Earth and Human Activity/Earth Systems ■ HIGH SCHOOL Grades 9–12

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).

high school

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.

NASAWAVELENGTH
Find this collection and more at:
http://nasawavelength.org/list/1775

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.

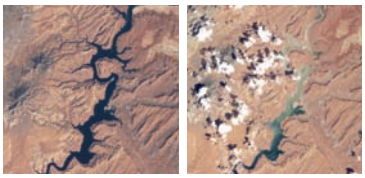
SAMPLE INVESTIGATIONS, LESSONS & RELATED RESOURCES

Earth's Dynamically Changing Climate
https://climate.nasa.gov/resources/education/pbs_modules/lesson10verview

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.

NASA WAVELENGTH

Find this collection and more at: ***http://nasawavelength.org/list/1777***

high school

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

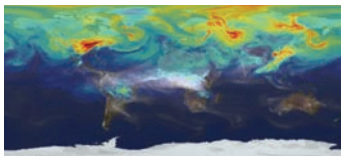
Carbon Connections

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 past, present, and future contexts. Students use NASA and other data, to investigate the evidence of climate change.

A Year in the Life of Earth's CO_2

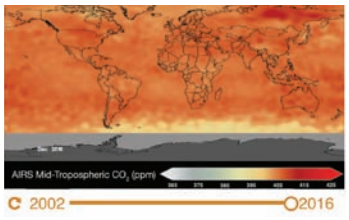
http://svs.gsfc.nasa.gov/goto?11719



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 CO_2 data. The time series shows global distribution and variation of the concentration of mid-tropospheric carbon dioxide. Links to NASA missions that observe CO_2.

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.

Exploring Remote Sensing

http://nasawavelength.org/resource/nw-000-000-004-290

Students simulate the process of remote sensing by using common materials to represent Earth's different ground coverings and a light meter to represent satellite instruments. The concept of albedo, and its importance in Earth's radiation budget, is introduced. The lesson uses the 5E instructional model and is part of the book, *Tour of the Electromagnetic Spectrum.*

Earth Radiation Budget: Seasonal Cycles in Net Radiative Flux

http://nasawavelength.org/resource/nw-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/nw-000-000-002-944

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