**Climate and the Cryosphere**

**Suggested Workshop Outline and Leader Notes**

Although the Cryosphere module covers many topics, there are three key science ideas addressed in the module that connect the Cryosphere with Earth’s climate; they are highlighted in this suggested workshop plan.

1) Albedo, which plays a key role in determining how much solar energy is reflected back into space and therefore helps keep the planet cool

2) the Cryosphere’s role in influencing global ocean circulation, which helps redistribute solar energy absorbed by the equatorial ocean towards the poles

3) the Cryosphere’s role in helping scientists collect data about Earth’s climate from hundreds of thousands of years in the past.

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| Section | Detailed Notes |
| **Workshop Introduction** [15 minutes] | **CLIMATE AND THE CRYOSPHERE**(While Slide #1 is showing)• Welcome and thank attendees• Introduce workshop leaders• Give a brief overview of the schedule• Point out other logistics (bathrooms; location of water or refreshments; etc.) • Find out if everyone has been able to download and install the pertinent software• Distribute an agenda and ask if there are questions about the schedule before you start.• Explain that you will start with some slides to orient them to the EarthLabs project and to an EarthLabs general climate science resource before starting work on the Cryosphere module itself. • Show PowerPoint slides 2-12 of *Climate and the Cryosphere.pptx* Suggested comments are included in the Notes section at the bottom of each slide. Be sure to highlight the workshop goals.• At slide #12 (shows names of the six Cryosphere sections or Labs ) ask if there are any questions about what participants have seen in the introduction.• Show Slide #13, with the EarthLabs url’s, and ask teachers to go first to the Educator web site and open the **Climate Series Intro**.  |
| **Climate Series Introduction**[30 minutes] | **CLIMATE SERIES INTRODUCTION**• **Switch from projecting the PowerPoint to projecting the EarthLabs module.** Project the EarthLabs Home Page for the Educator’s web site and open the Climate Series Intro web page. • Point out the 4 main sections of the Climate Series intro (Brief descriptions of the 4 climate modules; In the Classroom; Science Notes; and Keeping Up to Date• Mention briefly that the Introduction page just holds descriptions of the 4 climate modules. Then go to the section titled In the Classroom. Have participants do the same on their own computers.**In the Classroom**• Point out the link for “Student Prerequisite Knowledge: The Earth System”, and ask participants to share their prior understanding of “the Earth system”. What does that phrase mean to them?• Distribute: printed copies of Earth System: The Basics, and give participants time to read the document (5 – 6 minutes). • Discuss the Earth System reading: What did participants learn? Reactions, comments, questions. Having a general overview of the Earth system is important to understanding all of the EarthLabs modules, and in particular the Climate Series.• Open the Crosscutting Themes link and briefly summarize the four major crosscutting themes. (The Earth System has already been covered.) • Highlight one additional item on the list: Student Access to Computers. The module can certainly be adapted to be taught in a one-computer classroom, although it is preferable that all students have their own computers.  • Emphasize that teachers should read the rest of the In the Classroom material on their own as they prepare to teach the module.**Science Notes**• Explain that reading and discussing the science notes could be a workshop in itself, and so there is not time to go through all of them now, but prior to starting a climate module, teachers should take the time to read through them to add to their own background knowledge about the complex topic of climate and associated representations.• Highlight one element of the Science Notes: Under Greenhouse Gases and Climate, scroll down to the Scott Denning video and show it to the class. (6 minutes) • Give participants two minutes to discuss the video with a partner. Next, ask for responses to the video. Comments? Questions? Be prepared to address questions. **Keeping Up to Date**• Just show teachers that this resource exists, and mention that the web sites listed are kept up to date with current information about climate science and climate change.  |
| **Lab 1A & 1B** [60 minutes] | • Open Climate and the Cryosphere on the EarthLabs **Educator** web site. Point out the structure (see below), which is common to all Earthlabs module home pages.  Why teach about climate and the Cryosphere? Why use this set of lessons? Key questions Before starting this unit Assessments Resources• Ask participants to respond to the first question, without reading the text. What ideas do they already have about the significance of the Cryosphere? Why is it important? Then review the highlights of the text:The Cryosphere \* is found on all continents \* stores water that feeds rivers, supplies hundreds of millions of people \* has a major influence on climate by reflecting sunlight back into space \* is an archive of Earth’s past conditions (via ice cores) • Quickly show the Lab Overview page on the Educator site, go to Lab 1 to briefly highlight the Headings there. It is the same structure for every Lab. Highlight the importance of the resources on the Educator Web site, even though for most of the rest of the workshop participants will be using the Student site, which holds the actual curriculum.• Click the link in the upper right corner to open the Student home page of the Cryosphere module. Go to Lab 1. Have participants follow on their own computers. • Point out the cross-connections between the Student and Teacher web sites, and mention that assessments and answer keys are available to educators by application. Restricted files will prompt the user when clicked to submit an application.Lab 1• Briefly show the elements of the Lab level Intro page .Lab 1AShow how the Checking In multiple choice works and explain it as a quick self-assessment that is not part of the formal assessment Lab 1BAsk participants to move on to Lab 1B and read the text “Why we study the Cryosphere”. Allow 3 minutes for reading and studying the diagram. • Discuss the reading. Any questions? • Have participants complete the Albedo Lab as described in 1B. See *Cryosphere\_Equipment&Materials.docx*• Debrief the Lab experience: • Are participants clear about the albedo percent? (Albedo of .8 means that 80% of the incoming radiation is reflected and 20% absorbed by land.) • What numbers did participants get? • Address differences between groups. What range of the differences seems  reasonable?   |
| **Lab 1C**[15 minutes] | Lab 1C:• As a group, watch the video A Tour of the Cryosphere on the presentation computer.• Ask pairs to spend 2 minutes discussing the video and generating any questions or comments they might have.• Hold a group discussion about the video, asking for pairs to share any questions or comments they have come up with.  |
| **Break** 15 mins |  |
| **Lab 2 Intro & 2A**[55 minutes] | Intro: Have participants read the Lab 2 Introduction page (5 mins)2A: Have participants read the introductory text and watch the video *Ice Finger of Death*. (5 mins) Point out that the video is actual time-lapse footage and not an animation. Have participants complete the Ocean Circulation lab as described in 1B. See *Cryosphere\_Equipment&Materials.docx* (30 mins) Show the *Ocean Circulation* visualization on the classroom computer. Be sure to use the yellow arrows to move through all screens. This is one of the key ideas of the module. Discuss and encourage questions as you move through the visualization. (15 mins) |
| **Lab 2B**SKIP | **SEA ICE THICKNESS**  |
| **Lab 2C**[20 Minutes] | **ARCTIC SEA ICE EXTENT**2C: Have participants work through 2C, *Arctic Sea Ice Extent*, on their own computers, reading then using the visualization. Skip making the graph for schedule purposes but highlight that as a good student activity. Highlight the option for Fixed Month Animations. (20 mins) |
| **Lab 3 Intro & 3A**[10 Minutes] | Have participants read the Lab 3 Introduction on their own computers. Are there any questions or comments? (5 mins)3A Have participants read the first 3 paragraphs of 3A. Notice but skip the links to additional information. Discuss. Any questions? Any comments? (5 mins) Highlight but skip the interactive *Glaciers*. Their students should work through it. It is extensive.  |
| **Lab 3B**[20 Minutes] | 3B Have participants read the opening paragraph and the background essay Fastest Glacier. (5 mins)Show the video Fastest Glacier and then discuss. (10 mins)Highlight the feature “*How Do We Know What We Know*” that appears in all modules and that provides the background information about the tools and techniques scientists use to collect data and build knowledge. Move through the resource on the classroom computer but skip exploring the resources on the final slide. (10 mins) |
| **Lunch Break**[45 Minutes] | (Set up materials for Making a Glacier activity in Lab 3C.) |
| **Lab 3C**[50 Minutes] | 3C Have participants do the hands on lab, *Make a Glacier*. See *Cryosphere\_Equipment&Materials.docx* (60 mins) |
| **Lab 4 Intro** SKIP. | **CLIMATE HISTORY AND THE CRYOSPHERE**Although the Intro contains important information, the key ideas are returned to in the following sections. |
| **Lab 4A**[25 Minutes] | **GLACIAL AGES**Have participants read the introductory text in Part 4A. (3 minutes). H**ighlight the two graphs** using the classroom projector. The upper graph shows the natural cycles of Earth’s climate over the past million years. This leads to two questions: *What are the causes of that variation?* And *How do we know what the temperature was for the past million years*?To address the question about causes, use the classroom projector to **show each of the three animations** that address the orbital changes known as the Milankovitch cycle. Don’t ask participants to read the text; be prepared to **briefly describe the three elements verbally**. **An Important Note**: These orbital variations DO NOT change the total amount of solar radiation the Earth receives over the course of any one year, but they do change when and where that solar energy reaches Earth, and those changes can cause the cryosphere to expand or shrink. **For example**, right now the Earth is closest to the Sun in January, but the north pole tilts away from the Sun, causing winter in the Northern Hemisphere. Orbital changes can reverse that. If the Earth were farthest away from the Sun in January, while the north pole tilted away from the Sun, Northern hemisphere winters would be colder, causing the Cryosphere to expand. That would result in more solar energy being reflected off Earth (increased albedo) and cause the Earth to cool.  |
| **Break**[10 Minutes] |  |
| **Lab 4B**[60 Minutes] | **ICE CORES**Have workshop participants work through this entire section. This section includes the most complex work of the module: gaining some understanding of the proxy data that scientists find in the ice cores to learn about climates of the past, and using Excel to create graphs that reveal the relationships between some of the indicators found in the ice cores. It is important to develop a good understanding of the science in this section so you can help workshop participants become comfortable with the content. Here is some information about the ice cores that are addressed in this section.1. Layers: Summer snow has a different texture and moisture content than winter snow, so the stripes that appear in an ice core are similar to the annual rings in a tree; each set of a light colored layer and a darker colored layer represents one year. Counting the stripes provides one way to determine the age of the ice at any particular depth. 2. Dust: Dust in an ice core can be analyzed for its chemical composition and matched with soils in different locations on the Earth. This allows scientists to estimate wind direction and strength at the time the dust was deposited. Pollen particles provide evidence of what kinds of vegetation existed at different points in time and give clues about the climate associated with that vegetation.3. Oxygen Isotope Ratios: Increased amounts of O16 indicate colder temperatures while increased amounts of O18 indicate warmer temperatures. 4. Air Bubbles: Although air that is mixed with new layers of snow is not immediately trapped, scientists have determined how long it takes air to become entrapped by successive layers of falling snow and thus can determine the are of the air from the age of the adjacent ice. The composition of that air can be analyzed for the level of CO2 and other gases. ExcelFamiliarize yourself with how to create the graphs that participants are asked to create in this section. (See the completed graphs available for download on the Teacher site.) Having participants have a “buddy” during this part can help those who may need support.  |
| **Lab 4C**[20 Minutes] | Have participants explore the interactive visualization that shows the general relationship between the Cryosphere, temperature, and ocean level. Point out that the visualizations provide general trends and are not intended to be accurate at finer levels of detail. Point out that the temperature scale is more accurate than the ice cover animation: a difference of just 8 or 9 degrees F in average global temperature is the difference between an almost ice-free planet and one which has massive ice sheets extending across much of North America.  |
| **Lab 5A & 5B**[10 Minutes] | Use the projector and screen to show the recent changes that have occurred to some glaciers, and that are examples of changes that are taking place to glaciers across the globe. |
| **Lab 6**Skip |  |
|  **Wrap-Up** [5 Minutes] |  |