

Chapter 13

Natural Hazards

Two great energy sources drive Earth's processes. Energy from the Sun drives the *external energy system*, while energy from Earth's hot core drives the *internal energy system*. Most natural hazards are related to one of these two energy systems. *Natural hazards* are events that can change and damage human and animal habitats. Earth's weather is part of the external energy system. What natural hazards are weather-related? The movement of the lithospheric plates is part of the internal energy system. What kinds of natural hazards are powered by Earth's internal energy?



Key Questions

1. *Does the Sun cause some natural hazards?*
2. *How do natural hazards affect habitats?*
3. *How does learning about earth science help you to stay safe?*



13.1 What Is a Natural Hazard?

A **natural hazard** is an event in nature that can cause extensive damage to land and property, and that threatens human lives. In this section, you'll be introduced to natural hazards. In Section 13.2, you'll learn about different kinds of hazards.

Energy for natural hazards

Two energy sources Most natural hazards are related to one of two energy sources—the Sun, or Earth's hot core. Earth's weather, driven by the Sun, is part of the *external energy system*. Weather-related natural hazards include hurricanes, flooding, and slumping. Plate tectonics, driven by the hot core, is part of the *internal energy system*. Natural hazards related to plate tectonics include earthquakes, tsunamis, and volcanic eruptions.

Earth science helps people Earth scientists can provide life-saving information in the event of a natural hazard. For example, because it is unlikely that humans will ever be able to stop a volcano from erupting, it is important to understand how volcanoes work. A volcanologist is an earth scientist who studies volcanoes (Figure 13.1).

Technology helps people Satellite and computer technology, and good communication also help protect people from natural hazards. Communication systems allow officials to alert people quickly if a natural hazard is about to happen. Before 1960, hurricanes, for example, could hit a coast without warning. Since 1960, weather satellites have helped predict and track hurricanes. Figure 13.2 shows a satellite image of Hurricane Hugo about to make landfall on the coast of South Carolina in 1989. Government organizations like the National Hurricane Center (NHC) monitor storms that might become hurricanes. The NHC issues hurricane watches and warnings so that people can evacuate a threatened area.

VOCABULARY

natural hazard - an event in nature that can cause extensive damage to land and property, and that threatens human lives.



Figure 13.1: A volcanologist speaking to the media.

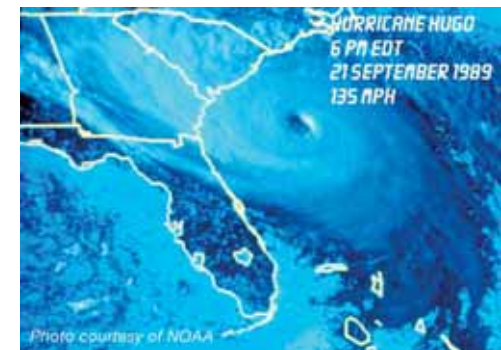


Figure 13.2: A weather satellite image of Hurricane Hugo making landfall on the coast of South Carolina.



Reducing the risks of natural hazards

Where do you live? Earth is an amazing place and this is especially true because there are so many interesting and scenic places to live. Where on Earth do you live? What's the best thing about where you live? What's the worst? It's possible that a potential natural hazard may be the worst thing, but it doesn't have to be. It's a good idea to study earth science so you understand natural hazards and how to stay safe!

Predicting natural hazards Some natural hazards, like hurricanes, can be predicted. Others, like earthquakes and volcanic eruptions, are very difficult to predict. Nonetheless, scientists who study natural hazards understand a great deal about why they occur and can judge when people should be warned.

Staying safe The time line for a hazard affects how the government manages resources to help the most people during a natural hazard. A *time line* is a description of what will happen during a particular event. Understanding the time line of a hazard is important in order to be able to take steps to reduce risks so that people do not get hurt and property is not damaged. For example, in an area with earthquakes, it is important to follow a plan like the one in Figure 13.3. But, the government has to be careful in how it issues warnings about hazardous events. If a warning is issued too early and the event doesn't happen, people may stop taking warnings seriously! This could lead to people getting hurt if an event eventually happens. As you read, ask yourself these questions:

- What natural hazards might occur where I live?
- How can I reduce the risks associated with a natural hazard?
- Do I know enough about this hazard to keep myself safe?
- Do I know what to do if the government issues a warning about the hazard?



Figure 13.3: Steps to earthquake safety.

13.1 Section Review

1. An earthquake can occur on the ocean floor where there is no human property and there are no people. Would this earthquake be considered a natural hazard? Explain your answer.
2. What energy source powers plate tectonics?
3. What energy source powers Earth's weather systems?
4. Name two natural hazards that occur as a result of plate tectonics.
5. Name a natural hazard that is related to weather.
6. How do earth scientists help keep people safe from natural hazards?
7. Hurricane hunters (Figure 13.4) include airplane pilots that fly into hurricanes. They can measure the wind speed of the hurricane and help track the hurricane. Why do you think taking these measurements helps keep people safe from hurricanes?
8. Before 1960, people living on the coast of the U.S. could not depend on hurricane warnings for protecting themselves. Why?
9. Can all natural hazards be easily predicted? Why or why not?
10. What is one thing you can do to protect yourself from risks associated with a natural disaster?
11. What is one danger associated with giving people a warning for a natural hazard that does not occur?
12. Write down three things you learned from studying the earthquake plan from Figure 13.3 (previous page).
13. A *habitat* is an environment in which an organism lives. How might a natural hazard affect the habitats of plants, animals, and people? Write your thoughts in a paragraph.

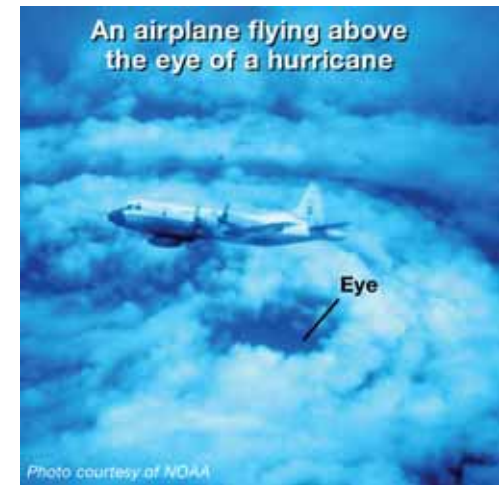


Figure 13.4: A hurricane hunter flying above the eye of a hurricane. The eye is a still place that is circled by the hurricane winds.

MY JOURNAL

There are four questions at the bottom of the previous page. Write responses to these questions on your own. Then, ask a parent or guardian to answer the questions. Talk about your responses together.



13.2 Natural Hazards Driven by External Energy

The Sun is Earth's external energy source. As you learned in Section 13.1, hurricanes, flooding, and slumping are some natural hazards that are driven by external energy from the Sun. In simple terms, a **hurricane** is wind that blows at speeds greater than 119 kilometers per hour (74 miles per hour). **Flooding** is an event that occurs when water overwhelms normally dry land. **Slumping** is an event that occurs when soil particles become surrounded by water so that the ground sinks or “slumps.”

Hurricanes

Wind, waves, and rain Hurricanes start as tropical storms and form over oceans. With the right ocean temperature, air moisture, and winds, a tropical storm can become a hurricane. For a coastline, the arrival of a hurricane means severe and dangerous winds, high waves, and a lot of rain.

Hurricane season During an average hurricane season (June 1 to November 30), six storms may form in the Atlantic Ocean, and over a three-year period an average of three hurricanes may hit the U.S. coast. The year 2005 was unusual in terms of hurricanes, with many “firsts.” For example, it was the first year with four major hurricanes hitting the U.S. (Figure 13.5). One of these hurricanes was Hurricane Katrina that made landfall in New Orleans.

How places are affected by hurricanes As long as hurricanes are at sea and away from ships, they are not threatening. Hurricanes become particularly hazardous to people and property when they arrive on land. Wind and waves damage property, and heavy rains cause flooding. The strong waves are called a *storm surge*. A storm surge is as dangerous as the wind so it is always important to leave a coastal area when a hurricane warning has been issued. After Hurricane Katrina, a storm surge breached the levees between Lake Pontchartrain and New Orleans, causing about 80% of the city to flood.

VOCABULARY

hurricane - wind that blows at speeds greater than 119 kilometers (74 miles) per hour.

flooding - an event that occurs when water overwhelms normally dry land.

slumping - an event that occurs when soil particles become surrounded by water so that the ground slides or “slumps.” Slumping is a form of mass wasting which is the falling of rock and soil due to the influence of gravity.



Figure 13.5: 2005 was a record season for hurricanes.

What you can do to stay safe

As stated in Section 13.1, hurricanes are a predictable natural hazard. However, it is only possible to predict the general path of a hurricane. It is hard to pinpoint where a hurricane will make landfall until a few hours before. This means that preparations have to be made along a wide band of possible landfalls to keep people safe. Therefore, it is important to pay attention to hurricane watches and warnings.

- A *hurricane watch* issued for your area means that there is the possibility of hurricane conditions within 36 hours. If you hear that a watch has been issued, you should make a plan with your family to evacuate the area as safely as possible.
- A *hurricane warning* issued for your area means that there is the possibility of hurricane conditions (sustained winds of at least 119 kilometers per hour) within 24 hours or less. If you hear that a warning has been issued, you and your family should begin to evacuate the area as quickly and as safely as possible.

Hurricane categories

The Saffir-Simpson Hurricane Scale (above right) rates the intensity of hurricanes (from 1 to 5) based on wind speed. The scale helps determine how much flooding and property damage might occur if a hurricane makes landfall. A tropical storm becomes a hurricane when the wind speed reaches 119 kilometers per hour or more.

Saffir-Simpson Hurricane Scale

Name	Wind speed	Damage	Storm surge
Tropical depression	> 63 kph	Little	None
Tropical storm	63 - 119 kph	Minor flooding	Very minor
Category 1 hurricane	120 - 153 kph	Minimal damage	1.2 - 1.5 m
Category 2 hurricane	154 - 177 kph	Moderate	1.6 - 2.4 m
Category 3 hurricane	178 - 209 kph	Extensive	2.5 - 3.7 m
Category 4 hurricane	210 - 249 kph	Extreme	3.8 - 5.5 m
Category 5 hurricane	< 250 kph	Catastrophic	> 5.6 m

kph = kilometers per hour



When Hurricane Andrew hit Florida in 1992, its winds were 265 km/h and it produced a storm surge of 5.2 meters. What category was Hurricane Andrew on the Saffir-Simpson Hurricane Scale?

Do research to find out more about Hurricane Andrew. How does Hurricane Katrina, which hit New Orleans in 2005, compare to Hurricane Andrew?



Flooding

- Rain causes flooding** Flooding commonly occurs when heavy rain or snowmelt add more water to a river than it can carry. The extra water overwhelms normally dry land areas. Fortunately, this type of flooding is usually predictable several days in advance. However, heavy rainfall can occur so quickly that the land cannot absorb the water. The result is a *flash flood*. Central Texas has been called “Flash Flood Alley” because it has more flash floods than any other place in the U.S. Figure 13.6 lists a few flood safety tips.
- River valleys and snowmelt** A river valley is created when rivers carve into mountains. Valleys are low-lying land features that are surrounded by higher land features such as mountains. River valleys are changing environments because the amount of water that flows into them changes. The amount of water increases or decreases based rain or snowmelt. Colonial mountain people of the Appalachian Mountains learned early on that the only safe place to build their homes was on the high hills. The rivers of this region often become full of water and dangerously fast in the spring after the snow melts. As a fast flowing, full river roars through a valley, plants and other important parts of a habitat (animal or human) will be swept away.
- Storm surges** Storm surges from hurricanes and other storms can cause coastal flooding. If these wind-driven waves occur at high tide, the combination can raise the sea level high enough to flood towns and cities that lie close to or below sea level.
- Floodplains** The area that floods near a river is called a **floodplain**. This area is usually located some distance from the source (headwaters) of the river. A flood plain is very good land for growing plants because seasonal flooding of the river deposits nutrients in the soil. However, because flooding occurs regularly, these areas are not ideal for buildings and homes.

VOCABULARY

floodplain - flat land near a river that tends to flood. A floodplain is usually located some distance from the headwaters of the river.

Stay safe in the event of a flood

- Pay attention to all National Weather Service Flood watches and warnings.
- Practice and maintain a flood safety plan with your family.
- Cars and trucks should never attempt to drive through moving water because flood waters can be very strong. The U.S. National Weather Service says “Turn Around Don't Drown!”



Figure 13.6: Flood safety.

Slumping

The difference between dry and wet soil

When soil is dry, friction between the grains of soil keeps it firm enough that you can build a house on it. However, if the soil is wet, the spaces between the grains are full of water. The water makes the grains slippery and friction is a lot lower. Wet soil is squishy. If you have walked on wet soil, you know that your feet sink into it!

What is slumping?

Slumping is a natural hazard that describes what happens when loose soil becomes wet and slides or “slumps” like a tired person (Figure 13.7). As with flooding, slumping can happen after a period of very heavy rainfall. Houses are at risk of being destroyed by slumping when they are built on steep, loose soil or below hills that are made of loose soil. A house could be destroyed if it slides down with the soil or if the soil on a hill above falls on the house!

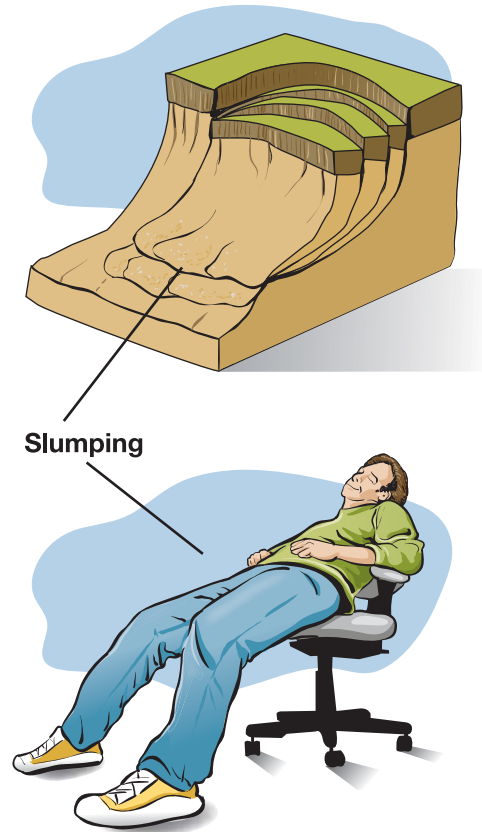
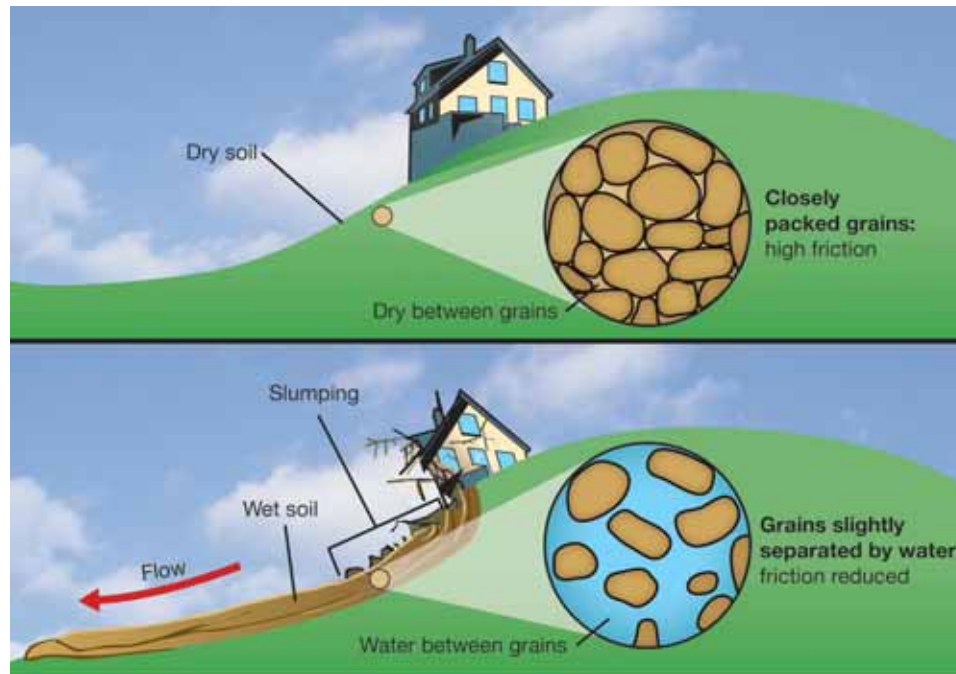


Figure 13.7: Loose soil experiences slumping (top). A tired person can slump just like the ground! (bottom).



Wildfires

Wildfire **Wildfire** is an unwanted fire that burns in a forest or other natural area. Three ingredients make a fire—fuel, oxygen, and heat. Our atmosphere is about 20% oxygen and a forest or grassland provides a lot of fuel for a fire. Lightning and even volcanic eruptions can provide heat to start fires. However, careless people start nine out of ten wildfires! The number of wildfires started by people can be reduced by educating everybody about fire safety.

Preventing forest fires You have probably encountered fire prevention rules if you have visited a wilderness area. Often camp stoves are allowed at a campsite, but campfires are forbidden. This is because many campers do not realize how easy it is for wildfires to start. A smoldering twig from a campfire or a burning cigarette, even if it is buried, can start a forest fire by burning underground until it ignites something dry, like leaves. Forest fires are much more likely to occur after a dry period than after a rainy period since a smoldering object is likely to burn out on wet or moist ground.

Fighting forest fires Rain is a factor in causing damage during hurricanes, flooding, and slumping. However, rain can also help stop a forest fire. A heavy rain can cause a forest fire to eventually die out. Hot, windy weather makes fighting fires difficult. Fire crews try to stop fires by removing fuel from their path. They do this by cutting or burning away a line, called a *firebreak* in front of the fire (Figure 13.8). Firebreaks are effective and are the first line of defense for firefighters. But, firebreaks are easily jumped by a forest fire when strong winds carry burning embers over them.

Beneficial fires Sometimes forest rangers and officials let fires burn a forest because a fire can benefit a natural area. A controlled fire can burn away dry, dead twigs that could fuel a large wildfire in the future. Fires also cause some plant seeds to germinate and grow. After a fire, the soil is filled with nutrients and supports new plant life.

VOCABULARY

wildfire - an unwanted fire that burns in a forest or other natural area.



Figure 13.8: A firebreak is a line that is cut or burned away in front of a wildfire. Firebreaks are very effective and are the first line of defense for firefighters.

13.2 Section Review

1. What is the main difference between a tropical storm and a hurricane?
2. What is the difference between a hurricane watch and a hurricane warning?
3. On the Saffir-Simpson Hurricane Scale, which is more intense: a Category 4 hurricane or a Category 5?
4. When does flooding happen inland (away from coastlines)?
5. When does coastal flooding occur?
6. During what time of year is a river valley likely to be flooded? Explain your answer.
7. Where and when might you see a sign that says “Turn Around Don't Drown”?
8. How can flooding be beneficial to the land?
9. What happens, on a small scale, when water gets in between grains of soil?
10. What happens, on a large scale, when water gets in between grains of soil?
11. What three ingredients make a fire?
12. Name a natural phenomenon that starts wildfires.
13. Why do land managers and the USDA Forest Service work so hard to educate people about preventing wildfires?
14. Weather plays a role in both causing and stopping forest fires. Do you agree with this statement? Justify your answer.
15. How do firefighters try to remove fuel from a fire's path?
16. Is there such a thing as a fire that benefits a forest? Explain your answer giving three reasons that justify it.



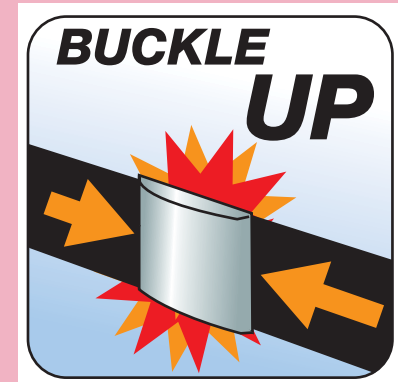
It is important to stay safe when a destructive natural event, like an earthquake or a hurricane, occurs.

You have learned one slogan for helping people stay safe during a flood.

Choose a natural hazard and research how people can stay safe during this event if it occurs.

Then, make up a slogan to help people remember at least one of the important safety tips.

Make a colorful sign that advertises your slogan. You may want to come up with a logo for your slogan as well.





13.3 Natural Hazards Driven by Internal Energy

Earthquakes, tsunamis, and volcanoes are driven by Earth's internal energy source—its core. You have learned about these natural hazards in previous chapters.

Earthquakes

A sudden movement in Earth's crust In Chapter 9 you learned that earthquakes are the result of sudden movement in Earth's brittle crust. The energy released by this movement is carried by seismic waves. These waves cause sudden, violent movement when they arrive at Earth's surface.

Scales to measure earthquakes Of course, strong movements at Earth's surface cause more damage than weak movements. However, other factors also contribute to the amount of damage done by earthquakes. This is why there is more than one scale for measuring earthquakes. The *Richter scale* is based on the measurements of seismic waves and gives a sense of the energy released by an earthquake. The *Mercalli Intensity scale* is based on the amount of earthquake damage (review Table 9.1).

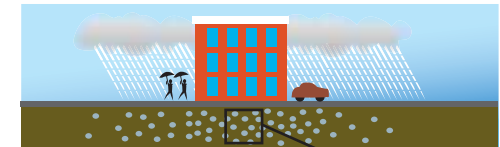
Liquefaction Soil types can affect the amount of damage caused by earthquakes. When seismic waves pass through the ground, the soil can act as a liquid. This is called **liquefaction** (Figure 13.9).



The 1989 Loma Prieta earthquake caused a lot of damage in San Francisco. The area most damaged had been built on top of San Francisco Bay mud.

VOCABULARY

liquefaction - when sediment shakes so much during an earthquake that it acts like a liquid.



- Water-saturated soil
- Particles slightly separated
- Water pressure is low



- Liquefaction
- Particles are further separated
- Water pressure is high

Figure 13.9: Liquefaction occurs when soil is saturated with water. An earthquake increases pressure on the soil so that the particles separate with water between them. The result is that the soil acts like a thick liquid!

Buildings and earthquakes

Brittle versus flexible materials

Earthquake vibrations easily damage heavy, brittle building materials like brick, mortar, and adobe. More-flexible building materials include wood and steel (Figure 13.10). Steel is a strong but flexible building material. Buildings with well-designed steel supports are less likely to be damaged during quakes.

Building height

Taller buildings are often more susceptible to earthquake damage than single-story buildings. However, this is not always true. Mexico City had short, medium, and tall buildings before an earthquake struck in 1985. After the quake, many of the medium-height buildings were destroyed. Why would short and tall buildings survive, while medium-height buildings were destroyed?

When earthquake vibrations match the sway of a building

Buildings naturally sway back and forth. Short buildings sway faster than tall buildings. In the Mexico City earthquake, the swaying of the medium-height buildings happened to match the earthquake vibrations. This made the medium-height buildings sway so much that they collapsed. The medium-height buildings—with the right timing of the push from the quake—were shaken apart. This is similar to how you can make someone go higher on a swing if you push them at the right time (Figure 13.11).



Easily damaged by earthquakes	Earthquake resistant
Brittle building materials	Flexible building materials
brick	steel
mortar	wood
adobe	

Figure 13.10: Brittle versus flexible building materials. More-flexible materials are better able to absorb energy from earthquakes so possible damage is diminished.

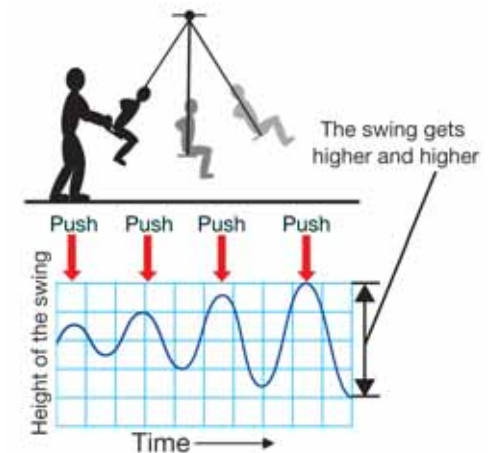


Figure 13.11: Each push of a swing at the right time increases the height of the swing.

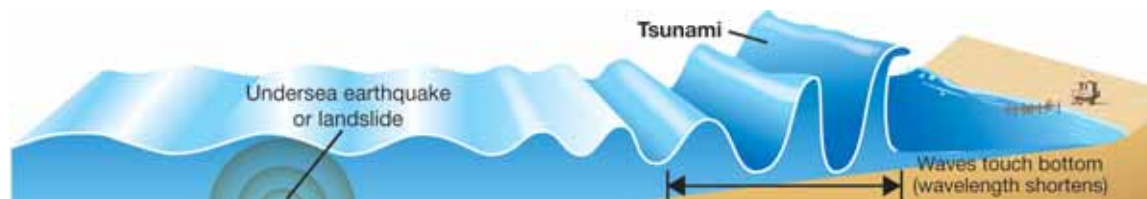


Tsunamis

A “harbor wave” **Tsunami** is a Japanese word that means “harbor wave.” Sudden movements of the sea floor cause tsunamis. These movements may be earthquakes, volcanic eruptions, or sediments slumping on a steep underwater face. You have learned that earthquake energy is spread by seismic waves. In a similar way, energy from these underwater movements is spread as a wave on the ocean surface.

Tsunamis in the open ocean In the open ocean, wind-driven waves and tsunamis are about the same height. But the wavelength of a tsunami is much longer than the wavelength of a wind-driven wave. The wavelength of a wind-driven wave may measure 20 to 40 meters from crest to crest. It may take ten seconds or so for a wind-driven wave to pass by. Wind-driven waves are small splashes compared to tsunamis. The wavelength of a tsunami is hundreds of kilometers long! Because the surface of Earth is curved, you can’t see enough of it to detect the crest of a tsunami as it approaches! If a tsunami approached your ship, you would see only a flat sea. As it passed under the ship, the tsunami would cause the ship to rise gently, about ten meters, and then gently settle back after several minutes.

Tsunamis in shallow water When a tsunami approaches land, the lower front edge of the wave begins to drag on the shallow bottom. As the front slows, the back of the wave catches up. This shortens the wavelength. Shortening the wavelength makes the wave crest higher. It’s this enormous crest of water, often 20 meters high or more, that comes crashing over beaches and harbors.



VOCABULARY

tsunami - a huge ocean wave caused by underwater earthquakes, volcanic eruptions, or slumping.

Read more about tsunamis



Find out more about tsunamis by reading the Chapter 9 Connection titled *2004 Indian Ocean Earthquake and Tsunami*. In this reading you will learn how a 10-year-old girl saved the day by remembering what she learned in her science class. You will learn a clue that indicates that a tsunami is coming, and you will learn about the very important tsunami warning networks.

Volcanic eruptions

Shield and composite volcanoes Volcanic eruptions from shield volcanoes are mild because they release runny lava. Of the 50 states in the U.S., only Hawaii has shield volcanoes. Active volcanoes found in the continental states are all composite volcanoes located near plate boundaries.

Predicting an eruption Composite volcanoes are formed from thick, sticky magma. The thick magma blocks the escape of gas and lava when the volcano is active. This makes a composite volcano like a shaken soda bottle with a loose cap. Scientists can tell that a composite volcano is becoming more active, but it's hard to tell exactly when or how it will erupt. Sometimes composite volcanoes seem ready to erupt, only to become quiet again for awhile.

Predicting a lava flow Glowing lava from shield volcanoes moves slowly enough that people can usually get out of the way. The path that lava will take can be predicted from earlier flows and from maps that show low areas that would make good pathways. The main threat posed by lava flow is destruction of property. Anything that will burn bursts into flame at the first touch of lava. Some structures are set on fire just by radiant heat, before the lava even touches it. The immediate danger passes after lava cools and becomes solid rock.

A town versus a volcano Cooled lava may block or fill harbors, streams, and lakes. In 1973, lava from a volcano on Iceland named Eldfell ("fire mountain" in Icelandic), was flowing toward an important fishing port near the town of Vestmannaeyjar (Figure 13.12). Firefighters saved the harbor by spraying the lava with water to cool and harden the flow. Although the harbor was saved and few people were injured, most of the town was destroyed. About 300 buildings burned or were buried by the lava flow. The residents of the town rebuilt it and used the cooling lava to create a heating system!



Figure 13.12: This map shows how far into the fishing port the lava reached. The cooled lava flow made the island bigger and improved the harbor.



SOLVE IT!

Use the scale on the map to measure the distance from the vent of Eldfell to the new coastline created by the lava flow in 1973.

Is Iceland a big country or a small one? Justify your answer using the scale.



Pyroclastic flow Pyroclastic flow is many times more dangerous than lava flow. A composite volcano sends an eruption column into the air. Shortly afterward, a wave of hot, toxic gases, ash, and larger fragments races down the side of the cone. The energy of this wave is enormous. A tourist, driving his car as fast as he could, was unable to outrun pyroclastic flow from the Mount St. Helens eruption. At times he was going more than 90 miles per hour! He only lived to tell about it because the flow stopped shortly after it caught up to him. Pyroclastic flow is forceful as well as fast. In the same Mount St. Helens eruption, hundreds of trees were knocked flat by the force of the pyroclastic flow.

Pompeii The Roman town of Pompeii was overrun by pyroclastic flow when Mount Vesuvius erupted in 79 C.E. Hot gases and ash quickly suffocated the inhabitants. Several additional flows buried the town under a thick blanket of ash. Pompeii remained buried until art collectors and scientists began removing the ash 1,700 years later. Hollow casts, formed by the bodies of the dead, were discovered as the ash was removed. The casts were filled with plaster so that today we can see these people in their last moments (Figure 13.13). The force of the pyroclastic flow struck down people who were outdoors. Many of the plaster casts show people shielding their faces from the hot gases and ash.

Lahars Lahars are mudflows that result from water mixing with loose material on the steep sides of a volcano. Lahars are common on most composite volcanoes because these volcanoes have steep sides with plenty of loose material on them. Because of their height, these volcanoes also often get plenty of water in the form of snow or rain. The mudflows of lahars can carry large boulders. Lahars can be dangerous because they often follow riverways that lead to town. The river path brings the lahar right into town, boulders and all!

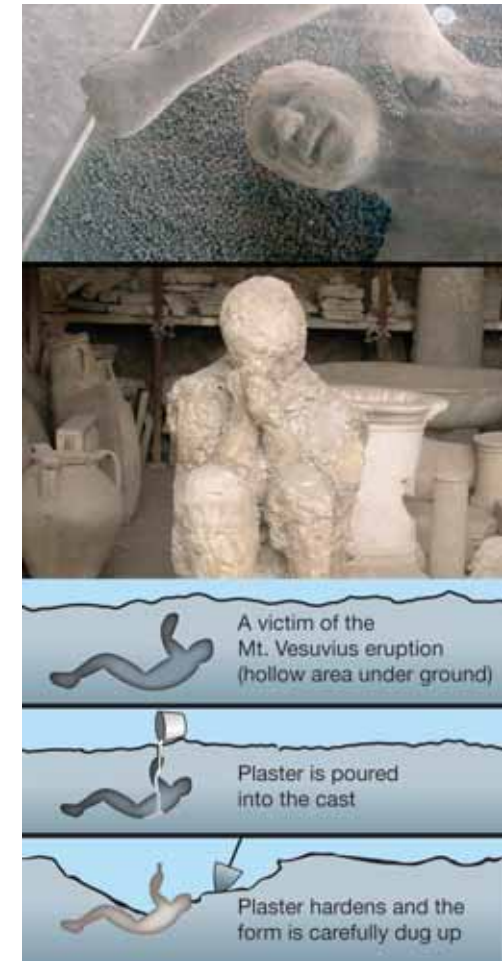
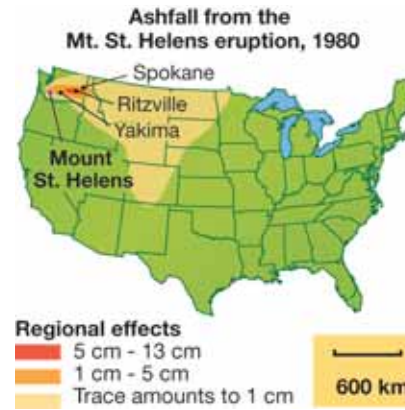


Figure 13.13: The two photographs show plaster casts of people who were caught by the Mount Vesuvius eruption near Pompeii. The lower part of the graphic shows how these plaster casts were made.

Ashfall **Volcanic ash** is made of tiny, cooled bits of magma. The ash is very fine because the magma explodes apart as trapped gases bubble out. Ash drifts with the wind because it is so fine. Eventually, it settles to the ground. This settling is called *ashfall*. The wind determines the direction and distance of ashfall.

Volcanic ash is abrasive and can damage delicate machinery. It jams moving parts and fills any low area. Streams may be dammed and farm crops buried. Like snow, ash adds weight to roofs of buildings. Unless the ash is removed, the roof may collapse. The weight and the danger become greater if rain soaks the ash. Unlike snow, the ash will not melt and go away, it must be removed.



Landslides A **landslide** (a form of “mass wasting”) occurs when a large mass of soil or rock on a steep slope slides down and away (Figure 13.14). Landslides are common on composite volcanoes. The slope is steep and the material is loose. Landslides may be triggered as magma rises and falls inside the volcano. This rising and falling often causes the side of the volcano to move. The Mount St. Helens eruption began when an earthquake occurred and one side of the volcano collapsed resulting in the largest landslide ever recorded. The landslide left a weak place in the side of the volcano that could no longer hold in the magma that had been building up inside the volcano for two months. The landslide and the subsequent eruption killed 57 people and destroyed 230 square miles of forest.

VOCABULARY

volcanic ash - fine particles of cooled magma.

landslide - a large mass of soil or rock that slides down a volcano or mountain. Landslides can be caused by volcanic events, earthquakes, or other factors. Landslides are a form of mass wasting which is the falling of rock and soil due to influence of gravity.



Figure 13.14: A landslide that occurred in La Conchita, California in 1995.



13.3 Section Review

1. One earthquake measurement scale is based on damage caused.
 - a. What is the name of this scale?
 - b. What is the highest value on the scale?
2. Name one thing that determines whether or not an earthquake causes a lot of damage, or just a little damage.
3. Flexible building materials like wood and steel help a building survive an earthquake because:
 - a. they reflect earthquake energy.
 - b. they block earthquake waves.
 - c. they absorb earthquake energy.
 - d. None of these.
4. Name three underwater movements that can cause tsunamis.
5. How do the wavelengths of tsunami waves compare to the wavelengths of wind-driven waves?
6. What happens when a tsunami reaches shallow water?
7. Answer the following questions about volcanoes.
 - a. Which is the only state in the U.S. to have shield volcanoes?
 - b. In the continental U.S., which type of volcanoes are especially hazardous?
 - c. What natural hazard caused the Mt. St. Helens eruption?
8. Why is a pyroclastic flow so dangerous?
9. A mudflow occurs that results from water mixing with loose materials on the side of a volcano. Name this type of event.
10. List three effects of ashfall on the local environment.
11. Describe how landslides occur.

CHALLENGE

Follow these steps then present your work on a poster or make a book!

1. Pick a natural hazard. Here is a list to choose from:

- hurricane
- flooding
- slumping
- earthquake
- tsunami
- volcanic eruption

2. Research on the Internet or in a library to find the name and date of the most recent event of this type of natural hazard. The U.S. Geological Survey website (www.usgs.gov) has good information about natural hazards.

3. Find out how the habitats of plants, animals, and people were affected by this event.

4. Find out how the habitats are recovering now that the event is over.

5. Make a list of tips for how to stay safe during this type of natural hazard.



The Shake, Rattle 'n' Roll of Earth

If you live in a region where there are snowstorms or hurricanes, you receive warning days in advance. Scientists use weather equipment and computers to predict such dangerous storms. But what about other natural hazards? In many parts of the world, earthquakes are a huge concern. Scientists are trying to learn as much as they can about earthquakes, in the United States and worldwide, so as to be able to predict when and where they will occur.

Where Earth quakes ...

Did you know that earthquakes could occur almost anywhere? Between 1974 and 2003 in this country, only eight U.S. states recorded no earthquakes: North Dakota, Wisconsin, Iowa, Florida, Delaware, Maryland, Connecticut, and Vermont. Guess which state has the most?

Alaska is so far the most earthquake-prone state, with a magnitude 7 quake occurring almost yearly. It was on March 28, 1964 at Prince William Sound in southern Alaska that the largest recorded earthquake in the United States (for

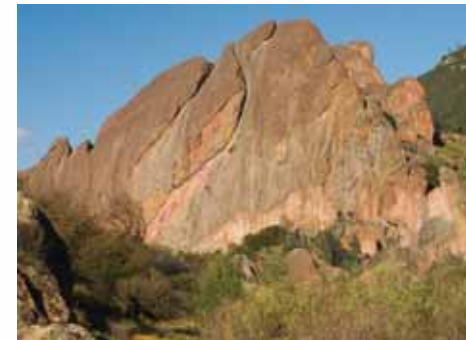
Top Ten Earthquake States			
Ranking	State	No. of Earthquakes 1974-2003	Percent of total
1	Alaska	12,053	57.2%
2	California	4,895	23.2%
3	Hawaii	1,533	7.3%
4	Nevada	778	3.7%
5	Washington	424	2.0%
6	Idaho	404	1.9%
7	Wyoming	217	1.0%
8	Montana	186	0.9%
9	Utah	139	0.7%
10	Oregon	73	0.3%

that matter, in the Northern Hemisphere) occurred, a magnitude 9.2. Luckily, it was a holiday (school was out, some businesses were closed) in a state not densely populated, or many more than 115 people would have died.

Southern California quakes, too

The Southern California Earthquake Center (SCEC) was founded in 1991, with headquarters at the University of Southern California. This is a perfect location to research earthquakes; the area is a natural laboratory with many active faults. The center's focus is learning why earthquakes happen and finding ways to predict them. The scientists' goal is to provide the public with life-saving information.

Earthquakes occur when mammoth plates beneath Earth's surface grind and scrape against each other, one sometimes pushing from underneath the other's edge. California has two huge plates, the Pacific Plate and the North American Plate. The boundary between them is the famous San Andreas Fault. The slab of granite in the photo on the previous page has been forced up along the fault by movement of the Pacific and North American Plates.



The San Andreas Fault is more than 800 miles long and as much as 10 miles deep. The fault moves an average of about two inches per year. Researchers at SCEC monitor the movement of this fault, these plates, and many other changes in Earth's crust.

Earthquake myths

If the SCEC is to prepare people for a possible earthquake by communicating safety information, it must also educate people to discard the myths about earthquakes. One myth is that big earthquakes happen only in early morning. Many do, but in fact, earthquakes can occur at any time of day. Another myth is that earthquakes are more common in hot, dry weather. In fact, there is no link between weather and earthquakes, which is logical when you think that quakes begin many miles below Earth's surface, where weather is not a factor. Many people believe that standing in a doorway is the safest place to be in an earthquake. But, in fact, doorways in modern houses are no stronger than other parts of the house. Experts say the safest place to be during an earthquake is under a table.



Did you feel it?

People usually turn to their televisions and radios for immediate news. Now the Internet has made its way into the news business and become another main source of fast information. Within minutes, data can be uploaded and available to millions of people. The U.S. Geological Survey (USGS) has a website called “Did You Feel It?” where people who experience an earthquake can share information. They can go online, enter their ZIP code, and answer a list of questions. Some of those are: “Did the earthquake wake you

up?” and “Did objects fall off shelves?” With all of this information, the USGS efficiently produces maps of shake intensities and damage. These Community Internet Intensity Maps, or CIIMs, provide valuable data to researchers.

There is still so much to learn about earthquakes. Scientists continue to gather data and perfect their monitoring tools. They hope to be able someday to reliably predict when these natural hazards will occur. People might have time to protect themselves, and many thousands of lives worldwide could be saved.

Questions:

1. Where do earthquakes most commonly occur in the United States?
2. What are the focus and main goals of the Southern California Earthquake Center (SCEC)?
3. What information does the Southern California Integrated GPS Network (SCIGN) provide researchers about earthquakes?
4. How has the Internet become a valuable tool in earthquake research?


**CHAPTER
ACTIVITY**

Composite and Shield Volcanoes

With a partner, use these diagrams to make clay models of two types of volcanoes—shield and composite volcanoes. Your models will show a cross-section of each volcano. You learned that shield volcanoes can be found in Hawaii and tend to have gentle eruptions. Composite volcanoes, which are found in the continental U.S., have explosive eruptions.

Materials

- Several colors of clay, including red for new lava/magma
- Wire or slicing tool to cut clay models in half
- Construction paper on which to place the models
- Toothpicks with labels

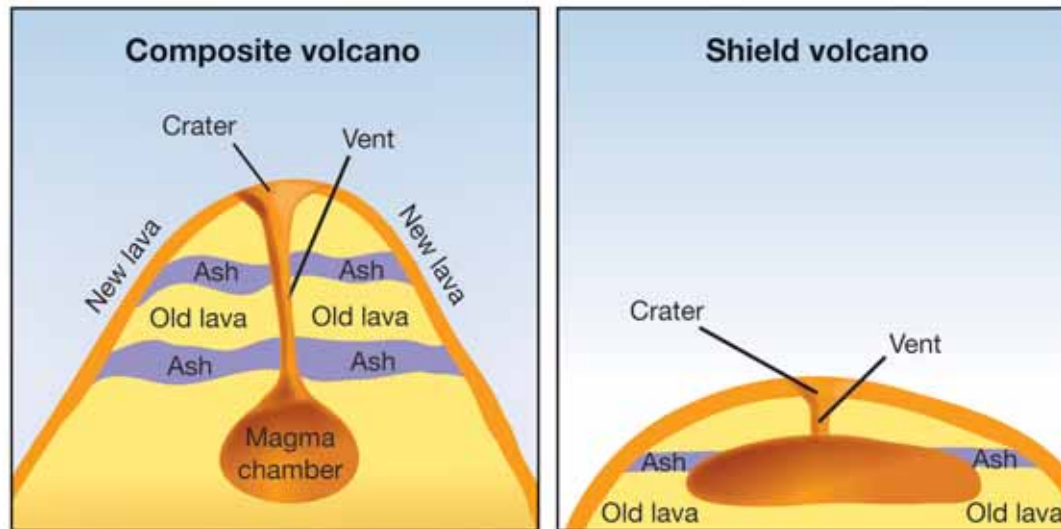
What you will do

1. Both volcanoes should have a magma chamber, vent, and crater. Your volcanoes will be built as though they are currently erupting, so make sure that your new lava/magma (red) is a different color than the old lava.

2. When you finish building your volcano, cut it in half to see a cross-section.
3. Then use your toothpicks to label the following parts:
Composite volcano—ash, old lava, magma, new lava, magma chamber, vent, crater
Shield: magma—new lava, old lava, magma chamber, vent, crater

Applying your knowledge

- a. How are the volcanoes different in shape?
- b. How are the volcanoes different in explosivity?
- c. Why is “composite” a good term for the composite volcano?
- d. Why is the term “shield” a good term to describe the shield volcano?



Chapter 13 Assessment

Vocabulary

Select the correct term to complete the sentences.

landslide	wildfire	flooding
tsunami	liquefaction	slumping
natural hazards	tsunami	floodplain
hurricane	volcanic ash	landslide

Sections 13.1 and 13.2

1. Scientists like volcanologists inform people about events called _____ which can cause damage and threaten human lives.
2. _____ is a natural hazard that occurs when the ground becomes so wet that it sinks.
3. _____ start as tropical storms and form over oceans.
4. _____ is a natural hazard that can occur after heavy rainfall.
5. _____ is a natural hazard common in dry, forested areas.
6. The land near a body of water like a river that experiences flooding is called a _____.

Section 13.3

7. The combination of an earthquake and wet sediment can cause _____.
8. A(n) _____ can be caused by an undersea earthquake or by sediments slumping underwater.
9. _____ can cover large areas after a volcanic eruption.
10. Earthquakes or volcanic eruptions can trigger a(n) _____.

Concepts

Section 13.1

1. Why is earth science an important scientific field regarding natural hazards?
2. Why are hurricanes easier to predict than earthquakes?
3. What are some important parts of a natural hazards safety plan. List at least three parts.

Section 13.2

4. A hurricane is a huge wind storm, but it does more than just produce strong wind. What are some effects of a hurricane on a location once it reaches land?
5. What is the difference between a category 1 hurricane and a tropical storm?
6. While listening to the radio, you hear that a weather service is reporting that a hurricane is expected to make landfall on a coastal region within the next 12 hours. Would this radio message be a hurricane warning or a hurricane watch?
7. How is snow involved in causing flooding of an area?
8. Why should a car or truck never attempt to drive through a river that has washed over a road?
9. What role does friction play in preventing slumping of land?
10. What is a firebreak?
11. Fire can be beneficial to a forest. How?

Section 13.3

12. Why is it helpful to have multiple scales by which to measure earthquakes?

13. If you experienced an earthquake and wanted to use your experience to figure out its rating, would you check the Richter scale or the Mercalli Intensity Scale? Justify your answer.
14. Describe how the height of a building can determine whether or not it is seriously damaged by an earthquake.
15. How do tsunamis become such huge waves?
16. Is it possible to predict a volcanic eruption? Explain your answer.
17. Discuss the dangers of a gentle eruption of runny lava from a shield volcano versus an explosive eruption from a composite volcano.
18. Why is pyroclastic flow from a volcanic eruption so devastating?
19. What determines the direction and distance of an ashfall?
20. The rising and falling of the side of a volcano due to the rising and falling of magma inside a volcano can trigger a ____.
21. ____ can be very dangerous because they often run into riverbeds on which towns are built.

Math and Writing Skills

Section 13.1

1. Where do you live?
 - a. Write a paragraph describe the climate and environment in which you live. Describe the kinds of natural hazards that people need to be aware of in your area.
 - b. For one natural hazard that you may be affected by, write a plan for staying safe if a natural hazard event

ever occurs. Talk to your family before, during, and after you have written your plan.

2. In the image below, a seismologist is standing next to a seismograph recording of the Loma Prieta earthquake. How are seismologists important in a natural disaster situation? See Chapter 9 to read about what seismologists do.



Section 13.2

3. The following table lists hurricanes and tropical storms that occurred during 2004. Identify the Saffir-Simpson Hurricane Scale rating for these storms.

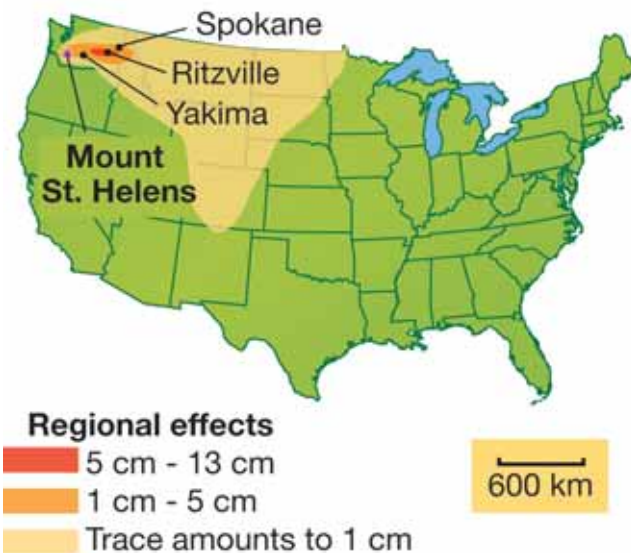
Hurricane	Wind speed (kph)	Category
A	169	
B	210	
C	63	
D	125	
E	260	



Section 13.3

4. In order to push someone on a swing, you have to push them at the right time. If you do this, the swing goes higher and higher. How is pushing someone on a swing related to how seismic waves damage buildings?
5. Ashfall from the eruption of Mount St. Helens covered a large area.
 - a. Using the scale on the map below, what was the greatest distance covered by the ashfall from the volcano?
 - b. Which city—Spokane or Ritzville—had ashfall that was 5 cm-13 cm deep?

Ashfall from the Mt. St. Helens eruption, 1980



Chapter Project—Natural Hazard Time Lines

Pick one of the listed natural hazards or another that has happened in the past and create a time line for this event based on your research. Be creative in how you present your time line.

- The 1906 earthquake that destroyed old San Francisco was over in minutes, but the fires raged on for three days. This is because when earthquakes strike cities, fire often adds to the destruction. Gas pipes are broken and electrical lines fall down. To make matters worse, water mains often break so there is no water to fight the fires. Research the San Francisco earthquake and create a time line for what happened before, during, and after the earthquake.
- The Roman town of Pompeii was overrun by pyroclastic flow when Mount Vesuvius erupted in 79 C.E. Hot gases and ash quickly suffocated the inhabitants. Several additional flows buried the town under a thick blanket of ash.
- Others include:
 - The eruption of Mount St. Helens in Washington in 1980.
 - The landslide that occurred near San Bernardino, California in December 25, 2003.
 - The 2004 Indonesian tsunami.
 - Hurricane Katrina in 2005.
 - Flooding and landslides in Haiti in 2004 (aftermath of Hurricane Jeanne).
 - Pakistan-India border earthquake that struck in October 2005.