MIDDLE SCHOOL EARTH SCIENCE: CLIMATE

Standards Bundle

Standards are listed within the bundle. Bundles are created with potential instructional use in mind, based upon potential for related phenomena that can be used throughout a unit.

MS-ESS2-6 Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. (SEP: 2; DCI: ESS2.C, ESS2.D; CCC: Systems) [Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.] [Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.]

MS-ESS3-5 Ask questions to clarify evidence of the factors that may have caused a change in global temperatures over the past century. (SEP: 1; DCI: ESS3.D; CCC: Stability/Change)[Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]

Content Overview

This section provides a generic overview of the content or disciplinary core ideas as an entry point to the standards.

Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. Weather can be predicted, but because these patterns are so complex, weather forecasting has not been perfected.

The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. Greenhouse gases in the atmosphere absorb and retain the energy radiated from land and ocean surfaces, thereby regulating Earth's average surface temperature and keeping it habitable.

Phenomena

Phenomena can be used at varying levels of instruction. One could be used to anchor an entire unit, while another might be more supplemental for anchoring just a unit. Please remember that phenomena should allow students to engage in the SEP and use the CCC/DCI to understand and explain the phenomenon.

- The Arctic sea ice is melting.
- Global sea level rose about 8 inches in the last century.

- Fossils of a tropical plant fossil were found in Wyoming.
- Fossils of subtropical animals were found in South Dakota.
- The average global temperature has steadily increased from the year 1850 to 2016.
- The Greenland and Antarctic ice sheets have decreased in mass.
- Glaciers are retreating almost everywhere around the world — including in the Alps, Himalayas, Andes, Rockies, Alaska and Africa.
- The number of record high temperature events in the United States has been increasing, while the number of record low temperature events has been decreasing, since 1950.

Storyline

This section aims to decode not only the DCI connections, but also the SEP and CCC in a detailed account of how they possibly fit together in a progression for student learning, including both rationale and context for the bundle.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems ● Ask questions to identify and clarify evidence of an argument. **Developing and Using Models** ● Develop and use a model to describe phenomena.	**ESS2.C: The Roles of Water in Earth's Surface Processes** ● Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. **ESS2.D: Weather and Climate** ● Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. ● The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. **ESS3.D: Global Climate Change** ● Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as	**Systems and System Models** ● Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. **Stability and Change** ● Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

	understanding of human behavior and on applying that knowledge wisely in decisions and activities.	

Weather, which varies from day to day and seasonally throughout the year, is the condition of the atmosphere at a given place and time. Climate is longer term and location sensitive; it is the range of a region's weather over one year or many years, and, because it depends on latitude and geography, it varies from place to place. Weather and climate are shaped by complex interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions can drive changes that occur over multiple time scales—from days, weeks, and months for weather to years, decades, centuries, and beyond—for climate. Decisions to reduce the impact on Earth and its systems depend on understanding climate, science, engineering capabilities, and social dynamics.

The ocean exerts a major influence on weather and climate. It absorbs and stores large amounts of energy from the sun and releases it very slowly; in that way, the ocean moderates and stabilizes global climates. Energy is redistributed globally through ocean currents (e.g., the Gulf Stream) and also through atmospheric circulation (winds). Sunlight heats Earth's surface, which in turn heats the atmosphere. The resulting temperature patterns, together with Earth's rotation and the configuration of continents and oceans, control the large-scale patterns of atmospheric circulation. Winds gain energy and water vapor content as they cross hot ocean regions, which can lead to tropical storms.

The "greenhouse effect" keeps Earth's surface warmer than it would be otherwise. To maintain any average temperature over time, energy inputs from the sun and from radioactive decay in Earth's interior must be balanced by energy loss due to radiation from the upper atmosphere. However, what determines the temperature at which this balance occurs is a complex set of absorption, reflection, transmission, and redistribution processes in the atmosphere and oceans that determine how long energy stays trapped in these systems before being radiated away. Certain gases in the atmosphere (water vapor, carbon dioxide, methane, and nitrous oxides), which absorb and retain energy that radiates from Earth's surface, essentially insulate the planet. Without this phenomenon, Earth's surface would be too cold to be habitable. However, changes in the atmosphere, such as increases in carbon dioxide, can make regions of Earth too hot to be habitable by many species.

Climate changes, which are defined as significant and persistent changes in an area's average or extreme weather conditions, can occur if any of Earth's systems change (e.g., composition of the atmosphere, reflectivity of Earth's surface). Some climate changes in Earth's history were rapid shifts (caused by events, such as volcanic eruptions and meteoric impacts, that suddenly put a large amount of particulate matter into the atmosphere or by abrupt changes in ocean currents); other climate changes were gradual and longer term—due, for example, to solar output variations, shifts in the tilt of Earth's axis, or atmospheric change due to the rise of plants and other life forms that modified the atmosphere via photosynthesis. Scientists can infer these changes from geological evidence.

Natural factors that cause climate changes over human time scales (tens or hundreds of years) include variations in the sun's energy output, ocean circulation patterns, atmospheric composition, and volcanic activity. When ocean currents change their flow patterns, such as during El Niño Southern Oscillation conditions, some global regions become warmer or wetter and others become colder or drier. Cumulative increases in the atmospheric concentration of carbon dioxide and other greenhouse gases, whether arising from natural sources or human industrial activity, increase the capacity of Earth to retain energy. Changes in surface or atmospheric reflectivity change the amount of energy from the sun that enters the planetary system. Icy surfaces, clouds, aerosols, and larger particles in the atmosphere, such as from volcanic ash, reflect sunlight and thereby decrease the amount of solar energy that can enter the weather/ climate system. Conversely, dark surfaces (e.g., roads, most buildings) absorb sunlight and thus increase the energy entering the system.

Formative Assessment

Formative assessment is crucial because all learners benefit from timely and focused feedback from others. It promotes self-reflection, self-explanation, and social learning. It can also make learning more relevant. Each of the questions below might be used throughout the formative assessment process. Specific prompts may focus on individual practices, core ideas, or crosscutting concepts, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given bundle, standard or lesson-level performance expectation.

Resources to inform your formative assessment.

http://stemteachingtools.org/brief/30
http://stemteachingtools.org/brief/41
http://stemteachingtools.org/pd/sessionb

SEP Asking Questions and Defining Problems

- Formulate descriptive questions about the global sea level rising about 8 inches in the last century.

SEP Developing and Using Models

- Draw and label a model of the transfer of heat by the global ocean convection cycle.

CCC Systems and System Models

- What causes the change of temperature on Earth?

CCC Stability and Change

- Can we affect climate change?

Performance Outcomes

These are statements of how students use knowledge and are similar to the standards in how they blend DCI, SEP, and CCC, but at a smaller grain-size. These are potential outcomes for instruction as it plays out in lessons and activities in the classroom. It is important to also think of these as smaller outcomes that build toward the larger goal of mastering the standards.

- **Obtain, evaluate, and communicate** how weather and climate are *influenced by interactions* involving sunlight, the ocean, the atmosphere, ice, landforms, and living things.
- **Ask questions and define problems** on how the ocean *exerts* a major *influence* and collect and **analyze** weather and climate **data** to predict future weather *patterns*.
- **Develop and use a model** to describe how unequal heating and rotation of the Earth cause *patterns* of atmospheric circulation.
- **Develop and use a model** to describe how *patterns* of atmospheric and oceanic circulation determine regional climates.
- **Ask questions to clarify evidence** of the factors that may have *caused* a change in global temperatures over the past century.
- **Analyze and interpret data** to show that interactions vary with latitude, altitude, and local and regional geography, all of which can affect **oceanic and atmospheric** flow ***patterns*.**