Perfection Learning
Perfect for YOUR Classroom

Perfection Learning
Correlation of *Earth Science: The Physical Setting* to the Next Generation Science Standards (NGSS)
Performance Expectations and Disciplinary Core Ideas

Performance Expectations
HS.ESS-SS Space Systems Students who demonstrate understanding can: a. Construct explanations from evidence about how the stability and structure of the sun change over its lifetime at time scales that are short (solar flares), medium (the hot spot cycle), and long (changes over its 10-billion-year lifetime). [Clarification Statement: Evidence for long-term changes includes the Hertzsprung-Russell Diagram.] b. Use mathematical, graphical, or computational models to represent the distribution and patterns of galaxies and galaxy clusters in the Universe to describe the Sun's place in space.] c. Construct explanations for how the Big Bang theory accounts for all observable astronomical data including the red shift of starlight from galaxies, cosmic microwave background, and composition of stars and nonstellar gases.] d. Obtain, evaluate, and communicate information about the process by which stars produce all elements except those elements formed during the Big Bang. [Clarification Statement: Nuclear fusion within certain stars produce atomic nuclei lighter than and including iron; heavier elements are produced when certain massive stars achieve a supernova stage and explode.] e. Use mathematical representations of the positions of objects in the Solar System to predict their motions and gravitational effects on each other. [Assessment Boundary: Mathematical representations, which include Kepler's Laws, should not deal with more than 2 bodies.] f. Analyze evidence to show how changes in Earth's orbital parameters affect the intensity and distribution of sunlight on Earth's surface, causing cyclical climate changes that include past Ice Ages. [Assessment Boundary: Orbital parameters are limited to change in orbital shape and orientation of the planetary axis.] g. Construct explanations for how differences in orbital parameters, combined with the object's size and composition, control the surface conditions of other planets and moons within the solar system.]

Disciplinary Core Ideas	References
ESS1.A: The Universe and Its Stars *The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (a) *The sun is one of more than 200 billion stars in the Milky Way galaxy, and the Milky Way is just one of hundreds of billions of galaxies in the universe. (b) *The spectra and brightness of stars are used to identify their compositional elements, movements, and distances from Earth and to develop explanations about the formation, age, and composition of the universe. The Big Bang theory is supported by the fact that it provides an explanation of observations of distant galaxies receding from our own, of the measured composition of stars and nonstellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (c) *Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (c),(d)	681-702
ESS1.B: Earth and the Solar System *Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (e) *Cyclic changes in the shape of Earth's orbit around the sun, together with changes in the orientation of the planet's axis of rotation, have altered the intensity and distribution of sunlight falling on Earth. These changes, both occurring over tens to hundreds of thousands of years, cause cycles of ice ages and other gradual climate changes. (f),(g)	255-259, 605-632, 639-655, 661-675

Correlation for Earth Science: The Physical Setting, Second Edition (McGuire)	
Performance Expectations	
HS.ESS-HE History of Earth Students who demonstrate understanding can: a. Analyze determined or hypothetical isotope ratios within Earth materials to make valid and reliable scientific claims about the planet's age, the ages of Earth events and rocks, and the overall time scale of Earth's history. [Assessment Boundary: Radiometric dating techniques using complex methods such as multiple isotope ratios are not included.] b. Construct an explanation, using plate tectonic theory, for the general trends of the ages of continental and oceanic crust and the patterns of topographic features. [Clarification Statement: Trends of crustal ages involve the youngest seafloor rocks located at mid-ocean ridges and the oldest ocean rocks often located near continental boundaries, with age bands of rocks parallel across mid-ocean ridges. Major topographic features are ocean ridges, trenches, and hot spot islands.] c. Construct explanations about changes that occurred to Earth during the Hadean Eon based on data from Earth materials, planetary surfaces, and meteorites. [Clarification Statement: Dynamic Earth processes have destroyed most of Earth's very early rock record; however, lunar rocks, asteroids, and meteorites have remained relatively unchanged and provide evidence for conditions during Earth's earliest time periods.] d. Construct scientific arguments to support the claim that dynamic causes, effects, and feedbacks among Earth's systems result in a continual coevolution of Earth and the life that exists on it. [Assessment Boundary: Students examine examples of feedbacks between Earth's different systems to understand how life has coevolved with Earth's surface (e.g., the atmosphere and biosphere affect the conditions for life, which in turn affects the composition of the atmosphere.]	
Disciplinary Core Ideas	**References**
ESS1.C: The History of Planet Earth *Radioactive-decay lifetimes and isotopic content in rocks provide a way of dating rock formations and thereby fixing the scale of geologic time. (a) *Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (b) *Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (c)	380-401, 407-431

ESS2.B: Plate Tectonics and Large-Scale System Interactions *Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (b) *Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (b)	306-315, 334-355
ESS2.E Biogeology *The many dynamic and delicate feedbacks among the biosphere, geosphere, hydrosphere, and atmosphere cause a continual co-evolution of Earth's surface and the life that exists on it. (d)	7-8, 156-159, 168-169, 239-241, 262-265, 413-417, 566-571

Performance Expectations

HS.ESS-Earth Systems
Students who demonstrate understanding can:

a. Apply scientific reasoning to explain how geophysical, geochemical, and geothermal evidence was used to develop the current model of Earth's interior. [Clarification Statement: Evidence should include drill cores, gravity, seismic waves, and laboratory experiments on Earth materials.]
b. Use a model of Earth's interior and the mechanisms of thermal convection to explain the cycling of matter and the impact of plate tectonics on Earth's surface. [Assessment Boundary: Convection mechanisms should include heat from radioactive decay and gravity acting on materials of different densities as the drivers of convection and tectonic activity.]
c. Analyze the impact of water on the flow of energy and the cycling of matter within and among Earth systems. [Assessment Boundary: Should explore the unique physical and chemical properties of water, such as the polar nature of the molecule and water's ability to absorb/store/release energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.]
d. Use Earth system models to explain how Earth's internal and surface processes work together at different spatial and temporal scales to form landscapes and sea floor features.]
e. Construct an evidence-based claim about how a change to one part of an Earth system creates feedbacks that causes changes in other systems (e.g., coastal dynamics, watersheds and reservoirs, stream flow and erosion rates, changes in ecosystems).]
f. Use mathematical expressions of phenomena to simulate how temperature, relative humidity, air pressure, and the dew point vary from the windward to the leeward side of a mountain range. [Clarification Statement: The phenomena include latent heat, adiabatic heating/cooling, absolute/relative humidity, and dew point.]

g. Use models to analyze data to make claims about how energy from the sun is redistributed throughout the atmosphere. [Clarification Statement: Unequal heating of the atmosphere results in high and low pressure systems; air moves from areas of high pressure to low pressure; clockwise and counter-clockwise atmospheric circulations develop in response to Earth's rotation (the Coriolis Effect).]

Disciplinary Core Ideas	References
ESS2.A: Earth Materials and Systems *Evidence from drill cores, gravity, seismic waves, and laboratory experiments on Earth materials, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of geophysical and geochemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, and a solid mantle and crust. (a) *Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and the increased downward gravitational pull on denser mantle material. (b) *Earth's systems interact over a wide range of temporal and spatial scales and continually react to changing influences, including those from human activities. Components of Earth's systems may appear stable, change slowly over long periods of time, or change abruptly. Changes in part of one system can cause dynamic feedbacks that can increase or decrease the original changes, further changing that system or other systems in ways that are often surprising and complex. (d),(e) *Weather is driven by interactions of the geosphere, hydrosphere, and atmosphere. (f),(g)	35-40, 86-90,114-119, 124-139, 164-177, 229-231, 294-295, 324-329, 451-462, 496-505
ESS2.B: Plate Tectonics and Large-Scale System Interactions *The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (b)	341-343
ESS2.C: The Roles of Water in Earth's Surface Processes *The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb/store/release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (c)	164-167, 184-186, 188-199, 204-213, 218-219, 227-234, 247-250, 253-254, 259-264, 271-283

Performance Expectations
HS.ESS-CC Climate Change Students who demonstrate understanding can: a. Evaluate and communicate the climate changes that can occur when certain components of the climate system are altered. [Clarification Statement: For example, evaluate variations in incoming solar radiation as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems.] b. Construct a scientific argument showing that changes to any one of many different Earth and Solar System processes can affect global and regional climates. [Clarification Statement: Examples of these processes include the sun's energy output, Earth's orbit and axis orientation, tectonic events, ocean circulation, volcanic activity, glacial activity, the biosphere, and human activities.] [Assessment Boundary: Use evidence from the geologic record only.] c. Analyze geologic evidence that past climate changes have occurred over a wide range of time scales. [Clarification Statement: Examples of evidence are ice core data, the fossil record, sea level fluctuations, glacial features.] d. Engage in critical reading of scientific literature about causes of climate change over 10s-100s of years, 10s-100s of thousands of years, or 10s-100s of millions of years. [Clarification Statement: Examples of causes are changes in solar output, ocean circulation, volcanic activity (10s-100s of years); changes to Earth's orbit and the orientation of its axis (10s-100s of thousands of years); or long-term changes in atmospheric composition (10s-100s of millions of years).] e. Use global climate models in combination with other geologic data to predict and explain how human activities and natural phenomena affect climate, providing the scientific basis for planning for humanity's future needs. [Clarification Statement: For example, use global climate models together with topographic maps to investigate effects of sea level change or combine global climate models with precipitation maps to investigate locations where new water supplies will be needed.] f. Apply scientific knowledge to investigate how humans may predict and modify their impacts on future global climate systems (e.g., investigating the feasibility of geoengineering design solutions to global temperature changes).] g. Use models of the flow of energy between the sun and Earth's atmosphere and surface to explain how different wavelengths of energy are absorbed and retained by various greenhouse gases in Earth's atmosphere, thereby affecting Earth's radiative balance. [Clarification Statement: Students will work with absorption spectra of different Earth materials.]

Disciplinary Core Ideas	References
ESS2.D: Weather and Climate *The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. Climate change can occur when certain parts of these systems are altered. (a) *The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (b),(c),(d) *Geologic evidence indicates that past climate changes were either sudden changes caused by alterations in the atmosphere; longer-term changes (e.g., ice ages) due to variations in solar output, Earth's orbit, or the orientation of its axis; or even more graduate atmospheric changes due to plants and other organisms that captured carbon dioxide and released oxygen. The time scales of these changes varied from a few to millions of years. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate (link to ESS3.D). (b),(c),(d) *Global climate models are often used to understand the process of climate change because these changes are complex and can occur slowly over Earth's history. Global climate models incorporate scientists' best knowledge of the physical and chemical processes and of the interactions of relevant systems. They are tested by their ability to fit past climate variations. (e) *Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. Hence the outcomes depend on human behaviors (link to ESS3.D) as well as on natural factors that involve complex feedbacks among Earth's systems (link to ESS3.A). (f)	254-255, 437-439, 442-462, 467-476, 485 488,496-515, 580-596

ESS3.D: Global Climate Change *Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (g) *Thus science and engineering will be essential both to understanding the possible impacts of global climate change and to informing decisions about how to slow its rate and consequences–for humanity as well as for the rest of the planet. (g)	568-569, 578-580

Performance Expectations
HS.ESS-HS Human Sustainability Students who demonstrate understanding can: a. Construct arguments for how the developments of human societies have been influenced by natural resource availability including: locations of streams, deltas, and high concentrations of minerals, ores, coal, and hydrocarbons.] b. Reflect on and revise design solutions for local resource development that would increase the ratio of benefits to costs and risks to the community and its environment. [Clarification Statement: Examples of local resource development include soil use for agriculture, water use, mining for coal and minerals, pumping for oil and natural gas.] c. Construct scientific claims for how increases in the value of water, mineral, and fossil fuel resources due to increases in population and rates of consumption have sometimes led to the development of new technologies to retrieve resources previously thought to be economically or technologically unattainable.] d. Construct scientific arguments from evidence to support claims that natural hazards and other geologic events have influenced the course of human history. [Clarification Statement: Famines that result from reduced global temperatures can follow large historic volcanic eruptions. Large earthquakes and tsunamis can destroy cities, and there is a strong correlation between historic climate changes and the number of wars.] e. Construct scientific claims about the impacts of human activities on the frequency and intensity of some natural hazards. [Clarification Statement: Natural hazards to include floods, droughts, forest fires, landslides, etc.] f. Identify mathematical relationships using data on the rates of production and consumption of natural resources in order to assess the global sustainability of human society. [Assessment Boundary: Students construct equations for linear relationships, but not expected to construct equations for non-linear relationships.] g. Construct arguments about how engineering solutions have been and could be designed and implemented to mitigate local or global h. Use results from computational General Circulation Models (GCMs) to investigate how the hydrosphere, atmosphere, geosphere, and biosphere are being modified in response to human activities.]

Perfection Learning®
Perfect for YOUR Classroom

Disciplinary Core Ideas	References
ESS3.A: Natural Resources *Resource availability has guided the development of human society. Resource availability affects geopolitical relationships and can limit development. (a) *All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (b) *As the global human population increases and people's demands for better living conditions increase, resources considered readily available in the past, such as land for agriculture or drinkable water, are becoming scarcer and more valued. (c)	144-159
ESS3.B: Natural Hazards *Natural hazards and other geologic events have shaped the course of human history by destroying buildings and cities, eroding land, changing the courses of rivers, and reducing the amount of arable land. These events have significantly altered the sizes of human populations and have driven human migrations. (d) *Natural hazards can be local, regional, or global in origin, and their risks increase as populations grow. Human activities can contribute to the frequency and intensity of some natural hazards. (e)	7-8, 186-187, 361-375, 550-566
ESS3.C: Human Impacts on Earth Systems *The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (f) *Scientists and engineers can make major contributions–for example, by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. When the source of an environmental problem is understood and international agreement can be reached, human activities can be regulated to mitigate global impacts (e.g., acid rain and the ozone hole over Antarctica). (g) *Through computer simulations and other studies, important discoveries are still being made about how the ocean, atmosphere, and biosphere interact and are modified in response to human activities and changes in human activities. (h)	412-417, 566-571