

Streams and Steam

Effects of Climate Change on the Water Cycle

Description

Students play a Chutes-and-Ladders-style board game to understand the effects of climate change on the water cycle.

Grade Level

5 – 12

Objectives

Students will:

- Predict how increasing temperatures on Earth will affect the water cycle
- Synthesize information about the effects of climate change on the water cycle
- Explain how changes in the water cycle affect humans

Time

1 Hour

Common Core State Standards

English Language Arts Standards >> Reading: Informational Texts >> Grade 5

CCSS.ELA-LITERACY.RI.5.4: Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 5 topic or subject area.

English Language Arts Standards >> Speaking & Listening >> Grade 5

CCSS.ELA-LITERACY.SL.5.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly.

English Language Arts Standards >> Science & Technical Subjects >> Grade 6-8

CCSS.ELA-LITERACY.RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts. [Extension Activity]

CCSS.ELA-LITERACY.RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 6-8 texts and topics*.

CCSS.ELA-LITERACY.RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

English Language Arts Standards >> Science & Technical Subjects >> Grade 9-10

CCSS.ELA-LITERACY.RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. [Extension Activity]

CCSS.ELA-LITERACY.RST.9-10.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 9-10 texts and topics*.

CCSS.ELA-LITERACY.RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

English Language Arts Standards >> Science & Technical Subjects >> Grade 11-12

CCSS.ELA-LITERACY.RST.11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. [Extension Activity]

CCSS.ELA-LITERACY.RST.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11-12 texts and topics*.

New Mexico State Science Standards

(Strand – Standard – Benchmark – Performance Standard)
5th Grade

2-2-1-4: Describe how human activity impacts the environment.

2-3-2-1: Understand that water and air relate to Earth's processes, including how the water cycle relates to weather.

3-1-1-1: Describe the contributions of science to understanding local or current issues (e.g., watershed and community decisions regarding water use).

6th Grade

2-3-2-5: Understand factors that create and influence weather and climate, including: heat, air movement, pressure, humidity, oceans, how clouds form by condensation of water vapor, how weather patterns are related to atmospheric pressure, global patterns of atmospheric movement (e.g., El Niño), factors that can impact Earth's climate (e.g., volcanic eruptions, impacts of asteroids, glaciers).

3-1-1-1: Examine the role of scientific knowledge in decisions (e.g., space exploration, what to eat, preventive medicine and medical treatment).

7th Grade

2-1-2-1: Know how various forms of energy are transformed through organisms and ecosystems, including: effect of mankind's use of energy and other activities on living systems (e.g., global warming, water quality).

3-1-1-3: Describe how scientific information can help individuals and communities respond to health emergencies (e.g., CPR, epidemics, HIV, bio-terrorism).

8th Grade

2-2-1-1: Describe how matter moves through ecosystems (e.g., water cycle, carbon cycle).

2-2-1-3: Explain how a change in the flow of energy can impact an ecosystem (e.g., the amount of sunlight available for plant growth, global climate change).

2-3-2-2: Understand the unique role water plays on Earth, including: ability to remain liquid at most Earth temperatures, properties of water related to processes in the water cycle: evaporation, condensation, precipitation, surface run-off, percolation, dissolving of minerals and gases and transport to the oceans, fresh and salt water in oceans, rivers, lakes, and glaciers, reactant in photosynthesis.

3-1-1-2: Describe how scientific information can help to explain environmental phenomena (e.g., floods, earthquakes, volcanoes, fire, extreme weather).

9th – 12th Grade

1-1-2-2: Use scientific reasoning and valid logic to recognize: faulty logic, cause and effect, the difference between observation and unsubstantiated inferences and conclusions, potential bias.

2-2-1-4: Critically analyze how humans modify and change ecosystems (e.g., harvesting, pollution, population growth, technology).

2-3-2-8: Describe the patterns and relationships in the circulation of air and water driven by the sun's radiant energy, including patterns in weather systems related to the transfer of energy, differences between climate and weather, global climate, global warming, and the greenhouse effect, El Niño, La Niña, and other climatic trends.

2-3-2-12: Explain how the availability of ground water through aquifers can fluctuate based on multiple factors (i.e., rate of use, rate of replenishment, surface changes, and changes in temperature).

Next Generation Science Standards

5th Grade

5-ESS2-1: Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

Middle School

MS-ESS2-4: Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

MS-ESS3-1: Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

High School

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-ESS3-5: Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

Materials

- *What Is Happening to Our Water?* handout [1 per student]
- *Streams and Steam* handout [1 per student]
- *Streams and Steam* game board [1 per group]
- Optional: *Water Cycle* diagram [1 per group]
- PowerPoint presentation
- Computer and projector*
- Four unique coins, e.g. penny, nickel, dime, and quarter* [1 set per group]
- Die [1 per group]

* Not included in kit

Background

The availability of water resources for humans, our crops, and our livestock is changing because of the enhanced greenhouse effect and resulting global warming and climate change.

The greenhouse effect ensures that Earth is warm enough to sustain life. Electromagnetic radiation from the sun, mostly at short wavelengths in the form of light, is able to pass through the atmosphere and is absorbed by Earth. Earth re-radiates some of this energy back toward space as thermal energy, more of which was able to pass through the atmosphere and escape into space. However, we are currently

experiencing the enhanced greenhouse effect, which is caused by increased greenhouse gases in our atmosphere. As higher levels of greenhouse gases are released into the atmosphere, more of the re-radiated thermal energy from Earth is re-emitted back to Earth instead of escaping to space. This is causing the average global temperature to increase. The increasing temperature of Earth is called global warming.

Global warming is leading to additional changes to our climate, such as increased frequency of extreme weather events and changing precipitation patterns, wind patterns, and length of seasons. These long-term changes in measures of climate are called climate change.

The water cycle is the movement of water on, in, and above Earth, and it is largely driven by energy from short-wave electromagnetic radiation (sunlight) absorbed by Earth's surface. The effects of climate change on the water cycle are numerous because of how warmer temperatures affect water cycle processes. Warmer water evaporates more readily, and warmer air has the capacity to hold more water vapor. As a result, in some areas, the frequency of intense precipitation events will increase, and other areas will experience more drought. Also, because of higher temperatures, more precipitation is falling as rain instead of snow. In parts of the Northern Hemisphere, early arrival of warm spring season temperatures results in earlier snowmelt and altered streamflows.

Tips for Entire Class Participations

- Students can be divided into small groups of up to 4. Each student will have a coin and will be playing the Streams and Steam board game against their group members.
- If extra game boards are available, even smaller groups may allow for more participation from some students.

Preparation

1. Plan to divide students into groups of up to four.
2. Set up a computer and projector and display the PowerPoint presentation.

Teaching Guide

Activity Introduction (~10 minutes)

1. Pass out a *What is Happening to Our Water?* handout to each student.
2. Instruct students to read the excerpt at the top of the handout.
3. Once most students have had enough time to read the excerpt, introduce the activity with the PowerPoint presentation.
 - a. Slide 2: Earth is getting warmer because of the enhanced greenhouse effect. Increased greenhouse gases in the atmosphere have resulted in global warming, which includes higher global surface temperatures and also higher air and water temperatures. (Review the greenhouse effect and global warming if needed.)
 - b. Optional: Pass out copies of the *Water Cycle* diagram.
 - c. Ask students to draw on their understanding of the water cycle to predict the effects of warmer air and water temperatures on the processes of the water cycle; direct them to write their predictions on the handout. Students can use the *Water Cycle* diagram (if they have a copy) and the excerpt at the top of the handout.

Procedures: Playing Streams and Steam (~35 minutes)

1. Divide students into groups of four.
2. Pass out a *Streams and Steam* handout to each student.
3. Pass out a *Streams and Steam* game board to each group.

4. Use the PowerPoint presentation to explain the game.
 - a. Slide 3: This is the *Streams and Steam* game board. The game is played like “Chutes and Ladders.”
 - b. Slide 4: Rules of the game:
 - i. Roll the die to determine who starts the game.
 - ii. The player who rolls the highest number goes first.
 - iii. Players follow in turn from left to right.
 - iv. All players begin with their coin on the start space.
 - v. Roll the die and move the coin the number of spaces indicated.
 - vi. When a player lands on a space that is at the top of a stream, they will “raft” down the stream by moving their coin to the square at the bottom of the stream.
 1. Move in the direction of the arrows, from the smaller to larger end of the stream.
 - vii. When a player lands on a space that is at the bottom of a column of steam, they will rise up the column of steam by moving their coin up to the square at the top of the steam column.
 1. Move in the direction of the arrows, from smaller to larger puffs of steam.
 - viii. The squares without pictures do not require any further action. The player will rest there until their next turn.
 - ix. Two or more players may stop at the same square together.
 - x. The first player to cross into the finish space wins the game. An exact roll of the die is not required to win.
5. In the *Streams and Steam* handout, instruct students to list all of the causes and effects that each student from their group lands on during the game. On the game board, causes are written in the beginning stream or steam square, and effects are listed in the square where the stream or steam ends. Example: cause – increased evaporation; effect – more water in the atmosphere.
 - a. Instruct students to only write each pair of causes and effects once if they are landed on multiple times.
 - b. Instruct students to use the Key of Possible Actions on page 1 to write in the third column possible actions that can be taken to mitigate or adapt to the cause and effect listed.
6. Slide 5: Explain the Key of Possible Actions
 - a. Instruct students to look at the example that has been done on their handout.
 - b. Review example of using the Key of Possible Actions as students play the game.
 - c. Keep this slide up as students play the game for their reference as they complete the third column of their table.
7. Pass out a set of four unique coins and a die to each group. Ask students to give each player one coin and begin playing.
8. Play as many rounds of the game as time permits. One round of the game takes approximately 10 – 15 minutes.

Results and Conclusions (~15 minutes)

1. Ask students to volunteer to summarize the effects of climate change on the water cycle that they learned from playing *Streams and Steam*. Return to the PowerPoint presentation to review the effects summarized by students and to wrap up the activity.
 - a. Slide 6: Review some of the important effects of climate change on the water cycle.
 - i. Because surface, air, and water temperatures on Earth are increasing, there is a higher rate of evaporation of water into the atmosphere. Warmer air holds more water, which changes precipitation patterns. Also, water vapor is a greenhouse gas, so more water in the atmosphere further enhances the greenhouse effect and changes the climate.

- ii. We will experience more severe drought in some areas. As climate change intensifies, climate scientists predict less rainfall in the Mediterranean, southwest North America, and southern Africa.
 - iii. Earth will receive increased precipitation in some areas. More precipitation is predicted in Alaska and other high latitudes of the Northern Hemisphere and near the equator.
 - iv. As global surface temperatures continue to increase, most areas on Earth will have warmer winter temperatures.
 - 1. Warmer winter temperatures mean that more precipitation falls as rain instead of snow. Snowpack will be reduced, and there will be less water stored in snow to supply watersheds.
 - 2. With warmer winters and spring-like temperatures coming earlier, snow is melting earlier, altering the timing of streamflow. The increased temperature in springtime increases evaporation from surface water bodies, reducing overall streamflow. This generally means that less water is available during late spring and summer months when demand is highest for crops, livestock, and general public use.
2. To answer question 1 on page 2 of the handout, ask students to explain how these changes to the water cycle will affect humans [possible answers: less water available for crops, livestock, and general public use; less food available because of decreased water supply for crops and livestock and increased water temperatures in fisheries; loss of life and property due to flooding and more extreme weather events; increased soil erosion due to flooding and drought; less snow for recreation; changes in ability to produce hydroelectric power because of changes in streamflow].
 3. Slide 7: Instruct students to think in more detail about mitigations and adaptations to the effects of climate change on the water cycle. Guide them to fill in the table in question 2 on page 2 of the handout. Ask them to choose three effects from the game table and go into more detail about how the actions they listed for each of the effects could be carried out.

Extensions

1. Students read and discuss the National Public Radio (NPR) article, “There’s a Big Leak in America’s Water Tower.” <http://www.npr.org/2014/08/27/341372550/theres-a-big-leak-in-americas-water-tower>
 - a. Following reading, students can predict how climate change will affect organisms, directly or indirectly, in their region.

Additional Resources

1. National Aeronautics and Space Administration (NASA), Earth Observatory. The Water Cycle and Climate Change. Web. Accessed 7 May 2015. <<http://earthobservatory.nasa.gov/Features/Water/page3.php>>.
2. Online quiz about the effects of global warming on the water cycle for students: National Oceanic and Atmospheric Administration (NOAA), Ocean Explorer. Global Warming and the Water Cycle. Modified 12 Feb. 2013. Web. Accessed 30 Apr. 2015. <http://oceanexplorer.noaa.gov/edu/learning/7_water_cycle/activities/global_warming.html>.

This lesson has been adapted for New Mexico Climate Champions from “Streams and Steam” by the Asombro Institute for Science Education and the Southwest Climate Hub. < <https://swclimatehub.info/education/climate-change-and-water-cycle/day4>>