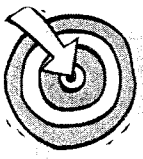
Lesson 4: Forecasting Severe Weather Systems



Lesson Focus

After completing this lesson, you will be able to

- ❑ read and interpret the symbols on a weather map
- ❑ explain how severe weather systems form
- ❑ understand the dynamics of severe weather events

Key Words

- high and low pressure systems
- air mass
- warm and cold fronts
- weather station glyphs (or symbols)
- isobars
- isotherms
- humidity
- dew point
- tornadoes
- hurricanes
- extreme temperature events
- cyclones
- thunderstorms
- jet stream
- blizzards

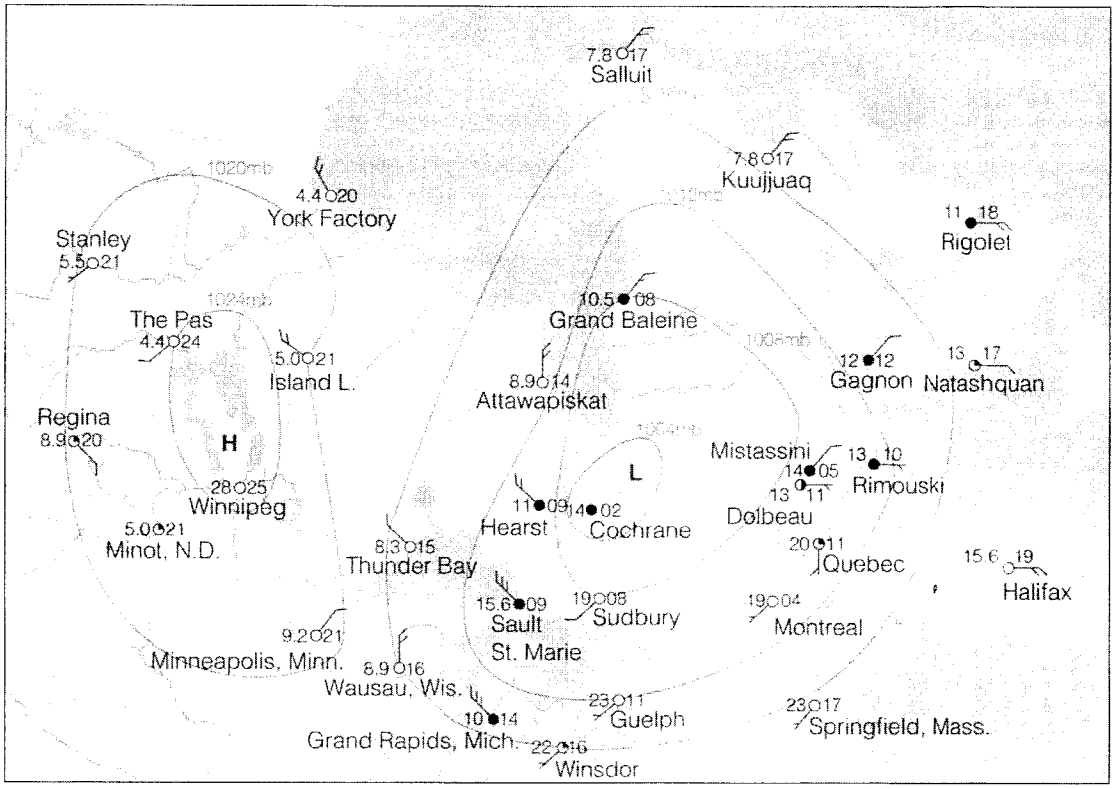
Introduction

In the last lesson you learned how heat energy is transferred in our atmosphere and how the transfer of heat energy results in the creation of winds. In this lesson you will continue to explore how the transfer of heat energy creates differences in pressure and how the change in pressure can result in severe weather events. To start this lesson you will review weather forecasting terms and symbols.

Interpreting Weather Maps

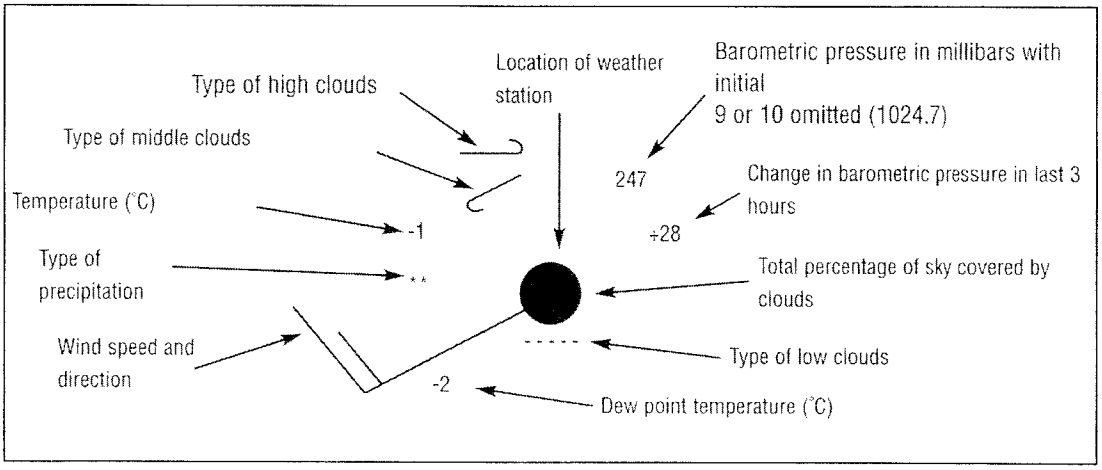
Weather maps are made by combining meteorological data (information about the atmosphere, especially weather and weather conditions) collected from stations all over the country or the world. Weather stations are maintained at airports, broadcasting stations, and some schools, by private citizens and by Environment Canada.

Weather maps usually have an outline of the area being surveyed, the names of the cities where the reporting stations are located, and symbols that represent the weather data. If you combine information from many stations on a map, the map will give you a picture of the large weather systems across the country.



Source: Grace, Eric, et al. Figure 16.16 B. *Sciencepower 10: Science, Technology, Society, Environment.* Toronto, ON: McGraw-Hill Ryerson Limited, 2000. 534. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff.*

A **weather station symbol (glyph)** provides information about the atmospheric pressure, wind speed and direction, cloud cover, temperature, current weather conditions, and dew point of an exact location.

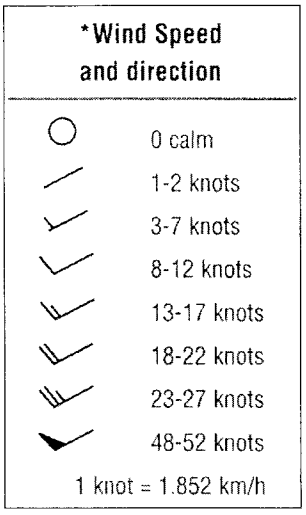


Source: Grace, Eric, et al. "Weather Map Symbols: Sample Plotted Report at Each Station." *Sciencepower 10: Science, Technology, Society, Environment.* Toronto, ON: McGraw-Hill Ryerson Limited, 2000. 576. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff.*

Atmospheric pressure is the force exerted on an object or person by the weight of the air above it. You may not have realized that air has weight.

The force of gravity pulls molecules and particles in the atmosphere toward the centre of Earth. The resulting weight of the air pushing down on itself and on the surface of the planet creates atmospheric pressure.

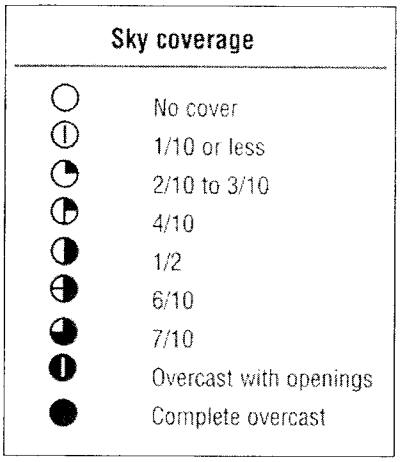
In Canada, the unit of atmospheric pressure most often heard on weather broadcasts is the **kilopascal (kPa)**. The average pressure exerted by the atmosphere at sea level is one kilogram per square centimetre or 101.325 kPa. Often weather maps have curved lines called **isobars**. These lines are drawn to connect locations on the map with the same atmospheric pressure. The highs and lows (or the **H** and **L** symbols) on weather maps represent the centres of large regions of relatively high or low surface air pressure. Highs bring pleasant weather while low pressure systems bring clouds and stormy weather.



Wind speed is measured in knots and shown by the small lines that look like barbs. Each full line represents approximately 10 knots (1 knot = 1.852 km/h) of wind speed. Shorter lines represent wind speeds of approximately 5 knots. Adding the lines (10 + 5) gives you the total wind speed.

Wind direction: If you think of the wind speed lines as the feathers on an arrow, the circle represents the arrowhead. The arrow points in the direction that the wind is blowing, **but** wind direction is designated as the direction the wind is blowing from. If an arrow points to the southeast, the wind direction is called "from the northwest."

Source: Grace, Eric, et al. "Weather Map Symbols: Symbols Used in Plotting Report." *Sciencepower 10: Science, Technology, Society, Environment.* Toronto, ON: McGraw-Hill Ryerson Limited, 2000. 576. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff.*



Cloud cover is shown by the amount of the circle that is blackened. If the circle is not blackened then the skies would be "clear."

Source: Grace, Eric, et al. "Weather Map Symbols: Symbols Used in Plotting Report." *Sciencepower 10: Science, Technology, Society, Environment.* Toronto, ON: McGraw-Hill Ryerson Limited, 2000. 576. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff.*

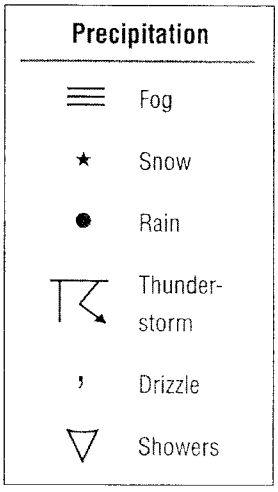
Dew point is the temperature the air would have to be cooled to for the air to become saturated and for water vapour to condense.

The very small amount of water in the atmosphere is necessary for creating Earth's weather systems and climate. Atmospheric heating, humidity, cloud formation, and precipitation are all directly related to the amount of water vapour in the atmosphere.

Warm air can hold much more water than cool air. **Humidity** is a measure of the amount of moisture (water vapour) in the air. It is reported as a percentage for a given temperature (relative humidity).

When air holds all the water vapour it can, we say that the air is saturated and the relative humidity is 100 percent. If warm, unsaturated air is cooled, it will in time reach a temperature where the amount of water vapour already in the air will equal the total amount that the air can hold. At this temperature, the **dew point**, the air becomes saturated and the water vapour will begin to condense to form water droplets, clouds, fog, or dew.

Current weather conditions are shown by the list of symbols below:



Source: Grace, Eric, et al. "Weather Map Symbols: Symbols Used in Plotting Report." *Sciencepower 10: Science, Technology, Society, Environment.* Toronto, ON: McGraw-Hill Ryerson Limited, 2000. 576. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff.*

By combining the information from many stations, an accurate picture of large weather systems can be formed, forecasts can be made, and severe weather can be anticipated.

Temperature in Canada is measured in Celsius degrees (°C) while some other countries use Fahrenheit degrees (°F). Just like weather maps that have curved lines called isobars that connect locations on the map with the same atmospheric pressure, weather maps can also have **isotherms**, which are lines drawn to connect locations on the map with the same temperatures.

Air Masses and Fronts

Air masses are large bodies of air that have different temperatures and relative humidity. When air masses meet they do not mix easily. Warmer air masses rise over cooler air masses, and cooler air masses wedge themselves underneath warmer air masses. This happens because cool air is more dense than warm air.

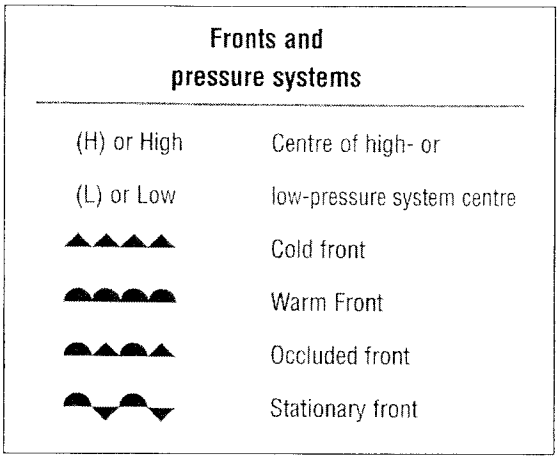
The boundary that forms between warm and cool air masses is called a **front**. There are different types of fronts—the most common ones are cold fronts, warm fronts, and stationary fronts.

Cold front: A cold air mass advances against a warm air mass, forcing the warm air upward. Clouds, precipitation, and sometimes severe weather result during the passage of a cold front. Cooler, dryer air moves into an area after the passage of a cold front.

Warm front: A warm air mass advances against a cold air mass, riding up over the cooler air in front of it. Clouds and precipitation in the form of rain, snow, sleet, or freezing rain can result during the passage of a warm front. Warmer, moist air moves into an area after the passage of a warm front.

Stationary front: A stationary front occurs when neither the cold air mass nor the warm air mass advance against one another. The interaction of warm and cool air along the front is responsible for rain, thunderstorms, and snow.

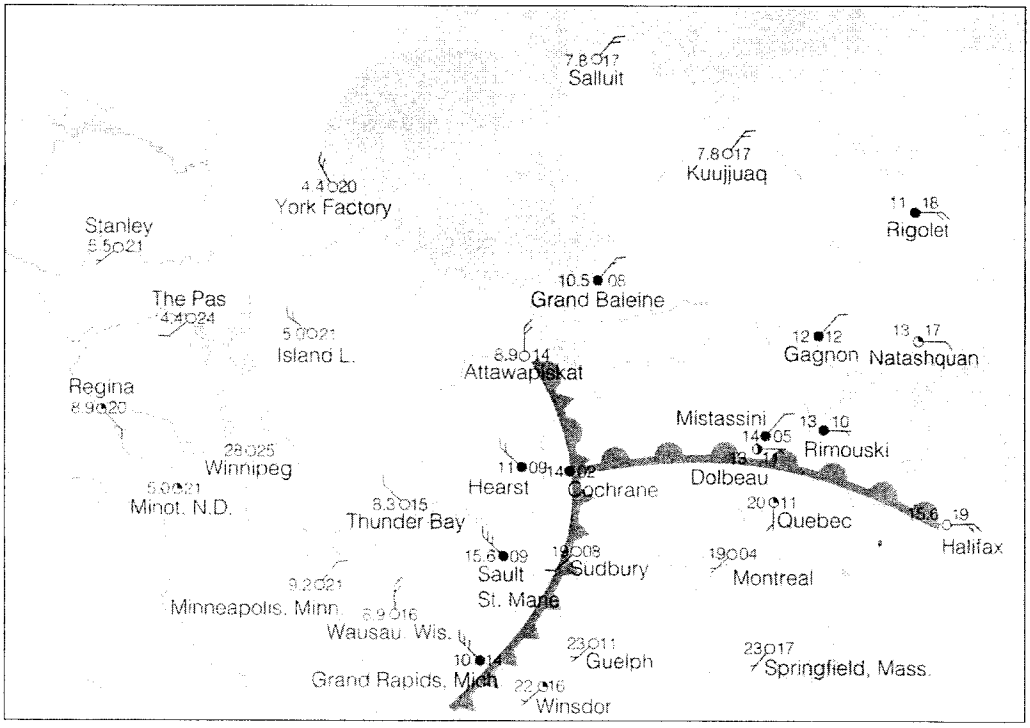
Fronts are responsible for creating clouds, rain, and snow, and are represented by the following symbols on a weather map. The triangles and half-circles point in the direction the front is moving.



Source: Grace, Eric, et al. "Weather Map Symbols: Symbols Used in Plotting Report." *Sciencepower 10: Science, Technology, Society, Environment.* Toronto, ON: McGraw-Hill Ryerson Limited, 2000. 576. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff.*

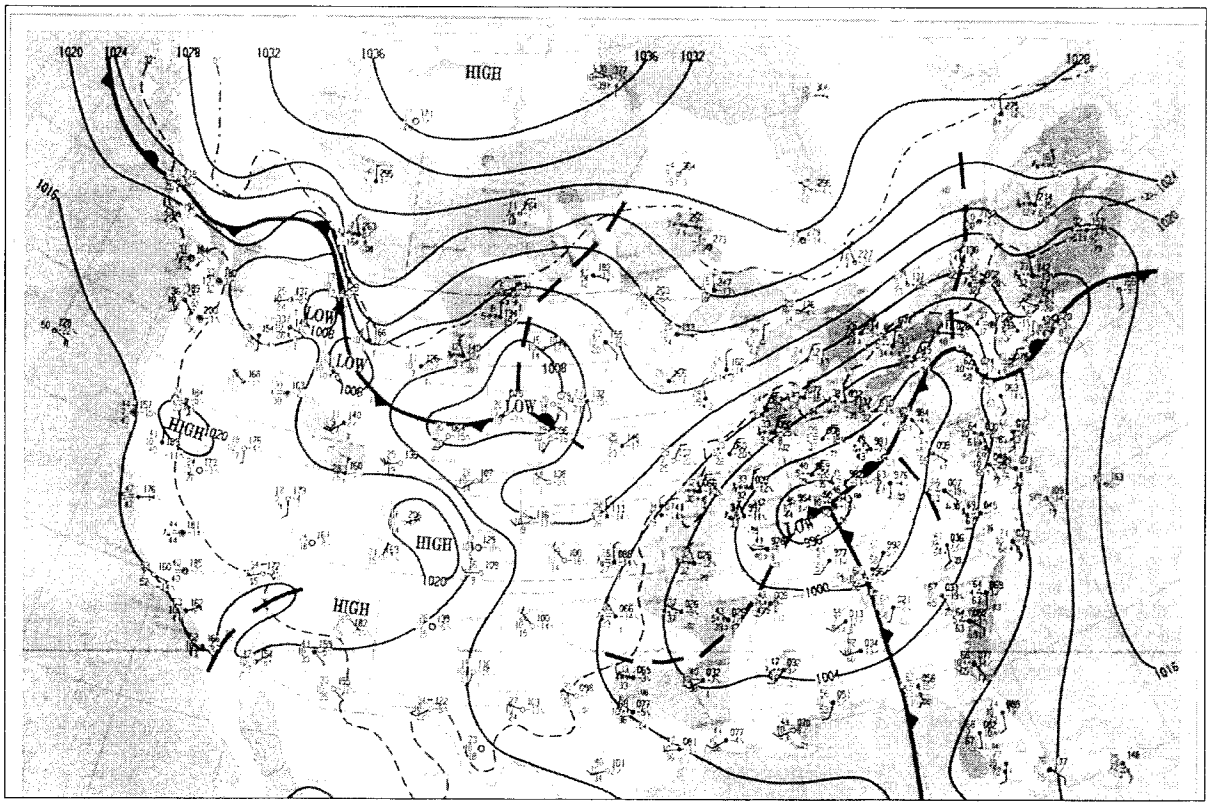
As warmer air comes in contact with colder air and is forced to rise, it expands into the lower pressure found at higher altitudes. This expansion cools the air and the moisture in the air condenses, forming clouds. If the warm air continues to rise and expand, rain or snow may form.

Clouds are a result of the interactions of air masses. Clouds have many patterns, and by looking at cloud types it is possible to predict changes in the weather and the movement of fronts.



Source: Grace, Eric, et al. Figure 16.17. *Sciencepower 10: Science, Technology, Society, Environment.* Toronto, ON: McGraw-Hill Ryerson Limited, 2000. 534. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff.*

Learning Activity 4.4: Reading a Weather Map



Source: National Oceanic and Atmospheric Administration's National Weather Service Forecast Office: Burlington, VT. "Surface observations plot from January 8, 1998." *10th Anniversary of the Devastating 1998 Ice Storm in the Northeast.* 6 Jan. 2008. <www.erh.noaa.gov/btv/events/IceStorm1998/ice98.shtml> (27 Apr. 2012). Public Domain.

1. Over what area do you find a cold front?
2. What type of front is over the northeastern United States?
3. Locate the areas of high pressure. What do you notice about the isobars around the high pressure areas?
4. Locate the weather glyph near Edmonton.
   a. What is the temperature?
   b. What is the dew point?
   c. What is the cloud cover?
   d. What is the atmospheric pressure?
   e. In what direction is the wind blowing?

continued

Learning Activity 4.4 (continued)

5. Symbols for sky cover have also been included on this chart.
   a. In general, do you find cloudy or clear skies in low-pressure areas?
   b. In high-pressure areas, what occurs with cloud cover?
6. Using the symbols on this map, identify what the weather is like in Churchill (include **percentage of cloud cover**, **temperature**, and **wind direction**).

Check the Learning Activity Answer Key found at the end of this module.

How Severe Weather Systems Develop

Predicting weather changes requires an understanding of how weather systems work. Knowing how severe weather works is important for predicting when it will occur. In this part of Lesson 4 you will learn how thunderstorms, tornadoes, and hurricanes begin.

Severe Thunderstorms

Thunderstorms are something most of us have experienced. They are accompanied by heavy rain, thunder, and lightning. You can recognize one that may be coming by looking at the clouds.

A hot sunny day will cause water vapour from Earth to rise and cool into water droplets. A large amount of water vapour cooling will build up enormous clouds with tightly packed water droplets near the base. If the rising moist air is strong enough, the water vapour gets pushed very high.

Lightning is the result of the rapidly moving cloud particles being rubbed against each other so much that electrical charges occur. The particles become loaded with extra negative charges. When this negatively charged cloud passes over anything that is positively charged the negative charges (electrons) want to leave the cloud and jump to the positively charged object. This jump is called lightning. Lightning can occur from cloud to Earth, cloud to cloud, or even inside a cloud itself.

The big bang (thunder) you hear after lightning occurs is really the air, near the lightning, that has been heated up so fast that it explodes, and the rumbling you hear after is the sound of the thunder bouncing from cloud to cloud.

Thunderstorms that occur with a strong **jet stream** flow (high speed winds in the troposphere that occur around the mid-latitudes) can produce tornadoes.

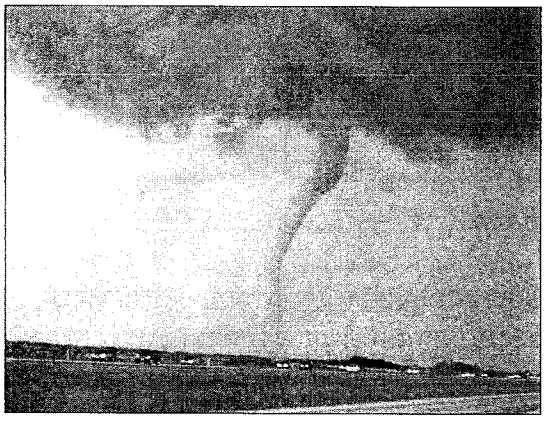
Tornadoes

Tornadoes look like twisting gray funnels, cylinders, or ropes extending down from a cloud. They are extremely loud and have an intense period of lightning connected with them. Most tornadoes are small, measuring a few hundred metres in diameter and are usually short lived, lasting a minute or two in any one area. However, with wind speeds up to 500 kilometres per hour and extremely low pressures, tornadoes can cause a great deal of damage as they pass.

Tornadoes are usually created when a very cold air front moves into an area where the air is very hot and humid. Most tornadoes form over land in open areas where the land is quickly heated during hot summer days.

Tornadoes are also called twisters and act like vacuum cleaners. When a tornado "touches down," any object it comes in contact with will be sucked up by the tremendous vacuum-like funnel. Since the air pressure inside the tornado is extremely lower than normal, any buildings in its path will be exploded from the inside out as the normal pressure in the building disperses into the low pressure of the tornado.

Tornadoes carry debris for great distances, zigzagging in an unpredictable route across the country.



Cyclones

Where tornadoes are local severe weather events, **cyclones** are large-scale systems of rotating winds around a central low-pressure area that cover large areas of the ocean or land. Depending on where they form, cyclones are given different names. A **hurricane** is a tropical cyclone that forms in the Atlantic Ocean, Caribbean Sea, Gulf of Mexico, or eastern Pacific. A **typhoon** is a tropical cyclone that forms in the north-western Pacific Ocean. In the Indian Ocean and South Pacific Ocean, these types of storms are just called cyclones.

Hurricanes

Hurricanes are probably the worst type of storm you could experience. Hurricanes that move inland bring heavy rains, strong winds, and flooding. They start over water in low pressure areas where rapidly rising warm, moist air from the ocean cools to form rain. As a result, clouds form and latent heat is released into the atmosphere. The low pressure area causes an increase in the flow of air into the storm. Because of Earth's rotation, the incoming air is deflected (Coriolis effect). The rotating winds evaporate water from the ocean's surface, carrying it into the growing storm system.

Hurricanes are not considered hurricanes until their wind speeds exceed 64 knots or 118 kilometres per hour—below this wind speed the system is considered a tropical storm. Hurricanes have different names in different parts of the world. In Asia they are known as typhoons.

Once the wind speed reaches 118 kilometres per hour, the winds spin so quickly that they are forced into a ring surrounding the central low pressure area. In the central low pressure area called the "eye," the winds are light, and there are few if any clouds and little rain. The eye is surrounded by a thick wall of intense thunderstorms.

As the hurricane and its thunderstorms move over the ocean, the winds create large waves. When the hurricane reaches a coastline, the winds and low pressure also cause a large increase in water level. This unusual rise in sea level is called a storm surge. Storm surges are responsible for the flooding that occurs in low-lying coastal areas.

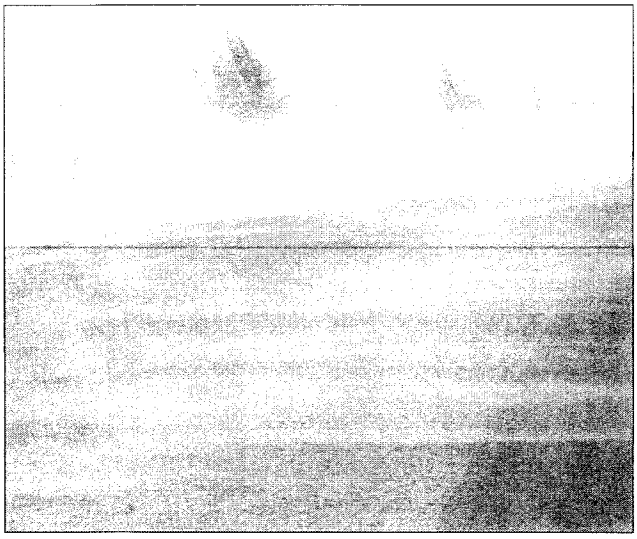
Hurricanes can last for over a week. Fuelled by warm ocean waters, hurricane season occurs when water temperature is high enough to support the development of a storm system. This usually happens in late summer and early fall. Hurricanes lose their energy as they move over land or cooler water.

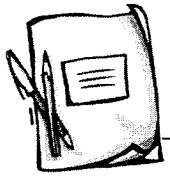
Winter Storms

A winter storm is a large weather disturbance connected to a low-pressure system (another type of **cyclone**) that develops along a front during the cooler part of the year. Winter storms can produce strong winds, heavy precipitation (rain, freezing rain, ice pellets, or snow), and cold temperatures.

Winter storms occur when warm, humid air meets cold air along a front separating the two air masses. At first the front is slow moving or stationary. A cyclonic storm starts when a deep low-pressure centre forms, and the wind speed increases in the rotating system. Warm, moist air is lifted upward, producing clouds and precipitation along the front.

A **blizzard** comes about when winds exceed 50 kilometres per hour with snow and blowing snow that reduce visibility to near zero. The wind chill is usually high during a blizzard.



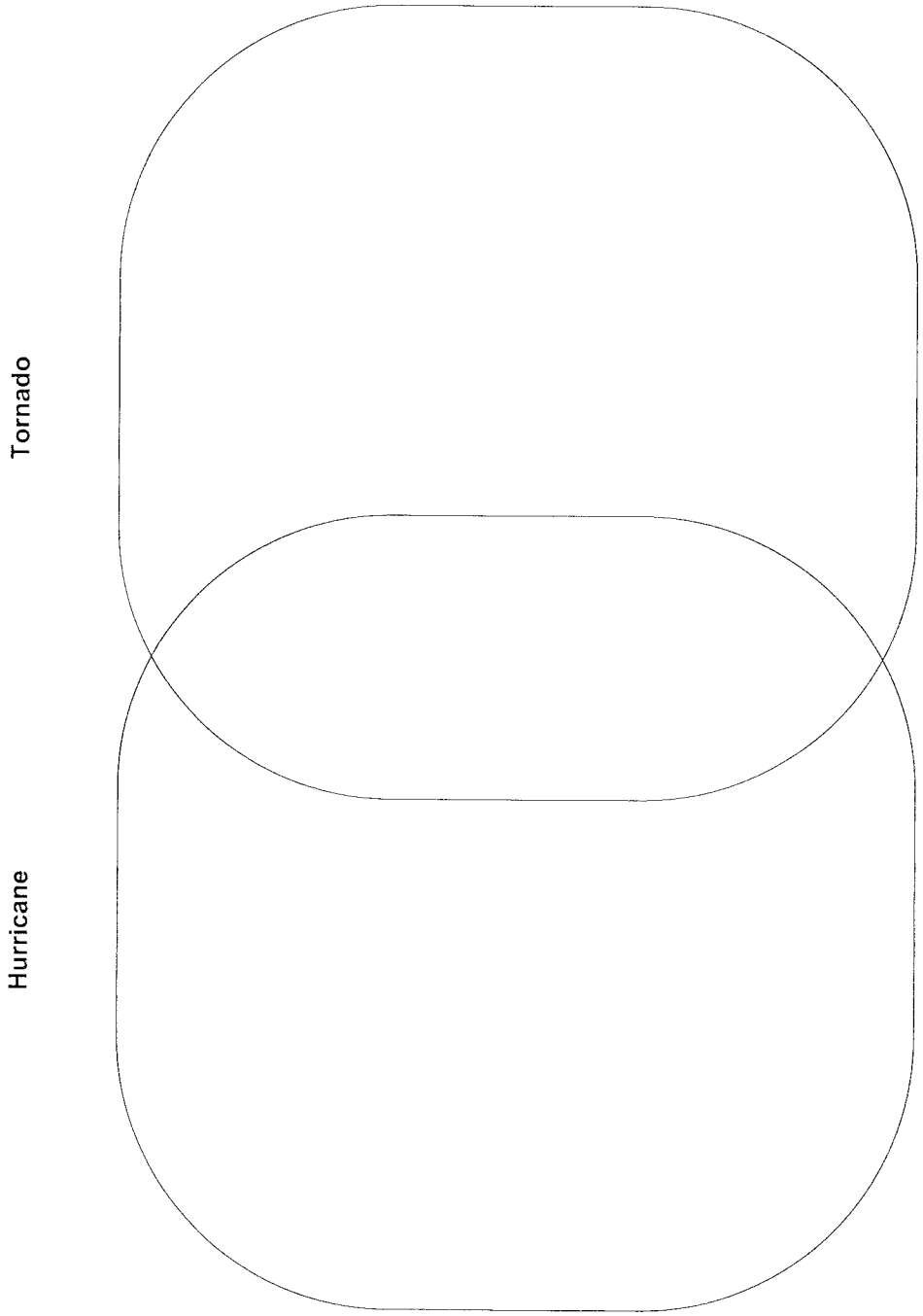


Learning Activity 4.5: Severe Weather

You will compare and contrast what you've learned about hurricanes and tornadoes using the Venn Diagram provided. In the two outer areas, list information that is unique to tornadoes on one side and information that is unique to hurricanes on the other side. In the overlapping area in the middle, list information about tornadoes and hurricanes that is the same.

continued

Learning Activity 4.5 (continued)



Check the Learning Activity Answer Key found at the end of this module.

Summary

Weather maps outline the area being surveyed, the names of the cities where the reporting stations are located, and symbols that represent the weather data.

A weather station symbol provides information (the atmospheric pressure, wind speed and direction, cloud cover, temperature, current weather conditions, and dew point) of an exact location.

Although complex, both global and local weather systems are based in simple processes of heat transfer. Fronts, wind patterns, and convection cells (pockets of air where convection is occurring) each result from the unequal buildup of heat energy over Earth's surface.

Storms are very powerful forces that can do great damage. In the next lesson you will learn how meteorologists track severe weather systems and warn the public.