**Oakland Schools Science Scope**

**High School Earth System Science**

**Unit 1 – The Big Ideas of**

**Earth System Science**

**High School**

**Unit 1 — Earth System Science**

**The Big Ideas of Earth System Science**

**About Our Scope Unit/Lesson Template**

This template is designed to serve several teaching and learning principles considered as staples of state of the art science instruction. Here are the key principles in summary:

* It’s critical to **elicit prior knowledge** as a unit or lesson begins.
* **Key questions** should drive student explorations and investigations.
* **Activity Before Concept** – Student inquiry-based explorations which give personal experience with phenomena and ideas should precede a presentation of science ideas.
* **Evidence is the heart of the scientific enterprise.** Students generate evidence and analyze patterns in data that help to construct scientific explanations around key questions.
* **Concept Before Vocabulary** – Attaching science vocabulary to concepts developed by student investigations yields more success than beginning a unit or lesson with a list of science vocabulary.
* **Talk, argument** **and writing** are central to scientific practice and are among the most important activities that develop understanding.
* **Application** of the ideas provides review, extends understanding, and reveals relevance of important ideas.
* **Assessment** of knowledge, skill and reasoning should involve students throughout the learning process and be well aligned to the main objectives and activities of the unit.

The Scope Science template is designed to put these principles into practice through the design of the ***SCOPE LEARNING CYCLE FOR SCIENCE***. Each unit has at least one cycle. The components are listed below:

|  |  |
| --- | --- |
| The Key Question for the Unit | Each unit has one, open ended Focus Question that relates to all the content and skills of the unit. The Key Question is presented at the opening of the unit and revisited at the unit’s conclusion. |
| Engage and Elicit | Each unit begins with an activity designed to elicit and reveal student understanding and skill prior to instruction. Teachers are to probe students for detailed and specific information while maintaining a non-evaluative stance. They also can record and manage student understanding which may change as instruction proceeds.  |
| Explore  | A sequence of activities provides opportunities to explore phenomena and relationships related to the Key Question of the unit. Students will develop their ideas about the topic of the unit and the Key Question as they proceed through the Explore stage of the learning cycle.Each of the activities may have its own Key Question or central task that will be more focused than the unit question. The heart of these activities will be scientific investigations of various sorts. The results, data and patterns will be the topic of classroom discourse and/or student writing. A key goal of the teacher is to reference the Key Question of the unit, the Explore and Elicit of the students and to build a consensus especially on the results of the investigations. |
| Explain | Each unit has at least one activity in the Explain portion of the unit when students reconcile ideas with the consensus ideas of science. Teachers ensure that students have had ample opportunity to fully express their ideas and then to make sure accurate and comprehensible representations of the scientific explanations are presented. A teacher lecture, reading of science text or video would be appropriate ways to convey the consensus ideas of science. Relevant vocabulary, formal definitions and explanations are provided. It’s critical that the activity and supporting assessments develop a consensus around the Key Questions and concepts central to the unit. |
| Elaborate  | Each unit cycle has at least one activity or project where students discover the power of scientific ideas. Knowledge and skill in science are put to use in a variety of types of applications. They can be used to understand other scientific concepts or in societal applications of technology, engineering or problem solving. Some units may have a modest Elaboration stage where students explore the application of ideas by studying a research project over the course of a day or two. Other units may have more robust projects that take a few weeks. |
| Evaluation | While assessment of student learning occurs throughout the unit as formative assessment, each unit will have a summative assessment. Summative assessments are posted in a separate document. |

**High School**

**Earth System Science**

**Unit 1 – The Big Ideas of Earth System Science**

**Contents**

**Unit Introduction** **4**

**Learning Objectives** **4**

**Key Question** **4**

**Engage and Elicit**

Activity 1: The GLOBE Earth System Poster **5**

**Explore**

Activity 2: Video: Why Earth Science **7**

Activity 3: Mapping Tools for Earth Systems Science **9**

Activity 4: The Scale of Deep Time **12**

Activity 5: Using an Earth Systems Science Perspective **14**

Activity 6: How Permanent is Permafrost? **16**

**Explain**

Activity 7: Summarizing the Nature of Earth Systems Science **18**

**Unit 1 -The Big Ideas of Earth System Science**

**Unit Introduction**

This unit sets the stage for a full-year high school course on Earth Systems Science. It introduces some of the major conceptual themes of Earth Systems Science, while developing an awareness of the special relevance of Earth Systems Science in today’s world. The unit focuses on how science is conducted in the earth sciences through professional fields.

*On the Common Core State Standards for English Language Arts and Literacy in Science*

All science teachers will find the Common Core State Standards of ELA a tremendous asset for reaching learning objectives in science education. Reading, writing, argumentation and discourse are central proficiencies necessary for success in science. All teachers should become fluent with the document and will likely find it validating.

[**http://www.corestandards.org/assets/CCSSI\_ELA%20Standards.pdf**](http://www.corestandards.org/assets/CCSSI_ELA%20Standards.pdf)

These standards are best reached with science instruction that connects content to real-world problems and experiments, complimented with scientific writing, challenging questions, processes for classroom discussion, and debate and use of scientific text.

It is recommended that teachers require students to use an interactive science notebook to support learning in this unit. Here are some features and policies to consider:

* Use a bound notebook – cut and paste some other materials into it.
* The right facing page is for teacher content, the left is for student reflection.
* Leave four pages for a table of contents.
* Leave the notebooks in the room.

**Learning Objectives**

Students will:

1. Begin to understand the distinction between direct and indirect measures as it pertains to research in Earth Systems Science.
2. Begin to understand the use of scientific models and spatial data in the professional fields of Earth Systems Science.
3. Use the Earth Systems Science concept to understand natural features and phenomena as well as interactions between humans and the earth systems.
4. In a simple example, trace the movement and transformation of matter and energy through the four key earth systems (geosphere, hydrosphere, atmosphere and biosphere).
5. Recognize that the plate tectonic theory is the central organizing theory for the field of geology.

**Key Question: How do scientists research questions about earth and space science using direct and indirect measures and scientific models?**

**Engage and Elicit**

**Activity 1 – The GLOBE Earth System Poster Learning Activities 1 - 5**

**Purpose**

To elicit student understanding of earth systems concepts from a global perspective. Also, to establish norms of collaboration that are not only central to science but necessary for this class.

**Activity Description**

In small collaborative groups, students analyze sets of global maps that show color contoured datasets (temperature, precipitation, insolation, biological, cloud fraction, aerosol). The activity is very well scripted and organized. Students conduct the first five general activities, the first Assessment Activity, and a short research paper on one of the six datasets using the content in the appendix. This is a product of The GLOBE Project, which hosts online all the required maps and activity guides.

A simpler version of this activity is written into the 7th grade OS Scope unit called “The Hydrosphere and Global Change.” Returning to the activities with extensions we describe here will build more solid comprehension of important earth systems concepts.

**Focus Question**

What modern tools and approaches are used in the earth system sciences?

**Duration**

Two class periods

**Materials**

* 2007 Earth as a System Learning Activities Guide and the 36 global maps, printed two per sheet (color, laminated, cut into individual maps):

<http://www.globe.gov/teaching-and-learning/materials/earth-system-science-posters>

 Atlas URL:

<http://oaklandk12.rubiconatlas.org/links/Science7/Unit%204/Earth_System_Poster_07_Activities.pdf>

**Teacher Preparation**

1. Download, print and read the activity guide for teacher use. It is common for teachers and students to misunderstand what aerosols are in the atmosphere. Page 22 in the Activity Guide is an “Aerosol Information Page” and well worth reading.
2. Download and color print the 36 maps that are part of this activity. One set allows for teams of 4 in a class of 24. With larger classes a second set of images will be necessary to keep groups from being too large. This will mean that two groups will be analyzing some parameters.
3. Make a teacher note card with leading questions for whole group discussion.
4. Create the requirements of a short research paper on one of the six datasets, using the content in the Appendix and Internet resources.
5. Print the two pages in the Appendix that describe the satellites used to gather the data use to make the global maps.

**Classroom Procedure**

1. Use the instructions in the GLOBE Activity Guide to set up the task for student. Use the first five activities from the guide as a first stage in the activity.
2. The activity will elicit student thinking and skill. Teachers should catalog observations to help guide discussion and decisions in future activities.
3. As soon as the activity commences, emphasize good habits for collaborative inquiry (supportive listening, sharing of talk-space, respectful disagreement, arguments centered on evidence). Since this course will depend a great deal on student collaboration, both small and whole group discussion, it may be fruitful to create a class concept map that describes norms of interactions that support scientific research.
4. Use the teacher note card with leading questions for whole-group discussion. Be sure to probe for ideas about energy transformation (changing) and transference (moving).
5. During group presentations, display maps from the website onto the class screen with a projector. This allows all students to see the details while they are being presented.
6. During group presentations, other students will want to make connections to their map. Allow a couple of these comments, but keep them limited so each team can have the floor with ample time.
7. During the whole group discussion, the teacher can emphasize these ideas:
	* Four spheres of the Earth System Science paradigm
	* Where the data comes from, and the role of “indirect measures” and “proxies” since satellites measure incoming radiation and light, yet also allow interpretations on the six variables.
8. In the follow section of the guide called “Assessments,” use the first activity to emphasize the nature of spatial data. Explain how images are made up of pixels. By transferring the pixels to simple line graphs, students will develop an understanding that many images in earth science are actually datasets (spatial data).
9. Introduce the use of an interactive science notebook that will be used throughout the course. Prompt a writing assignment that asks students to describe how one of the six datasets was gathered. The content in the Appendix will get them started, but more specific information may be found online. Students could be required to answer these questions:
	* How was the data gathered? How does the satellite work (in general)?
	* What type of orbit does the satellite use?
	* When was it launched? Is it still in use?
	* How has this been useful in the study of Earth Systems Science?

**Explore**

**Activity 2 – VIDEO: “Why Earth Science?”**

**Purpose**

To reveal the nature and purpose of inquiry in the earth sciences, as well as the current societal relevance of the field.

**Activity Description**

This is a focused discussion around a short video called *Why Earth Science?* Students are divided into small discussion groups before the video is shown. Each group has a specific assignment to address during the video that they will discuss afterwards. Another product from the same group (American Geoscience Institute - AGI) is the video segments on the *Nine Big Ideas in Earth Science*. The videos move fast and mention some of the big ideas of earth science in passing. Some to note and emphasize are these:

* Earth sciences include a number of distinct scientific fields: geology, meteorology, climatology and even astronomy.
* Earth Systems Science focuses on the interactions between the four major earth systems (geosphere, hydrosphere, atmosphere and biosphere).
* Earth Systems Science focuses on the dynamics of “systems,” which include concepts like the carbon cycle (matter) or how heat (energy) moves between the atmosphere and oceans.
* Many questions are addressed by the use of “indirect measures” which are “proxy measurements,” (e.g., satellites, seismic waves, magnetism, gravity). For example, a buried rock type or structure may be identified by measuring changes in gravity because higher density rock causes an increase in the force of gravity. This technique is indirect because we aren’t observing the rock itself. Gravity serves as a “proxy” for a rock contact.
* The earth sciences help humans as we tackle many critical challenges of our time (e.g., acquiring sustainable energy sources and other necessary natural resources, sustaining water resources, responding to climate change, responding to the risks of natural hazards, sustaining soils, dealing with pollution and protecting the environment).
* There are many diverse careers in the earth sciences. These ideas should be pointed out and emphasized throughout the course.

**Focus Question**

Why is earth science important?

**Duration**

One class period

**Materials**

* The Video *Why Earth Science?*

<http://216.11.99.113/VBP/Oakland%20Schools/Why%20Earth%20Science.wmv>

* A global plate tectonic map that can be shown on a screen.

<http://vulcan.wr.usgs.gov/Glossary/PlateTectonics/Maps/map_plate_tectonics_world.html>

**Teacher Preparation**

1. Preview the video. There are places where major concepts are depicted by the animation. It will be helpful to pause and rerun some of these sections so students don’t miss the concepts.
2. Prepare the assignments for each group on small strips of paper.
3. Create question cards for groups of three or four students. It’s fine if two or three groups have the same assignment. Here are questions to print on the cards:
	* What events in earth history are portrayed in the video? (For example, the break up of Pangaea, the ice ages, the great floods from melting glacial lakes.)
	* What kinds of models and tools do earth scientists use?
	* Near the end, the video says that earth systems surround us and include us. Discuss some examples of this.
	* What is it like to work as an earth scientist?

**Classroom Procedure**

1. Form student groups and distribute cards with the questions.
2. Discuss what you observed in small groups and prepare to share with a larger group.
3. Show the video (it is less than seven minutes long).
4. Prompt small-group and whole-group discussion.
5. Be sure some key points are discussed:
	* The earth sciences are an historical science concerned with reconstructing the past. Also, modern-day processes are studied to understand earth history.
	* Earth scientists use a great deal of indirect measurement and models to study earth systems.
	* Technology is widely applied to the earth sciences.
	* There are many types of professional roles in the geosciences: resource geologists (oil, gas, and strategic minerals), hydrologists (concerned with water resources), climatologists, and academic researchers for universities or government agencies (USGS, NOAA, NASA).
	* Life science and biological evolution is a key part of Earth System Science.
	* Earth System Science is important because it addresses questions related to food supply, water sustainability, air quality, and sources of natural resources and energy. For all of our lives we can safely predict that every week, some American media outlet will be reporting on climate change, the global water crisis, the need for strategic minerals, energy system, soil sustainability and ecosystem sustainability.
6. To summarize, emphasize the plate tectonic theory. While this will be investigated in depth later in the course, it should be understood that in the science of geology, all we observe can be related to a plate tectonic context.

**Explore**

**Activity 3 – Mapping Tools for Earth Systems Science**

**Purpose**

To understand how to interpret spatial data and that maps can be regarded as scientific models.

**Activity Description**

Spatial data plays an important and central role in the earth and space sciences. Students should be proficient in reading and interpreting spatial data presented in a variety of forms (i.e., contours, pixels, profiled in two dimensions). This lesson begins to build familiarity with spatial data by using physical models, line graphs and software. While elevation data will be the subject of this lesson, students should understand that the same representations can be used for many types of spatial data. Over the course of the lesson students work at three stations:

* Station 1: Mapping Potato Island
* Station 2: Exploring Seafloor Topography using GeoMapApps
* Station 3: Remote Sensing: Using Radar to Look Through

**Duration**

Four class periods

**Materials**

* Station 1: Mapping Potato Island
	+ Step-by-step instructions: <http://www.windows2universe.org/teacher_resources/teach_taterland.htm>
	+ Atlas URL: (includes slight modifications)
	+ Materials for Station 1: (make eight sets from Windows2Universe)
		- One long potato for each set, split lengthwise
		- One clear plastic deli tub for each student
		- Lid of a clear plastic container larger than deli tub
		- An extra lid or transparency with a grid (find in link above)
		- Dry erase marker for each student
		- Ruler (cm) for each student
		- Kitchen knife
		- Sharpie marker
		- Blue water (add a little blue food coloring)
* Station 2: Exploring Seafloor Topography using GeoMapApps
	+ Step-by-step instructions: <http://serc.carleton.edu/eet/seafloor/index.html>
	+ GeoMapApps Software (free, a light Java software that draws in online data): <http://www.geomapapp.org/>
	+ Gridded paper, rulers, colored pencils
* Station 3: Remote Sensing: Using Radar to Look Through Ice
	+ Step by step instructions from Lamont-Doherty Earth Observatory: <http://www.ldeo.columbia.edu/edu/polareducation/Activities/Remote%20Sensing%20Radar/Seeing%20Through%20the%20ice102511_sm2.pdf>

Atlas URL:

* + Higher quality graph of Oxygen isotopes over time graph

Atlas URL:

* + Free, online customizable graph paper

<http://incompetech.com/graphpaper/>

* Printed instructions for students and create graph paper if necessary
* Exploring Earth Chapter on Earth’s Topography

<http://www.classzone.com/books/earth_science/terc/content/investigations/es0307/es0307page01.cfm>

* Optional: Small (2 feet x 4 feet) white boards for small groups to depict representations for whole group discussions. These are best gathered at Lowes or Home Depot. They sell 4’ x 8’ sheets for bathroom walls and can cut them into the smaller sizes. These are a great asset that can be used throughout the year for informal small group presentations.

**Teacher Preparation**

1. Station 1:
	* The instructions above describe how to set up the model and run the activity. Prepare to debrief in a way that helps students recognize the three types of models being used (i.e., a physical model, a contoured data model, and a pixelated data model which in computers is called a DEM or Digital Elevation Model).
	* Gather all materials.
2. Station 2:
	* Install GeoMapApps on the computers students will be using.
	* Practice the activity to become familiar with GeoMapApps and the instructions. The step-by-step instructions are excellent, as is the activity, but it will require about an hour of preparation time to practice.
	* Gather materials.
	* Print the instructions into durable packets, one per computer station.
3. Station 3:
	* Print and review the activity. It includes a graph of oxygen isotopes over time that is important but too low in quality. Print the higher quality image as well.
	* Notice that a number of important scientific practices are related in this task: use of proxy measures, modeling, spatial data presented in different multiple representations (map view and x-y graphs).
	* Create an excel file of the grid on page 7. A student could do this as an extra homework task.

**Classroom Procedure**

1. Divide the class into two groups. One group will start at Station 1, the others at Station 2. After one class period they will switch. On the third day, the whole class will do the activity of Station 3. On the fourth day a whole class discussion will occur in order to emphasize the key points of gathering and representing data in Earth Systems Science.
2. Provide a general overview of the activities and orient the students to the materials/GeoMapApps.
3. The product for both stations will require students to complete as homework.
4. One the second day, have the students switch stations.
5. On the third day provide the resources for Station 3 on using RADAR data to map polar ice thickness. Follow these procedures to orient them to the task.
	1. Have them analyze the two maps (Greenland and Antarctica).
	2. Ask them to compare the two ways that scale is represented (use of a line scale and use of Texas for reference). Have them read the first three paragraphs.
	3. Before they proceed through the “So how old is the ice?” paragraph provide the higher quality graph of the famous Oxygen isotope graph. Lead them through the graph so they understand that the upper horizontal axis is the scale of Oxygen isotopes which was measured in a laboratory. Point out that it serves as a proxy for past temperatures (paleo-temperatures) which is depicted on the lower horizontal axis. Geologic time will be studied in a subsequent activity and isotopes will be studied in a later unit.
	4. Have student continue reading through the sections and complete the task as described. Have students create a color contour scale. Challenge them to determine the color ranges that best represents the data. Engage the class in a discussion and voting process to determine the best solution.
	5. A worthwhile extension would be to rewrite the data points on graph paper and draw a contour map.
6. To prepare for the whole group discussion, distribute the white boards to several small groups and give them all a specific questions to present and answer. They should write the question, then makes sketches, graphs and words to depict their best answers. Topics could include these:
	1. What kinds of data did we map in these activities? What other types of earth science data can you imagine mapping? (potato shape, ocean floor depths, land elevation below ice).
	2. In these activities, how did we study variations over space? What other variables can you imagine earth scientists mapping in order to study variations over space? (Elevation and depth vary over space.)
	3. How have we used modeling to as a way of investigating earth science topics? (Potato represents landforms; all maps are models of whatever they depict).
	4. Why is it necessary to use a proxy to study important questions in earth science? (we can’t measure everything directly, such as paleo-temperature, ocean depth and elevation of land buried by ice).
	5. When is it useful to gridded data, countered data and profile (x-y) data when representing spatial data?? (gridded data is easy for computers to analyze, also it usually shows actual measurements, countered data is easy for the eye to interpret, extremes (max or min), trends (slopes, cliffs) and shapes (ridges, troughs, saddles).
7. During a whole group discussion ask each group to present their topic to the others. These should be short but substantive. Others should respond with comments, reflections and questions. Try to foster a classroom climate of deliberation and interaction between students.
8. Close the activity using the 12 slides from the Exploring Earth website to round out the coverage on contour maps.

**Explore**

**Activity 4 – The Scale of Deep Time**

**Purpose**

To comprehend the scale and major divisions of earth history.

**Activity Description**

Student teams use outdoor space or a school hallway to create a simple scale model of geologic time. The activity closes with the video: *Big Idea #2: The Earth is 4.6 Billion Years Old*.

**Duration**

Two class periods

**Materials**

* Short video from Earth-Time project (only Chapter 1)

 <http://www.earth-time.org/movs.html>

* Short video from ES Literacy Principles (*Big Idea #2: The Earth is 4.6 Billion Years Old*)

[http://216.11.99.113:80/VBP/Oakland Schools/Big Idea 2 Earth is 4.6 Billion Years Old.wmv](http://216.11.99.113:80/VBP/Oakland%20Schools/Big%20Idea%202%20Earth%20is%204.6%20Billion%20Years%20Old.wmv)

* Toilet Roll Method:
	+ Activity Guide for the Toilet Paper Timeline:

<http://www.worsleyschool.net/science/files/toiletpaper/history.html>

Atlas URL:

* + Rolls of toilet paper, markers
* Football field method (and other scales) from Dr. S. Lewis, Carroll College:
	+ Conversion table for geologic time:

Geology: <http://www.actionbioscience.org/education/figures/lewis-table-1.xls>

Life History: <http://www.actionbioscience.org/education/figures/lewis-table-2.xls>

Atlas URL:

* Geologic Time Scale

<http://geology.com/time.htm>

**Teacher Preparation**

1. Gather and print materials.
2. Preview videos to determine good stopping points.
3. Determine the best space to create the timeline. It is preferable to use a very large space so you may want to have students do this work outdoors.

**Classroom Procedure**

1. Open the activity by showing the short video on the Earth-Time Project website. During the video, have students look for three categories of events: geological, climatic and paleontological. Briefly discuss these categories after the video.
2. Provide students with the instructions on the Activity Guide for the Toilet Paper Timeline.
3. Organize students into groups and have them create the geologic timescale. Label major geologic, climatic and paleontological earth events.
4. After the activity, discuss student impressions and summarize some of the major events in earth history.
5. Provide students with a geologic timeline that that they can refer to throughout the course. Students should label their timeline with a few major events.
6. Close with the video from the Earth Science Literacy Project, *Big Idea #2: The Earth is 4.6 Billion Years Old*.
7. Have students record impressions about Deep Time in their interactive science notebooks.

**Explore**

**Activity 5 – Using an Earth Systems Science Perspective**



**Purpose**

To understand Earth Systems Science more specifically as it relates to currently relevant issues.

**Activity Description**

Students use an Earth System Science analysis process to identify the spheres influencing elements of specific issues. Afterward they form teams to make posters diagramming the issue in a scientific poster session.

**Focus Question**

How is an Earth Systems Science perspective used to understand natural phenomena or current issues?

**Duration**

Four class periods

**Materials**

* *Big Idea 3: Earth Systems Interact*

[http://216.11.99.113:80/vbp/Oakland Schools/Big Idea 3 Earth Systems Interact.wmv](http://216.11.99.113:80/vbp/Oakland%20Schools/Big%20Idea%203%20Earth%20Systems%20Interact.wmv)

* Big Idea 4: Earth Continually Changes

[http://216.11.99.113:80/vbp/Oakland Schools/Big Idea 4 Earth Continually Changes.wmv](http://216.11.99.113:80/vbp/Oakland%20Schools/Big%20Idea%204%20Earth%20Continually%20Changes.wmv)

* Documents: What is Earth Science? / Earth’s Spheres / Basic ESS analysis

<http://esseacourses.strategies.org/whatisESSPBL.html>

<http://esseacourses.strategies.org/earthspheres.html>

<http://esseacourses.strategies.org/basicESSanalysisYF.html>

Atlas URL (all above in one MSWord doc):

* Source of content (e.g. Science Daily News:

<http://www.sciencedaily.com/>):

* Poster board and related materials

**Teacher Preparation**

1. Preview videos to locate interesting stopping points.
2. Become familiar with the analysis process described by the documents. It is **not** recommended that teachers distribute what is called the “typical student response” because it is quite advanced and reflects a long-term research project.
3. Determine the topics and articles that students will analyze. Gather and print articles, or determine a way to transmit resources to students electronically.

**Classroom Procedure**

1. Begin the activity by showing the video *Big Idea #3: Earth Systems Interact* and *Big Idea #4: Earth Continually Changes.*
2. Allow students to select a current issue and print out 1-2 page articles to analyze. Teachers can suggest some, or have a set of ready-to-use articles in place. Here are some ideas:
* Coral bleaching
* Polar science: permafrost, habitat loss, change of ice pack
* Climate change: agriculture, effects of sea level change, ocean temperatures or acidification, biome changes, seasonal changes in biology
* Deforestation
* Carp in Great Lakes
* Soil sustainability
* Ground water sustainability
* Mining
* Hydraulic fracturing for natural gas (a.k.a., fracking)
* Ocean fisheries
* Ocean floor methyl hydrates in warming oceans
1. Here are some reliable sources of articles:
* Science Daily News (<http://www.sciencedaily.com>)
* Earth Exploration Toolbook (go into chapters, then to case studies): (<http://serc.carleton.edu/eet/>)
1. Have students read over “What is Earth Systems Science?” from (<http://esseacourses.strategies.org/whatisESSPBL.html>) and the link to “Earth’s Spheres: (<http://esseacourses.strategies.org/earthspheres.html>). (Note: these documents are united and available in Atlas.)
2. Follow the links at the bottom of the page.
3. Basic ESS Analysis: <http://esseacourses.strategies.org/basicESSanalysisYF.html>
4. Ask students to conduct such an analysis on the issue they choose.
5. Form groups of three students, and have them share with one another with the purpose of choosing one topic from which to make a poster that diagrams the issue.
6. Provide students with the time and materials to produce the posters. Then hold a gallery walk or science conference style poster session where the posters are presented to one another during a class period.
7. Select two or three of the posters for a whole-group presentation.

**Explore**

**Activity 6 – How Permanent is Permafrost?**

**Purpose**

To put the Earth System Science perspective to use through an analysis of a real world issue, and to develop skill with spatial and numeric data analysis.

**Activity Description**

This is what is called a chapter from the online resource “Earth Exploration Toolbook.” This activity is described on the Earth Exploration Toolbook:

Students will utilize Google Earth and team up with fictional students in Chersky, Russia, a small town in Siberia, to investigate possible causes of thawing permafrost in Siberia and other Arctic regions. You will first explore the nature of permafrost: what it is, where it is found, why it is important, and what the effects of thawing permafrost mean both locally and globally. Next, you will use Microsoft Excel to explore soil temperature data from permafrost boreholes (holes drilled into the ground) and surface air temperature datasets from in and around the Chersky region for a 50-year time span. By graphing and analyzing the borehole soil temperature data, and comparing it to surface air temperature trends, you can explore possible relationships between temperature changes below and above Earth's surface.

**Focus Question**

What types of science processes are used in Earth Systems Science research?

**Duration**

Four class periods

**Materials**

* Web browser
* Google Earth (free downloadable software)
* Instructions and Case Study from the “How Permanent is Permafrost?” chapter:

<http://serc.carleton.edu/eet/permafrost/index.html>

**Teacher Preparation**

1. An important component of preparation is to determine if the class will have enough computer access to complete the activity. If a computer lab or cluster of eight or so computers is available for four or five days, the class can proceed in small groups. If the class does not have that number of computers, a teacher can lead the class through the process with a single, Internet-connected station and a projector.
2. Go to the Earth Exploration Toolbook and find the “How Permanent is Permafrost?” chapter. One way is to click on “Chapters in the EET” and use the search or sorting functions. Or, more directly: <http://serc.carleton.edu/eet/permafrost/index.html>.
3. Print out and copy the Case Study for students to learn the background.
4. Determine to what degree you will involve students in the handling of data. These projects are designed to develop skills for teachers and student in accessing real world data from the Internet. However, if time or tolerance are limited, you can use the provided process data in Excel format to spare the processing tasks.
5. With a clear sense of how much of the data handling tasks are to be included, show or hide the details in the Step by Step instructions.
6. Print out and copy a limited set of Step by Step instructions. These are lengthy so just print one copy per computer station, staple into a folder, and keep for in-class use only.
7. Students will need a file-saving strategy for images and graphs that are created during the activity. This could be a flash drive, or district network drive.

**Classroom Procedure**

1. Assign the Case Study to be read. The Teacher Notes section has links to other sources on the topic of permafrost. Look through those and determine if there is other background content that you will share with students.
2. Follow the Step by Step analysis provided at the Earth Exploration Toolbook.
3. Prompt students to save images for a written analysis they will provide.
4. As students finish their analysis, have them write up a report with a section that addresses the scientific processes involved in Earth System Science.
5. During a whole class discussion, prompt a question on how the Earth System Science perspective can be used to better understand this issue. Review the Key Question for this unit and all the learning objectives.

**Explain**

**Activity 7 – Summarizing the Nature of Earth System Science**

**Purpose**

To help students solidly internalize the key principles of Earth System Science.

**Activity Description**

Start the activity by show the video *Why Earth Science?* again. Then students participate in a conversation line. To do so, the class stands up and is divided in two lines that face one another. Each student has a talking partner with whom they talk through a concept for 60 seconds. The partner listens. The pairs of students take turns talking, and then shift to a new partner (someone at the end of one of the lines needs to step down and over so that everyone has a partner). With new partners, students repeat the process. They shift again, and repeat the process a third time. The strength of the activity is not so much that students hear three responses to the teacher prompt, but that they have to speak through it three times. The teacher then follows up with a question about how the student statement changed over the three efforts. It’s usually revealing to the teacher and the student.

After the conversation line, the teacher provides a lecture on the importance of the earth sciences using concepts from the Material list below. Students complete the unit by creating a concept map about Earth Systems Science.

**Focus Question**

Explain a real world issue using what you understand about Earth System Science.

**Duration**

One class period

**Materials**

* “Seven Critical Needs”from AGI’s Transition document

<http://www.agiweb.org/gap/transition/geotrans08.pdf>

* “Careers in the Geosciences” brochure

<http://www.agiweb.org/workforce/brochure.html>

* The Video *Why Earth Science?*

<http://216.11.99.113/VBP/Oakland%20Schools/Why%20Earth%20Science.wmv>

**Teacher Preparation**

1. The teacher needs to consider how the classroom space will be used for the conversation line.
2. The teacher needs to be clear on the question, and what he/she hopes it will elicit.
3. Review the “Seven Critical Needs” described by the AGI Transition Document. Decide on some images or major points to share with students at this time. Many of these issues connect with the content of the course.

**Classroom Procedure**

1. Ask exactly half the students to stand up and form a line in the classroom, which may be a snaking line if you’re limited on space.
2. Ask the other half of the class to stand up and face a partner who is in the line.
3. Explain the rules:
	* Each student has to speak for the FULL 60 seconds.
	* The listener must NOT speak.
	* After the first speaker finishes, the teacher will prompt the partner to take his/her turn.
	* After the shift, the speaker must respond again to the question.
4. Prompt with the activity’s focus question: ***Explain a real world issue using what you understand about Earth System Science.***
5. The teacher should walk slowly near the students and listen to their perspectives. When students are seated afterward, the teacher can use insights gained from what was heard. Listen for well-explained concepts that match the unit objectives. Listen for misunderstandings. Listen for interesting perspectives. Make notes on good questions for the whole group discussion.
6. When you begin the whole-group discussion, start with the question: ***How did your explanations change from your first effort to your third?***
7. Since this is the “Explain” part of the learning cycle, the teacher should present a summary of the main ideas about Earth Systems Science. The AGI Transition document contains content that will emphasize the critical nature of this area of science. The “Careers in Geosciences” brochure will also offer important content. The unit’s key questions should be addressed.
8. Again, the nature of the earth sciences should be pointed out:
	* Earth sciences include a number of distinct scientific fields: geology, meteorology, climatology and event astronomy.
	* Earth Systems Science focuses on the interactions between the four major earth systems (geosphere, hydrosphere, atmosphere and biosphere).
	* Earth Systems Science focuses on the dynamics of “systems,” which include concepts like the carbon cycle (matter) or how heat (energy) moves between the atmosphere and oceans.
	* Many questions are addressed by the use of “indirect measures” and “proxy measures,” (e.g., satellites, seismic waves, magnetism, gravity). For example, a buried rock type or structure may be identified by measuring changes in gravity since higher density rock causes an increase in the force of gravity. This technique is indirect because we aren’t observing the rocks itself. Gravity serves as a “proxy” for a rock contact.
	* The earth sciences help humans as we talk about many critical challenges of our time (e.g., acquiring sustainable energy sources and other necessary natural resources, sustaining water resources, responding to climate change, responding to the risks of natural hazards, sustaining soils).
	* There are many diverse careers in the earth sciences.
9. To summarize their understanding, students will create a concept map in their science notebook about Earth System Science. It will illustrate these four categories: scientific practices, careers, earth systems, and relevance to society.



**Science Scope on Atlas Rubicon Curriculum Manager:** http://oaklandk12.rubiconatlas.org/public/

**Oakland Schools:**

http://www.oakland.k12.mi.us/