INTRODUCTION TO PERFORMANCE EXPECTATIONS

“The NGSS are standards or goals, that reflect what a student should know and be able to do; they do not dictate the manner or methods by which the standards are taught. . . . Curriculum and assessment must be developed in a way that builds students’ knowledge and ability toward the PEs [performance expectations]” (Next Generation Science Standards, 2013, page xiv).

This chapter shows how the NGSS Performance Expectations were bundled in the Water and Climate Module to provide a coherent set of instructional materials for teaching and learning.

This chapter also provides details about how this FOSS module fits into the matrix of the FOSS Program (page 39). Each FOSS module K–5 and middle school course 6–8 has a functional role in the FOSS conceptual frameworks that were developed based on a decade of research on science education and the influence of A Framework for K–12 Science Education (2012) and Next Generation Science Standards (NGSS, 2013).

The FOSS curriculum provides a coherent vision of science teaching and learning in the three ways described by the NRC Framework. First, FOSS is designed around learning as a developmental progression, providing experiences that allow students to continually build on their initial notions and develop more complex science and engineering knowledge. Students develop functional understanding over time by building on foundational elements (intermediate knowledge). That progression is detailed in the conceptual frameworks.

Second, FOSS limits the number of core ideas, choosing depth of knowledge over broad shallow coverage. Those core ideas are addressed at multiple grade levels in ever greater complexity. FOSS investigations at each grade level focus on elements of core ideas that are teachable and learnable at that grade level.

Third, FOSS investigations integrate engagement with scientific ideas (content) and the practices of science and engineering by providing firsthand experiences.

Teach the module with the confidence that the developers have carefully considered the latest research and have integrated into each investigation the three dimensions of the Framework and NGSS, and have designed powerful connections to the Common Core State Standards for English Language Arts.
Disciplinary Core Ideas Addressed

The Water and Climate Module connects with the NRC Framework for the grades 3–5 grade band and the NGSS performance expectations for grade 3. The module focuses on core ideas for Earth’s systems, Earth and human activity, properties of matter, and engineering design.

Earth and Space Sciences

Framework core idea ESS2: Earth’s systems—How and why is Earth constantly changing?

- **ESS2.C:** The roles of water in Earth’s surface processes
  How do the properties and movements of water shape Earth’s surface and affect its systems? [Water is found almost everywhere on Earth: as vapor; as fog or clouds in the atmosphere; as rain or snow falling from clouds; as ice, snow, and running water on land and in the ocean; and as groundwater beneath the surface. The downhill movement of water as it flows to the ocean shapes the appearance of the land. 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.]

- **ESS2.D:** Weather and climate
  What regulates weather and climate? [Weather is the minute-by-minute to day-by-day variation of the atmosphere’s condition on a local scale. Scientists record the patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. Climate describes the ranges of an area’s typical weather conditions and the extent to which those conditions vary over years to centuries.]

The following NGSS Grades 2–3 Performance Expectations for ESS2 are derived from the Framework disciplinary core ideas above.

- **3-ESS2-1:** Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. [Clarification Statement: Examples of data could include average temperature, precipitation, and wind direction.] [Assessment Boundary: Assessment of graphical displays is limited to pictographs and bar graphs. Assessment does not include climate change.]

- **3-ESS2-2:** Obtain and combine information to describe climates in different regions of the world.

- **2-ESS2-3:** Obtain information to identify where water is found on Earth and that it can be solid or liquid (extended from G2).
Framework core idea ESS3: Earth and human activity—How do Earth’s surface processes and human activities affect each other?

- **ESS3.A: Natural resources**
  
  How do humans depend on Earth’s resources? [All materials, energy, and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.]

- **ESS3.B: Natural hazards**
  
  How do natural hazards affect individuals and societies? [A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions, severe weather, floods, coastal erosion). Humans cannot eliminate natural hazards but can take steps to reduce their impacts.]

- **ESS3.C: Human impact on Earth systems**
  
  How do humans change the planet? [Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth’s resources and environments.]

The following NGSS Grade 3 Performance Expectations for ESS3 are derived from the Framework disciplinary core ideas above.

- **3-ESS3-1:** Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.  
  [Clarification Statement: Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lightning rods.]

**Physical Science**

Framework core idea PS1: Matter and its interactions—How can one explain the structure, properties, and interactions of matter?

- **PS1.A: Structures and properties of matter**
  
  How do particles combine to form the variety of matter one observes? [Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means (e.g., by weighing or by its effects on other objects). For example, a model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon; the effects of air on larger particles or objects (e.g., leaves in wind, dust suspended in air); and the appearance of visible scale water droplets in condensation, fog, and, by extension, also in clouds or the contrails of a jet.]

**NOTE**

We have included experiences that engage students with DCI ESS3.A: Natural resources, and ESS3.C: Human impact on Earth systems because they are so important to environmental literacy and should be a part of the experiences for students K–8 at every grade level. There are not specific NGSS Performance Expectations at this grade level that incorporate these DCIs.

**REFERENCES**


The following NGSS Grades 2 and 5 Performance Expectations for PS1 are derived from the Framework disciplinary core ideas above.

- **2-PS1-1**: Plan and conduct an investigation to describe and classify kinds of materials by their observable properties (extended from G2).

**Engineering, Technology, and Applications of Science Framework core idea ETS1: Engineering design—How do engineers solve problems?**

- **ETS1.A**: Defining and delimiting an engineering problem  
  *What is a design for? What are the criteria and constraints of a successful solution?*  
  [Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.]

- **ETS1.B**: Developing possible solutions  
  *What is the process for developing potential design solutions?*  
  [Research on a problem should be carried out before beginning to design a solution. An often productive way to generate ideas is for people to work together to brainstorm, test, and refine possible solutions. Testing a solution involves investigating how well it performs under a range of likely conditions. Tests are often designed to identify failure points or difficulties, which suggest the elements of a design that need to be improved. At whatever stage, communication with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.]

- **ETS1.C**: Optimizing the design solution  
  *How can the various proposed design solutions be compared and improved?*  
  [Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.]
The following NGSS Grades 3–5 Performance Expectations for ETS1 are derived from the Framework disciplinary core ideas above.

- **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 the criteria and constraints of the problem.
- **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.

**Framework core idea ETS2: Links among engineering, technology, science, and society—How are engineering, technology, science, and society interconnected?**

- **ETS2.A**: Interdependence of science, engineering, and technology
  
  *What are the relationships among science, engineering, and technology?*
  
  [Tools and instruments (e.g., rulers, balances, thermometers, graduated cylinders, telescopes, microscopes) are used in scientific exploration to gather data and help answer questions about the natural world. Engineering design can develop and improve such technologies. Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. Knowledge of relevant scientific concepts and research findings is important in engineering.]

- **ETS2.B**: Influence of engineering, technology, and science on society and the natural world
  
  *How do science, engineering, and the technologies that result from them affect the ways in which people live? How do they affect the natural world?*
  
  [Over time, people’s needs and wants change, as do their demands for new and improved technologies. Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. When new technologies become available, they can bring about changes in the way people live and interact with one another.]

Note: There are no separate performance expectations described for core idea ETS2 (see volume 2, appendix J, for an explanation and elaboration).
Science and Engineering Practices Addressed

1. **Asking questions and defining problems**
   - Ask questions that can be investigated based on patterns such as cause-and-effect relationships.

2. **Developing and using models**
   - Develop models to describe phenomena.

3. **Planning and carrying out investigations**
   - Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
   - Evaluate appropriate methods and/or tools for collecting data.
   - Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.

4. **Analyzing and interpreting data**
   - Represent data in tables and various graphical displays to reveal patterns that indicate relationships.
   - Analyze and interpret data to make sense of phenomena using logical reasoning.
   - Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.
   - Use data to evaluate and refine design solutions.

5. **Using mathematics and computational thinking**
   - Organize simple data sets to reveal patterns that suggest relationships.

6. **Constructing explanations and designing solutions**
   - Use evidence (e.g., observations, patterns) to construct or support an explanation or design a solution to a problem.
   - Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.

7. **Engaging in argument from evidence**
   - Construct an argument with evidence, data, and/or a model.
   - Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

8. **Obtaining, evaluating, and communicating information**
   - Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.
Crosscutting Concepts Addressed

Patterns
- Similarities and differences in patterns can be used to sort and classify natural phenomena. Patterns of change can be used to make predictions.

Cause and effect
- Cause-and-effect relationships are routinely identified and used to explain change.

Scale, proportion, and quantity
- Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.
- Observable phenomena exist from very short to very long time periods.

Systems and system models
- A system can be described in terms of its components and their interactions.

Connections: Understandings about the Nature of Science

Scientific knowledge is based on empirical evidence.
- Science findings are based on recognizing patterns.
- Science investigations use a variety of methods, tools, and techniques.

Science is a human endeavor.
- Science affects everyday life.

Scientific knowledge assumes an order and consistency in natural systems.
- Science assumes consistent patterns in natural systems.

Connections: Science, Technology, Society, and the Environment

The influence of engineering, technology, and science on society and the natural world
- Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

CROSSCUTTING CONCEPTS
A Framework for K–12 Science Education describes seven crosscutting concepts as essential elements of a K–12 science and engineering curriculum. The crosscutting concepts listed here are those recommended for grade 3 in the NGSS and are incorporated into the learning opportunities in the Water and Climate Module.

The learning progression for this dimension of the framework is addressed in volume 2, appendix G, in the NGSS. Elements of the learning progression for crosscutting concepts recommended for grade 3, as described in the performance expectations, appear after bullets below each concept.

CONNECTIONS
See volume 2, appendix H and appendix J, in the NGSS for more on these connections.

For details on learning connections to Common Core State Standards English Language Arts and Math, see the chapters FOSS and Common Core ELA—Grade 3 and FOSS and Common Core Math—Grade 3 in Teacher Resources.
FOSS CONCEPTUAL FRAMEWORK

In the last half decade, teaching and learning research has focused on learning progressions. The idea behind a learning progression is that core ideas in science are complex and wide-reaching, requiring years to develop fully—ideas such as the structure of matter or the relationship between the structure and function of organisms. From the age of awareness throughout life, matter and organisms are important to us. There are things students can and should understand about these core ideas in primary school years, and progressively more complex and sophisticated things they should know as they gain experience and develop cognitive abilities. When we as educators can determine those logical progressions, we can develop meaningful and effective curriculum for students.

FOSS has elaborated learning progressions for core ideas in science for kindergarten through grade 8. Developing a learning progression involves identifying successively more sophisticated ways of thinking about a core idea over multiple years.

If mastery of a core idea in a science discipline is the ultimate educational destination, then well-designed learning progressions provide a map of the routes that can be taken to reach that destination. . . . Because learning progressions extend over multiple years, they can prompt educators to consider how topics are presented at each grade level so that they build on prior understanding and can support increasingly sophisticated learning. (National Research Council, A Framework for K–12 Science Education, 2012, p. 26)

The FOSS modules are organized into three domains: physical science, earth science, and life science. Each domain is divided into two strands, as shown in the table “FOSS Next Generation—K–8 Sequence.” Each strand represents a core idea in science and has a conceptual framework.

- Physical Science: matter; energy and change
- Earth and Space Science: dynamic atmosphere; rocks and landforms
- Life Science: structure and function; complex systems

The sequence in each strand relates to the core ideas described in the NRC Framework. Modules at the bottom of the table form the foundation in the primary grades. The core ideas develop in complexity as you proceed up the columns.
Information about the FOSS learning progression appears in the **conceptual framework** (page 41), which shows the structure of scientific knowledge taught and assessed in this module, and the **content sequence** (pages 46–47), a graphic and narrative description that puts this single module into a K–8 strand progression.

FOSS is a research-based curriculum designed around the core ideas described in the NRC Framework. The FOSS module sequence provides opportunities for students to develop understanding over time by building on foundational elements or intermediate knowledge leading to the understanding of core ideas. Students develop this understanding by engaging in appropriate science and engineering practices and exposure to crosscutting concepts.

The FOSS conceptual frameworks therefore are **more detailed and finer-grained** than the set of goals described by the NGSS performance expectations (PEs). The following statement reinforces the difference between the standards as a blueprint for assessment and a curriculum, such as FOSS.

Some reviewers of both public drafts [of NGSS] requested that the standards specify the intermediate knowledge necessary for scaffolding toward eventual student outcomes. However, the NGSS are a set of goals. They are PEs for the end of instruction—not a curriculum. Many different methods and examples could be used to help support student understanding of the DCIs and science and engineering practices, and the writers did not want to prescribe any curriculum or constrain any instruction. It is therefore outside the scope of the standards to specify intermediate knowledge and instructional steps. (Next Generation Science Standards, 2013, volume 2, p. 342)
BACKGROUND FOR THE CONCEPTUAL FRAMEWORK in Water and Climate

The Wondrous Liquid

How would you answer the question “What is water?” Water is so common and familiar that we usually don’t think about it as something to be defined or described. To the biologist, water is the sanctuary in which life was born. The complex chemistry of life was then, as it is today, water based. We might well think of ourselves as measures of water carried around in complex containers. Because we are essentially water, water is the baseline, the standard against which everything else is compared. Consequently, it is intuitive to describe water in terms of what it isn’t: water has no color, no odor, and no taste, and is not heavy or light, having a density almost the same as our bodies. However, to an alien life-form from a methane or ammonia planet whose chemical history is fundamentally different, pure water might have a very offensive odor, taste like sour grapes, and prove toxic if ingested.

To the geologist, water is a liquid earth material, one of the substances (along with solid rocks and minerals and atmospheric gases) that make up or come from Earth. Water plays a central role in sculpting the planet’s surface and in causing and moderating Earth’s weather and climate. To the chemist, water is a molecule composed of two atoms of hydrogen and one atom of oxygen (H₂O). The atoms are joined by chemical bonds. Water is more complex than this formula suggests, but for our purposes, this simple formula will suffice.

Where Is the Water?

On planet Earth, water is found naturally everywhere—in puddles, ponds, streams, and the ocean. Even though water covers nearly three-quarters of our planet’s surface—hardly scarce—it is still the most precious substance on Earth. The ocean contains more than 97% of Earth’s supply of water. Because water has run through, washed over, and worn down the rocky crust for billions of years, the ocean has become a repository for a huge burden of dissolved minerals, mostly salts. Although salt water is the one and only environment for thousands of life-forms on Earth, salt water will not support human life.

Less than 3% of Earth’s water is fresh, and much of this fresh water is not readily accessible. The water in rivers and lakes is easy to scoop up to quench a thirst, but water in underground aquifers, glaciers, and the atmosphere is harder to get for human use.
CONCEPTUAL FRAMEWORK
Earth Science, Dynamic Atmosphere:
Water and Climate

Structure of Earth

Concept A  The hydrosphere has properties that can be observed and quantified.
- Water is found almost everywhere on Earth: in fog, clouds, rain, snow, ice, rivers, lakes, groundwater, and the ocean. Most of Earth’s water is in the ocean; most of Earth’s fresh water is in glaciers and underground.
- Water exists in three states on Earth: solid, liquid, and gas.
- Sometimes water is absorbed when placed on a surface, and at other times it forms a bead or dome.
- Cold water is more dense than warm water; liquid water is more dense than ice; liquid or solid water is more dense than water vapor.

Concept B  The atmosphere has properties that can be observed and quantified.
- Water vapor is a gas in the air.

Concept C  Humans depend on Earth’s land, ocean, atmosphere, and biosphere for many different resources.
- Soils retain more water than rock particles alone.

Earth Interactions

Concept A  Weather and climate are influenced by interactions of the Sun, the ocean, the atmosphere, ice, landforms, and living things.
- The Sun is the major source of energy that heats Earth.
- Climate is the average or typical weather that can be expected to occur in a region of Earth’s surface, based on long-term observation and data analysis.
- Weather is described in terms of variables including temperature, wind direction, wind speed, and precipitation.
- Scientists record patterns of the weather across different times and areas so that they can predict what kind of weather might happen next.
- Water expands when heated, contracts when cooled, and expands when it freezes.
- The water cycle is driven by the Sun and involves evaporation, condensation, precipitation, and runoff.
- High temperatures, greater surface area, and moving air (wind) increase the rate of evaporation.
- Water moves downhill; the steeper the slope, the faster water moves. Flowing water can do work.

Concept B  Natural hazards impact humans and society.
- A variety of natural hazards result from weather-related phenomena. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.
Water’s Unique Properties

Water has some unique properties. It is the only material that occurs naturally on Earth in all three states of matter: solid, liquid, and gas (water vapor). Earth’s temperature range, allied with the particular properties of water, allows all three forms to exist. Water changes into a solid, or freezes, when it cools to 0 degrees Celsius (°C). It melts, or changes into a liquid, when it warms to above 0° C. And when water is heated to 100°C, it changes into a gas.

The general rule that governs the behavior of matter is that when matter gets hot, it expands; when matter gets cold, it contracts. Most liquids contract steadily as they get colder and colder. But not water! When water cools below 4°C, it begins to expand and continues to expand until it freezes into a solid at 0°C. Water is the only substance that behaves this way. If water is trapped in a closed space, the pressure created by expansion during freezing is enough to burst water pipes and fracture rock formations.

Because water expands as it freezes, a given mass of water occupies a greater volume as ice than it does as liquid water. This means ice is less dense than liquid water. If ice were more dense than water, ice would long ago have accumulated in Earth’s lakes and the ocean from the bottom up, and virtually all the water on the planet would be permanently frozen. Earth might be an ice planet instead of a water planet.

Water boils and turns into water vapor at 100°C. Individual energized water molecules leave the liquid, changing into invisible gas in the process. As gas, water enters the atmosphere, becoming part of the complex mixture of gases called air. Water vapor is not tiny droplets of water. Water vapor is a true gas, dispersed in the air as individual water molecules, in the same league with oxygen, helium, nitrogen, and carbon dioxide.

Water can also vaporize at temperatures below its boiling point. Both ice and liquid water can evaporate into the air. Rain puddles evaporate when exposed to the Sun’s radiation, and ice cubes in the freezer slowly disappear into the air. Factors that affect the rate of evaporation include the size of the surface area, the speed of the air moving over the water’s surface, and the temperature.

Warm air can hold more water vapor than cool air, but there is a limit to how much water vapor the air can hold. When the limit is reached, the number of molecules evaporating from the water’s surface equals the number of molecules going from vapor to liquid. On hot, humid days you feel uncomfortable and sticky because the air is filled to capacity with water vapor, a condition called 100% humidity.
Did you ever watch a dripping faucet and note how water forms a “drop” shape with a point on top as it falls? This simple observation is misleading. A split second after the drop starts its plunge, in response to gravity, the drop is traveling too fast to see. So we are left with an incomplete idea of a drop, based on its appearance just as it leaves the faucet. If we had a slow-motion movie of the drop falling, we could see clearly that the drop immediately pulls itself into a sphere.

This shape change is the effect of surface tension, the skinlike surface that covers water where it interfaces with air. A small quantity of water will quickly pull itself into a sphere, the geometric shape with the smallest surface-to-volume ratio. When water is at rest in a cup, basin, or lake, the same skinlike surface forms at the top where the water meets the air. Water’s strong surface tension enables it to support objects, such as sewing needles and insects called water striders.

Where Did the Water Come From?

How did water come to Earth? Modern theories consider volcanoes to be the source of most of Earth’s water. It is thought that a very large amount of water existed in the assemblage of dust that was compressed by gravitational forces billions of years ago to form the Sun and its planets. Water trapped inside Earth was released to the atmosphere through volcanic eruptions. (Today, volcanic emissions are about 80% water vapor by volume.) Because Earth was very hot during its formative years, the water remained vapor in the atmosphere.

When Earth cooled to below 100°C, the massive accumulation of vapor began to condense and fall as rain. Scientists think that it rained hard and continuously for many millions of years as Earth continued to cool. In time, the low places on Earth’s surface were covered with water to a great depth, and the ocean formed. It was probably in the primitive ocean that life began.

Over the billions of years of Earth history, water from the ocean evaporated into the atmosphere, cooled, condensed into a liquid or solid, and fell back to Earth as precipitation. As water flowed back to the ocean, this continual recycling of water eroded Earth’s surface. If it weren’t for the ongoing mountain-building forces, Earth’s surface would have been leveled and covered by one vast ocean long ago.

The water cycle has been operating ever since the first water vapor condensed and fell back to Earth. A significant amount of water doesn’t find its way directly back to the ocean. It gets waylaid in lakes and underground aquifers. It can take many different routes between the atmosphere, Earth’s surface, and the ocean. Evaporation and condensation can happen at any point along the way.

NOTE

Most scientists agree that Earth’s total water supply doesn’t change much. They have calculated the total supply to be about 1,360,000,000 cubic kilometers (km³). Of that amount, only 65,000 km³ (a fraction of 1 percent) is in motion; the rest is stored in the ocean, glaciers and lakes, or underground.
Weather and Climate

Weather is the activity taking place in the atmosphere at any given time and place. It’s determined by the amount of heat, movement, and moisture in the atmosphere. If the amount of heat is modest, the movement slight, and the moisture negligible, we judge the weather to be good and don’t think about it. If one of the variables is excessive, however, we fret about it and plan around it. Thunderstorms, hurricanes, tornadoes, blizzards, and droughts can dominate our lives. What causes those radical swings in weather?

The Sun. All that movement, heat, and thrashing about is driven by energy. Energy from the Sun, either directly or indirectly, produces effects in the atmosphere. Some effects are obvious. Direct intense insolation (exposure to solar radiation) transfers energy to land and water and then to the air itself. Warming of water enhances evaporation. Other less obvious effects are equally influential on weather. Differential heating of Earth’s surface produces associated air masses of different temperatures. Warm air is less dense than cool air. Dense cool air flows to areas of less-dense air. This produces convection currents in the atmosphere, which results in wind. Another cryptic energy interaction that intensifies thunderstorms, hurricanes, and tornadoes is the release of heat when water condenses from water vapor. This process is not discussed in depth with students, but the foundation is laid for this concept.

Weather and climate? What’s the difference? Climate is what you expect; weather is what you get. Weather is the day-to-day experience, the condition of the atmosphere over a short period of time in a specific location. Climate is the aggregate of all the weather recorded over a long period of time; it is the trends, patterns, and averages.

Climate affects every part of our lives, from when and where we want to take our vacations to how our food is produced. Knowing about the climate can tell us the right time and place to plant crops; help us design comfortable, cost-effective houses; and plan efficient delivery of goods and services.

Weather varies from day to day and year to year. Climate varies on a much larger scale—centuries or more. Complete interaction among the geosphere, atmosphere, hydrosphere, and biosphere have created climate changes in the past and will continue to do so.

Water Use, Water Quality, and Water Power

Several properties of water determine its quality and how it can be used. Taste, odor, salinity, and color are just some of these properties.
The quality of drinking water is very different from the quality of water required to cool car engines, irrigate crops, or wash trucks.

The fact that so many substances dissolve in water has a great effect on its quality. Most natural water carries some concentration of dissolved solids, usually salts, such as calcium sulfate or sodium chloride. Even rain contains dissolved salts. The concentration of salts in water is so small that it is expressed in parts per million (ppm). Distilled (pure) water has a salt concentration of 0 ppm. The water in Lake Michigan has been measured at 170 ppm, the ocean at 35,000 ppm, and the Dead Sea at 250,000 ppm.

Water has mass and flows downhill, urged on by the inexorable acceleration of gravity. Mass times acceleration equals force. If an object is placed in the path of flowing water, the force can be used to do some work. Early on, humans figured out that a waterwheel in a flowing or falling stream of water could create rotational motion. By harvesting the energy in moving water to turn the wheels of industry, humans could grind more grain, saw more lumber, and lift heavier loads more efficiently than they could by hand or with animals. Today, water and gravity still work together to turn the mammoth turbines in hydroelectric power plants.

**Water’s Future**

Hydrologists are the scientists who study Earth’s water supply and inform the management strategies that will help provide an adequate supply of water for the future. Reducing pollution, improving waste treatment, using water efficiently, recycling water for industry, and desalination are some of the global issues being studied at this time.

Environmental economists predict that water issues will be the most important global resource issues in this century. It has been suggested that the energy crisis of the late 20th century will pale in comparison to the water crisis of the decades ahead. The world climate is changing and bringing more severe weather (both floods and droughts). As the world population continues to grow (7 billion reached in October 2011), bringing with it the need for food and escalating expectations for higher standards of living, the demand placed on Earth’s resources will double and redouble many times. Water, the most precious of Earth’s jewels, will be the focal point of a conscientious rethinking of our relationship to a small water planet.

Water defines our planet, it is the cradle of life, and it dominates the character of our global environments. FOSS wants students to start on a path of understanding that will help them appreciate the importance of water and its unique characteristics.
Dynamic Atmosphere Content Sequence

This table shows the five FOSS modules and courses that address the content sequence “dynamic atmosphere” for grades K–8. Running through the sequence are the two progressions—structure of Earth and Earth interactions. The supporting elements in each module (somewhat abbreviated) are listed. The elements for the Water and Climate Module are expanded to show how they fit into the sequence.

<table>
<thead>
<tr>
<th>Module or course</th>
<th>Structure of Earth</th>
<th>Earth interactions</th>
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<tbody>
<tr>
<td>Weather and Water</td>
<td>• Weather is the condition of Earth’s atmosphere at a given time in a local place; climate is the range of an area’s weather conditions over years. • Weather happens in the troposphere. • Density is a ratio of a mass and its volume. • The angle at which light from the Sun strikes the surface of Earth is the solar angle.</td>
<td>• Complex patterns of interactions determine local weather patterns. • Energy transfers from one place to another by radiation and conduction. • Convection is the circulation of a fluid that results from energy transfer in a fluid. • When air masses of different densities meet, weather changes. • The Sun’s energy drives the water cycle and weather. • Climate change affects life.</td>
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<td>(middle school)</td>
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<tr>
<td>Earth and Sun</td>
<td>• Most of Earth’s air resides in the troposphere, where weather happens. • Most of Earth’s water is in the ocean; most of Earth’s fresh water is in glaciers and underground. • Weather is described in terms of variables including temperature, humidity, precipitation, wind, and air pressure. • Scientists observe, measure, and record patterns of weather to make predictions. • The Sun is the major source of energy that heats Earth.</td>
<td>• The different energy-transferring properties of earth materials lead to uneven heating of Earth’s surface and convection currents. • The water cycle is driven by the Sun and involves evaporation and condensation. • Energy transfers to Earth materials by radiation, conduction, and convection. • Climate—the range of an area’s typical weather conditions—is changing globally; this change will affect all life.</td>
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<td>(grade 5)</td>
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<td>Water and Climate</td>
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<td><strong>DYNAMIC ATMOSPHERE</strong></td>
<td></td>
</tr>
<tr>
<td>(grade 3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air and Weather</td>
<td>• Air is matter (gas) and takes up space. • Weather describes conditions in the air outside. • Weather conditions can be measured using tools such as thermometers, wind vanes, anemometers, and rain gauges. • Clouds are made of liquid water drops. • Natural sources of water include streams, rivers, lakes, and the ocean.</td>
<td>• The Sun heats Earth during the day. • Wind is moving air. • Daily changes in temperature, precipitation, and weather type can be observed, compared, and predicted. • Each season has typical weather conditions that can be observed, compared, and predicted. • Weather affects animals and plants.</td>
</tr>
<tr>
<td>(grade 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trees and Weather</td>
<td>• Weather is the condition of the air outside; weather changes. • Temperature is how hot or cold it is, and can be measured with a thermometer. • Wind is moving air; wind socks indicate direction and speed.</td>
<td>• Each season has typical weather conditions that can be observed, compared, and predicted. • Trees change through the seasons.</td>
</tr>
<tr>
<td>(grade K)</td>
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</tr>
</tbody>
</table>
WATER AND CLIMATE – Framework and NGSS

FOSS Conceptual Framework

Structure of Earth

- Water is found almost everywhere on Earth (e.g., vapor, clouds, rain, snow, ice). Most of Earth’s water is in the ocean.
- Water expands when heated, contracts when cooled, and expands when it freezes.
- Cold water is more dense than warmer water; liquid water is more dense than ice.
- Scientists observe, measure, and record patterns of weather to make predictions.
- Soils retain more water than rock particles alone.

Earth interactions

- Water flows downhill; the steeper the slope, the faster water moves. Flowing water can do work.
- Ice melts when heated; water freezes when cooled.
- The water cycle is driven by the Sun and involves evaporation, condensation, precipitation, and runoff.
- High temperatures, greater surface area, and moving air (wind) increase the rate of evaporation.
- Density determines whether objects float or sink in water. A material that floats in water is less dense than the water.
- Climate is the range of an area’s typical weather.
- A variety of natural hazards result from weather-related phenomena.

NOTE
See the Assessment chapter at the end of this Investigations Guide for more details on how the FOSS embedded and benchmark assessment opportunities align to the conceptual frameworks and the learning progressions. In addition, the Assessment chapter describes specific connections between the FOSS assessments and the NGSS performance expectations.

The NGSS Performance Expectations addressed in this module include

Earth and Space Sciences
3-ESS2-1
3-ESS2-2
3-ESS3-1
2-ESS2-3 (extended from G2)

Physical Sciences
2-PS1-1 (extended from G2)

Engineering, Technology, and Applications of Science
3–5 ETS1-1
3–5 ETS1-2
3–5 ETS1-3

See pages 32–35 in this chapter for more details on the Grade 3 NGSS Performance Expectations.
## Water and Climate — Framework and NGSS

### Connections to NGSS by Investigation

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<td>Developing and using models</td>
<td>RI: 1: Ask and answer questions.</td>
</tr>
<tr>
<td></td>
<td>Planning and carrying out investigations</td>
<td>RI 2: Determine the main idea of a text.</td>
</tr>
<tr>
<td></td>
<td>Analyzing and interpreting data</td>
<td>RI 3: Describe in a text the steps in technical procedures.</td>
</tr>
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<td></td>
<td>Using mathematics and computational thinking</td>
<td>RI 5: Use text features to locate information.</td>
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<tr>
<td></td>
<td>Constructing explanations</td>
<td>RI 7: Use information gained from illustrations to demonstrate understanding of the text.</td>
</tr>
<tr>
<td></td>
<td>Engaging in argument from evidence</td>
<td>RF 4: Read with fluency, purpose, and understanding.</td>
</tr>
<tr>
<td></td>
<td>Obtaining, evaluating, and communicating information</td>
<td>W 5: Strengthen writing by revising and editing.</td>
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<tr>
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<td></td>
<td>SL 1: Engage in collaborative discussions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SL 2: Determine main ideas and supporting details of information presented in diverse formats.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SL 3: Ask and answer questions about speaker's information.</td>
</tr>
<tr>
<td></td>
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<td>SL 4: Recount an experience.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L 4: Use glossaries to determine or clarify the precise meaning of key words.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L 5: Demonstrate understanding of word relationships.</td>
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<tr>
<td></td>
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<td>L 6: Acquire and use domain-specific words.</td>
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<td>RI: 1: Ask and answer questions to demonstrate understanding of a text.</td>
</tr>
<tr>
<td></td>
<td>Planning and carrying out investigations</td>
<td>RI 2: Determine the main idea of a text; recount key details.</td>
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<td>RI 3: Describe the relationship between scientific concepts using language that pertains to cause and effect.</td>
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<tr>
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<td>Using mathematics and computational thinking</td>
<td>RI 4: Determine the meaning of domain-specific words and phrases in a text.</td>
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<td>Constructing explanations</td>
<td>RI 6: Distinguish their own point of view from that of the author of a text.</td>
</tr>
<tr>
<td></td>
<td>Engaging in argument from evidence</td>
<td>RI 7: Use information gained from illustrations to demonstrate understanding of the text.</td>
</tr>
<tr>
<td></td>
<td>Obtaining, evaluating, and communicating information</td>
<td>W 2: Write informative texts.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>W 8: Gather information from print; take brief notes and sort evidence into categories provided.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SL 1: Engage in collaborative discussions.</td>
</tr>
<tr>
<td></td>
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<td>SL 4: Report on a topic or text.</td>
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<tr>
<td></td>
<td></td>
<td>L 5: Demonstrate understanding of word relationships.</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>RI 2: Determine the main idea of a text; recount key details.</td>
</tr>
<tr>
<td></td>
<td>Planning and carrying out investigations</td>
<td>RI 3: Describe the relationship between scientific ideas.</td>
</tr>
<tr>
<td></td>
<td>Analyzing and interpreting data</td>
<td>RI 6: Distinguish their own point of view from that of the author of a text.</td>
</tr>
<tr>
<td></td>
<td>Using mathematics and computational thinking</td>
<td>RI 7: Use information gained from illustrations to demonstrate understanding of the text.</td>
</tr>
<tr>
<td></td>
<td>Constructing explanations</td>
<td>W 2: Write informative texts.</td>
</tr>
<tr>
<td></td>
<td>Engaging in argument from evidence</td>
<td>W 8: Gather information from print; take brief notes and sort evidence into categories provided.</td>
</tr>
<tr>
<td></td>
<td>Obtaining, evaluating, and communicating information</td>
<td>SL 1: Engage in collaborative discussions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SL 4: Report on a topic or text.</td>
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<td></td>
<td>L 6: Acquire and use domain-specific words.</td>
</tr>
</tbody>
</table>
### Disciplinary Core Ideas

**ESS2.C: The roles of water in Earth’s surface processes**  
- Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form. (*2-ESS2-3 extended from G2)*

**ESS2.D: Weather and climate**  
- Climate describes a range of an area’s typical weather conditions and the extent to which those conditions vary over years. (*3-ESS2-2*)

**ESS3.B: Natural hazards**  
- A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. (*3-ESS3-1, foundational*)

**PS1.A: Structures and properties of matter**  
- Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties. (*2–PS1-1, extended from G2*)

**PS1.A: Structures and properties of matter**  
- Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. (*3-ESS2-1*)

### Crosscutting Concepts

- Patterns
- Cause and effect
- Cause and effect
- Scale, proportion, and quantity
- Patterns
- Cause and effect
- Scale, proportion, and quantity
## Water and Climate – Framework and NGSS

### Science and Engineering Practices

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<tr>
<th>Inv. 5: Waterworks</th>
<th>Inv. 4: Seasons and Climate</th>
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<tr>
<td>Asking questions and defining problems</td>
<td>Analyzing and interpreting data</td>
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<tr>
<td>Planning and carrying out investigations</td>
<td>Constructing explanations</td>
</tr>
<tr>
<td>Analyzing and interpreting data</td>
<td>Obtaining, evaluating, and communicating information</td>
</tr>
<tr>
<td>Constructing explanations and designing solutions</td>
<td>Engaging in argument from evidence</td>
</tr>
<tr>
<td>Engaging in argument from evidence</td>
<td>Obtaining, evaluating, and communicating information</td>
</tr>
</tbody>
</table>

### Connections to Common Core State Standards—ELA

| RI 3: | RI 8: Describe logical connections in text. |
| RI 9: | RF 4c: Use context to confirm word understandings. |
| SL 1: | SL 4: Report on a topic or text. |
| SL 2: | 

| RI: | RI 1: Ask and answer questions to demonstrate understanding of a text. |
| RI 2: | RI 2: Determine the main idea of a text; recount key details. |
| RI 3: | RI 3: Describe the relationship between scientific ideas in a text. |
| RI 6: | RI 6: Distinguish their own point of view from that of the author of a text. |
| RI 7: | RI 7: Use information gained from illustrations to demonstrate understanding of the text. |
| RF 3: | RF 3: Apply word analysis skills in decoding words. |
| RF 4: | RF 4: Read with fluency. |
| W 2: | W 2: Write informative texts. |
| W 7: | W 7: Conduct a short research project. |
| SL 1: | SL 1: Engage in collaborative discussions. |
| SL 2: | SL 2: Determine main ideas from information presented orally. |
| SL 4: | SL 4: Report on a topic or text. |
| SL 6: | SL 6: Speak in complete sentences to provide requested details. |
| L 4: | L 4: Determine or clarify the meaning of unknown words. |
## Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>ESS2.D: Weather and climate</th>
<th>ESS3.B: Natural hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. (3-ESS2-1)</td>
<td>• A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. (3-ESS3-1)</td>
</tr>
<tr>
<td>• Climate describes a range of an area’s typical weather conditions and the extent to which those conditions vary over years. (3-ESS2-2)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ESS3.A: Natural resources</th>
<th>ETS1.A: Defining and delimiting engineering problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.</td>
<td>• Possible solutions are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5–ETS1-1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ESS3.B: Natural hazards</th>
<th>ETS1.B: Developing possible solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>• A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. (3-ESS3-1)</td>
<td>• At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5–ETS1-2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ETS1.C: Optimizing the design solution</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5–ETS1-3)</td>
<td></td>
</tr>
</tbody>
</table>

## Crosscutting Concepts

- Patterns
- Cause and effect
- Scale, proportion, and quantity
- Cause and effect
- Systems and system models
# RECOMMENDED FOSS NEXT GENERATION K–8

## SCOPE AND SEQUENCE

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<th>Earth Science</th>
<th>Life Science</th>
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<td>Mixtures and Solutions</td>
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<tr>
<td>3</td>
<td>Motion and Matter</td>
<td>Water and Climate</td>
<td>Structures of Life</td>
</tr>
<tr>
<td>2</td>
<td>Solids and Liquids</td>
<td>Pebbles, Sand, and Silt</td>
<td>Insects and Plants</td>
</tr>
<tr>
<td>1</td>
<td>Sound and Light</td>
<td>Air and Weather</td>
<td>Plants and Animals</td>
</tr>
<tr>
<td>K</td>
<td>Materials and Motion</td>
<td>Trees and Weather</td>
<td>Animals Two by Two</td>
</tr>
</tbody>
</table>

*Half-length courses

### Physical Science content

### Earth Science content

### Life Science content

### Engineering content

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**WATER AND CLIMATE — Framework and NGSS**

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Full Option Science System