Earth's Climate System for Introduction to Earth Science College Course

For Seminars on Science
American Museum of Natural History
Climate Change
Fall 2014

I. Introduction

I currently teach a course titled "Introduction to Earth Science" at a community college. The material for this course is based on the textbook by McConnell titled "The Good Earth: Introduction to Earth Science". I chose this book for its advanced pedagogical approach to teaching the subject of Earth Science. The authors of the book have done extensive research on inquiry learning and are subject experts on Earth Science. I appreciate how this book helps me to guide the students through the learning process with a combination of reading material, inquiry lessons, and thoughtful discussions.

Through this lesson plan I will be taking one of the chapters of "The Good Earth" and expanding the lessons to include material learned in this course and develop activities to better include the national teaching standards. This unit will be directly incorporated into the current course that I teach online using the Moodle learning platform.

Before a person can begin to understand the concepts of Global Climate change, one must have a grasp of the Earth's climate system and the basic interactions within. This unit will connect some of the concepts already covered in the course, such as the sun, oceans and atmosphere and add some new concepts relating to what we know about Earth's climate in the past and how it acts today. This will set up the course for the next unit that will cover how scientists predict the climate will change in the future.

II. Define Learners

A. Course is completely online with zero face to face contact with students.

B. Course will have between 10-20 students each term.

C. All assignments are completed at the students own pace with no group work required.

D. Grade Level: Community college, upper high school students.

E. Population Characteristics: Many of the students taking courses from my college are dual enrollment, early college age students. However, there are some students who are taking courses for enrichment purposes only. There is a wide range of backgrounds of the students from very little science background to currently employed in science-related fields.

F. Lesson Groupings: Discussion activities will be done asynchronously as a whole class. Simulations and assignments will be completed individually.

III. Standards

National Science Education content and teaching standards that apply:

Teaching Standard A

Teachers of science plan an inquiry-based science program for their students. In doing this, teachers

Develop a framework of yearlong and short-term goals for students.

Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students.

Select teaching and assessment strategies that support the development of student understanding and nurture a community of science learners.

Work together as colleagues within and across disciplines and grade levels.

(3 Science Teaching Standards." , p. 30)

Teaching Standard B

Teachers of science guide and facilitate learning. In doing this, teachers

Focus and support inquiries while interacting with students.

Orchestrate discourse among students about scientific ideas.

Challenge students to accept and share responsibility for their own learning.

Recognize and respond to student diversity and encourage all students to participate fully in science learning.

Encourage and model the skills of scientific inquiry, as well as the curiosity, openness to new ideas and data, and skepticism that characterize science.

(3 Science Teaching Standards." , p. 32)

Teaching Standard C

Teachers of science engage in ongoing assessment of their teaching and of student learning. In doing this, teachers

Use multiple methods and systematically gather data about student understanding and ability.

(3 Science Teaching Standards." , p. 37)

Teaching Standard D

Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. In doing this, teachers

Structure the time available so that students are able to engage in extended investigations.

(3 Science Teaching Standards." , p. 43)

Unifying Concepts and Processes Standard

Conceptual and procedural schemes unify science disciplines and provide students with powerful ideas to help them understand the natural world. Because of the underlying principles embodied in this standard, the understandings and abilities described here are repeated in the other content standards. Unifying concepts and processes include

Systems, order, and organization.

Evidence, models, and explanation.

Change, constancy, and measurement.

Evolution and equilibrium.

Form and function.

("6 Science Content Standards.", p. 104)

TABLE 6.1. SCIENCE AS INQUIRY STANDARDS

LEVELS K-4	LEVELS 5-8	LEVELS 9-12
Abilities necessary to do scientific inquiry	Abilities necessary to do scientific inquiry	Abilities necessary to do scientific inquiry
Understanding about scientific inquiry	Understanding about scientific inquiry	Understanding about scientific inquiry

("6 Science Content Standards.", p. 105)

TABLE 6.4. EARTH AND SPACE SCIENCE STANDARDS

LEVELS K-4	**LEVELS 5-8**	**LEVELS 9-12**
Properties of earth materials	Structure of the earth system	Energy in the earth system
Objects in the sky	Earth's history	Geochemical cycles
Changes in earth and sky	Earth in the solar system	Origin and evolution of the earth system
		Origin and evolution of the universe

TABLE 6.5. SCIENCE AND TECHNOLOGY STANDARDS

LEVELS K-4	**LEVELS 5-8**	**LEVELS 9-12**
Abilities to distinguish between natural objects and objects made by humans	Abilities of technological design	Abilities of technological design
Abilities of technological design	Understanding about science and technology	Understanding about science and technology
Understanding about science and technology		

("6 Science Content Standards.", p. 107)

TABLE 6.6. SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

LEVELS K-4	LEVELS 5-8	LEVELS 9-12
Personal health	Personal health	Personal and community health
Characteristics and changes in populations	Populations, resources, and environments	Population growth
Types of resources	Natural hazards	Natural resources
Changes in environments	Risks and benefits	Environmental quality
Science and technology in local challenges	Science and technology in society	Natural and human-induced hazards
		Science and technology in local, national, and global challenges

TABLE 6.7. HISTORY AND NATURE OF SCIENCE STANDARDS

LEVELS K-4	LEVELS 5-8	LEVELS 9-12
Science as a human endeavor	Science as a human endeavor	Science as a human endeavor
	Nature of science	Nature of scientific knowledge
	History of science	Historical perspectives

("6 Science Content Standards.", p. 108)

IV. Topic

Define the main Science concept from the course that will be your focus and give details about the specific subject covered in the lesson.

The main science concept focus of this lesson will be "Earth's Climate System". The Earth's climate system is comprised of many interacting parts. This includes interactions between the sun and the Earth's spheres (hydrosphere (and cryosphere), biosphere, atmosphere, and geosphere. By the end of the unit the student will be able to identify and explain the interactions between the spheres that contribute to the Earth's climate system. The students will investigate the following general concepts to develop an overall understanding of the Earth's Climate System: Global Air Circulation, Global Climate Regions, Extreme Climate Environments (Polar Ice and Deserts), Records of Climate Change, and Causes of Climate Change.

V. Curriculum Links

Describe how this lesson might fit with the rest of the units and/or curriculum, what goes before it, how you will connect this lesson to this prior knowledge, what comes after this lesson, and how will you link it to what follows.

The students have already completed chapters on the Earth in Space, Oceans, and Atmosphere. When learning about the Earth in Space, students were introduced to the relationship between the Sun and the Earth and how the Sun's proximity and angle determine the seasons and the distribution of solar radiation on the Earth. In the Ocean unit, the students learned about oceanic circulation, ENSO and Thermohaline circulation, and about ocean chemistry and temperature. The students are introduced to the following concepts in the atmosphere unit: structure and processes of the atmosphere, solar radiation and the atmosphere, water in the atmosphere, effects of pressure and temperature, cloud formation, winds and circulation of the atmosphere. The interactions of all of these concepts will be applied to the study of climate in this unit.

After this unit on "Earth's Climate System" students will enter into a unit of "Global Climate Change" in which they will investigate and learn about Ozone in upper and lower atmosphere, CFCs, Greenhouse gasses, Modeling Global Climate Change, and the choices people have for the future.

VI. Objectives

What are the main concepts, skill, behaviors, values, attitudes, etc. you want students to get from the lesson; objectives should be stated in terms of what students will be able to do after completing the lesson, do not tell what students will do during instruction (that's scope & sequence).

The objectives of this unit are:

- ✓ Knowledge Level: To be able to recognize and define terms related to Earth's Climate System.
- ✓ Knowledge Level: To acquire knowledge of science of the Earth's Climate System and its effects on human activities;
- ✓ Comprehension Level: To be able to explain the scientific interactions between some of the climate drivers and feedbacks;
- ✓ Analysis Level: To be able to evaluate scientific information in the mass media related to Earth's climate system;
- ✓ Evaluation Level: Upon completion of their study of Earth's Climate systems, to be able to create a concept map to evaluate their understanding of the interactions between the earth systems and the climate.

VII. Materials

What will you need to teach this lesson, which supplies, technologies, tools and resources will you need to access or create?

Students will need access to the course site platform setup in Moodle, various other websites containing videos, essays, and interactive activities. The students will need access to a reliable internet-ready computer and transportation to complete the self-directed field trip activity. The course content materials and directions will be accessed through the Moodle course site, as this is a completely online course. Worksheets, assignment instructions, and other materials are listed in the Supplemental Materials section of this document. Rubrics for all assignments (as included in the evaluation section of this document) are posted and available for the students to access throughout the activities. There are not any additional physical materials required for this unit due to the fully online nature of the course.

VIII. Time

The duration of this plan will be one week — the amount of time needed to cover this one curricular unit. The whole-class asynchronous online discussion will be announced at the beginning of the week and students will be required to participate interactively with other classmates for 3 out of the 7 days of the week at a minimum. Readings, investigations, and assignments will be done during the week at the student's own pace.

IX. Scope and Sequence

Outline of the lessons itself; what will you teach and in what order; include the major points you want to make, any interactives or multi-media materials you may need and their function; all the activities students will undertake, and the products they will deliver at the lesson's end.

For each section of this unit, the students will be reading their textbook (McConnell), accessing the provided lecture PowerPoint supplied by the textbook author, a live online lecture with additional information will be given (and recorded afterwards for access), and accessing the supplemental materials described below. For each lesson I will highlight the main points that I want to make sure and stress during the live lecture.

A. Polar Ice Changes

Polar Ice Changes are, in recent history, observable and measureable from satellites. As the ice melts and freezes over its annual cycles the increase and decrease of the volume of ice is measured and analyzed by scientists. The annual changes are currently being studied because of significant decreases in the volume of ice that is remaining frozen from year to year.

Key points for this topic to make sure and mention:

- Climate is different from weather. Weather is short term, whereas Climate is the average weather conditions over a long period of time.
- The flowing of oceans and atmosphere are responsible for moving energy from the equator (peak area of sun's input into the system) to the poles.
- The poles are experiencing increases in temperature that are causing significant physical changes to the polar environments.

- Similar changes can be observed in other parts of the world in the form of changes in the permanent glaciers. These large bodies of ice are rapidly decreasing in size as well. (McConnell, Mathez, SoS Videos)

Students will be introduced to the topic of Polar Ice Changes and then be directed to watch the following video that illustrates the changes observed by the satellites.

1. Video: Science Bulletins: Sea Ice 2000-2008

Students will be directed to complete the following short answer quiz in Moodle in response to viewing this video on Sea Ice (It will be graded using the "Short Answer Rubric" as provided later in this document):

a) What is the most surprising information you took away from watching this video on Sea Ice Changes? Explain why.

b) Why do you think the changes in sea ice have been more significant than the climate change models that scientists use?

c) How can scientists use the current observations of sea ice levels to make their models more accurate?

d) Student Note: As you continue through this unit, keep in mind (and take note of) the interactions between the climate and the polar sea ice and what effects these two systems have on each other. You will be applying this information to your Concept Mapping Project at the end of the unit.

Students are provided the following additional resources to supply background and research material to support their responses in the Polar Ice Discussion activity in which they will participate all week. The instructions for the discussion activity are provided in the "Supplemental Materials" section of this document.

2. Repeat photography activity: http://nrmsc.usgs.gov/repeatphoto/
3. Archived in Ice: Rescuing the Climate Record: Essays and Videos: http://www.amnh.org/explore/science-bulletins/(watch)/earth/documentaries/archived-in-ice-rescuing-the-climate-record
4. Classroom Activity from Archived in Ice for online discussion, leading questions will be used throughout the week to further the student's inquiry learning and thinking about the topic (Discussion activity description provided in "Supplemental Materials" and grading criterion provided in rubric form in "Assessment of Students".

a) Students will review and interact with the "Archived in Ice" essays and video to formulate their responses to the discussion questions and prompting questions.

b) Students will participate in discussion and will be graded on their responses.

B. Global Air Circulation

To get a better understanding and basis for the influence the climate has on the polar ice we will step back and look at how the Earth's atmosphere circulates air from one region to another. In previous units of study the students have covered Albedo and the influence of the Sun on the Earth's systems and spheres. So with a quick review that the Sun's solar radiation is at its peak at the equator and at its least at the poles we will move on to learning about the major circulation patterns of Jet Streams and Trade Winds.

1. Solar Radiation

Points to make sure and make with the students on Solar Radiation:

- Because of heat sink, fluid and albedo differences, the continents have a greater temperature range between the equator and the poles than the oceans.
- Cloud patterns affect the amount of solar radiation that reaches the Earth's surface and oceans. However certain latitudes have a higher probability of clouds than others.
- Convection is the physical sinking of cooler, denser air and the natural rising of warmer, less dense air. All fluids move this way (can be observed in a lava lamp). Atmosphere acts this way all the time, with additional forces at play as well. (McConnell, Mathez)

2. Jet Streams and Trade Winds

Other ways that the atmosphere circulates, and some terms the students need to be familiar with:

Coriolis Effect: occurs because the Earth is spinning on its axis. The winds are deflected opposite directions in each hemisphere due to the spinning of the Earth.

Hadley Cells: circulation of air in firm cells due to convection, the cool air sinks and warm air rises.

Ferrel and Polar Cells: In the far north and south, polar cells stay in one place due to the extreme cold air masses that are pulling air down. These cells push the cold air towards the equators. Because of the Coriolis effect, the Hadley cells are broken up and an eddy forms between the Hadley cells and Polar Cells. These circulation patterns in between are named Ferrel Cells. All of this moving air creates high and low pressure pockets of air between them, which results in movement of air and zones of unstable severe weather.

Jet Streams: Jet Streams are "high-speed, horizontal rivers of wind some hundreds of kilometers wide and several kilometers thick... These locations correspond to the downward limbs of the Hadley cells. " (Mathez)

Trade Winds: Trade winds are called that because they are the winds that used to carry ships across the oceans. They are a result of the deflection of air masses in predictable

directions that frequently cause strong winds in a certain location/direction. (McConnell)

3. Video: Global Atmospheric Circulation http://youtu.be/Ye45DGkqUkE

This video will reinforce the concepts of Atmospheric Circulation with excellent illustrations and explanation of the concepts covered in this lesson.

4. Essay: Atmospheric Circulation and Global Climate (Mathez)

For reinforcing the content learned from the text and lecture, this article will bring another perspective on the topics of this lesson. I will use the images from this essay during the lecture on this topic.

5. Self-reflection Question:

If you were blind and were taken somewhere in the world, you weren't told where (I am imagining you getting picked up like the little Wii Mi and dropped somewhere), what features could you use to identify where on Earth you are located? What is the basis for your reasoning?

C. Records of Climate Change

Where does our information about the Earth's past climates come from? Students will be taken on a journey of investigation of the sources of our information from the past. Key points to make sure are shared with the students:

- Only 150 years of historical weather data.
- Proxy indicators are used to determine past climates as a substitute for observed weather data.
- Average global temperatures change over time periods as short as a decade or less and as long as billions of years.

1. Ice Core Samples: Review information studied earlier in the week related to ice core samples

Students read the essay: Expedition for and Ice Core: http://www.amnh.org/explore/science-bulletins/(watch)/earth/documentaries/archived-in-ice-rescuing-the-climate-record#fancybox-video

Students will add to their discussion for this week in the Polar Ice Discussion with the newly learned material from this section. Their writings will be evaluating along with the other discussion participation for this unit.

2. Technology recording climate change

Satellites are one of the most powerful tools in our arsenal to collect climate data. The video shared at the beginning of this unit showing satellite images of the polar ice caps is a great illustration of the usefulness of satellite data analyzed over time. Other technologies, such as those used to analyze data from ice core, tree rings, mineral contents in rocks, and many other sources of data are also critical to fill in the gaps of information and complete the "climate picture". The following two videos illustrate and teach about the use of technology to record climate data and view the changes.

a) Video: Shrinking Glaciers: a Chronology of Climate Change

http://www.amnh.org/explore/science-bulletins/(watch)/earth/documentaries/shrinking-glaciers-a-chronology-of-climate-change

b) Video: Graphic: Global Warming from 1880-2013 (NASA)
http://climate.nasa.gov/climate_resources/28/

3. Lake Sediments and Tree Rings

Students will investigate the various Proxy Climate data sources at the following site, to supplement the material found in the text: Introduction to Proxies: Paleo Proxy Data (NOAA)
http://www.ncdc.noaa.gov/paleo/proxies.html

4. Interpreting Climate Record

Technology is also used to compile the data from all of the climate records and model the future predictions of climate change. Supercomputers are needed to compile and calculate the billions of equations and iterations in order to make the attempt at a glimpse into the future of our planet's climate. The surface of the Earth is broken into small sections and formulas that represent the physical interactions of the Earth's variables are calculated for a given set of starting data and the interactions between each of these sections is calculated over and over, day after day. With the most powerful computer models today using the most powerful computers available, it still takes one week to run one simulation of climate for the Earth in the future. The variables within these models will be taught in the next lesson of this unit.

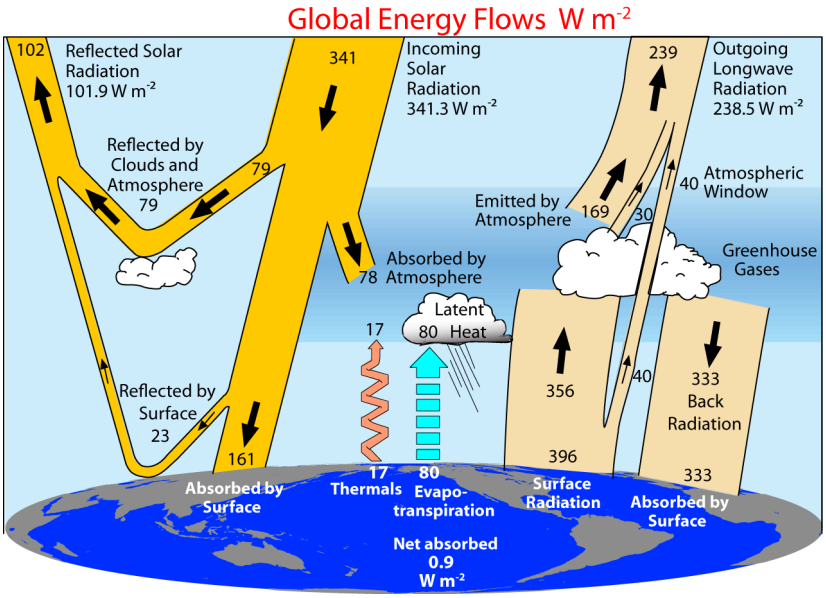
Students will watch the following video get gain a larger appreciation for the computers and models scientists use to forecast future climate change: "Supercomputing the Climate".
http://vimeo.com/53685201

D. Causes of Climate Change

1. Introduction to Climate Change Video (Mathez):
http://vimeo.com/24186282

2. Drivers

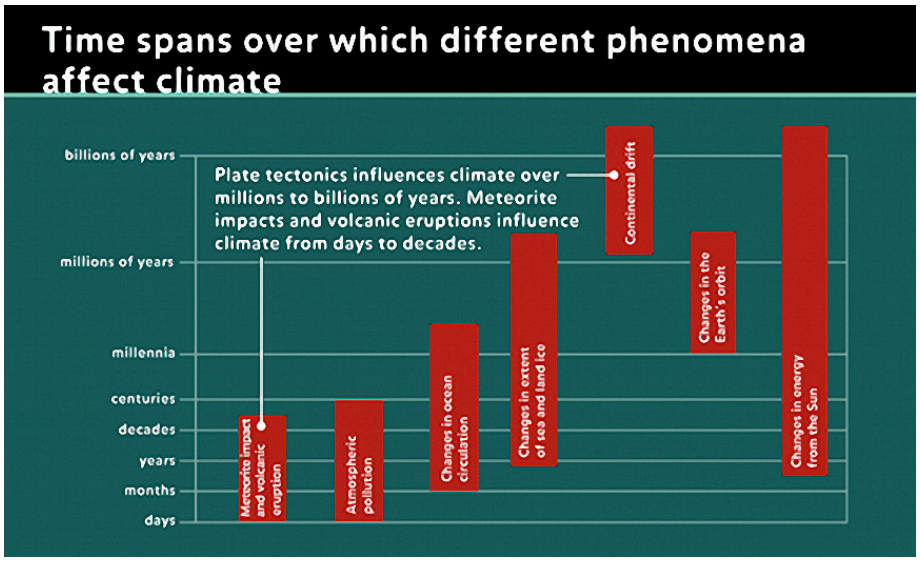
Drivers of climate change are a very important aspect of understanding the system as a whole. The students will be shown the following image from the Climate Change course:



(SoS Climate Change, Importance of Drivers Discussion)

Key points to ensure students understand:

- Drivers are influences on the climate that are not directly affected by the climate in return. Key drivers in the Earth's climate system are: solar radiation, Earth's orbit and orientation, meteorite activity, pollution, volcanic activity, changes in sea and land use, and changes in ocean circulation.
- Drivers have an effect on the climate's change in short and long timescales depending on the driver. The following image, from the Climate Change course, graphing these timescales will be shown and discussed:



(SoS Climate Change, Timeline of Drivers Discussion)

3. Solar Radiation Effects – interactive activity: http://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::800::600::/sites/dl/free/0073369365/78778/Seasons_Nav.swf::Seasons%20Interactive

a) Students will be given directions on how to use the interactive activity and will be asked to explore the variables to observe the outcome and effect on temperature of the Earth's Surface. (Given in Supplementary Materials in this document)

b) Students will take a quiz on the Moodle platform at the culmination of the activity to assess understanding of the concepts, quiz will include the following short answer inquiry questions:

(1) How does your position on the Earth effect how you are influenced by the Sun's radiation?

(2) How might the Earth's systems be different if the angle of the axis were to change by a few degrees?

(3) What are the limitations of this simulation to accurately portray the interactions between the Earth and the Sun?

(4) How might the model/simulation be improved to minimize these limitations?

4. Feedbacks

Feedbacks are interactions in the Climate system that are affected by changes. Students will read the following essay as supplement to the material covered in the text: "Climate Feedback and Processes by Shindell.

E. Synthesis Evaluation Project: Concept Map Project

At the culmination of this unit the students are asked to create a concept map project to evaluate their understanding of the interactions between the earth systems and the Earth's climate system. Students are asked to label and explain as many interactions as they can with information from this unit of lessons. Instructions for this assignment can be found in the "Supplementary Materials" section of this document and the grading scale can be found in the "Student Evaluation" section.

X. Supplementary Materials

Describe any off-line worksheets and/or activities you will design.

Students will have a discussion activity to participate in during the week for an activity. In addition, the students will participate in an activity that I will provide for inquiry and interaction with the simulation of radiometric dating. At the culmination of the activity, the students will create a concept map project.

A. Polar Ice Discussion Activity

Student Instructions:

Polar Ice Discussion Activity

Read and watch the material provided in this Week's Moodle section on Polar Ice and the changes that have been happening in the recent past. Feel free to do additional research on the topic at reputable educational websites to support your position and answers to the following questions:

Choose two news articles with opposing points of view on the effects that polar ice depletion is having on the environment and climate. Use what you have learned so far in this course to analyze the articles and determine which points made are supported by scientific fact and which do not have scientific basis. Draw your own conclusions as to whether you believe the decreasing polar ice will have significant effects on the future climate of our planet. What do you conclude some of the consequences of this lack of ice will be on the rest of the Earth's systems (include as many connections with as many systems as you can think of). Use research from the course materials to support your position.

Any additional information learned during the course of this unit may be added to your responses this week to enhance your quality of responses to your classmates. Please cite all sources, course materials and outside resources alike. Consult the Discussion Rubric for details on how this assignment will be graded.

B. Solar Radiation Effects – interactive activity

Student Instructions:

This simulation of the effect of Solar Radiation on the temperature of the Earth's surface. This simulation allows you to change the Earth's inclination angle from 90 degrees to zero degrees to investigate the effects based on the modeled formulas programmed into the simulation. The simulations also allows the user to simulate the inclination angles of Earth as it is today, Venus and Uranus to compare the differences. Observe the number of hours of daylight, the changing temperatures, how the seasons temperatures would change. Manipulate the inclination angle to observe and record these changes.

If you need help on how to use the simulation, click on the "How To" tab at the top for more detailed instructions on how to use the software. The "Interactive" tab is where you will complete your investigation in order to answer the quiz questions you will submit in Moodle. To help you prepare for the Short Answer questions in Moodle, please complete the "Exercises" questions for practice. The answers for these exercises are given in the "Solutions" tab.

Once you have completed these activities, log into Moodle and complete the "Solar Radiation Effects Assessment" you will submit your short answers to the following questions:

(1) How does your position on the Earth effect how you are influenced by the Sun's radiation?

(2) How might the Earth's systems be different if the angle of the axis were to change by a few degrees?

(3) What are the limitations of this simulation to accurately portray the interactions between the Earth and the Sun?

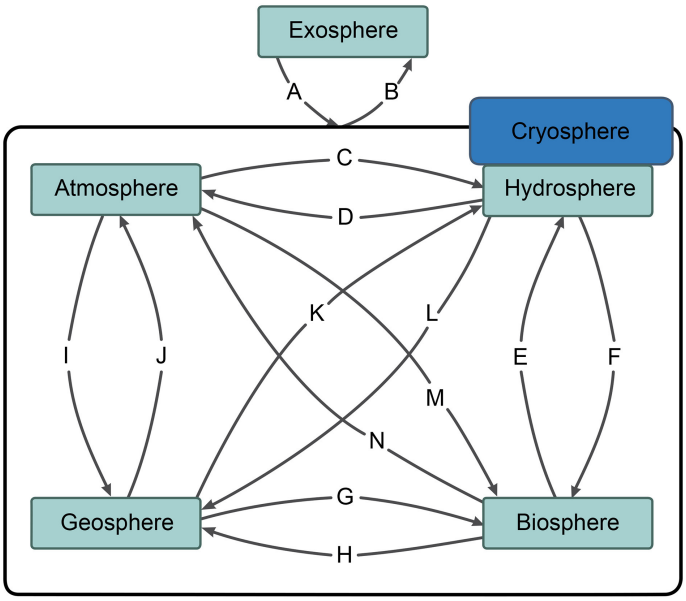
(4) How might the model/simulation be improved to minimize these limitations?

C. Concept Map Evaluation Project

Student Instructions:

Using what you have learned from this unit on the Earth's Climate System you will create a project that demonstrates your understanding of the connections between the earth system and the climate system. Make sure and include the Cryosphere (and content that you researched for your discussion prompt) in your

description of interactions with each of the Earth's spheres. You will need to utilize the text, Moodle lessons and activities, and outside resources to complete this activity. Make sure and cite your sources at the end for all sources you use to create this project. You may present your material in a Power Point, a drawing, in written form, or another form of your liking (must be pre-approved if not already mentioned). It is expected that you will use the terms and concepts of this unit in your work and demonstrate your understanding and ability to apply these concepts and connections to the earth system. The more connections you are able to explain and analyze the higher your score on this project. Please refer to the rubric for the grading scale and criterion.



XI. Assessment of Students

How will you grade or otherwise evaluate students' participation in this lesson?

Students will be graded on their responses to the polar ice discussion and further prompting questions. They will be graded both on their initial response to the prompt as well as the quality of the interactions with their classmates and further answering of the instructor's questions.

The short answer questions of the assignments will be designed to require a higher level of analysis and thinking in order to completely and successfully answer. The students will also be evaluated at the culmination of the inquiry lesson with a Concept Map Project. The following rubrics will be used to evaluate the student's work submission for the various activities and assignments:

A. Discussion Rubric

	Exceeds Expectations 10 points	Meets Expectations 7 points	Approaches Expectations 5 points	Did Not Meet Expectations 2 points	Did not post 0 points
Response to Discussion Prompt	Reflected on the discussion question using course materials while drawing on other resources and asking	Reflected on the discussion question using course materials. Cited resources.	Did not adequately reflect on the discussion question or did not relate post to course materials.	Posted without addressing the discussion question.	

	additional questions. Includes original concepts and ideas.		Mostly a duplication of other classmates' ideas and material.		
Response to classmates	Posted more than two substantive and timely responses to other learners and course faculty over two different days.	Responded two times in a substantive and timely manner to other learners and course faculty on two different days.	Occasionally responded substantively to other learners and course faculty, or failed to post in a timely manner. Or made all postings on one day.	Posted no substantive responses.	

B. Short Answer Rubric

	Exceeds Expectations 10 points	Meets Expectations 7 points	Approaches Expectations 5 points	Did Not Meet Expectations 2 points	Did not post 0 points
Response to Short Answer Question	Reflected on the short answer question using activity materials. Drawing your own educated conclusions and supporting with factual evidence.	Reflected on the discussion question using course materials. Cited resources.	Did not adequately reflect on the discussion question or did not relate post to course materials. Mostly a duplication of other classmates' ideas and material.	Posted without addressing the discussion question.	
Communicating Scientific Ideas	Responded with superior application, spelling and number of vocabulary terms used in the lesson. Communicated ideas effectively using appropriate course- related language.	Responded with properly applied, spelled, and an adequate number of the vocabulary terms used in the lesson. Generally communicated ideas using appropriate course-related language.	Occasionally responded with properly applied, spelled, and an adequate number of the vocabulary terms used in the lesson. Generally communicated ideas but did not use course-related	Posted no substantive response with use of vocabulary from the lesson. Did not communicate scientific ideas.	

			language. OR Writing contained significant errors.		

A. Concept Map Evaluation Project

	Exceeds Expectations 10 points	Meets Expectations 7 points	Approaches Expectations 5 points	Did Not Meet Expectations 2 points	Did not submit 0 points
To demonstrate content knowledge	Project demonstrated mastery of course content by applying appropriate scientific concepts.	Project demonstrated understanding of course content by applying appropriate scientific concepts.	Project demonstrated a limited understanding of course content by applying appropriate scientific concepts.	Project failed to demonstrate an understanding of course content.	Did not submit
To demonstrate scientific inquiry	Project supported scientific inquiry by demonstrating in-depth connections and by gathering, organizing, analyzing, and evaluate relevant information of all interactions for this unit.	Project supported scientific inquiry by demonstrating in-depth connections and by gathering, organizing, analyzing, and evaluate relevant information for at least 80% of the connections for this unit.	Project sought to demonstrate scientific inquiry by partially addressing important connections between spheres and interactions	Project did not demonstrate use of scientific inquiry.	
To integrate and organize content	Incorporated all of the required elements, as well as a clearly articulated connections and interactions in an organized sequence that demonstrates the goals of the project.	Incorporated all of the required elements, as well as a clearly articulated connections and interactions in an organized sequence that demonstrated the goals of the project. Some elements lacked depth and/or clarity.	Incorporated most but not all of the required elements, or lacked an organized sequence that demonstrated the goals of the project.	Did not incorporate the required elements.	Did not submit
To use resources	Critically analyzed all	Incorporated personal ideas,	Drew upon some course-	Did not use resources	Did not submit

(essays, books, videos, websites, etc.)	resources. Incorporated personal ideas, course based materials, and additional resources. Cited all resources.	course based materials, and additional resources. Cited all resources.	related resources. Did not use resources effectively in the project. Cited some resources.	effectively in the project. Did not cite resources.	

Table 2-6. Essential Features of Classroom Inquiry and Their Variations

Essential Feature	Variations			
1. Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies question provided by teacher, materials, or other source	Learner engages in question provided by teacher, materials, or other source
2. Learner gives priority to **evidence** in responding to questions	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyze	Learner given data and told how to analyze
3. Learner formulate **explanations** from evidence	Learner formulates explanation after summarizing evidence	Learner guided in process of formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence and how to use evidence to formulate explanation
4. Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	
5. Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided broad guidelines to use sharpen communication	Learner given steps and procedures for communication
More ——— **Amount of Learner Self-Direction** ——— **Less**				
Less ——— **Amount of Direction from Teacher or Material** ——— **More**				

Table 2-7. Common Components Shared by Instructional Models

- Phase 1: Students engage with a scientific question, event, or phenomenon. This connects with what they already know, creates dissonance with their own ideas, and/or motivates them to learn more.
- Phase 2: Students explore ideas though hands-on experiences, formulate and test hypotheses, solve problems, and create explanations for what they observe.
- Phase 3: Students analyze and interpret data, synthesize their ideas, build models, and clarify concepts and explanations with teachers and other sources of scientific knowledge.
- Phase 4: Students extend their new understanding and abilities and apply what they have learned to new situations.
- Phase 5: Students, with their teachers, review and assess what they have learned and how they have learned it.

XII. Evaluation of the Lesson

How will you judge whether or not the lesson was successful? (This should relate back to the objectives.)

Overall, the lesson will be judged whether it is successful based on the assessment of the students on their performance on activities, projects, short answers, and their level of participation in the discussion. Carefully worded guiding questions in both the assignments and discussion will aid in this assessment. If 80% of the actively participating students in the course have performed at a level of 70% or higher on all

graded assignments, then I would consider this lesson successful. I exclude students who have vanished from the course prior to this unit so as not to skew this determination of success.

Knowledge Level: To be able to recognize and define terms related to Earth's Climate System.	Students will demonstrate their understanding during the discussion and the quiz by answering the "Knowledge Level" questions and prompts correctly.
Knowledge Level: To acquire knowledge of science of the Earth's Climate System and its effects on human activities;	Students will demonstrate their understanding during the discussion and the quiz by answering the "Knowledge Level" questions and prompts correctly.
Comprehension Level: To be able to explain the scientific interactions between some of the climate drivers and feedbacks;	Students will demonstrate this by effectively communicating the effects of the drivers and feedbacks on the polar regions in the discussion.
Analysis Level: To be able to evaluate scientific information in the mass media related to Earth's climate system;	Students will demonstrate their understanding by answering the Article short answer questions correctly.
Evaluation Level: Upon completion of their study of Earth's Climate systems, to be able to create a concept map to evaluate their understanding of the interactions between the earth systems and the climate.	Students will demonstrate their understanding of this unit of study by analyzing the connections between the climate and the Earth's systems and presenting it in a project.

XIII. Cite References

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XIV. Conclusion

What are your final thoughts about the project? What potential challenges will you face in teaching these lessons? How well will this unit fit into what you currently teach (or anticipate teaching in the future)?

In the past, this unit of my course has been rather weak and lacking current research and basis. I look forward to incorporating the new activities and discussions into my course in future terms. This unit will fit very well into the current course and curriculum as it is a topic I have taught in the past, but not to this level of quality. I believe the potential issues will be to not overwhelm the students with the amount of material and challenging activities. It may need to be spread across more than a week to get the material digested and understood by the students. I will be flexible and adjust, if necessary, based on the student's responses to questions in the group discussion.