Earth and Human Activity/Earth Systems

These resources can be used to build towards the following dimensions of the Next Generation Science Standards.

Find these collections — and more — at the links to NASAWavelength.org lists (at the top of each table).

**HS-ESS3. EARTH & HUMAN ACTIVITY**

**HS-ESS3-6.** Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

**Science and Engineering Practices**

Analyzing and Interpreting Data. Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Using Mathematics and Computational Thinking. Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.

**Disciplinary Core Ideas**

ESS3.D Global Climate Change. Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)

**Cross Cutting Concepts**

Stability and Change. Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Systems and System Models. When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

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**SAMPLE INVESTIGATIONS, LESSONS & RELATED RESOURCES**

**Earth’s Dynamically Changing Climate**
https://climate.nasa.gov/resources/education/pbs_modules/lesson1Overview

Guide students through the causes and effects of global climate change—

ENGAGE: Students watch videos and identify evidence of global climate change;

EXPLORE: Students dig deeper into global climate change indicators using interactive simulations and graphical data analysis;

EXPLAIN: Students read an article by a NASA scientist answering questions about global climate change;

ELABORATE: Students use the NASA Sea Level Viewer to show how data can be analyzed; and

EVALUATE: Students look at albedo and begin to think about feedback in a system and test their knowledge with an interactive quiz.

**World of Change**
https://earthobservatory.nasa.gov/Features/WorldOfChange

This series of articles with time series of images documents how our planet’s land, oceans, atmosphere, and Sun are changing over time. Topics include both natural and human-caused changes.

**Global Climate Change: Vital Signs of the Planet**
https://climate.nasa.gov/vital-signs

Includes global measurements and interactive graphs and images to explore five “vital signs” of our Earth system: carbon dioxide, global temperature, Arctic sea ice minimum, land ice, and sea level.

**How to Calculate Sea Ice Changes**
http://nasawavelength.org/resource/nw-000-000-003-994

In these videos, a NASA climate scientist explains how the Arctic and Antarctic sea ice covers are measured from satellite data and how math is used to determine trends in the data. Supplemental resources include data files to do the calculations for 1978–2016, classroom suggestions, and data for different regions in the Arctic and Antarctic.

**Bringing the Universe to America’s Classrooms: Earth Science Modules**
http://pbslearningmedia.org/universe

New instructional modules contain digital media that address the content and practices in the K–12 Framework for Science Education and feature innovative media formats — including satellite images, data visualizations, and videos drawn from WGBH’s signature programs like NOVA and PEEP & the Big Wide World. Resources have been designed to be accessible for diverse learners and include support materials, such as background essays, teaching tips, and student handouts. Grade 9–12 Instruction module is on the topic of Weather & Climate.
### HS-ESS2. EARTH SYSTEMS

**HS-ESS2-2.** Analyze geoscience data to make the claim that one change to Earth’s surface can create feedbacks that cause changes to other Earth systems.

**HS-ESS2-4.** Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate.

**HS-ESS2-6.** Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

### Science and Engineering Practices

**Analyzing and Interpreting Data.** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Use a model to provide mechanistic accounts of phenomena.

**Developing and Using Models.** Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

### Disciplinary Core Ideas

**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. (HS-ESS2-2)

Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6)

Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-4)

### Cross Cutting Concepts

**Cause and Effect.** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Feedback (negative or positive) can stabilize or destabilize a system.

**Energy and Matter.** The total amount of energy and matter in closed systems is conserved.

### SAMPLE INVESTIGATIONS, LESSONS & RELATED RESOURCES

**Carbon Connections**
http://carbonconnections.bscs.org

This three-unit, online curriculum was designed to improve understanding of the carbon cycle and Earth’s climate. Each lesson includes focus questions, hands-on activities, virtual field trips, and interactive models. The three units follow carbon in and out of Earth’s systems result in changes to other Earth systems.

**A Year in the Life of Earth’s CO₂**
http://svs.gsfc.nasa.gov/goto?711719

Plumes of carbon dioxide in this simulation swirl and shift as winds disperse the greenhouse gas away from its sources. The simulation also illustrates differences in carbon dioxide levels in the northern and southern hemispheres and distinct swings in global carbon dioxide concentrations as the growth cycle of plants and trees changes with the seasons. The site includes an “inquiry” version of the visualization — without annotations — that can be used to initiate student questions.

**Vital Signs of the Planet: Carbon Dioxide**
https://climate.nasa.gov/vital-signs/carbon-dioxide

Explore interactive times series of graphs and images, and download the latest atmospheric CO₂ data. The time series shows global distribution and variation of the concentration of mid-tropospheric carbon dioxide. Links to NASA missions that observe CO₂.

**Seasonal Changes in Carbon Dioxide**
https://climate.nasa.gov/climate_resources/152

Carbon dioxide is the most important greenhouse gas released to the atmosphere through human activities. It is also influenced by natural exchange with the land and ocean. This visualization provides a high-resolution, 3-D view of global atmospheric carbon dioxide concentrations from September 1, 2014 to August 31, 2015.

**Earth Radiation Budget: Seasonal Cycles in Net Radiative Flux**
http://nasawavelength.org/resource/hw-000-000-001-681

Students examine radiation data to understand how the Earth’s tilt causes seasonal differences in incoming solar energy, and to explore how clouds, deserts, and ice modulate the reflection of energy from the Sun.

**MY NASA DATA: Comparing Graphs of Temperature and Radiation**
http://nasawavelength.org/resource/hw-000-000-002-944

Students analyze plots of temperature and radiation data to determine change over time.