Earth, Climate, and Change: Observing Human Impact
Standards
The content is in accordance with the Next Generation Science Standards (NGSS), specifically:

**ESS2, Earth’s Systems**
- The Roles of Water in Earth’s Surface Processes (water cycle, relationship between patterns of water movement in the atmosphere and local weather patterns)
- Weather and Climate (influence of interactions between the geosphere, hydrosphere, atmosphere, and biosphere; major influence of ocean on weather and climate)
- Biogeology (feedback between the biosphere and other Earth systems)

**ESS3, Earth and Human Activity**
- Human Impacts on Earth Systems (damage or destruction of natural habitats)
- Global Climate Change (factors affecting the rise of Earth’s mean surface temperature and the impact on climate)

The content also addresses climate, earth science, and atmospheric literacy principles, which are considered essential information by the Earth and Space Sciences community. (See the Framework for Science Education in “References and Further Reading.”)

Prerequisite Knowledge
Before doing these activities, especially Activity 3: Where Does the Water Go? A Global Journey, students should be familiar with the water cycle.

Introduction
Climate change means the unusually rapid warming of the atmosphere and its scientifically documented effects around the world. The warming is measurable: although annual local weather patterns vary, the average global temperature has increased by nearly 0.8°C (1.5°F) in the last 100 years. This might not sound like much, but even small temperature changes, occurring worldwide, have a noticeable effect on the climate, which affects habitats for all organisms, including humans. In addition, the pace of change is increasing—most of the rise in average global temperature has occurred in the last few decades.
Climate change and the human contribution to this change is sometimes denied or depicted as an uncertainty. However, according to the American Association for the Advancement of Science (see References and Further Reading), climate change is not controversial: 97 percent of climate scientists are certain that human-caused climate change is occurring. Climate research is continuing, with scientists and engineers working to predict the consequences of climate change and finding ways to overcome its negative impact.

People around the world, in cities and in rural areas, are experiencing more extreme temperatures, stronger storms, and loss of land from rising sea levels. Some of the most dramatic effects of climate change are related to water: either too much water that results in flooding or too little that results in droughts and wildfires.

For example, even slightly increased temperatures that result from climate change will melt sea ice. Both melting sea ice and higher temperatures increase the volume of the ocean. Greater ocean volume means higher levels of water along coastal areas, which adds to erosion of these areas. In addition, melting sea ice can lead to global changes in water circulation. Water from the melted ice forms a layer at the sea surface that is less dense than the underlying water because it is less salty, potentially preventing the patterns of deep ocean currents from rising to the surface. Melting sea ice also speeds up the warming of the Arctic because water absorbs 80 percent of sunlight, which is about the amount of sunlight that a cover of sea ice reflects.

In this collection, students will use photographs as data to observe and identify changes over time in water-related features such as coastlines or glaciers. They will use photographs to prompt discussions on the consequences of climate change to humans and habitats. They might even use photographs as motivation to explore how they can be citizen scientists and engineers in studying climate change and mitigating its negative effects in their own communities.

*Note: The term “weather” refers to short-term atmospheric features such as precipitation, wind, and temperature. “Climate” means the long-term weather patterns of an area; for example, average temperatures over many years.*

Older references might use the term “global warming” to refer to climate change. Global warming refers to the heating effect of greenhouse gases accumulating in the atmosphere. Scientists study more than just how temperature is affected by human activity, however. To emphasize that human activity does more than just influence temperature, the more common term for rising average global temperatures and its effect is “climate change.”
**Key Learning Targets**

**Students will:**

- Observe how living organisms alter Earth’s processes and structures over time.

- Consider how human activity changes the atmosphere, hydrosphere, and biosphere over time.

- Discuss the interactions between processes on the Earth’s surface and human activities.
ACTIVITY 1

Activating Students’ Prior Knowledge

In pairs or small groups, give students one or more of the photographs. Ask students to first talk about their overall impressions of the image, what they see, and what they think the image is of and/or trying to portray. Then have the groups write their observations about evidence they see of effects on habitats, signs of human activity, or the impact of humans. (Students might or might not see any or all of these features in their photographs. For example, although they can’t see the dam in 3506, they can figure out where it is, hypothesize that the dramatic change in the water is the result of human activity, and brainstorm about its effects on habitats. Although they can’t see how climate change increases coastal erosion, they can begin to hypothesize about its impact on habitats, including for humans.) In groups or as a class, discuss how any activity or impacts they see might be affecting or have affected communities of organisms, including humans.

Emphasize that at this point, no questions or ideas are considered right or wrong.

Note: Frequently asked questions by students about sea level are: What causes sea levels to rise? What is the impact? Some answers are that changes in sea level are caused by several factors:

* Exchange of water stored on land in glaciers and ice sheets with ocean water
* Water expansion as the ocean warms
* Storm surges affected by alterations in surface and deep ocean circulation
* Changes in terrestrial water storage, such as extraction of groundwater, building of reservoirs, and runoff
* Subsidence (caving or sinking of land) in river delta regions, land movements, and tectonic displacements

Impacts of rising sea level include shoreline erosion, effects on wetlands and coral reefs, and loss of habitats and land near coasts or rising rivers and streams.
Notes: Students might ask about permafrost. Permafrost is soil that is permanently frozen. When the permafrost melts, the soil is more susceptible to erosion. (In addition, permafrost stores carbon. When the icemelts, the stored carbon is released as greenhouse gases such as carbon dioxide, which further contributes to climate change.)

The term hurricane is used for high wind, cyclonic storms in the Atlantic and Northeast Pacific. The same storm is a typhoon in the Northwest (Asian) Pacific, and a cyclone in the South Pacific and Indian Ocean. Monsoon is the term for a seasonal wind in Southeast Asia. Some monsoons bring heavy rain.

Also, see the Habitable Planet resources (see “References and Further Reading”), which have potential discussion topics and common student misconceptions, such as the possibility of a technological fix or the impossibility of human extinction.
ACTIVITY 2
What Is the Evidence?

Learning Targets:

• I can use photographs to observe changes over time and make inferences on the effects of these changes.

• I can ask questions about the evidence of change that is altering the global climate.

Background

Weather changes and overall climate can vary between warm and cool periods; however, average global temperatures have unquestionably risen in the last 100 years. Photographs can record how the effects of small changes in temperature will, over time, result in dramatic changes in oceans, coastlines, and other habitats. Photographs are essential for recording these changes because they might occur slowly, with variation over months or years that obscures a definite overall trend. For example, because coral reefs grow slowly, changes to their structure or composition are difficult to observe day to day. The same slow alterations occur to polar caps, glaciers, and sea level. Over time, however, these small changes add up to a noticeable difference. In this activity, students will use photos taken of a single location at different times to look for evidence of climate change.

Climate scientists have overwhelming evidence that human activities are affecting our climate, mainly through increased production of greenhouse gases such as methane and carbon dioxide (CH4 and CO2). Many sources generate these gases, including normal metabolism. Humans exhale CO2 and several types of bacteria generate CH4. Burning fossil fuels also generates greenhouse gases, however, and our use of petroleum-based fuels and the amount of greenhouse gases in the atmosphere have increased dramatically since the nineteenth century. Greenhouse gases re-radiate heat, raising atmospheric temperatures. Higher temperatures increase the amount of water that evaporates from oceans into the air. This affects land conditions as precipitation patterns change, potentially leading to floods or droughts.

Although we sometimes think of climate change as affecting only summer temperatures, in many ecosystems, warming winters also severely affect plants, animals, and humans. For example, increased atmospheric moisture makes snowstorms more severe. A lack of freezing days can cause infestations of insects that would normally be killed by freezing temperatures.
Another consequence of climate change is rising sea levels because of several factors, including higher water temperatures, and increased volume as water that is trapped as ice sheets and glaciers melts. When sea levels are higher, islands and coastal regions are more seriously affected by storm surges and, on an everyday basis, by encroaching salt water that changes habitats. Plants, animals, and microorganisms that are adapted to particular environmental conditions must adapt or change habitats to survive. Changing habitats affect conditions for humans, such as our supply of food and water.

Begin the Activity

In pairs or small groups, give students a series of photographs of the same location taken at different times. Have students observe, and then list and describe all the features in each photograph. Have them pay particular attention to anything that changed or anything that is exactly the same in the photos.

Once they have generated a list, have the students mark the list for items that changed and items that did not change in the photo series. Have the students use the list to draw a Venn diagram. One circle will list items in the earlier photo, with their descriptions, that look different from items in the later photo. The other circle will list items in the later photo, with descriptions, that look different from the earlier photo. The intersection will list items that appear the same in both photos. (So the nonintersecting parts might list the same items—such as a mountain or a rock—but will have different descriptions for those items, such as snow-covered or bare. The intersecting part will have items that have the same descriptions for both photos, such as a rocky ridge with a little snow.)

Optional, advanced, or group discussion example: Photo 3516 show photos before and after Hurricane Sandy, a particularly strong hurricane in 2012. Although an individual hurricane might seem like an isolated event, increased atmospheric moisture can make storms more severe.

Students’ answers will vary depending on the set of photos they received. Their answers should reflect the changes they have already noticed and what will happen if those changes continue.

For example, if they noticed that the amount of water in an area has increased over time, they might say that the area is likely to continue flooding, and people who live in the area will have to move.

They might note that coral reef death affects species that depend on coral habitats. (Coral bleaching, which is loss of the algae that live in coral tissues, occurs when water is too warm and can lead to death of the coral.)

Materials:
- Paper, pencils or pens

Questions to Consider
- What might be the impact of these changes beyond what is in the photo?
- What changes might be disruptive for wildlife habitats, vegetation, or human communities?
- What ways can you think of to reduce the disruptive effects of the changes you observed?

* Suggested activity for this question: Have students make a two-column table with pros and cons of trying to reduce a disruptive effect of climate change. For example, if students think of building a dam to prevent floods, a good exercise might be writing down the upstream effects of a dam.

Optional question if your class has covered material on Earth’s Systems (ES22): What might be the scientific basis for any changes your team noted in the earlier and later photographs?
They might note that flooding could continue if warmer temperatures result in increased water evaporation, leading to the heavy rainfall that causes flooding. In contrast, increased evaporation in places that are normally dry results in droughts. Other impacts include heat waves; warmer winters; changing ecosystems; a possible loss, decrease, or increase in species; and effects on agriculture from drought, heat, and floods.

Anything that causes changes in the ecosystem is likely to be disruptive to wildlife. For example, flooding will disrupt a habitat for any wildlife living in the flooded area. Students might note that, although humans often have the technology to help them live in changing conditions, severe changes, such as extreme flooding or drought, might cause people to move from a community.
ACTIVITY 3
Where Does the Water Go? A Global Journey

Learning Targets

• I can describe the cycling of water through Earth’s systems.

• I can interpret and explain how the complex interactions of air and water movements results in changes in local weather.

Background

This activity should be done after the class has learned about the water cycle. Consider reviewing the essential features of the cycle before starting this activity.

Water is three-fourths of the Earth’s surface. Most of that water (97%) is in oceans, so changes in our oceans also have profound effects on the atmosphere and conditions on land. As students learned in the class, water is solid (ice), liquid (water), or gas (vapor), moving between these states and around the planet. Sunlight melts ice and evaporates water, creating atmospheric water vapor, which condenses into rain or snow. Gravity causes the water to fall to Earth, where it returns to oceans, lakes, and rivers.

Materials

• Sticky notes
Begin the Activity

Students might have noticed that many of the consequences of climate change that they have been observing in the photo collection are related to water. Increased atmospheric moisture leads to stronger storms and flooding, for example. Ask students what percent of the Earth’s water they think is in oceans (97%). Ask them to identify other locations of water (including ice) on Earth and in the Earth’s atmosphere.

After reviewing the locations of water, have students work in small groups or pairs to re-create the water cycle by using the provided photos. As they arrange photos on their desks, have them explain the different water states (ice, liquid, and vapor), how water might travel between locations while in the different states, and the factors—such as sunlight or air temperature—that might cause water to be converted to one state or another. (Optional: have them refer to a diagram of the water cycle from their textbook or other source.)

Ask students to reflect and comment on connections between the states of water and its global locations. Have them discuss the likely consequences of climate change on each step, each component, and the entire system. To keep track of their ideas, they might add sticky notes to each picture, predicting the effects of climate change on this part of the water cycle.

Students might predict acceleration or intensification of parts of the cycle; for example, they might predict increased evaporation with increased temperature. They might predict stronger rain and snowstorms after the increased evaporation.

Questions to Consider

- What ideas did your group come up with about the possible effects of climate change on the water cycle? Share your results with other groups. How do your ideas compare to the ideas of other groups?

- Overall, how would you describe the effects that climate change might have on the water cycle, especially if current trends continue?

- What are the impacts that water and changes in water level can have on the surface of the earth?

- How did photographs help organize ideas about climate change and the water cycle?

- Optional/advanced: If you have studied other cycles that occur on the earth, do you think that they would also be affected by climate change? If climate change continues with recent trends, what might happen on the surface of the Earth?
ACTIVITY 4
Citizen Science

Learning Targets:
• I can apply scientific principles to evaluating methods for monitoring and minimizing human impact on my local environment.

Background
Scientists and the public are noticing more extreme weather of all types, such as stronger winter storms, earlier springs, and warmer summers. These observations give students opportunities to design or contribute to public science projects. For example, temperatures, storm frequencies, and rain and snowfall can all be measured. Your school might even be involved in recording local meteorological data. Long-term weather data for your area might be available at local or national websites. Climate change affects habitats, which influences the plants and animals in an area and the timing of their seasonal appearances. Conservation societies often organize volunteers to keep records of local flora and fauna; for example in annual bird and fish counts or plant surveys. Teachers, students at your school, or their families might be involved in these efforts. Other examples of ways that students might participate in public science projects are in the photos.

In this activity, students will use photographs as prompts to discuss what they are or could be doing to apply what they have learned in this collection to observe or address climate change in their community.

Begin the Activity
Give students photos of climate scientists and student-citizen scientists at work. Use the photos as prompts for discussions about what problems climate change is creating around the world, either issues students have heard of or effects they would predict based on what they have learned about climate change, the water cycle, weather, and climate. Have students discuss possible studies and research projects they might conduct locally.

Photographs for This Activity (Appendix, pgs. 55-59)
3556, 3557, 3569, 3570, 3571

Question to Consider
• What are some actions an ordinary citizen scientist can take to counteract the negative impact of climate-change-related local weather patterns? Choose a possible action and discuss whether a community affected by climate change should take this action. If so, what might some consequences be? If not, why not?
Extension Activities

1. Explore current extreme weather events around the globe. Check news sources to find examples of extreme weather events. Find news stories with photos and examine the photos, using the questions from the activities in this collection. An additional option is to write an essay in a style your class has been learning (such as persuasive) based on one or more news stories and the accompanying photos.

2. Join the U.S. Geological Survey’s iCoast project, and analyze coastline photographs before and after a major storm. Human eyes are better than computers at noting changes in complex coastline features, so the U.S. Geological Survey needs your help.

Essential Lens
Video Connections

• Watch A Closer Look to learn more about analyzing photographs
Reference Materials & Further Reading

Framework for Science Education

http://www.nap.edu/catalog.php?record_id=13165

Graph from the California Department of Water Resources
http://cdec.water.ca.gov/cdecapp/resapp/getResGraphsMain.action

The Habitable Planet
http://www.learner.org/courses/envsci/unit/text.php?unit=12&secNum=0


Gary Braasch website
http://www.worldviewofglobalwarming.org

Facing the Future
https://www.facingthefuture.org

American Association for the Advancement of Science (AAAS)
http://whatweknow.aaas.org/

NASA maps and climate change
http://earthobservatory.nasa.gov/Features/WorldOfChange/decadaltemp.php
http://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html

USGS Image gallery
http://gallery.usgs.gov/collections/Climate_Change

Erosion in Alaska
http://www.usgs.gov/newsroom/article.asp?ID=2141#.U5zXh41dVe5

Journey North
https://www.learner.org/jnorth/

GLOBE
www.globe.gov
Project Budburst
http://budburst.org

Cornell Laboratory of Ornithology
http://www.birds.cornell.edu

University Corporation for Atmospheric Research (UCAR) LEARN Project
http://www.ucar.edu/learn

Intergovernmental Panel on Climate Change
http://www.ipcc.ch

United Nations Educational, Scientific and Cultural Organization (UNESCO)

Education for Sustainable Development Toolkit
http://www.esdtoolkit.org

National Oceanic and Atmospheric Administration Climate Literacy
http://cpo.noaa.gov/OutreachandEducation/ClimateLiteracy.aspx

Loren Eiseley, anthropologist and author
http://www.eiseley.org

American Geophysical Union
http://virtualoptions.agu.org

Permafrost
http://www.wunderground.com/resources/climate/melting_permafrost.asp

California Drought Article

Books
http://www.earthunderfire.com


**Film and Video**

*Chasing Ice*
http://www.chasingice.com


**Additional Photographic Collections to Support this Topic**

NASA: Images of Change
http://climate.nasa.gov/state_of_flux#Drought_California_930x308.jpg

Thomas Lovejoy
http://www.nationalgeographic.com/explorers/bios/thomas-lovejoy/

The Shrinking Aral Sea and related student activities
http://www.columbia.edu/~tmt2120/introduction.htm

Annenburg Learner: Teaching Geography
http://www.learner.org/workshops/geography/pdf/1aralsea.pdf

NASA: Earth Observatory
http://earthobservatory.nasa.gov/IOTD/view.php?id=4463
APPENDIX

Activity 1
pgs. 18-33
3500, 3505, 3506, 3507, 3509, 3513, 3515, 3520, 3521, 3522, 3551, 3558, 3561, 3563, 3564, 3565

Activity 2
pgs. 34-42
3503, 3504, 3516, 3518, 3554, 3555, 3560, 3572, 3573

Activity 3
pgs. 43-54
3526, 3528, 3531, 3532, 3536, 3537, 3538, 3544, 3545, 3546, 3549, 3552

Activity 4
pgs. 55-59
3556, 3557, 3569, 3570, 3571
Activity 1

Permafrost Erosion Measurement

USGS researcher Benjamin Jones measures erosion near a collapsed block of ice-rich permafrost at the Arctic coast of Alaska. August 2008. (Christopher Arp/U.S. Geological Survey)
Activity 1

The Mirani Dam on the Dasht River in southern Pakistan was completed in 2006. The resulting reservoir provides water for drinking, irrigation, and hydroelectric power. Though the dam helps to control flooding, heavy rains in 2007 increased the reservoir depth from 244 to 271 feet (74 to 82 meters), which caused flooding that displaced more than 15,000 people. The left image shows the region before the dam was built. The image on right shows the dam in 2011 with the expanded reservoir.
Activity 1 - 3507

Aerial views of damage to Long Beach due to Hurricane Sandy. Following the hurricane, a nor'easter struck the area, causing more power outages and additional flooding.

A cabin along the Arctic Alaska coastline was recently washed into the ocean because the bluff it was sitting on top of was eroded away. August 2005. Alaska. (Benjamin Jones/U.S. Geological Survey)
Activity 1

How people are adapting to climate change and fighting food insecurity

For people who live in areas covered by water during the monsoon season, such as the riverine areas of Bangladesh, it is impossible to grow food on dry farmland. Practical Action has developed a technology to allow farmers to grow food on flooded land.

The floating garden is a clever solution that employs the use of water hyacinths, which are collected and used to construct a raft. This raft is then covered with soil and crops are grown. The raft floats on the water, and the crops grow in the flooded soil.

To grow food on dry farmland, farmers must adapt to the flooded conditions. This solution is particularly important for people who are affected by climate change and are adapting to new conditions.

October 3, 2006. Bangladesh. (Practical Action)
How people are adapting to climate change and fighting food insecurity

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The floating garden

is a clever solution that employs the use of water hyacinth, which is collected midway through the dry season. The plant is dried and can be composted to provide a new raft. A new raft is constructed every year, but the old one can be used as fertilizer during the dry season.

Date unknown. Bangladesh. (Practical Action)
Near Drew Point, Alaska, along the northern coast. The photo shows what often follows such undercutting: chunks of coastline tumbling into the sea. June 20, 2008. Alaska. (Stratus Consulting/University of Colorado)
Activity 1 - 3521 - Near Drew Point, Alaska, along the northern coast. The photo shows how ocean waves have undercut the land nearest the shore. Grassy turf extends out over a wave-cut notch.

Ocean waves slowly eat away coastal cliffs the world over, but in parts of Alaska, these processes have accelerated due to changing climate. There, coastal erosion owes its accelerated pace to two climate-driven phenomena: declining sea ice and thawing permafrost. August 9, 2007. Alaska. (Stratus Consulting/University of Colorado)
Activity 1 - 3522

Large parts of New Orleans remain flooded two weeks after several levees failed in the wake of Hurricane Katrina.

Activity 1

Many parts of New Orleans remain underwater with rescue operations ongoing over two weeks after Hurricane Katrina made landfall. September 16, 2005. New Orleans. (Bob McMillan/FEMA News Photo)
Activity 1 - 3558

Augusta city crew cleans up fallen trees off Broad Street in downtown Augusta. Throughout the east Georgia region, the grand total was 36,000 outages.

Georgia Power set up a massive staging area for utility trucks—many of them supplied by out-of-state contractors—in the Parking lot of the defunct Regency Mall South of downtown Augusta. February 13, 2014. Augusta, Georgia. (Hyosub Shin/Atlanta Journal Constitution/AP Photo)
Activity 1: 3561

Hurricane Sandy created widespread flooding, power outages, and devastation on Long Island, New York.

Activity 1

A view of a residential area flooded by heavy rains, with some areas receiving as much as 18 inches in a 24-hour period in Boulder, Colo., Sept. 14, 2013.

U.S. Soldiers with the 2nd General Support Aviation Battalion, 4th Combat Aviation Brigade, 4th Infantry Division, assist state and local emergency response officials and members of Colorado and Wyoming National Guard units who assisted Boulder and Larimer County civil officials September 14, 2013. Boulder, Colorado. (Staff Sgt. Wallace Bonner/U.S. Army)
Activity 1 - 3564

A view of state infrastructure destroyed by massive flooding along Colorado’s Front Range, September 14, 2013. Boulder, Colo. (Staff Sgt. Wallace Bonner/US Army)
Activity 1 - An extended area of Longmont, Colo., is mostly submerged as flooding continues to devastate the Front Range, Friday, Sept. 13, 2013. The flooding has affected parts of a 4,500-square-mile area, almost the size of Connecticut. September 13, 2013. Longmont, Colorado. (John Wark/AP Photo)
Activity 2 - 3503 - Muir Glacier and Muir Inlet, Alaska

This ship-deck-based August 1980 photograph of Muir Glacier and Muir Inlet, Glacier Bay National Park and Preserve, St. Elias Mountains, Alaska, shows the nearly 200-ft-long retreating tidewater end of Muir Glacier with part of its face capped by a few angular pinnacles of ice, called seracs. Note the icebergs in the ship's wake in the lower right side of the photograph. The location of Muir's terminus is less than a mile from the landward end of Muir Inlet, August 1, 1980. Alaska (Bruce Molnia/USGS, Survey).
Activity 2

Muir Glacier and Muir Inlet, 2003

This photo was taken in September 2003. In the 23 years between photographs (see image 3503), Muir Glacier has retreated more than a mile and ceased to have a tidewater terminus. Since 1980, Muir Glacier has thinned by more than 600 ft, permitting a view of a mountain with a summit elevation of greater than 4000 ft. Located in the center of the photograph, a re-examination of the 1980 photograph shows that the summit of this mountain was visible but that it was blended with adjacent clouds. September 1, 2003, Alaska.
Activity 2

The two aerial photographs show a portion of the New Jersey coastal town of Mantoloking, just north of where Hurricane Sandy made landfall. The photographs were taken 2 days before and 3 days after Hurricane Sandy passed through on October 29, 2012. The photographs were acquired by the NOAA’s National Oceanographic and Atmospheric Administration (NOAA) on October 27, 2012.

The two photographs show a dramatic comparison of the coastal town before and after the hurricane. In the before photograph, the town appears relatively intact. In the after photograph, the town is severely damaged with many houses washed away by the storm surge.

On the after image, the entire town is inundated by water, and blocks of houses down Route 35 are completely submerged. The storm surge was so powerful that it caused many houses to collapse, and debris from the beach and water were blown inland. The town of Mantoloking was hit particularly hard by Hurricane Sandy, which caused roughly $29.4 billion in damage.

The town of Mantoloking is located on the Jersey Shore, just south of New York City. It is considered to be one of the most vulnerable coastal towns in the United States due to its location on a narrow barrier island.

In 2013, the town of Mantoloking was one of many communities along the New Jersey coast that received significant financial assistance from the Federal Emergency Management Agency (FEMA) to help recover from the damage caused by Hurricane Sandy.

The two aerial photographs serve as a powerful reminder of the devastating impact that hurricanes can have on coastal communities and the importance of preparing and planning for such events.
Activity 2

Drought Conditions in California

California is undergoing its most severe drought in decades, due in part to decreased rainfall and reduced winter snowpack in the Sierra Nevada mountain range, as seen in these images. In 2013, California received less precipitation than in any other year since it became a state in 1850. Water conservation efforts are already in place for many locations, and the potential for wildfire and major agricultural impact is high. February 2011, 2013, and 2014. Lake Tahoe, California (U.S. Geological Survey Landsat Missions Gallery)
Activity 2

1894, Juneau, Alaska. (William Ogilvie/NSIDC/NOAA)
Activity 2 - Mendenhall Glacier has retreated 2800 meters since 1910 and 580 meters since 1948. The trimline on the north side of the glacier is evident. In this part of Alaska, vegetation grows rapidly on deglaciated terrain, usually developing substantial vegetation within 50 years. The lake began to form in 1910 as the glacier retreat reached the southern margin of the lake. Juneau, Alaska. (Gary Braasch Photography)
Activity 2 - Comparison photos showing the historic Millerton Courthouse as it sits atop a bluff overlooking Millerton Lake in Friant, Calif. in 2009, top, with the water at a high point; and on Aug. 5, 2014, where the water isn’t visible at the same angle. Currently, the level of water is at 270,284 acre feet or 51.9 percent of capacity. 2009 (top) and 2014 (bottom). Friant, California. [Darrell Wong (top) and Craig Kohlruss (bottom)/Fresno Bee/AP Photo]
Activity 2 - 3573
A dying Buck Island Barrier Reef, caused by a myriad of reasons, including bleaching caused by warmer ocean waters. 2011. St. Croix, U.S. Virgin Islands. (David Arnold/doublexposure.net/Marine Photobank)
Activity 3 - 3528

Reflection on Lake McDonald in Glacier National Park. May 14, 2012 Montana. (David Restivo/U.S. National Park Service)
Activity 3

Firehole River, Yellowstone National Park. February 26, 2014, Wyoming (Neal Herbert/U.S. National Park Service)
Activity 3

Morning fog in the Yellowstone River Valley, Yellowstone National Park, June 28, 2014, Wyoming. (Neal Herbert/U.S. National Park Service)
Activity 3 - 3538

Activity 3 - 3549

Activity 3 - Icebergs in Beascochea Bay, photographed during the 2013 LARISSA Expedition. The Larsen Ice Shelf System, Antarctica (LARISSA Project).
High in the Alps at more than 3000 m/9700 ft, botanists re-establish plots, set up ten years before, to see how climate warming has affected alpine plants. The regional average temperature is up 1.2°C/2°F in the last 30 years, and wildflowers and grasses adapted to colder elevations are being forced up the mountain. Botanist Harald Pauli, who, with colleagues from University of Vienna, set up the original study, counts individual plants and compares their location with the photos made in 1994. Other plots are being followed to see how climate change can be seen on the glaciers behind. August 2001. Schrankogel Mountain, Austria. (Gary Braasch Photography)
Activity 4 - Dr. Harald Pauli notes increased growth of moss campion and decreases in other plants in a plot first inventoried in 1994 (see photo record in his hand). The site is part of a world-wide study of how climate is changing ecosystems in mountains. August 2004. Schrankagel Mountain, Austria. (Gary Braasch Photography)
Activity 4 - 3569 - Identifying alpine species during a vegetation survey on Pitamakan Peak in the Two Medicine region of the park for the Global Observation Research Initiative in Alpine Environments (GLORIA) project. GLORIA surveys are conducted in the same locations every four years to study changes in vegetation patterns on conical mountaintops all over the world. Photographs are used to verify that each plot is set up in the precise location of previous surveys. August 2009. Glacier National Park, Montana. (U.S. National Park Service)
Activity 4 - 3570

Activity 4 - 3571
Students during the Cascades Climate Challenge at North Cascades National Park, July 2012, Washington. (Karlie Roland/U.S. National Park Service)