What causes a heat wave?

Why are these children playing in a fire hydrant?

The deadliest weather phenomena are not blizzards or hurricanes but heat waves. People who are poor or who live in areas where the weather is usually not hot may not have air conditioning. Children have a way of finding a solution to a problem that usually involves fun.

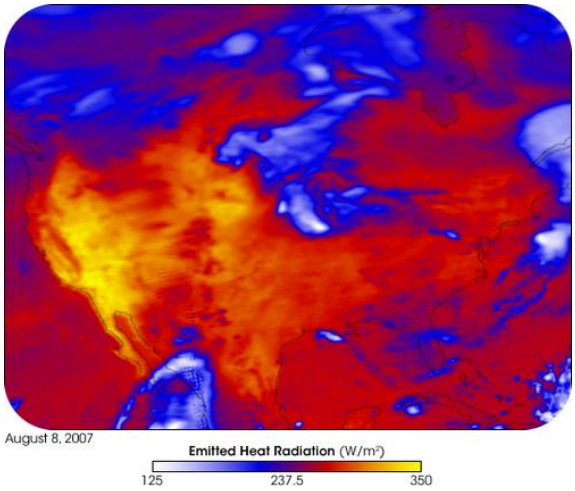
Section 1: Heat Waves

A heat wave is different depending on its location. According to the World Meteorological Organization a region is in a heat wave if it has more than five consecutive days of temperatures that are more than 9oF (5oC) above average.
Heat waves have increased in frequency and duration in recent years. The summer 2011 North American heat wave brought record temperatures across the Midwestern and Eastern United States. Many states and localities broke records for temperatures and for most days above 100oF.

CAUSES

A high pressure cell sitting over a region with no movement is the likely cause of a heat wave. What do you think caused the heat wave in the image below (Figure below)? A high pressure zone kept the jet stream further north than normal for August.

A heat wave over the United States as indicated by heat radiated from the ground. The bright yellow areas are the hottest and the blue and white are coolest.



Droughts

Droughts also depend on what is normal for a region. When a region gets significantly less precipitation than normal for an extended period of time, it is in drought. The Southern United States is experiencing an ongoing and prolonged drought.
Drought has many consequences. When soil loses moisture it may blow away, as happened during the Dust Bowl in the United States in the 1930s. Forests may be lost, dust storms may become common, and wildlife are disturbed. Wildfires become much more common during times of drought.

- It's hard to define a heat wave or a drought because these phenomena depend are deviations from normal conditions in a region.
- A heat wave is caused when a warm high-pressure cell sits over a region.
- Drought may have extremely severe consequences depending on its duration and intensity.

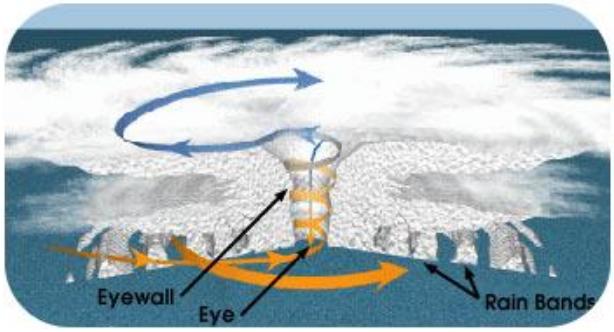
Section 2: Hurricanes

Hurricanes–called typhoons in the Pacific–are also cyclones. They are cyclones that form in the tropics and so they are also called tropical cyclones. By any name, they are the most damaging storms on Earth.

Formation

Hurricanes arise in the tropical latitudes (between 10o and 25oN) in summer and autumn when sea surface temperature are 28oC (82oF) or higher. The warm seas create a large humid air mass. The warm air rises and forms a low pressure cell, known as a tropical depression. Thunderstorms materialize around the tropical depression.

If the temperature reaches or exceeds 28oC (82oF), the air begins to rotate around the low pressure (counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere). As the air rises, water vapor condenses, releasing energy from latent heat. If wind shear is low, the storm builds into a hurricane within two to three days.



A cross-sectional view of a hurricane.

Hurricanes are huge and produce high winds. The exception is the relatively calm eye of the storm, where air is rising upward. Rainfall can be as high as 2.5 cm (1") per hour, resulting in about 20 billion metric tons of water released daily in a hurricane. The release of latent heat generates enormous amounts of energy, nearly the total annual electrical power consumption of the United States from one storm. Hurricanes can also generate tornadoes.

Hurricanes move with the prevailing winds. In the Northern Hemisphere, they originate in the trade winds and move to the west. When they reach the latitude of the westerlies, they switch direction and travel toward the north or northeast. Hurricanes may cover 800 km (500 miles) in one day.

Damage

Damage from hurricanes comes from the high winds, rainfall, and storm surge. Storm surge occurs as the storm's low pressure center comes

onto land, causing the sea level to rise unusually high. A storm surge is often made worse by the hurricane's high winds blowing seawater across the ocean onto the shoreline. Flooding can be devastating, especially along low-lying coastlines such as the Atlantic and Gulf Coasts. Hurricane Camille in 1969 had a 7.3 m (24 foot) storm surge that traveled 125 miles (200 km) inland.

The End

Hurricanes typically last for 5 to 10 days. The winds push them to the northwest and then to the northeast. Eventually a hurricane will end up over cooler water or land. At that time the hurricane's latent heat source shut downs and the storm weakens. When a hurricane disintegrates, it is replaced with intense rains and tornadoes.

There are about 100 hurricanes around the world each year, plus many smaller tropical storms and tropical depressions. As people develop coastal regions, property damage from storms continues to rise. However, scientists are becoming better at predicting the paths of these storms and fatalities are decreasing. There is, however, one major exception to the previous statement: Hurricane Katrina.

HURRICANE KATRINA

The 2005 Atlantic hurricane season was the longest, costliest, and deadliest hurricane season so far. Total damage from all the storms together was estimated at more than $128 billion, with more than 2,280 deaths. Hurricane Katrina was both the most destructive hurricane and the most costly.

Flooding in New Orleans after Hurricane Katrina caused the levees to break and water to pour through the city.

News about Hurricane Katrina from the New Orleans Times-Picayune:

http://www.nola.com/katrina/graphics/flashflood.swf

An animation of a radar image of Hurricane Katrina making landfall is seen here:

http://upload.wikimedia.org/wikipedia/commons/9/97/Hurricane_Katrina_LA_landfall_radar.gif

NASA's short video, "In Katrina's Wake":

http://www.youtube.com/watch?v=HZjqvqaLltI

Hurricanes are explored in a set of National Geographic videos found at National Geographic Video:

http://video.nationalgeographic.com/video/environment/environment-natural-disasters/hurricanes

At this link, watch the following videos:

- "Hurricanes 101" is an introduction to the topic.
- "How Katrina Formed" looks at the history of Hurricane Katrina as it formed and passed through the Gulf coast.
- Follow that up with "Doomed New Orleans," which explores how the devastation to the city is a man-made disaster.

- "The Hurricane Ike of 1900" looks at what happened in the days when there was little warning before a hurricane hit a coastal city.

Lots of information about hurricanes is found in this online guide from the University of Illinois:

http://ww2010.atmos.uiuc.edu/%28Gh%29/guides/mtr/hurr/home.rxml

Lesson Summary

- Hurricanes are actually tropical cyclones because they originate in the tropical latitudes.
- The damage hurricanes cause is due largely to storm surge, but high wind speeds and rain also cause damage.
- Hurricane Katrina was so damaging because the levees that protected New Orleans broke.

What is a tsunami?

"Tsunami" is a Japanese word meaning "harbor wave." Some people call them tidal waves. But these deadly waves are not related to tides and they are not restricted to harbors. Few words can express the horror these waves can bring.

Tsunami as Waves

Tsunami are deadly ocean waves from the sharp jolt of an undersea earthquake. Less frequently, these waves can be generated by other shocks to the sea, like a meteorite impact. Fortunately, few undersea earthquakes, and even fewer meteorite impacts, generate tsunami.

Wave Height

Tsunami waves have small wave heights relative to their long wavelengths, so they are usually unnoticed at sea. When traveling up a slope onto a shoreline, the wave is pushed upward. As with wind waves, the speed of the bottom of the wave is slowed by friction. This causes the wavelength to decrease and the wave to become unstable. These factors can create an enormous and deadly wave.

How a tsunami forms is shown in this animation:

http://highered.mcgraw-hill.com/olcweb/cgi/pluginpop.cgi?it=swf::640::480::/sites/dl/free/0072402466/30425/16_19.swf::Fig.%2016.19%20-%20Formation%20of%20a%20Tsunami

Landslides, meteorite impacts, or any other jolt to ocean water may form a tsunami. Tsunami can travel at speeds of 800 kilometers per hour (500 miles per hour)

A video explanation of tsunami is here:

http://www.youtube.com/watch?v=StdqGoezNrY&feature=channel

Wavelength

Since tsunami are long-wavelength waves, a long time can pass between crests or troughs. Any part of the wave can make landfall first.

In 1755 in Lisbon, Portugal, a tsunami trough hit land first. A large offshore earthquake did a great deal of damage on land. People rushed out to the open space of the shore. Once there, they discovered that the water was flowing seaward fast and some of them went out to observe. What do you think happened next? The people on the open beach drowned when the crest of the wave came up the beach.

Large tsunami in the Indian Ocean and more recently Japan have killed hundreds of thousands of people in recent years. The west coast is vulnerable to tsunami since it sits on the Pacific Ring of Fire. Scientists are trying to learn everything they can about predicting tsunamis before a massive one strikes a little closer to home.

See more at:

http://science.kqed.org/quest/video/scary-tsunamis/

Lesson Summary

- Tsunami have relatively low wave heights, so they are not noticeable until they move up a shore.
- Tsunami have long wavelengths. The time between two crests or two troughs can be many minutes.
- Tsunami warning systems have been placed in most locations where tsunami are possible.

Think Like a Hydrologist

1. What does the word tsunami mean?

2. Why has Japan had so many tsunamis?

3. What causes a tsunami?

4. How fast do the waves travel?

5. What happens to the tsunami as it reaches the continental shelf?

6. How do tsunamis differ from regular waves?

7. What was the deadliest tsunami ever recorded?

8. What does the Pacific Tsunami Warning Center do?

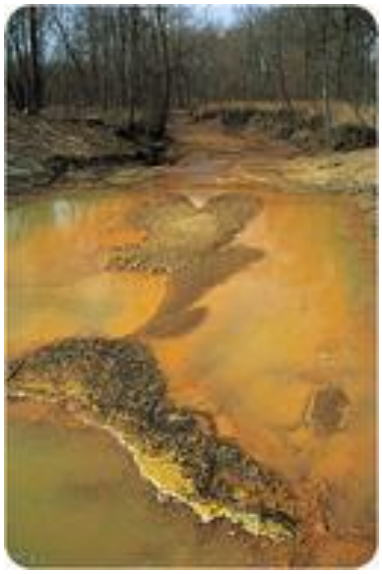
9. Why is a wave that is so powerful and tall on land unnoticeable at sea?

10. What should you do if you are at the beach and the water suddenly is sucked offshore?

11. Describe tsunami as waves in the way they travel up a shoreline and may strike as crests or troughs.

Which human activities contribute to the frequency and intensity of natural hazards?

How much does your mp3 player really cost? Many of the things we want come partly from minerals. But making minerals useful often causes environmental damage.



Acid drainage from a surface coal mine in Missouri.

Mining and the Environment

Although mining provides people with many needed resources, the environmental costs can be high. Surface mining clears the landscape of trees and soil, and nearby streams and lakes are inundated with sediment. Pollutants from the mined rock, such as heavy metals, enter the sediment and water system. Acids flow from some mine sites, changing the composition of nearby waterways (Figure left).

U.S. law has changed in recent decades so that a mine region must be restored to its natural state, a process called reclamation. This is not true of older mines. Pits may be refilled or reshaped and vegetation planted. Pits may be allowed to fill with water and become lakes or may be turned into landfills. Underground mines may be sealed off or left open as homes for bats.

- Surface mining clears the land, completely destroying the ecosystems that were found there.
- Mining releases pollutants, which affect the immediate area and may travel downstream or downwind to cause problems elsewhere.

- Reclamation occurs when people attempt to return the mined land to its original state.

What would cause such a tremendous dust storm?

Farmers were forced off their lands during the Dust Bowl in the 1930s when the rains stopped and the topsoil blew off these former grasslands. A wind storm blew huge amounts of soil into the air in Texas on April 14, 1935. This scene was repeated throughout the central United States.

Causes of Soil Erosion

The agents of soil erosion are the same as the agents of all types of erosion: water, wind, ice, or gravity. Running water is the leading cause of soil erosion, because water is abundant and has a lot of power. Wind is also a leading cause of soil erosion because wind can pick up soil and blow it far away.

Activities that remove vegetation, disturb the ground, or allow the ground to dry are activities that increase erosion. What are some human activities that increase the likelihood that soil will be eroded?

Farming

Agriculture is probably the most significant activity that accelerates soil erosion because of the amount of land that is farmed and how much farming practices disturb the ground (Figure below). Farmers remove native vegetation and then plow the land to plant new seeds. Because most crops grow only in spring and summer, the land lies fallow during the winter. Of course, winter is also the stormy season in many locations, so wind and rain are available to wash soil away. Tractor tires make deep grooves, which are natural pathways for water. Fine soil is blown away by wind.

The soil that is most likely to erode is the nutrient-rich topsoil, which degrades the farmland.

(a) The bare areas of farmland are especially vulnerable to erosion. (b) Slash-and-burn agriculture leaves land open for soil erosion and is one of the leading causes of soil erosion in the world.

Grazing

Grazing animals (Figure below) wander over large areas of pasture or natural grasslands eating grasses and shrubs. Grazers expose soil by removing the plant cover for an area. They also churn up the ground with their hooves. If too many animals graze the same land area, the animals' hooves pull plants out by their roots. A land is overgrazed if

too many animals are living there.

Logging and Mining

Logging removes trees that protect the ground from soil erosion. The tree roots hold the soil together and the tree canopy protects the soil from hard falling rain. Logging results in the loss of leaf litter, or dead leaves, bark, and branches on the forest floor. Leaf litter plays an important role in protecting forest soils from erosion (Figure right).

Logging exposes large areas of land to erosion.

Much of the world's original forests have been logged. Many of the tropical forests that remain are currently the site of logging because North America and Europe have already harvested many of their trees (Figure right). Soils eroded from logged forests clog rivers and lakes, fill estuaries, and bury coral reefs.

Deforested swatches in Brazil show up as gray amid the bright red tropical rainforest.

Surface mining disturbs the land (Figure below) and leaves the soil vulnerable to erosion.

(a) Disturbed land at a coal mine pit in Germany. (b) This coal mine in West Virginia covers more than 10,000 acres (15.6 square miles). Some of the exposed ground is being reclaimed by planting trees.

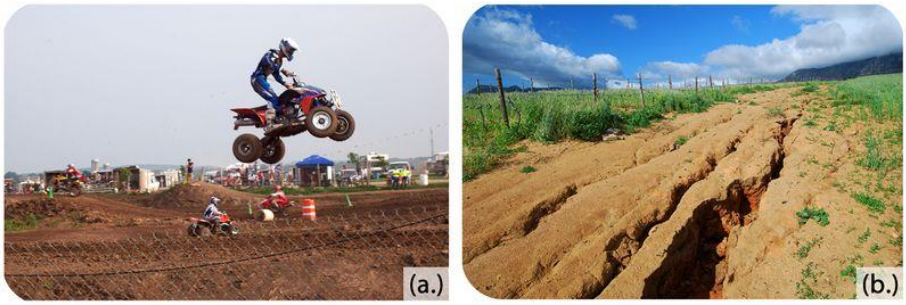
Construction

Constructing buildings and roads churns up the ground and exposes soil to erosion. In some locations, native landscapes, such as forest and grassland, are cleared, exposing the surface to erosion (in some locations the land that will be built on is farmland). Near construction sites, dirt, picked up by the wind, is often in the air. Completed construction can also contribute to erosion (Figure right).

Urban areas and parking lots result in less water entering the ground. Water runs off the parking lot onto nearby lands and speeds up erosion in those areas.

Recreational Activities

Recreational activities may accelerate soil erosion. Off-road vehicles disturb the landscape and the area eventually develops bare spots where no plants can grow. In some delicate habitats, even hikers' boots can disturb the ground, so it's important to stay on the trail



(Figure below).

(a) ATV'S churn up the soil, accelerating erosion. (b) Hiking trails may become eroded.

Soil erosion is as natural as any other type of erosion, but human activities have greatly accelerated soil erosion. In some locations soil erosion may occur about 10 times faster than its natural rate. Since

Europeans settled in North America, about one-third of the topsoil in the area that is now the United States has eroded away.

Lesson Summary

- Although soil erosion is a natural process, human activities have greatly accelerated it.
- The agents of soil erosion are the same as of other types of erosion: water, ice, wind, and gravity.
- Soil erosion is more likely where the ground has been disturbed by agriculture, grazing animals, logging, mining, construction, and recreational activities.

Think Like a Geologist

PRACTICE

Use this resource to answer the questions that follow.

`http://www.scalloway.org.uk/phye6.htm`

1. What is soil erosion?

2. Where is soil erosion common?

3. How can soil erosion be reduced?

4. What are good farming techniques?

5. What are some natural causes for soil erosion?

REVIEW

6. What is soil erosion? Why did soil erosion accelerate so greatly during the Dust Bowl?

7. How do human activities accelerate soil erosion? Since soil erosion is a natural process, is this bad?

8. What is the consequence of the acceleration of soil erosion?

How do Humans Impact the Carbon Cycle?

Humans have changed the natural balance of the carbon cycle because we use coal, oil, and natural gas to supply our energy demands. Fossil fuels are a sink for CO2 when they form, but they are a source for CO2 when they are burned.

The equation for combustion of propane, which is a simple hydrocarbon looks like this (Figure below):

$$\underset{\text{propane}}{C_3H_8} + \underset{\text{oxygen}}{5\ O_2} \rightarrow \underset{\text{carbon dioxide}}{3\ CO_2} + \underset{\text{water}}{4\ H_2O}$$

The equation shows that when propane burns, it uses oxygen and produces carbon dioxide and water. So when a car burns a tank of gas, the amount of CO2 in the atmosphere increases just a little. Added over millions of tanks of gas and coal burned for electricity in power plants and all of the other sources of CO2, the result is the increase in atmospheric CO2 seen in the graph above.

The second largest source of atmospheric CO2 is deforestation (Figure right). Trees naturally absorb CO2 while they are alive. Trees that are cut down lose their ability to absorb CO2. If the tree is burned or decomposes, it becomes a source of CO2. A forest can go from being a carbon sink to being a carbon source.

Why the Carbon Cycle is Important?

Why is such a small amount of carbon dioxide in the atmosphere even important? Carbon dioxide is a greenhouse gas. Greenhouse gases trap heat energy that would otherwise radiate out into space, which warms Earth. These gases were discussed in Concept

This forest in Mexico has been cut down and burned to clear forested land for agriculture.

Atmospheric Processes

This video “Keeping up with Carbon” from NASA, focuses on the oceans. Topics include what will happen as temperature warms and the oceans can hold less carbon, and ocean acidification:

http://www.youtube.com/watch?v=HrIr3xDhQ0E (5:39)

A very thorough but basic summary of the carbon cycle, including the effect of carbon dioxide in the atmosphere, is found in this video:

http://www.youtube.com/watch?v=U3SZKJVKRxQ (4:37)

Wildfires and Humans

The "Utah, Let's Do Our Part" campaign is the result of an interagency effort to reach the public with fire prevention messages relevant to Utah. The program targets three major preventable causes of fires in Utah. They are campfires, debris burning, and vehicle fires. It is the goal of the program to reach specific audiences with fire prevention messages in hopes of reducing the number of human-caused fires in the state. For example, many fires are started by unattended campfires left by teenagers or young adults out for an evening of fun in the mountains. Even on a cold night, campfires can burn all night and turn into major wildfires with a small breeze. The same problem exists with debris burning in the spring and fall. Just because the debris is burned on private land or in a remote corner of a large parcel of land doesn't mean it can be left unattended.

Vehicles are a major problem in Utah because vehicle fires are started in many ways. Often, people pull off the side of the road in the brush to get out of traffic and start fires by the hot cars without the driver ever knowing it. ATVs, trucks, and other vehicles that travel cross country are another major issue as exhaust sparks, dragging metal, hot engines, brake malfunctions, and more cause wildfires.

Source for the above info:

http://www.utahfireinfo.gov/prevention/campaign_info.html

Lesson Summary

- Carbon is essential for life as part of proteins, carbohydrates, and fats.
- The amount of carbon dioxide in the atmosphere is extremely low, but it is extremely important since carbon dioxide is a greenhouse gas, which helps to keep Earth's climate moderate.
- The amount of carbon dioxide in the atmosphere is rising, a fact that has been documented on Mauna Loa volcano since 1958.