Section 13.4

Objectives

- **Describe** recurring weather patterns and the problems they create.
- **Identify** atmospheric events that cause recurring weather patterns.
- **Distinguish** between heat waves and cold waves.

Review Vocabulary

Fahrenheit scale: a temperature scale in which water freezes at 32° and boils at 212°

New Vocabulary

drought
heat wave
cold wave
windchill index

Recurrent Weather

MAIN Idea Even a relatively mild weather system can become destructive and dangerous if it persists for long periods of time.

Real-World Reading Link Have you ever eaten so much candy you made yourself sick? Too much of any specific type of weather—cold, wet, warm, or dry—can also be unwelcome because of the serious consequences that can result from it.

Floods

An individual thunderstorm can unleash enough rain to produce floods, and hurricanes also cause torrential downpours, which result in extensive flooding. Floods can also occur, however, when weather patterns cause even mild storms to persist over the same area. For example, a storm with a rainfall rate of 1.5 cm/h is not much of a problem if it lasts only an hour or two. If this same storm were to remain over one area for 18 hours, however, the total rainfall would be 27 cm, which is enough to create flooding in most areas. In the spring of 2005, week-long storms caused flooding throughout much of New England, shown in **Figure 13.19.**

Low-lying areas are most susceptible to flooding, making coastlines particularly vulnerable to storm surges during hurricanes. Rivers in narrow-walled valleys and streambeds can rise rapidly, creating high-powered and destructive walls of water. Building in the floodplain of a river or stream can be inconvenient and potentially dangerous during a flood.

Figure 13.19 A week of prolonged rains caused this river in New York to flood. **Infer** *What areas are most affected by flooding?*

■ **Figure 13.20** Cotton plants struggle to survive in dried, cracked mud during a drought.

MiniLab

Model Flood Conditions

How can mild rains cause floods? Flooding can result from repeated, slow-moving storms that drop rain over the same area for a long period of time.

Procedure

1. Read and complete the lab safety form.
2. Place an **ice cube tray** on the bottom of a **large sink or tub.**
3. Pour **water** into a clean, **plastic dishwashing-detergent bottle** until it is two-thirds full. Replace the cap on the bottle.
4. Hold the bottle upside down with the cap open about 8 cm above one end of the ice cube tray. Gently squeeze the bottle to maintain a constant flow of water into the tray.
5. Slowly move the bottle from one end of the tray to the other over the course of 30 s. Try to put approximately equal amounts of water in each ice cube compartment.
6. Measure the depth of water in each compartment. Calculate the average depth.
7. Repeat Steps 2 to 4, but move the bottle across the ice cube tray in 15 s.

Analysis

1. **Compare** How did the average depth of the water differ in Steps 5 and 7? How might you account for the difference?
2. **Infer** Based on these results, infer how the speed of a moving storm affects the amount of rain received in any one area.
3. **Deduce** How could you alter the experiment to simulate different rates of rainfall?

Droughts

Too much dry weather can cause nearly as much damage as too much rainfall. **Droughts** are extended periods of well-below-average rainfall. One of the most extreme droughts in American history occurred during the 1930s in the central United States. This extended drought put countless farmers out of business, as rainfall was inadequate to grow crops.

Droughts are usually the result of shifts in global wind patterns that allow large, high-pressure systems to persist for weeks or months over continental areas. Under a dome of high pressure, air sinks on a large scale. Because the sinking air blocks moisture from rising through it, condensation cannot occur, and drought sets in until global patterns shift enough to move the high-pressure system. **Figure 13.20** shows some of the impacts of long-term drought.

Heat waves An unpleasant side effect of droughts often comes in the form of **heat waves,** which are extended periods of above-average temperatures. Heat waves can be formed by the same high-pressure systems that cause droughts. As the air under a large high-pressure system sinks, it warms by compression and causes above-average temperatures. The high-pressure system also blocks cooler air masses from moving into the area, so there is little relief from the heat. Because it is difficult for condensation to occur under the sinking air of the high-pressure system, there are few, if any, clouds to block the blazing sunshine. The jet stream, or "atmospheric railway," that weather systems normally follow is farther poleward and weaker during the summer. Thus, any upper-air currents that might guide the high-pressure system are so weak that the system barely moves.

Heat index Increasing humidity can add to the discomfort and potential danger of a heat wave. Human bodies cool by evaporating moisture from the surface of the skin. In the process, thermal energy is removed from the body. If air is humid, the rate of evaporation is reduced, which diminishes the body's ability to regulate internal temperature. During heat waves, this can lead to serious health problems such as heatstroke, sunstroke, and even death.

Because of the dangers posed by the combination of heat and humidity, the National Weather Service (NWS) routinely reports the heat index, shown in **Table 13.2.** Note that the NWS uses the Fahrenheit scale in the heat index, as well as several other scales it produces because most United States citizens are more familiar with this scale.

The heat index assesses the effect of the body's increasing difficulty in regulating its internal temperature as relative humidity rises. This index estimates how warm the air feels to the human body. For example, an air temperature of 85°F (29°C) combined with relative humidity of 80 percent would require the body to cool itself at the same rate as if the air temperature were 97°F (36°C).

Reading Check **Identify** the cause of serious health problems associated with heat waves.

Concepts In Motion
Interactive Table To explore more about the heat index, visit glencoe.com.

Table 13.2 The Heat Index

Relative Humidity (%)	Air Temperature (°F)										
	70	75	80	85	90	95	100	105	110	115	120
	Apparent Temperature (°F)										
0	64	69	73	78	83	87	91	95	99	103	107
10	65	70	75	80	85	90	95	100	105	111	116
20	66	72	77	82	87	93	99	105	112	120	130
30	67	73	78	84	90	96	104	113	123	135	148
40	68	74	79	86	93	101	110	123	137	151	
50	69	75	81	88	96	107	120	135	150		
60	70	76	82	90	100	114	132	149			
70	70	77	85	93	106	124	144				
80	71	78	86	97	113	136					
90	71	79	88	102	122						
100	72	80	91	108							

Source: National Weather Service, NOAA

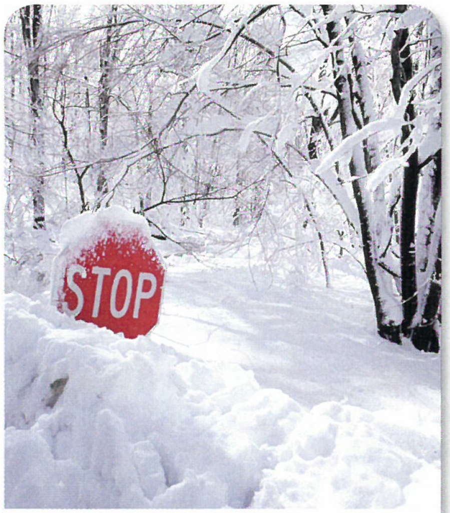

Figure 13.21 Prolonged cold or recurrent cold waves can create blizzard conditions such as these that fell on Denver in 2006.

Cold Waves

The opposite of a heat wave is a **cold wave,** which is an extended period of below-average temperatures. Interestingly, cold waves are also brought on by large, high-pressure systems. However, cold waves are caused by systems of continental polar or arctic origin. During the winter, little sunlight is available to provide warmth. At the same time, the snow-covered surface is constantly reflecting the sunlight back to space. The combined effect of these two factors is the development of large pools of extremely cold air over polar continental areas. Because cold air sinks, the pressure near the surface increases, creating a strong high-pressure system.

Because of the location and the time of year in which they occur, winter high-pressure systems are much more influenced by the jet stream than are summer high-pressure systems. Moved along by the jet stream, these high-pressure systems rarely linger in any area. However, the winter location of the jet stream can remain essentially unchanged for days or even weeks. This means that several polar high-pressure systems can follow the same path and subject the same areas to continuous numbing cold. Some effects of prolonged periods of cold weather are shown in **Figure 13.21.**

Reading Check **Explain** why the Sun's energy has little effect on air temperature in the arctic.

DATA ANALYSIS LAB

Based on Real Data*

Interpret the Table

How can you calculate a heat wave? The following data represent the daily maximum and minimum temperatures for seven consecutive summer days in Chicago. A heat wave is defined as two or more days with an average temperature of 29.4°C or higher.

Analysis

1. Calculate the average temperature for each day in your table.
2. Plot the daily maximum and minimum temperatures on a graph with the days on the *x*-axis and the maximum temperatures on the *y*-axis. Using the data points, draw a curve to show how the temperatures changed over the seven-day period. Add the average temperatures.

Think Critically

3. **Determine** What day did the city heat wave begin? How long did it last?
4. **Compare** the average temperature for the days of the heat wave to the average temperature of the remaining days.

Data and Observations

Daily Temperatures			
Day	Maximum (°C)	Minimum (°C)	Average (°C)
1	32	23	
2	37	24	
3	41	27	
4	39	29	
5	37	25	
6	34	24	
7	32	23	

* Data obtained from: Klinenberg, E. 2002. *Heat Wave: A social autopsy of disaster in Chicago, IL.* Chicago: University of Chicago Press.

Windchill Chart

Wind (mph)

Temperature (°F) / Calm	5	10	15	20	25	30	35	40	45	50	55	60
40	36	34	32	30	29	28	28	27	26	26	25	25
35	31	27	25	24	23	22	21	20	19	19	18	17
30	25	21	19	17	16	15	14	13	12	12	11	10
25	19	15	13	11	9	8	7	6	5	4	4	3
20	13	9	6	4	3	1	0	-1	-2	-3	-3	-4
15	7	3	0	-2	-4	-5	-7	-8	-9	-10	-11	-11
10	1	-4	-7	-9	-11	-12	-14	-15	-16	-17	-18	-19
5	-5	-10	-13	-15	-17	-19	-21	-22	-23	-24	-25	-26
0	-11	-16	-19	-22	-24	-26	-27	-29	-30	-31	-32	-33
-5	-16	-22	-26	-29	-31	-33	-34	-36	-37	-38	-39	-40
-10	-22	-28	-32	-35	-37	-39	-41	-43	-44	-45	-46	-48
-15	-28	-35	-39	-42	-44	-46	-48	-50	-51	-52	-54	-55
-20	-34	-41	-45	-48	-51	-53	-55	-57	-58	-60	-61	-62
-25	-40	-47	-51	-55	-58	-60	-62	-64	-65	-67	-68	-69

Frostbite times ■ 30 min ■ 10 min ■ 5 min

Figure 13.22 The windchill chart was designed to show the dangers of cold and wind.
What *wind speed and temperature is the same as 10°F on a calm day?*

Windchill index The effects of cold air on the human body are magnified by wind. Known as the windchill factor, this phenomenon is measured by the **windchill index** in **Figure 13.22.** The index estimates how cold the air feels to the human body. While the windchill index is helpful, it does not account for individual variations in sensitivity to cold, the effects of physical activity, or humidity. In 2001, the NWS revised the calculations to utilize advances in science, technology, and computer modeling. These revisions provide a more accurate, understandable, and useful index for estimating the dangers caused by winter winds and freezing temperatures.

Section 13.4 Assessment

Section Summary

- Too much heat and too little precipitation causes droughts.
- Too little heat and a stalled jet stream can cause weeks of cold weather in an area.
- Heat index estimates the effect on the human body when the air is hot and the humidity is high.
- Windchill index tells how wind and temperature affect your body in winter.
- Windchill is a factor used to warn about the effect of cold air and wind on the human body.

Understand Main Ideas

1. MAIN Idea **Explain** how everyday weather can become recurrent and dangerous.
2. **Describe** how relatively light rain could cause flooding.
3. **Compare and contrast** a cold wave and a heat wave.
4. **Explain** why one type of front would be more closely associated with flooding than another.

Think Critically

5. **Explain** why air in a winter high-pressure system is very cold despite compressional warming.
6. **Compare** the data of the heat-index scale and the windchill scale. What variables influence each scale?

MATH in Earth Science

7. A storm stalls over Virginia, dropping 0.75 cm of rain per hour. If the storm lingers for 17 hours, how much rain will accumulate?

NATIONAL GEOGRAPHIC **eXpeditions!**

ON SITE: STORM SPOTTERS

Figure 1: Storm chasers videotape a tornado crossing a road near Manchester, South Dakota.

When storm spotters hear that severe weather is approaching the area, do they seek the safety of their house or basement like most people do? No, they head out to the edge of town or to a high point to check on the exact wind and weather conditions.

Volunteers for the NWS Storm spotters work as volunteers for the National Weather Service (NWS) to help give NWS forecasters a clear picture of what is really happening on the ground. Although Doppler radar and other systems are sophisticated data collectors, these devices can only detect weather conditions that might produce a severe thunderstorm or a tornado. The NWS typically uses this information to issue a severe storm or tornado watch. When a watch is issued, spotters travel to key lookout points and report their observations. The observations made on the ground by storm spotters are essential to the NWS in upgrading watches to warnings.

Making Reports The NWS trains spotters to assess certain weather conditions such as wind speed, hail size, and cloud formation. For example, if large tree branches begin to sway, umbrellas are difficult to use, and the wind creates a whistling noise along telephone wires, spotters know that wind speed is between 40 and 50 km/h. If trees are uprooted or TV antennas break, wind speed is estimated to be between 85 and 115 km/h.

Spotters study the clouds to determine where hail is falling, where a tornado might develop, and in what direction the storm is headed. When they call in, they report the event, its location, its direction, and whether there is need for emergency assistance.

High Risk Mobile spotters risk their own safety in order to protect their community. The major risks they face stem from driving in bad weather and standing on a high spot where lightning might strike. Spotters always travel with a partner, so that one person can drive and the other can watch the sky. To stay safe, spotters keep watch in all directions, keep the car engine running, and have an escape plan.

The combination of technology and the work of spotters has saved many lives since the volunteer system was started by the NWS in the 1970s. The number of deaths as a result of tornadoes and other severe weather has decreased significantly since the program began.

WRITING in Earth Science

Make a Pamphlet Research more information about how to become a storm spotter and the training involved. Write and illustrate a pamphlet about storm spotting that includes this information. To learn more about storm spotting, visit glencoe.com.