IS3

Grade Five Instructional Segment 3: Interacting Earth Systems

Scientists have developed a way of thinking about the Earth as a system of systems (much like the human body is a system of systems). A system has internal components that interact with one another (like the water cycle on Earth or the nervous system in a human body), and a system also interacts with its surroundings (like when water in the water cycle causes a flood or when the nervous system causes a muscle to move). In this instructional segment students explore each of Earth's systems and how they work together to explain various phenomena. They then obtain information about the role of humans in altering natural interactions. Students finish with action plans about what they and their community can do to minimize the effects on humans and the impact of human activities on natural systems.

GRADE FIVE INSTRUCTIONAL SEGMENT 3: INTERACTING EARTH SYSTEMS

Guiding Questions

- How can we represent systems as complicated as the entire planet?
- Where does my tap water come from and where does it go?
- How much water do we need to live, to irrigate plants? How much water do we have?
- What can we do to protect Earth's resources?

Performance Expectations

Students who demonstrate understanding can do the following:

5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. [Clarification Statement: **The geosphere, hydrosphere (including ice), atmosphere, and biosphere are each a system and each system is a part of the whole Earth System (CA)**. Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system.] [*Assessment Boundary: Assessment is limited to the interactions of two systems at a time.*]

5-ESS2-2. Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. [*Assessment Boundary: Assessment is limited to oceans, lakes, rivers, glaciers, ground water, and polar ice caps, and does not include the atmosphere.*]

5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

3–5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3–5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet criteria and constraints of the problem.

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3–5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. *California clarification statements that are bolded and followed by* **CA** *were incorporated by the California Science Expert Review Panel.*		
The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:		
Highlighted Science and Engineering Practices	**Highlighted Disciplinary Core Ideas**	**Highlighted Crosscutting Concepts**
[SEP-2] Developing and Using Models [SEP-5] Using Mathematics and Computational Thinking [SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering) [SEP-8] Obtaining, Evaluating, and Communicating Information	ESS2.A: Earth Materials and Systems ESS2.C: The Roles of Water in Earth's Surface Processes ESS3.C: Human Impacts on Earth Systems	[CCC-2] Cause and Effect: Mechanism and Explanation [CCC-4] Systems and System Models [CCC-7] Stability and Change
Highlighted California Environmental Principles and Concepts: **Principle I** The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services. **Principle II** The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies. **Principle III** Natural systems proceed through cycles that humans depend upon, benefit from and can alter. **Principle IV** The exchange of matter between natural systems and human societies affects the long-term functioning of both. **Principle V** Decisions affecting resources and natural systems are based on a wide range of considerations and decision-making processes.		
CA CCSS Math Connections: 5.MD.1; 5.MD.5b; 6.RP.3; 5.NF.2; 5.G.2; MP. 2, 6		
CA CCSS for ELA/Literacy Connections: SL.5.1, 4, 5		
CA ELD Standards Connections: ELD.PI.5.1, 6		

To begin, students visit a small ecosystem in their schoolyard. Their goal is to observe and list as many objects in the ecosystem as possible. Returning to the classroom, they look at pictures of more ecosystems (ideally a wide variety of local settings they have visited) and again make lists of all the components in each ecosystem. Students then work in teams to group all these different items into four or five categories. Students will have to formulate these categories themselves based on the similarities they think are most important between groups of objects on their lists. To help students understand the process of making and assigning categories, teachers can demonstrate the process by assigning different items to categories of color (which is not a very useful organizational scheme for scientists). Groups then **communicate [SEP-8]** their rationale for selecting their categories. Professional scientists came up with the categories of Earth's four major systems: geosphere, hydrosphere, atmosphere, and biosphere (table 4.6). These spheres are no more real than the categories students created—they represent a consensus based upon evidence about how objects interact. In fact, some scientists argue that there should be a fifth sphere called the anthrosphere that highlights the importance of humanity and all its creations.

Table 4.6. Earth's Systems

EARTH'S SYSTEMS	EARTH'S MATERIALS
Geosphere	Rocks, minerals, and landforms at Earth's surface and in its interior, including soil, sediment, and molten rocks
Hydrosphere	Water, including ocean water, groundwater, glaciers and ice caps, rivers, lakes, etc.
Atmosphere	Gases surrounding the Earth (i.e., our air)
Biosphere	Living organisms, including humans

Students return to the photographs of the ecosystems and their lists, sorting the objects into the four different Earth systems. All four systems interact (exchange energy and matter) with all the other systems – they are completely interconnected, and as a result significantly influence each other. Students can try to identify some of these interactions in their ecosystem pictures. For example, a river flowing over rocks results in components of the hydrosphere causing erosion in the geosphere and helping support life in the biosphere. The water itself almost certainly comes from clouds in the atmosphere, and the cool water (along with shade from the trees of the biosphere) keeps the temperature low in the atmosphere immediately surrounding riverbanks. Table 4.7 shows a scientist's **model [SEP-2]** for different **cause and effect relationships [CCC 2]** between the different Earth systems. At grade five, students will not have background knowledge of all these interactions, but the blank table itself can prompt them to seek out these relationships. Each of the cells in the table describes one or more specific phenomena that students can investigate. Students should be able to create a **model [SEP-2]** of how one or more phenomena exemplify interactions between different Earth systems (5-ESS2-1). Several processes such as the water cycle (MS-ESS2-4) and the global carbon cycle (HS-ESS2-6) involve complicated interactions between multiple Earth systems and are the focus of middle and high school lessons, respectively. Grade five students focus on simpler interactions between two Earth systems.

Table 4.7. Examples of Interactions Between Earth Systems

	EFFECT			
CAUSE	GEOSPHERE	HYDROSPHERE	ATMOSPHERE	BIOSPHERE
GEOSPHERE	Rock cycle. Volcanoes erupt lava. Earthquakes thrust up mountains.	Topography affects where rivers go.	Volcanoes erupt gases. Mountains funnel winds and affect the movement of clouds.	Minerals in soil provide nutrients for plants.
HYDROSPHERE	Water erodes rocks.	Water cycle. Rivers flow into the ocean.	Water evaporates.	Water sustains all life.
ATMOSPHERE	Chemical weathering of rocks. Wind erodes rocks.	Winds blow clouds.	Weather and climate cycles.	Air sustains all life.
BIOSPHERE	Decomposers enrich soil.	Plant roots soak up water.	Plants give off water and gases as waste.	Food webs.

Opportunities for ELA/ELD Connections

In small groups, students choose and verbally describe and physically demonstrate the interactions between two of these four systems—geosphere, biosphere, hydrosphere, and atmosphere—using multimedia and/or visual displays. These demonstrations could include students recreating the interaction (e.g., one student is water and another student is wind) to illustrate what happens to land and ecosystems through weather and climate when two systems interact in the atmosphere.

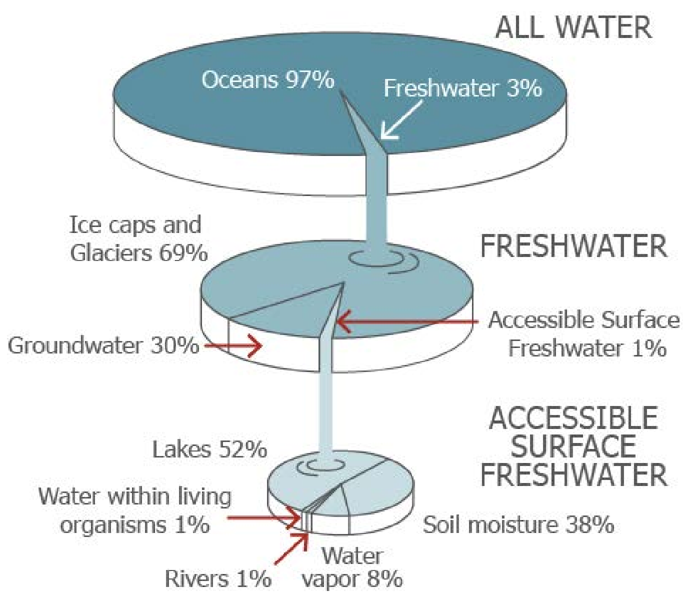
CA CCSS for ELA/Literacy Standards: SL.5.1, 4, 5

CA ELD Standards: ELD.PI.5.1, 6

One of the reasons for describing different Earth systems is to focus on their interactions and how they influence each other, especially the interactions that cross traditional disciplinary boundaries. Just as matter, like contaminants and pollution, crosses these boundaries (EP&C IV), the thinking of citizens of all ages and scientists must do so as well. Examples of contamination in the hydrosphere are tangible, as students already have mental models for how water flows and can extend those models to include interactions with other parts of the Earth system.

As part of their understanding of the hydrosphere, students must be able to describe where water is located on Earth. Students will build on this understanding in grade six when they develop a model of the water cycle (MS-ESS2-4) that describes how water moves within the hydrosphere and into other Earth systems. In addition to knowing where water is located, students should be able to use **mathematical thinking [SEP-5]** to describe the relative proportions of water found in different forms (figure 4.27). How much water is in the ocean, glaciers, rivers, underground? How much is salt water? Students describe and provide evidence that nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere (5-ESS2-2). Humans and all other life depend on this tiny fraction of Earth's water for survival (EP&C I). This relative scarcity is why drought and contamination are such important issues in California, and why human activities can have such large influences on natural cycles (EP&C III).

Figure 4.27. Distribution of Earth's Water



Ninety-seven percent of water is undrinkable (from the oceans) and only 3 percent is fresh water found in icecaps, ground, lakes, rivers and swamps. *Source*: Reiff and Law 2003
Long description of Figure 4.27.

Opportunities for Mathematics Connections

For 5-ESS2-2, students do not study percentages or ratios until grade six. Science teachers will need to provide some background math knowledge on this concept while teaching the science. Students will be able to compare fractions, however. Students could be challenged to find the state, country, or continent with the most/least amount of fresh water per person. Alternatively, students could be assigned a country or continent to investigate. Students could graph their results by liquid or ice form.

CA CCSSM: 6.RP.3, 5.NF.2, 5.G.2, MP. 2, 6

Students can **obtain information [SEP-8]** about the source of their local tap water and which human activities are the primary users of the local water sources. What measures are taken to protect these sources? A field trip to a local wastewater treatment plant or a local farm that uses dry farming techniques can help students think about problems and solutions that help us protect our resources. Student work focuses on **obtaining, evaluating, and communicating information [SEP-8]** that shows how human activities in agriculture, industry, and everyday life have major effects on the land, vegetation, streams, underground water storage levels (aquifer), and ocean (EP&C II).

This focus on water is then broadened to consider other human impacts on all Earth **systems [CCC-4]**. Group projects could investigate particular local resource issues and examine what individuals and communities are doing or could do to help protect Earth's resources and environments (5-ESS3-1). Students present their findings and solutions to each other, emphasizing specific **cause and effect [CCC-2]** relationships where a particular technology or action (EP&C V) prevents the exchange of pollutants between different parts of Earth's systems or otherwise reduces human-induced **changes [CCC-7]** to these systems.

Opportunities for Mathematics Connections

Students create a map of storm water flow on their schoolyard. Where does the water go when it leaves the schoolyard? What contaminants might it pick up and wash into the local waterways? (EP&C II). Using the area they **measure [SEP-5]** on a map of their schoolyard, students calculate the total volume of water that falls on their schoolyard or rooftop in a rainstorm. They **calculate [SEP-5]** how many 55-gallon rain barrels this water would fill up and how long this water would supply their school garden. Students then prepare a presentation to their school site council proposing the installation of a rainwater capture system on their schoolyard such as rain barrels or a cistern.

CA CCSSM: 5.MD.1; 5.MD.5b

Engineering Connection: Design a Simple Water Filtration Process

As water passes through layers of the Earth in nature, contaminants are filtered out or settle. Sometimes, however, humans pollute the water with contaminants that are not naturally filtered out (EP&Cs II, IV). To protect the environment, humans also use water filtration to clean water so that we can use it or it can be returned to the natural environment. In 2014, California's Proposition 1 allocated almost $1.5 billion to groundwater cleanup efforts and future investments are also likely. Engineers will need to develop new techniques and procedures, and existing ones need to be refined to make them more effective and cheaper (EP&C V). In this activity, students play the part of groundwater contaminant engineers and design a simple filter to clean dirty or contaminated water (see "Hands-on Activity: Water Filtration," at https://www.cde.ca.gov/ci/sc/cf/ch4.asp#link21). Students **define the problem [SEP-1]**, **gather information [SEP-8]**, **plan a solution [SEP-6]**, and design and carry out a prototype given a set of constraints or limits, such as available materials, money, and/or time. The students can then gather information, work in teams to brainstorm a number of solutions, and compare them against the criteria and constraints of the problem to see which is most likely to succeed. Students are given a sample of "dirty" water made of safe classroom materials like twigs, dirt, sand, brown liquids (tea) and are presented with the challenge of cleaning the water with available materials: cotton balls, coffee filter, etc. Students first design a working **model [SEP-2]**, build it, test it, and then compare their filtered water against a color standard. Students can refine their design by trying to keep it effective but use less material.

IS4 Grade Five Instructional Segment 4: Patterns in the Night Sky

Each night, the Sun appears to set and the stars become visible. At first glance, stars appear to be randomly strewn about the sky with some shining brighter than others. As the human eye is drawn to patterns, ancient people imagined the brightest stars marking the outlines of animals and people. Modern students can use detailed measurements of where stars are in the night sky, how bright they are, and when they become visible to discover patterns in the motion of celestial bodies. IS4 provides the data and analysis that set the stage for much more sophisticated models of planetary motion and the origin of the universe in the middle grades and high school. IS4 has three independent sections: (1) Gravitational Force; (2) Patterns of Motion; and (3) Brightness of Stars.