryosphere Module



EarthLabs

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a National Model
Earth Science Lab Co

EarthLabs for Educators > Climate and the Cryosphere

EarthLabs for Educators

Climate Series Intro

Climate and the Cryosphere

Lab Overviews

Lab 1: Getting to Know the Cryosphere

Lab 2: Earth's Frozen Oceans

Lab 3: Land Ice

Lab 4: Climate History & the Cryosphere

Lab 5: Evidence of Recent Change

Lab 6: Future of the Cryosphere

Climate and the

Climate and the Cryosphere: Unit Overview

The lab activities in this module were developed by Erin Bardar of TERC for the EarthLabs project.

Why Teach about climate and the cryosphere?

Snow and ice are everywhere. Many different kinds of snow and ice, including sea ice, lake and river ice, snow cover, glaciers, ice caps and sheets, and frozen ground, make up the **cryosphere** (a word derived from kryos, the Greek word for cold)—the places on Earth where water exists in solid form. Although most of Earth's frozen water is found near the poles, snow and ice can be found on all seven continents.



Snowman in Alabama. Photo taken by Melinda Shelton; Image source: Flickr.

Snow and ice affect lives all over the world. In many parts of the world, including much of the United States, the cryosphere is a seasonal visitor. For some, snow and ice are a source of recreational activities like skiing, sledding, ice skating, and building a snowman. For others, the cryosphere is a lifeline. With nearly 70% of Earth's fresh water stored in glaciers and ice caps, hundreds

Educator's Information Page

Educator's Information Page

Key Questions

- What is the cryosphere?
- How and why does the cryosphere change over time?
- What are the timescales associated with changes in the cryosphere?
- How do climate and the cryosphere influence each other?

Explore the Climate and the Cryosphere Module

- Teachers Guide
 - <http://serc.carleton.edu/earthlabs/cryosphere/1.html>
- Student Portal
 - <http://serc.carleton.edu/eslabs/cryosphere/index.html>
- Lab Overviews
- The Cryosphere Labs
 1. Getting to Know the Cryosphere
 2. Earth's Frozen Oceans
 3. Land Ice
 4. Climate History and the Cryosphere
 5. Evidence of Recent Change
 6. Future of the Cryosphere
- Cryosphere Glossary

EarthLabs - Cryosphere

- Getting to Know the Cryosphere
 - What are the components of the cryosphere
 - How climate and the cryosphere influence each other
- Earth's Frozen Oceans
 - How does sea ice form and how it influences ocean currents
 - How does sea ice thickness and extent change over time
- Land Ice
 - How does glacier mass balance reflect climate change
 - How do glaciers move



OCEAN CIRCULATION

The diagram illustrates the process of ocean circulation. It shows a cross-section of the ocean with a layer of air above it. A key identifies the components: Salt ions (Na⁺ and Cl⁻) and Water molecule (H₂O). A slider at the bottom indicates temperature, ranging from Warmer to Colder. The text explains that as seawater freezes to form sea ice, salt gets squeezed out into the water below, creating a denser layer of water. This denser water then sinks, driving the circulation. The diagram also shows a water molecule structure and a salt ion structure.

FREEZING SEAWATER

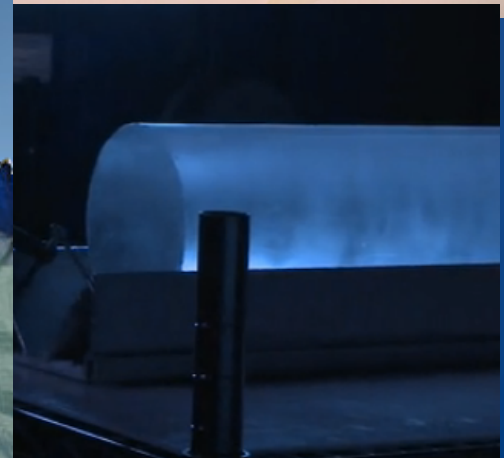
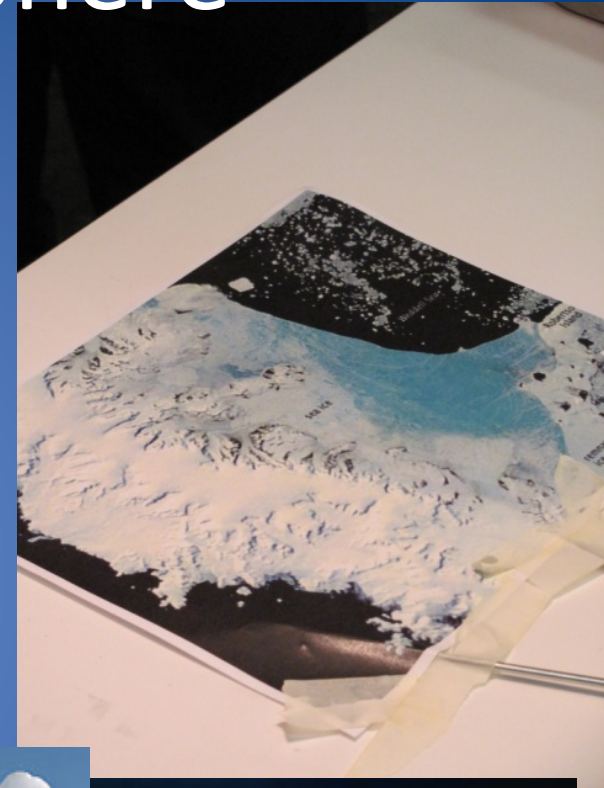
As seawater freezes to form sea ice, salt gets squeezed out into the water below. This water then has a higher concentration of salt and is more dense than the surrounding water.

Use the slider to adjust the temperature and see what happens to the molecules as salt water freezes.

credits

EarthLabs - Cryosphere

- Climate History and the Cryosphere
 - Timescales associated with glacial and interglacial periods
 - How do ice cores record atmospheric and climate data
 - Impacts of climate change on land ice and oceans
- Evidence of Recent Change
 - Examine how land glaciers and sea ice have changed over the recent past
 - What is the ice-albedo feedback loop
- Future of the Cryosphere
 - Explain how climate will change in the future based on model results
 - What are the potential impacts on life of predicted changes in the cryosphere



Cognitive Challenges to Understanding Climate Change – Education Research

- Earth System Science
 - Understanding the interconnectedness of all of the components of the system
 - Changes in one component can have large and unanticipated impacts on other components
- Change Over Time on Multiple and Embedded Time Scales
 - Daily, seasonal, annual, interannual, decadal, century, glacial, geologic...
 - Long-term change manifested as impact on shorter cycles



EarthLabs Educational Research Questions

- How does the on-line EarthLabs curriculum assist students in developing understanding of temporal and spatial dynamics, system interactions, and conceptual knowledge of climate?
- How do users engage with and navigate the on-line EarthLabs curriculum?



Preliminary Research Outcomes Climate & Biosphere, Climate & Cryosphere, and Climate & Carbon Modules

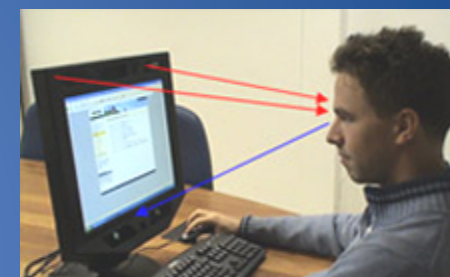
- 500 Students in 20 classrooms in Texas and Mississippi
- Pre- and Post- Test contained
 - Content multiple choice questions
 - Affective-based multiple choice questions
 - Confidence question
 - Open ended questions
- Positive gains on 90% of content questions (2%-42%)
- Significant increase in student confidence in answers
- Affective questions – significant gains in knowledge, awareness, and information about the Earth's climate system



EarthLabs

Populations & Methods

Cryosphere & Earth System Science Modules



Teachers (n=8)	Students (n=205)	External Users (n=49)
Post-implementation Interviews	Pre-post open-ended response surveys	Eye-tracking
Post-workshop surveys	Classroom observations	Interviews

<http://gettingsmart.com/cms/edreformer/new-report-highlights-real-teacher-retention-crisis-america/>

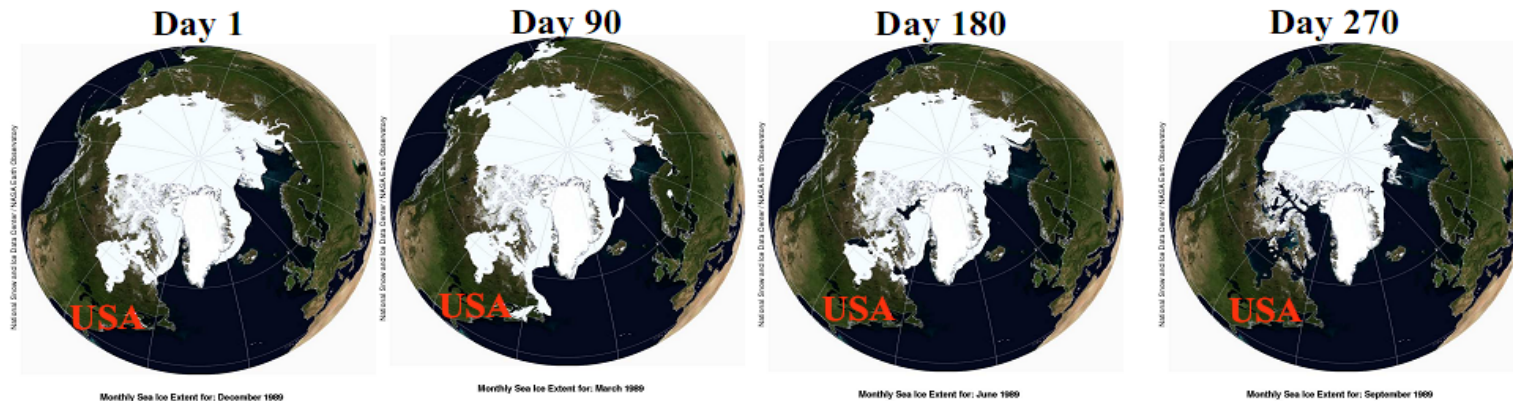
<http://www.mnsu.edu/newstudent/seminar/>

<http://www.uxmatters.com/mt/archives/2005/12/introduction-to-eyetracking-seeing-through-your-users-eyes.php>



Example open-ended *Cryosphere EarthLabs* pre-post assessment

The images below show ice extent (in white) in the Northern Hemisphere over a 270 day period. Notice that the approximate location of the United States (USA) is labeled in each of the figures. Answer the following questions to the best of your ability.






2. Explain in your own words why the ice extent in each of these images is different.



EarthLabs

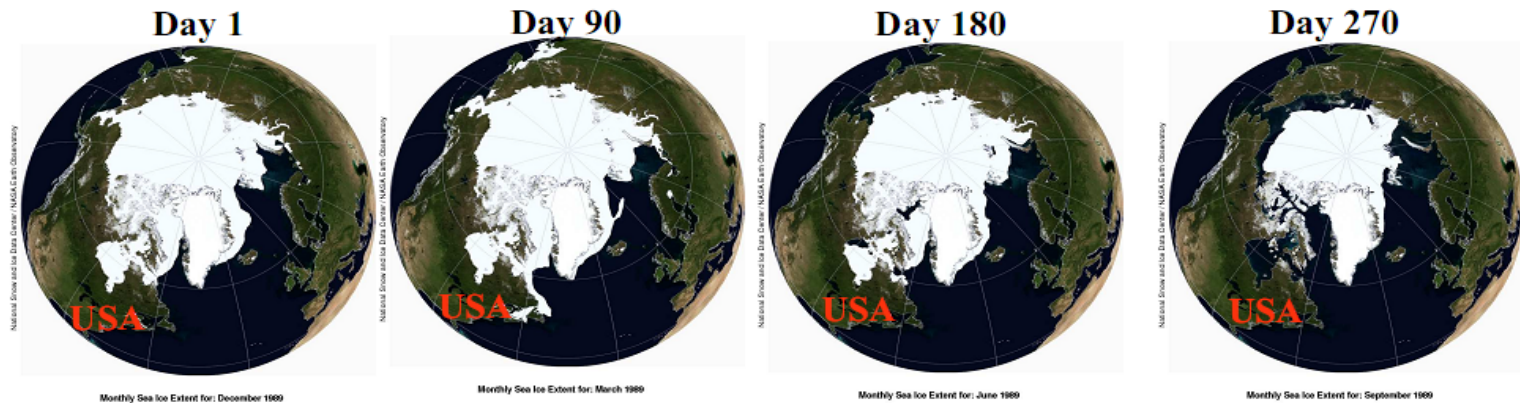
Student Methods: Systems Understanding Rubric

Symbol	Description	Points
Arrow 	Actions/Processes (Usually a verb)	1 point
Boxes 	Inputs/Outputs (Usually a noun)	2 points
Connections 	Between Actions/Processes or Inputs/Outputs (Usually a conjunction)	3 points



Example open-ended *Cryosphere EarthLabs* pre-post assessment

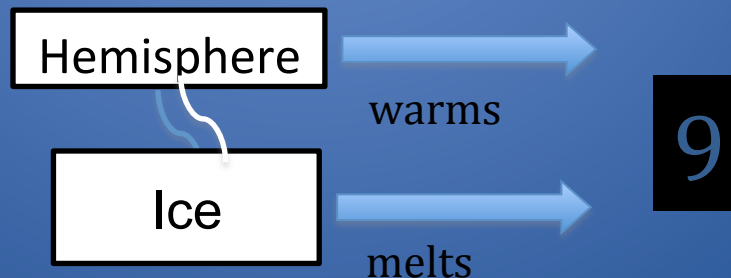
The images below show ice extent (in white) in the Northern Hemisphere over a 270 day period. Notice that the approximate location of the United States (USA) is labeled in each of the figures. Answer the following questions to the best of your ability.



2. Explain in your own words why the ice extent in each of these images is different.

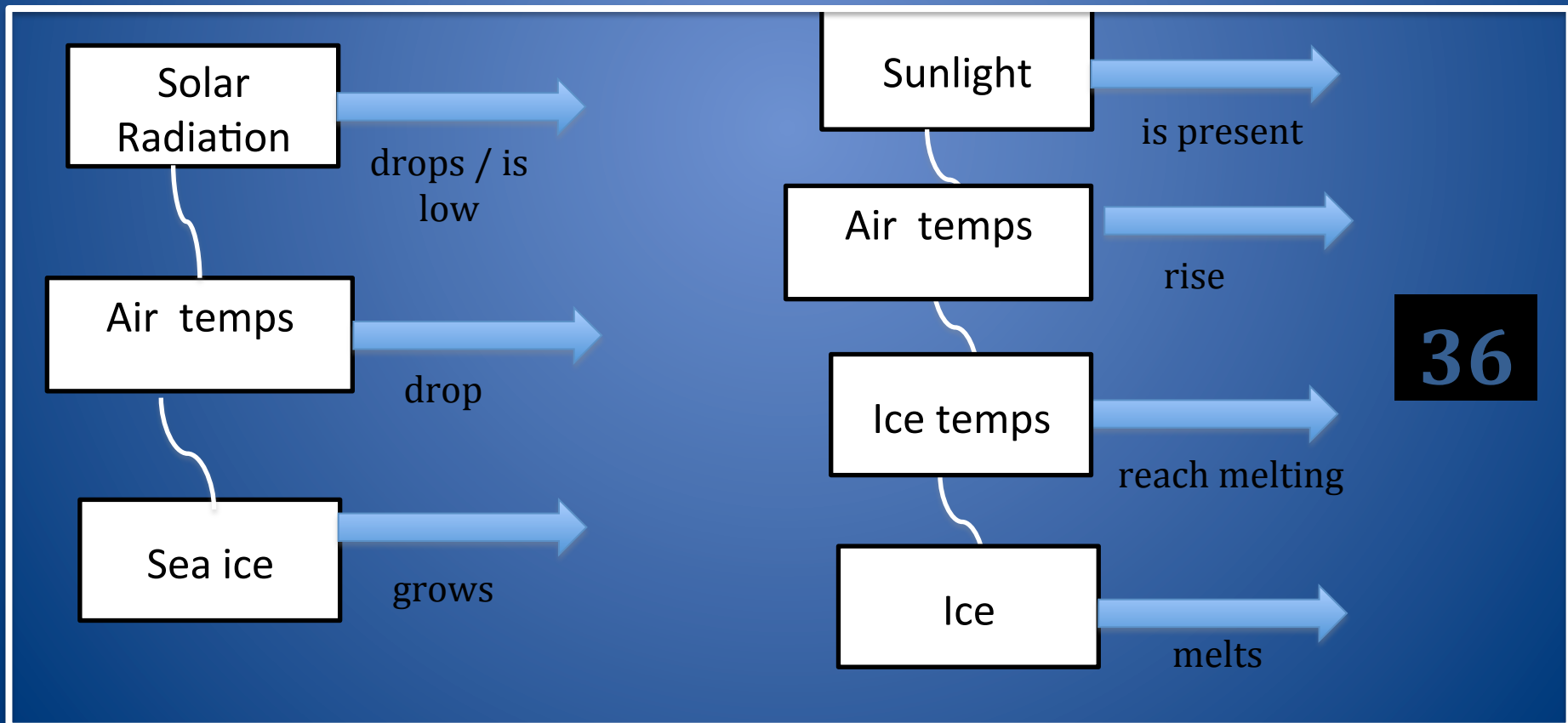
Student response:

“The hemisphere is warming, causing ice to melt.”





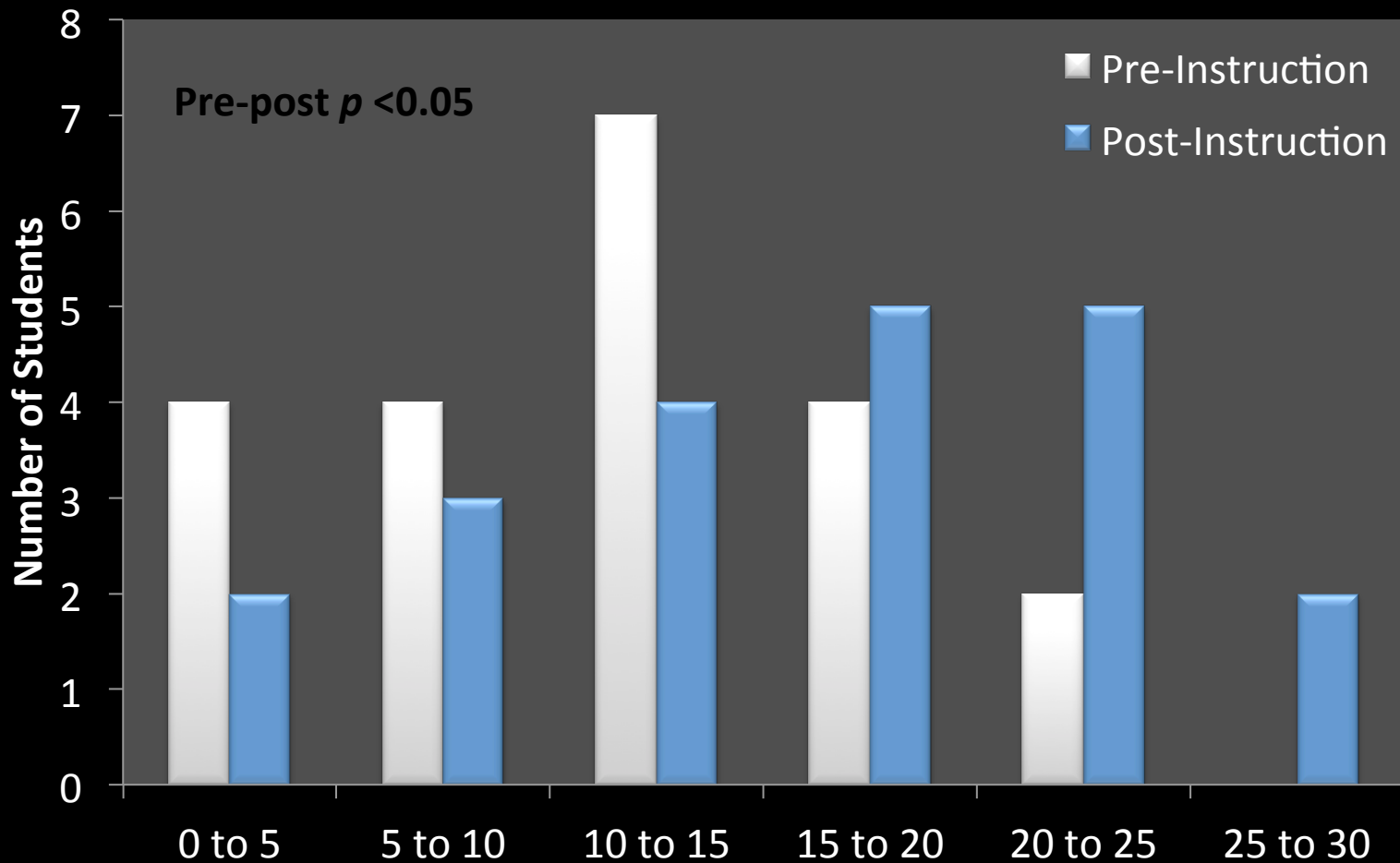
Expert response: “The images show the sea ice extent through the seasonal cycle. In the winter the sea ice extent would be the greatest. This is because there is no or little solar radiation over the region at that time of the year, causing air temperatures to be very low, resulting in a growth and expansion of sea ice at the surface of the ocean... The image for day 180 shows the sea ice extent reduced from the image for day 90 so that image shows the sea ice extent in the spring.”





Pre-post student response rubric scores

"Explain in your own words why the ice extent of these images is different"





EarthLabs

Student Methods: Rubric #2 – Conceptual Understanding

Level 0. Simple restating of the question.

Level 1. Statement of a single correct fact.

Level 2. Statement of multiple correct facts.

Level 3. A. Statement of multiple correct facts, with a single connection between facts. OR B. Statement of multiple correct facts, with multiple connections between facts. Misconceptions equal to or dominate over scientific conceptions.

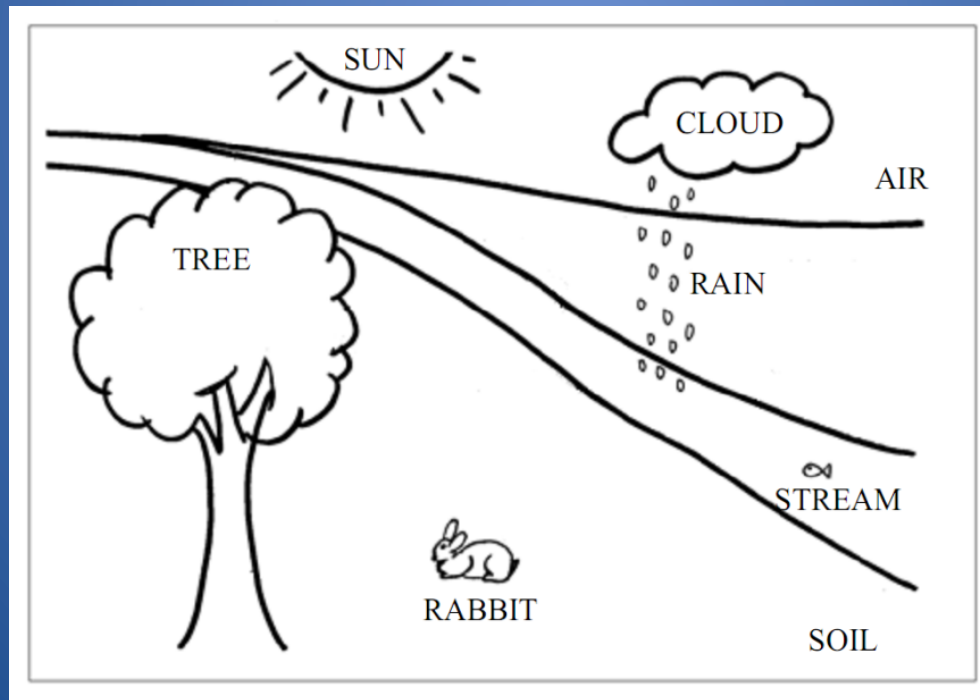
Level 4. Statement of multiple facts, with multiple connections between facts. Misconception(s) present, but scientific conceptions dominate.

Level 5. Statement of multiple facts, with multiple connections between facts. Misconceptions not present within a story that is cohesive; misconceptions about concepts outside of the core message may be present.

EarthLabs



“The following diagram represents a region in the continental United States. Draw in and label arrows to represent ALL of the important processes that move or change energy, water, or chemicals in this region”.



EarthLabs

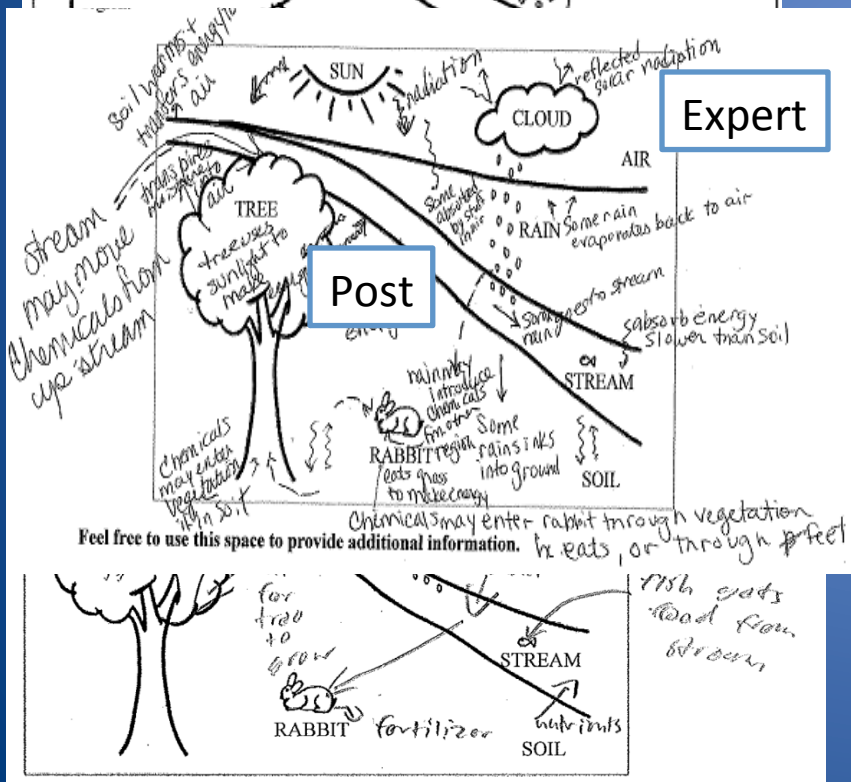


Pre

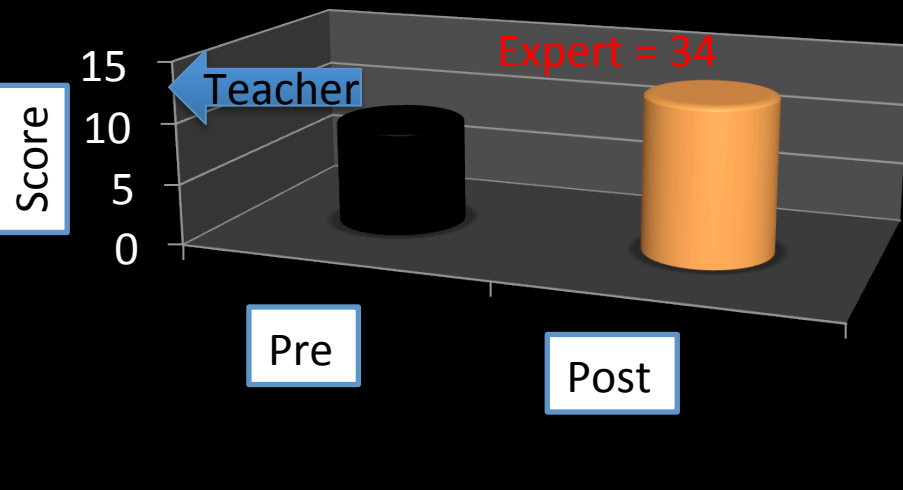


Expert

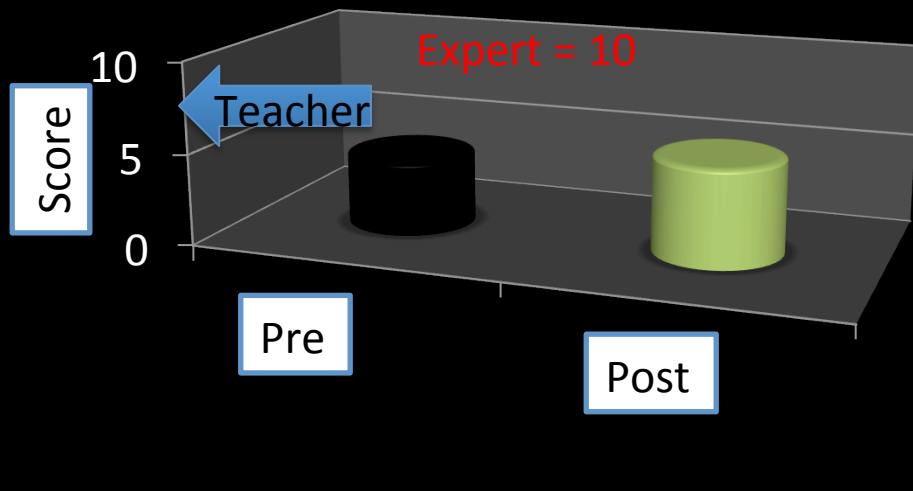
Post



Systems Understanding



Number of Arrows Drawn





EarthLabs

*Please describe and define
The Cryosphere in your own
words*

Student Example

Pre: *"I don't know, sorry."*

Post: *"The sphere with ice, snow,
sleet, etc."*

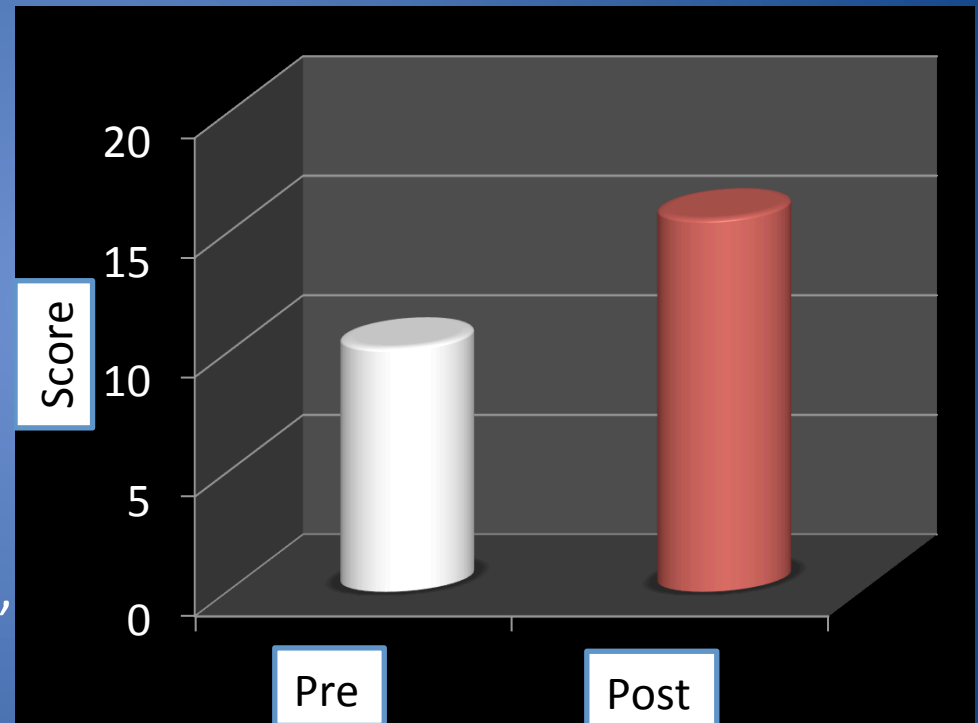
Pre-instruction = 42% *"I don't know"*

Post-instruction = 18% *"I don't know"*

Pre-instruction = 33% *"ice"*

Post-instruction = 57% *"ice"*

Systems Understanding



Paired Student's t-test $p < 0.05$
N = 163



EarthLabs

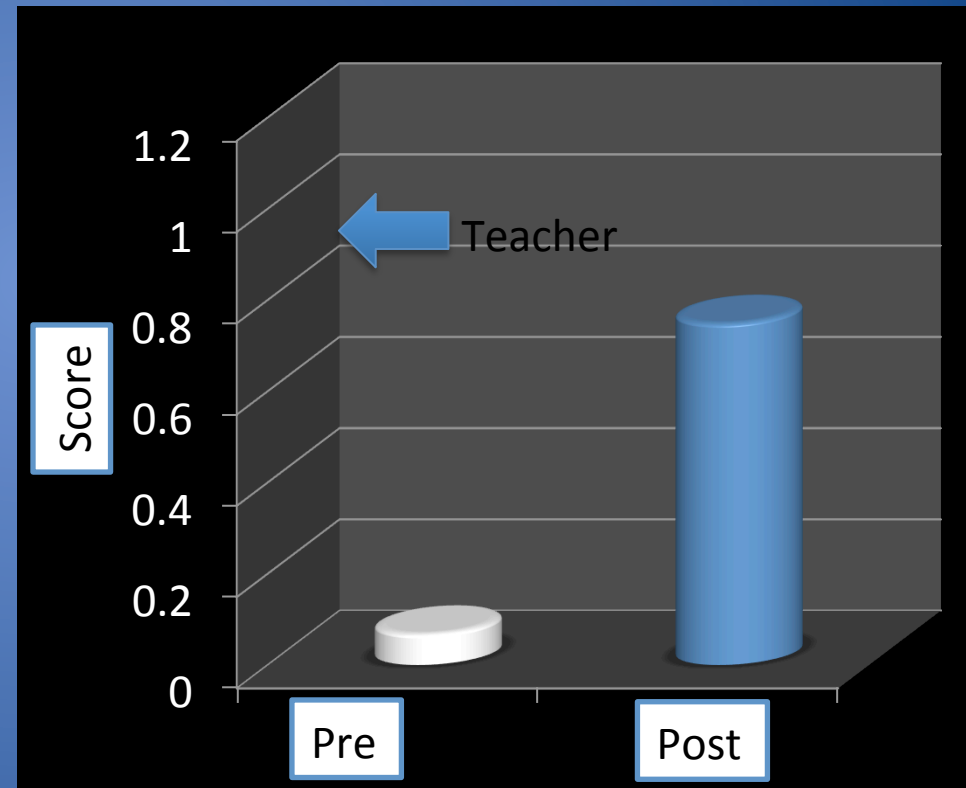
*Please describe and define
Earth system science in your own
words*

Student Example

Pre: “The research of the way that the Earth operates. This show us how the earth is changing as a whole.”

Post: “The work of geography such as biosphere, pedosphere, atmosphere, and hydrosphere used to find information and solve facts for future use and help us find out more about the way our planet works”

Conceptual Understanding

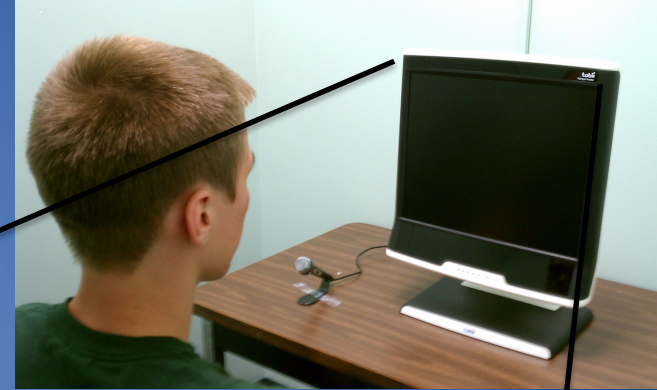


Paired Student's t-test $p < 0.05$
N = 163



Methods: Eye-tracking studies

- Pre-Study Measures
 - Color-blindness
 - Climate change conceptions
 - Demographics



Observe interaction
with page and words



- Time to complete - 23 and 32 minutes
- Engaged less with images than with text
- Difficulty engaging with some materials posted on external sites

Media: <http://serc.carleton.edu/eslabs/cryosphere/lab3.html> (CRC)
Time: 00:00:00.000 - 00:01:34.674
Participant filter: All

33 counts

EarthLabs > Cryosphere > Lab 3: Sea Ice Dynamics

EarthLabs

Corals

Cryosphere

Lab 1: Frozen In Time?

Lab 2: Sea Ice Thermodynamics

Lab 3: Sea Ice Dynamics

3A: Dynamic Forces

3B: The Arctic Oscillation

Lab 4: Ice Sheet Thermodynamics

Lab 5: Land Ice Dynamics

Lab 6: Interactions & Feedback

Lab 7: Climate Change & the Cryosphere

Lab 8: Future of the Cryosphere

Cryosphere Glossary

Drought

Earth System Science

Fisheries

Hurricanes

Sea Ice Dynamics

Introduction

Close your eyes and think about the ocean. Envision yourself swimming, sailing, or surfing. What does it feel like? Are you stationary or are you moving—bobbing, drifting, or getting pushed around? Depending on a number of different conditions, the ocean can be fairly calm or quite rough, but either way it is always in motion. Sea ice, like anything else afloat in the oceans, is constantly subjected to a number of different forces from things like wind, currents, and the Earth's rotation.

In this investigation, you will explore some of the different forces that influence sea ice dynamics as well as how the distribution and composition of sea ice changes over time due to these forces and subsequent motion of the ice.

After completing this investigation, you should be able to:

- explain the dynamic processes associated with sea ice; and
- describe the timescales associated with sea ice dynamics.

Keeping Track of What You Learn

In these pages, you'll find two kinds of questions.

- **Checking In** questions are intended to keep you focused on key concepts. They allow you to check if the material is making sense. These questions are often accompanied by hints or answers to let you know if you are on the right track.
- **Stop and Think** questions are intended to help your teacher assess your understanding of the key concepts and skills. These questions require you to pull some concepts together or apply your knowledge in a new situation.

Your teacher will let you know which questions you should answer and turn in.

« Previous Page Next Page »

Wind-ice Interaction Observed by Quikscat

09/21/1999

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Wind Speed (m/s)

NASA JPL Liu, Long, Xia, & Tang

Image source: [NASA](#). Click image for larger view.

TERC NSF Science Education Resource Center @ Carleton College

Last Modified: November 22, 2010 | Accessibility | About this Site | Printing | Shortcut: <http://serc.carleton.edu/50297> | Privacy | Terms of Use

Purple path is a participant with significant attention.

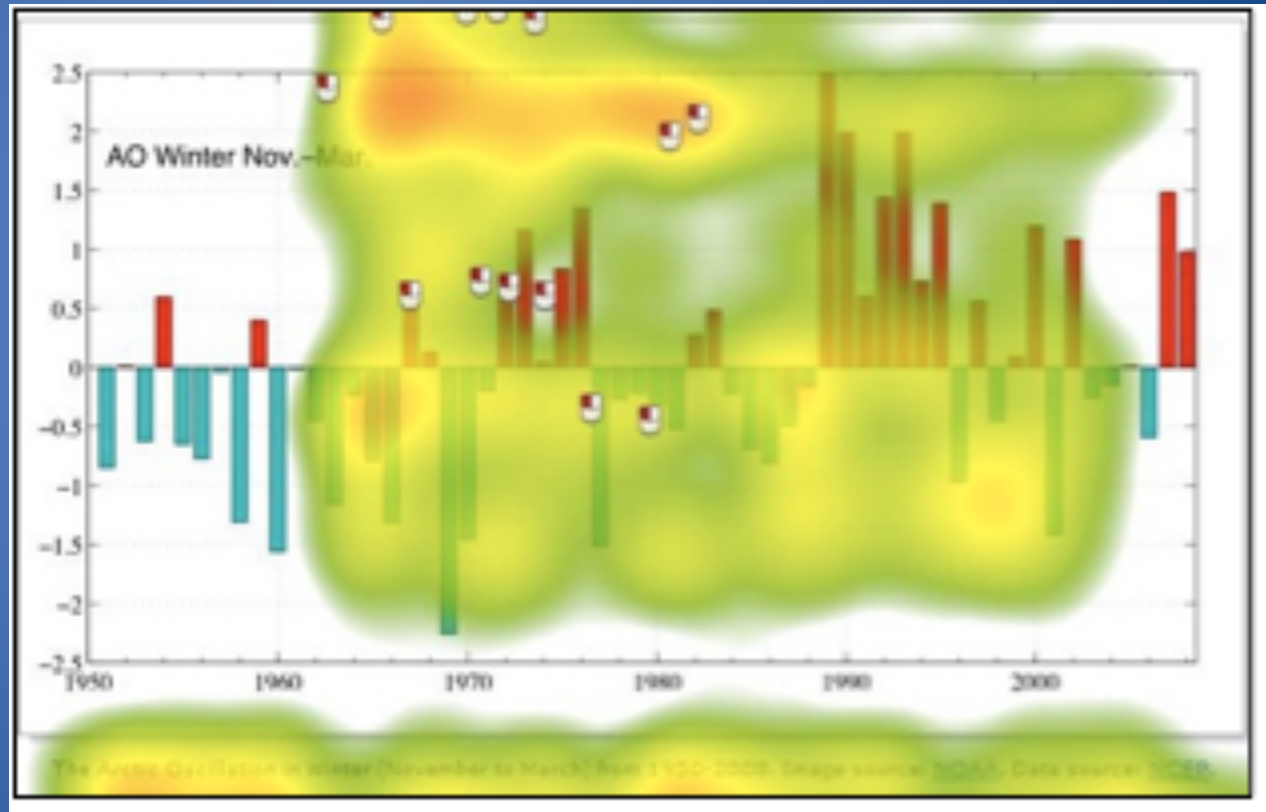
Blue path is cursory and is typical of most participants.

[illegible]

EarthLabs



Students had difficulty knowing where to look on complex scientific graphs/figures



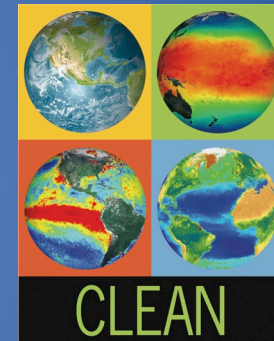


Conclusions

- Students' **SYSTEMS UNDERSTANDING** and **CONCEPTUAL UNDERSTAND** significantly improved after exposure to *EarthLabs* modules, although students did not reach mastery levels on par with expert responses.
- Classroom observations combined with eye-tracking measures of external users indicate that the *EarthLabs* modules were **ENGAGING TO USERS**.
- The *EarthLabs* **CURRICULUM-RESEARCH** model is an example of how research can be used to inform curriculum development.

Educational Resources Addressing Climate Science and Earth System Science

- Earth Exploration Toolkit
 - <http://serc.carleton.edu/eet>
- Climate Literacy and Energy Awareness Network (CLEAN)
 - <http://cleanet.org>
- EarthLabs
 - Teachers Guide
<http://serc.carleton.edu/earthlabs>
 - Student Guide
 - <http://serc.carleton.edu/eslabs>



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Tamara_Ledley@terc.edu, 617-873-9658

