

Topics in Biology - Climate Science

Unit 1 Earth's Energy Balance

Unit Overview: This unit begins by building on students background knowledge about weather, climate, and the differences between the two. Students use this information to investigate carbon fluctuations throughout the seasons. This then leads to two activities examining how information regarding climate and weather data can be obtained using a variety of instruments including tree rings. Unit 1 concludes with students study of Earth's energy balance.

Unit Storyline: As the unit begins students gain a greater understanding and appreciation of weather and climate. Students learn that weather is short term atmospheric conditions (temperature, precipitation, wind) and climate is the weather of a region over a long time period. This concept is a basic model that students should grasp prior to moving forward in the climate science lesson sequence. As students' progress through the lesson sequence they learn that even though there are seasonal variations in Earth's CO₂ concentration, the overall amount of CO₂ is increasing in Earth's atmosphere. Students gather information on various ways scientists obtain weather and climate data. Students then analyze and compare tree ring data and precipitation data to gain understanding how different sources of data can increase understanding of past climate conditions. Students expand their understanding with regards to use of tree ring data and data sets to determine past climate conditions before modern technological advances in data collection. Students will extend their knowledge with regards to weather and climate to learn Earth's energy balance concepts and the relationship between Earth's energy balance and climate change.

Anchor Phenomena

Energy from the Sun, atmospheric conditions surrounding Earth and cycling of energy and elements support life on Earth.

Essential Questions/ Driving Questions

What is the difference between weather and climate?

What is the carbon cycle?

Are there seasonal variations of atmospheric CO₂?

How has O₂ concentrations in the atmosphere changed in recent decades?

How can scientists gather information about Earths' past weather and climate?

How does data help understand what the climate was like in a particular location in the past?

How can tree ring patterns be used to study weather and climate in the past?

What is Earth's energy balance?

Why is it important for Earth's energy balance to be maintained?

What effects does Earth's energy balance have on climate?

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New York State Science Learning Standards (NYSSLS) by Lesson

<p>Lesson: Weather and Climate - Performance Expectations and Disciplinary Core Ideas:</p> <ul style="list-style-type: none"> • HS-EESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems results in changes in climate. <ul style="list-style-type: none"> • ESS2.D Weather and Climate* • HS-ESS2-8 Evaluate data and communicate information to explain how the movement and interactions of air masses result in changes in weather conditions. <ul style="list-style-type: none"> • ESS2.D Weather and Climate* 	<p>Lesson: Carbon Through the Seasons - Performance Expectations and Disciplinary Core Ideas:</p> <ul style="list-style-type: none"> • HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. <ul style="list-style-type: none"> • ESS2.D Weather and Climate* 	
<p>Lesson: Tree Rings - Performance Expectations and Disciplinary Core Ideas:</p> <ul style="list-style-type: none"> • HS-ESS2-8 Evaluate data and communicate information to explain how the movement and interactions of air masses result in changes in weather conditions. <ul style="list-style-type: none"> • ESS2.D Weather and Climate* • HS-ESS3-5 Analyze geoscience data and the results from global models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. <ul style="list-style-type: none"> • ESS3.D Global Climate Change* 	<p>Lesson: Trees: Recorders of Climate Change - Performance Expectations and Disciplinary Core Ideas:</p> <ul style="list-style-type: none"> • HS-ESS2-2 Analyze geoscience data to make a claim that one change to Earth's surface can create feedbacks that cause changes to other systems <ul style="list-style-type: none"> • ESS2.D Weather and Climate* • HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. <ul style="list-style-type: none"> • LS2-C Ecosystem Dynamics, Functioning, and Resilience* 	
<p>Lesson: Earth's Energy Balance - Performance Expectations and Disciplinary Core Ideas:</p> <ul style="list-style-type: none"> • HS-EESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems results in changes in climate. <ul style="list-style-type: none"> • ESS1.B Earth and the Solar System* • ESS2.A Earth Materials and Systems* • ESS2.D Weather and Climate* 	<p>Science and Engineering Practices*</p> <ul style="list-style-type: none"> • Analyzing and Interpreting Data • Developing and Using Models • Using Mathematics and Computational Thinking 	<p>Crosscutting Concepts*</p> <ul style="list-style-type: none"> • Patterns • Energy and Matter • Stability and Change • Cause and Effect • Scale, Proportion, and Quantity

*Denotes hyperlink for additional information

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Time Frame	Weather and Climate	5 E Model	Teacher Resources and Materials	In Class Student Activities Lab Resources	Online Resources
	<p>Phenomena - Sometimes the weather in Buffalo, NY is similar to Miami, Fl despite different climates.</p> <p>Vocabulary- climate climate change global warming weather</p>	<p>Engage - Students will be introduced to weather, climate, and how to collect weather data.</p>	<p>Weather-Climate Teacher Lesson Plan</p> <p>Weather and Climate PowerPoint</p>	<p>Weather and Climate What's the Difference Procedure for Measuring Daily Temperature</p>	<p>NASA – Climate Science Investigation The first three modules (Weather and Climate; Energy: The Driver of Climate; Temperature Over Time) may be used as an additional resource</p> <p>Climate and Weather – Characteristics of world weather and climate</p> <p>Weather or Climate...What's the Difference – Article further explaining the differences between weather and climate</p> <p>Weather.com – Information for long term climate and weather data.</p>
		<p>Explore - Students will collect and record weather data for at least three days.</p>	<p>Weather-Climate Teacher Lesson Plan</p> <p>Weather and Climate PowerPoint</p>	<p>Student Weather Data Collection Tool</p>	
		<p>Explain - Students will graph their data and compare their data to long term climate data, leading to a class discussion on the differences between weather and climate.</p>		<p>Student Weather vs. Climate Summary Data Table</p> <p>Student Instructions for Obtaining Climate Data</p> <p>Student Graph V1</p> <p>Student Graph V2</p>	
		<p>Elaborate - Students will compare national temperature trends from 1901-2011 to analyze trends in temperature and to discuss if any trends are indicative of climate change.</p>			
		<p>Evaluate - Data collection, graph, response to discussions questions.</p>			
	<p>Lesson Connection to Storyline: Students gain a greater understanding of weather and climate. At the end of this lesson students should know that weather is short term atmospheric conditions (temperature, precipitation, wind) and climate is the weather of a region over a long time period. This concept is a basic model that students should grasp prior to moving forward in the climate science lesson sequence.</p>				

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Time Frame	Carbon Through the Seasons	5 E Model	Teacher Resources and Materials	In Class Student Activities Lab Resources	Online Resources
	<p>Phenomena-Atmospheric carbon dioxide changes affect growing seasons.</p> <p>Vocabulary- carbon source carbon sink carbon carbon cycle carbon dioxide greenhouse gas ppm (parts per million) photosynthesis</p>	<p>Engage - Students are introduced to the carbon cycle, Earth's carbon sources and sinks.</p>	<p>Carbon Through the Seasons Teacher Lesson Plan</p> <p>Carbon Through the Seasons Lesson PowerPoint</p>		<p>Carbon Footprint Calculator – Gain information on your personal carbon footprint</p> <p>Global Carbon Budget – Annual updates of global carbon trends and budgets</p> <p>Video Link – NASA- A year in the Life of Earth's CO₂ (Nearpod)</p>
		<p>Explore - Students watch a video and study a diagram on the carbon cycle and how the cycle is changing.</p>		<p>The Greenhouse Effect Video (Nearpod video)</p>	
		<p>Explain - Students analyze and graph data sets of monthly average CO₂ concentration.</p>		<p>Student Data Worksheet</p> <p>Mauna Loa Observatory Data Graph Paper</p> <p>Student Data Set A Student Data Set B Student Data Set C Student Data Set D Student Data Set E</p>	
		<p>Elaborate - Students calculate annual average CO₂ concentrations identifying seasonal patterns.</p>		<p>Mauna Loa Monthly Average CO₂ Concentrations</p>	
		<p>Evaluate - Completed graphs, data tables, and discussion question responses.</p>			
	<p>Lesson Connection to Storyline: Students will learn that even though there are seasonal variations in Earth's CO₂ concentration, the overall amount of CO₂ is increasing in Earth's atmosphere.</p>				

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Time Frame	Tree Rings – Living Records of Climate	5 E Model	Teacher Resources and Materials	In Class Student Activities Lab Resources	Online Resources
	<p>Phenomena - Tree rings can provide information regarding climate from many years ago.</p> <p>Vocabulary tree ring climate climate change weather precipitation</p>	<p>Engage - After reviewing the differences between weather and climate students will examine how scientists gather data.</p>	<p>Tree Rings Teacher Lesson Plan Tree Rings Lesson PowerPoint</p>	<p>Think Like a Scientist Student Resource</p>	<p>Think Like a Scientist from EPA A Student's Guide to Global Climate Change</p> <p>weather.gov – Online resource for monthly mean annual precipitation data</p> <p>Dendrochronology visualization with data sets ** – Learn about biologist/artist Felipe Shibuya and his work fusing art and scientific data.</p> <p>Simulated Dendrochronology of Immigration to NYC – Felipe Shibuya **(Nearpod Video) This video is a visualization of immigration to NYC over 175 years as growing tree rings and demonstrates the artist's work.</p>
		<p>Explore - Students analyze tree ring data and compare tree ring data with precipitation data.</p>		<p>Tree Ring Analysis Student Resource Tree Rings – Jackson, MS Tree Rings – Columbia, MO Tree Rings – Boston MA</p>	
		<p>Explain - Students graph monthly mean annual precipitation data for location.</p>		<p>Tree Ring Analysis Student Resource Monthly Mean Annual Precipitation Student Graph</p>	
		<p>Elaborate - Students compare precipitation data to tree ring data.</p>		<p>Tree Ring Analysis Student Resource Monthly Mean Annual Precipitation Student Graph</p>	
		<p>Evaluate - Completed graphs, data tables, and discussion question responses.</p>			
	<p>Lesson Connection to Storyline: Students gather information on various ways scientists obtain weather and climate data. Students then analyze and compare tree ring data and precipitation data to gain understanding how different sources of data can increase understanding of past climate conditions.</p>				

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Time Frame	Trees: Recorders of Climate Change	5 E Model	Teacher Resources and Materials	In Class Student Activities Lab Resources	Online Resources
	<p>Phenomena- Tree ring thickness can be used to determine optimal tree growing conditions and climatic conditions.</p> <p>Vocabulary dendrochronology dendroclimatology</p>	<p>Engage - Students review how tree rings are formed.</p>	<p>Trees: Recorders of Climate Change – Teacher Lesson Plan</p> <p>Tree: Recorders of Climate Change PowerPoint</p>	<p>Trees: Recorders of Climate Change Student Resource</p>	<p>NOAA Paleoclimatology Data Sets - Archive of world climate and paleoclimatology data sets</p>
		<p>Explore - Students examine simulated tree core samples.</p>		<p>Trees: Recorders of Climate Change Student Resource</p> <p>Simulated Tree Cores</p>	<p>Tree Rings Provide snapshots of Earth’s Past Climate (NASA) – Additional background information about tree rings</p>
		<p>Explain – Students develop a hypothesis based on the question <i>Has the climate changed over the last 600 years?</i></p>		<p>Trees: Recorders of Climate Change Student Resource</p> <p>Simulated Tree Cores</p>	<p>Trees as Indicators of Climate – Dr. Keith Briffa – Supplemental article regarding trees as indicators of climate change.</p>
		<p>Elaborate – Students test their hypotheses by collecting and analyzing data from the tree rings</p>		<p>Trees: Recorders of Climate Change Student Resource</p> <p>Simulated Tree Cores</p>	
		<p>Evaluate – Students answer and discuss data analysis questions.</p>		<p>Trees: Recorders of Climate Change Student Resource</p> <p>Simulated Tree Cores</p>	<p>Tree Rings: A Cursory Look at These Well Known Features – Paul James – Provides pictures and information to supplement tree ring analysis.</p> <p>Dendrochronology visualization with data sets – An artist’s use of tree ring visualization with other types of data sets</p>
	<p>Lesson Connection to Storyline: Students expand their understanding with regards to use of tree ring data and data sets to determine past climate conditions before modern technological advances in data collection.</p>				

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Time Frame	Earth's Energy Balance	5 E Model	Teacher Resources and Materials	In Class Student Activities Lab Resources	Online Resources
	<p>Phenomena- Earth maintains a relatively constant temperature.</p> <p>Vocabulary Absorb Albedo Emit Energy Equilibrium state Heat Light energy Radiation System Temperature variable</p>	<p>Engage - Students will be introduced to Earth's energy balance by watching a video and starting a concept map.</p>	<p>Earth's Energy Balance Teacher Lesson Plan</p> <p>Earth's Energy Balance PowerPoint</p> <p>Earth's Energy Balance Concept Map – Teacher Resource</p>	<p>Earth's Energy Balance Concept Map - Student Resource</p>	<p>Video – Real World: Earth's Energy Balance (Nearpod)</p> <p>Video – Earths Energy Budget (Nearpod)</p> <p>Video – What is Albedo (Nearpod)</p> <p>Video – Albedo Measurements (Nearpod)</p> <p>Our Climate Our Future – Black Carbon – Learn where black carbon comes from and ways it impacts Earth's Energy Balance</p> <p>NASA – Climate Science Investigations – The first three modules (Weather and Climate; Energy: The Driver of Climate; Temperature Over Time) may be used as additional resource.</p>
		<p>Explore - Students are introduced to Earth's energy balance concepts; participate in Sun-Earth Modeling Activity; develop a conceptual model of Earth's Energy Budget with input and output variables.</p>	<p>Earth's Energy Balance Sun-Earth Modeling Activity – Teacher Resource</p>	<p>Earth's Energy Balance Two Column Notes</p> <p>Earth's Energy Balance – Sun-Earth Modeling Activity</p>	
		<p>Explain – Students will answer conceptual questions based on Earth's energy balance concepts.</p>	<p>Earth's Energy Balance- Conceptual Problems – Teacher Resource</p>	<p>Earth's Energy Balance Two Column Notes</p> <p>Earth's Energy Balance Conceptual Problems – Student Resource</p>	
		<p>Elaborate – Students will complete concept map identifying and detailing all science concepts related to Earth's energy balance.</p>	<p>Earth's Energy Balance Concept Map – Teacher Resource</p>	<p>Earth's Energy Balance Concept Map - Student Resource</p>	
		<p>Evaluate – Students will complete a writing assignment describing the flow of energy in Earth's system to maintain Earth's energy balance.</p>		<p>Earths Energy Balance – Writing Assignment and Scoring Rubric</p>	
		<p>Lesson Connection to Storyline: Students will extend their knowledge with regards to weather and climate to learn Earth's energy balance concepts and the relationship between Earth's energy balance and climate change.</p>			

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Resources

[NASA – Climate Science Investigations](#) – The first three modules (Weather and Climate; Energy: The Driver of Climate; Temperature Over Time)

[Climate Data Sources](#) – This collection of data sources from NOAA are grouped based on the following categories – Climate Data, Climate Data shown creatively, Plants & Animals, Human Health, Environmental Justice/Socio-economic data, Weather, Water, Agriculture, Other.

[Climate and Weather](#) – Characteristics of world weather and climate

[Weather or Climate...What's the Difference](#) – article further explaining the differences between weather and climate

[Weather.com](#) – Information for long term climate and weather data.

[Earths Energy Budget](#) – Nearpod video

[Real World: Earth's Energy Balance](#) Nearpod video

[Global Carbon Budget](#) – Annual updates of global carbon trends and budgets

[Carbon Footprint Calculator](#) – Gain information on your personal carbon footprint

[NYS P-12 Science Learning Standards \(HS\)](#) – NYSSLS Standards for grades 9-12

[NYSED Bilingual Glossaries](#) – NYS Statewide Language Regional Bilingual Education Resource for NYSED approved bilingual glossaries

Group Learning Routines	Group Learning Routines to Support All Learners – All Strategies	Group Learning Routines – Pairs Turn, Exchange, Sort (Elbow Exchange) Questions Starts/Questions Only Questions 2x2x2 Dialogue Lines/Dialogue Circles	Group Learning Routines – Small Groups Think-Talk-Open Exchange Read-Generate-Sort-Solve Buzzwords (Think-Talk-Exchange) – Teacher Directions Buzzwords (think-Talk-Exchange) – Template	Group Learning Routines – Whole Class Domino Share Rumors Idea Carousel Exhibition I used to think...Now I think...	
English Language Learners (ELL) Enhancements To access hyperlinked material, you must be logged into your BPS Google Drive	Listening <ul style="list-style-type: none"> • Cross- Linguistic Practices: Gives students opportunities to make connections between what they hear and their home language (For example, allow students to listen to a passage and identify cognates.) • Build background knowledge • Activating Prior Knowledge Activating prior knowledge means both eliciting from students what they already know and building initial knowledge that they need in order to access upcoming content • Activating Prior Knowledge • Visuals - GIFs, pictures- will assist students in understanding what they are listening to. Use 	Speaking <ul style="list-style-type: none"> • Sentence Frames To begin a sentence - such as <i>The water cycle is...</i> or <i>I think that water cycle is...</i> • Academic Conversation Starters: Have a visual of a list of academic sentence starters that students can refer to in a discussion. Examples include- I expect ____ to happen. My data shows that... This helps students have a more science focused dialogue. • Choral Reading - To build fluency, self-confidence and motivation with reading/speaking • Create movement to go with the word. Movement can be a 	Reading <ul style="list-style-type: none"> • Supplementary Text to help reinforce concepts. If necessarily, use lower Lexile levels to ensure comprehension. • Visual Aids - Pictures or models to support vocabulary words and concepts • Video to review or introduce a topic - use closed captioning to help students read along while they listen to the content • 4 Square / Frayer models to help students gain a deeper understanding of vocabulary. • Highlighting -important text to assist students in answering questions after the reading. • Chunking-Break reading of text into chunks or paragraphs 	Writing <ul style="list-style-type: none"> • Sentence Frames - to begin a sentence- such as <i>The water cycle is...</i> or <i>I think that water cycle is....</i> • Cloze passages with word banks • Word banks • Graphic Organizers to help break down the writing process and organize thoughts • Standards-based sentence stems • Performance Level Descriptors This document provides teachers with a description of what output they can expect from students based on earned NYSESLAT levels in the modality of writing. 	Instructional Accommodations (depending on the student's needs) <ul style="list-style-type: none"> • Extended time for tests in class, projects and assignments • Directions read. Broken down as necessary • Model how to complete the activity in the lesson • Oral simplification of directions or questions • Translated version of test when available. Student may have both version English and native language version • Use of approved bilingual glossaries from NYS in each subject

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	<p><u>visual thinking strategies</u> to set the lens for learning.</p> <ul style="list-style-type: none"> • Video to review or introduce a topic – use <u>closed captioning</u> to help students see the words and pronunciations while they listen to the content. • <u>Word stretching / Vowel stretching</u> when instructing allows student to listen closely to the pronunciation of the word • <u>Performance Level Descriptors</u> this document provides teachers with a description of what output they can expect from students based on earned NYSESLAT levels in the modality of listening. 	<p>motivating factor, as well as a kinesthetic tool for conceptualizing the rhythm and flow of fluent reading while triggering brain function for optimal learning</p> <ul style="list-style-type: none"> • <u>Performance Level Descriptors</u> This document provides teachers with a description of what output they can expect from students based on earned NYSESLAT levels in the modality of speaking. 	<ul style="list-style-type: none"> • <u>Performance Level Descriptors</u> - This document provides teachers with a description of what output they can expect from students based on earned NYSESLAT levels in the modality of reading. • <u>Vocabulary Morphology</u>- Morphology relates to the segmenting of words into affixes (prefixes and suffixes) and roots or base words, and the origins of words. Understanding that words connected by meaning can be connected by spelling can be critical to expanding a student’s vocabulary. 		
<p>Special Education Modifications</p> <p>Special Education students must have accommodations as per Individual Educational Plan (IEP)</p>	<p><u>Instructional</u></p> <ul style="list-style-type: none"> • Pre-teach vocabulary • Use picture vocabulary • Scaffold Depth of Knowledge questions • Provide copy of notes/notes in “cloze” form • Use of Think, Pair, and Share strategy to help process information • Scaffold written assignments with the use of graphic organizers • Allow for multiple ways to respond (verbal, written, response board) • Provide model of performance task • Modify informational text to fit the needs of the students • Provide a digital or paper interactive notebook • Present complex tasks in multiple ways • Provide mnemonic strategies for Environmental Science concepts. 	<p><u>Technology:</u></p> <ul style="list-style-type: none"> • Audio reading of text • Text to type functions • Videos to clarify/visualize Environmental Science concepts • Record class lecture/discussions and make accessible to student • Nearpod- interactive presentations of notes • Playposit - show a video clip about the topic and add your own questions for them to answer as they watch • Allow students to type answers in chat on Teams <p><u>Other:</u></p> <ul style="list-style-type: none"> • Arrange seating for maximum engagement and minimum distraction 	<p><u>In Class Assessments</u></p> <ul style="list-style-type: none"> • Provide review packet or review sheet of concepts covered on the test • Practice similar questions prior to the test • Provide multiple options for projects • Give a timeline of when things are due and remind them of the process often. • Use of timer in class • Break all complex tasks into chunks 		
<p>Step Up to Writing</p> <p>Step Up to Writing materials can be found in BPS Science K-12 Schoology Folder</p>	<p><u>SUTW Strategies/Skills</u></p> <ul style="list-style-type: none"> • Informal Outline • Color-Coding – Informative/Explanatory Text • Two-column notes 				

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<p>→12 Resources → Climate Science→Climate Science Curriculum Materials→ Step Up to Writing Materials</p>	<ul style="list-style-type: none">● I-V-F Topic Sentence progressing to Four Step Summary Paragraph● CUPS – Capitalization, Usage, Punctuation, Spelling● Transitions
<p>Culturally and Linguistically Responsive Teaching (CLRT) in the Science Classroom</p>	<ul style="list-style-type: none">● Materials, resources, and/or discussions address diverse cultural backgrounds and real-world applications● Artifacts (posters, charts, etc.) in the science classroom are representative of the cultures of the student population● All students are given an opportunity to engage in science discourse● Teacher demonstrates high expectations for all students <p>CLRT resources which align to Science content are denoted with a **</p>