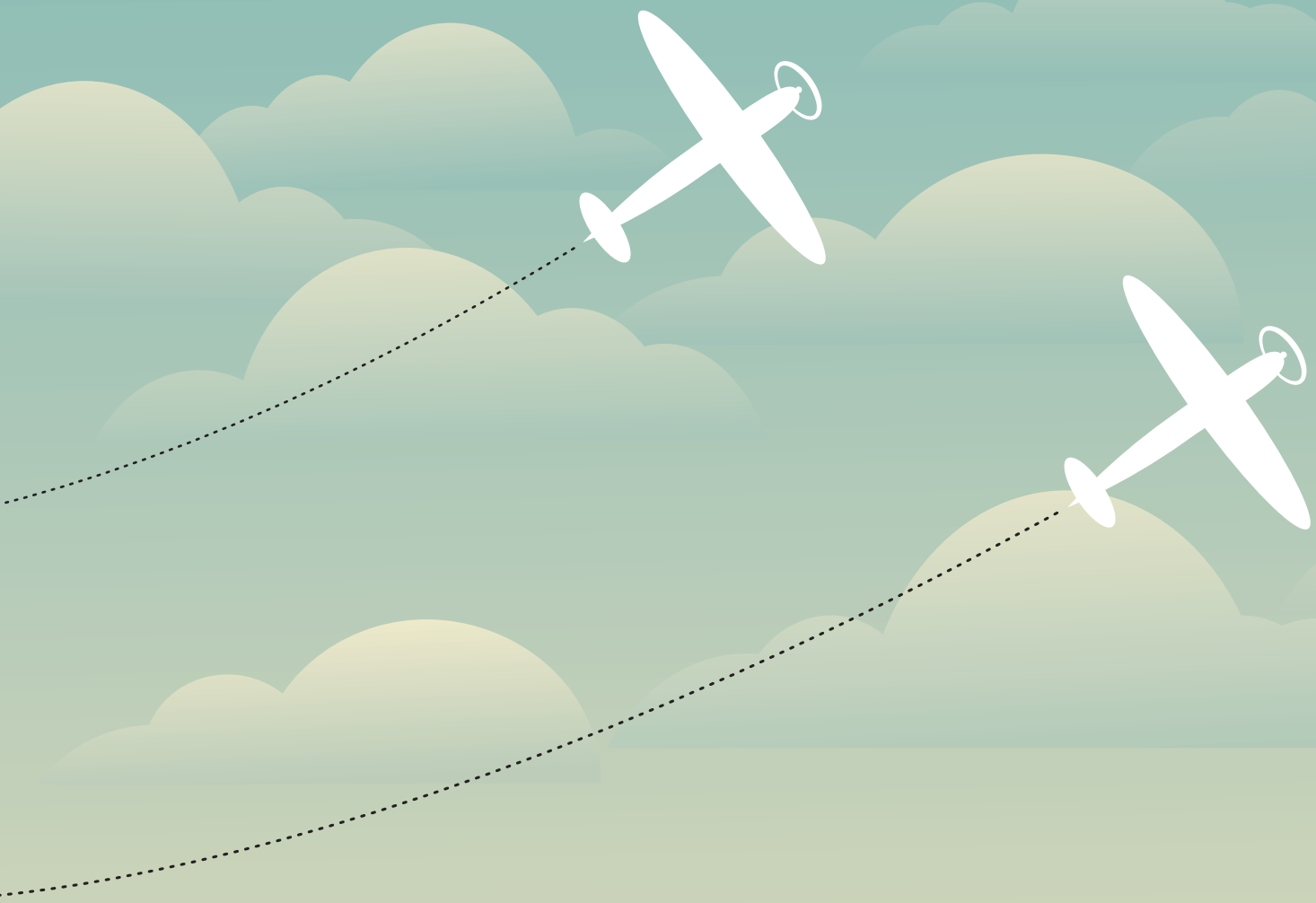
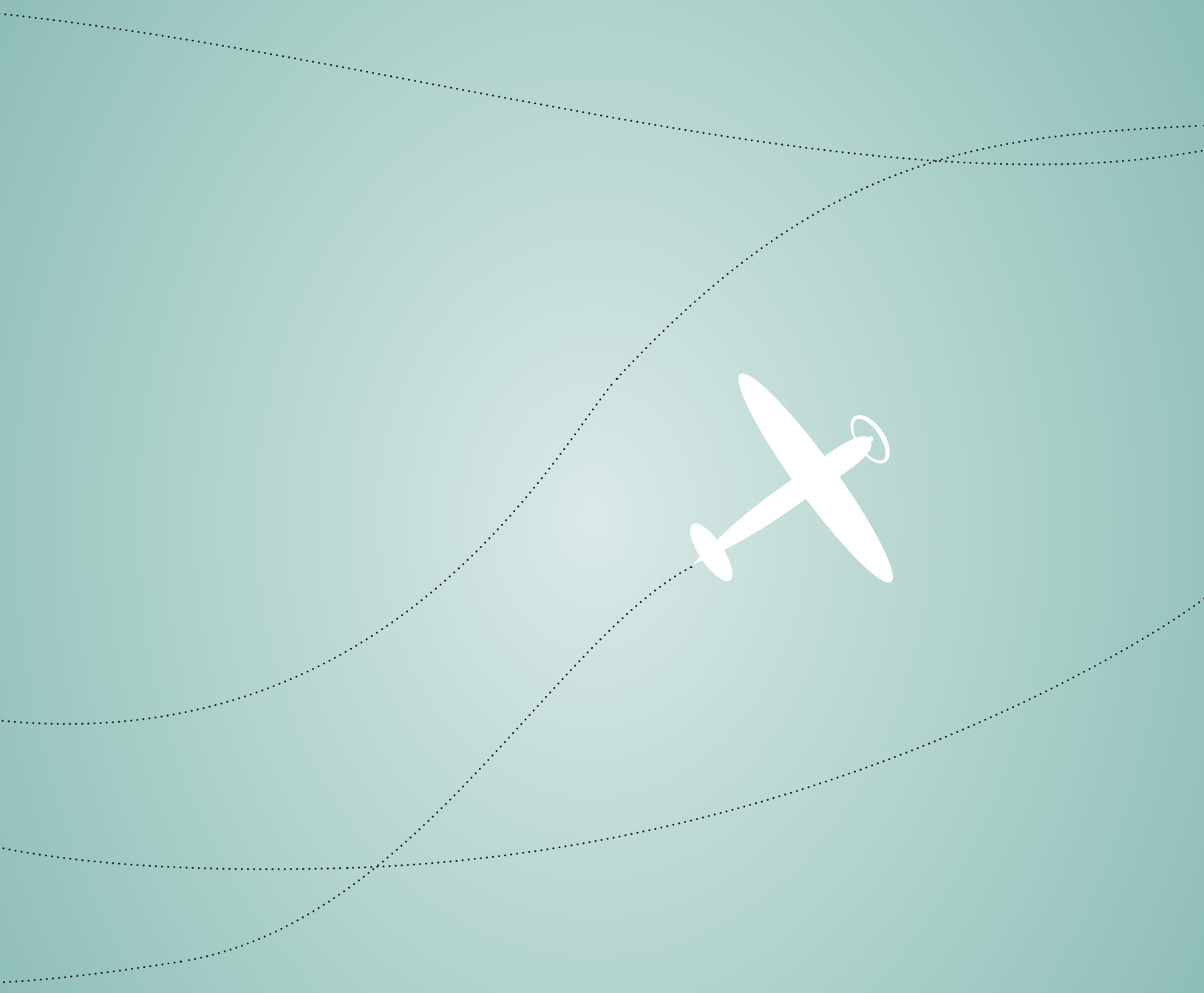
PURDUE EXTENSION

National PEER REVIEWED

WEATHER AND CLIMATE SCIENCE



4-H-1025-W LEVEL 3



WEATHER AND CLIMATE SCIENCE

Science • Level 3 • Grades 9-12

NOTE TO 4-H MEMBER

As you continue your study of weather and climate science, you will be increasingly responsible for collecting your own data and gaining information from sources outside this manual. Level 1 introduces basic weather terminology and concepts. Activities focus on understanding the signs of weather around you. Level 2 introduces more complex weather topics such as air pressure, winds, humidity, and fronts.

Level 3 delves even deeper into weather and introduces climate science concepts to help prepare you to fully understand weather and/or study these topics at a college or university. In Level 3 you are encouraged to supplement your learning by consulting knowledgeable people and recent written materials. The study of weather and the earth's climates has evolved significantly, so recent references are preferred.

The key to learning in this, or any 4-H project, is to enjoy your studies and to learn at your own pace. We hope this project is just the start of a lifetime enjoyment of understanding the climate you live in and watching the weather!

Safety First!

Ask a parent or other adult to help when you see a safety first icon.

Weather is the state of the atmosphere at a particular place and time and is influenced by climate and many local factors.

Climate describes the prevailing or general long-term weather conditions for an area, or for the entire planet.

Climate System: Earth's water and gases that flow or change state as a result of the sun's energy.

Climate: The average weather over time.

Weather: What is happening today and tomorrow.

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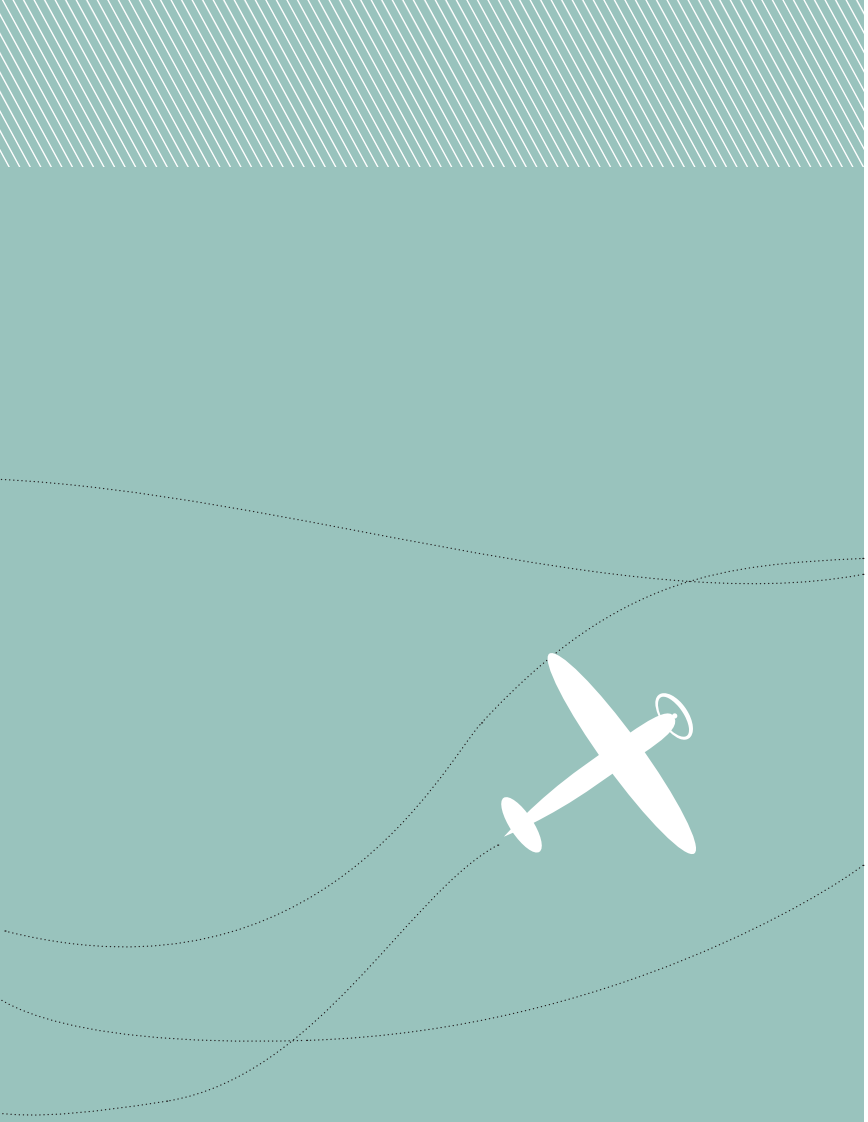

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NGSS indicates the Next Generation Science Standards for each activity. See www.nextgenscience.org/next-generation-science-standards for more information.

See Purdue Extension's Education Store, www.edustore.purdue.edu, for additional resources on many of the topics covered in the 4-H manuals.

AIR MASSES AND FRONTS

How are the movements of air masses involved in the formation of fronts and their resulting weather?

RECOMMENDATION: Before beginning, review the Cold Front and Cloud Formation activities from the Level 2 manual.

Air masses have distinct temperature and moisture characteristics. These characteristics develop when air masses spend time over large areas of the earth's surface. As they begin to move, fronts form. Each type of front brings weather that depends on the air masses involved. Knowing the characteristics of air masses and how they move helps meteorologists predict the type of weather that will develop along the resulting fronts.

OBJECTIVE: Explain the development of air masses, the resulting formation of fronts, and the weather those fronts produce.

Weather Tote

Air Masses and Fronts worksheet on pages 4-9

1 Complete the worksheet.

2 Discuss the Chat questions with a parent or other adult helper.

SHARE WHAT HAPPENED: What causes stormy weather in the Midwest?

APPLY: When you see stratus and nimbostratus clouds, what weather would you predict?

GENERALIZE TO YOUR LIFE: How can you use the information you learned to help you understand TV weather reports?

Fly Higher

- Observe weather reports at the NOAA website, www.noaa.gov/wx.html.
- Observe the fronts approaching your area for several days.
- Keep track of how they move and the kind of weather they cause.

AIR MASSES AND FRONTS WORKSHEET

ACKNOWLEDGEMENT: Some text and graphics for this activity are from the National Oceanic and Atmospheric Administration (NOAA), www.srh.noaa.gov/crp/?n=education-airmasses, downloaded August 2014.

Air Mass

An air mass is a large body of air that has relatively uniform temperature and humidity characteristics. The regions where air masses form are called air mass source regions. If air remains over a source region long enough, it will acquire the properties of the surface below. Ideal source regions are generally flat and of uniform composition. Examples include central Canada, Siberia, the northern and southern oceans, and large deserts.

NOAA, www.srh.noaa.gov/crp/?n=education-airmasses

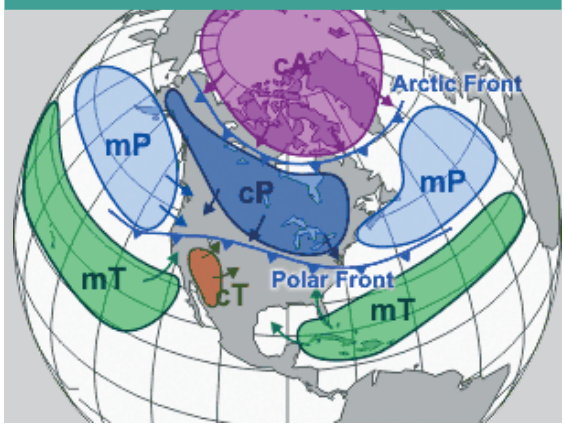
Air masses are classified according to their temperature and moisture characteristics. They are grouped into four categories based on their source region. Air masses that originate in the cold, polar regions are designated with a capital "P" for polar. Air masses that originate in warm, tropical regions are designated with a capital "T" for tropical. Air masses that originate over land are dry and designated with a lowercase "c" for continental. Air masses that originate over water are moist and designated with a lowercase "m" for maritime. In winter, one more type of air mass may form, an extremely cold, dry air mass called "cA," continental arctic. Once formed, air masses can move out of their source regions, bringing cold, warm, wet, or dry conditions to other parts of the world.

NOAA, www.srh.noaa.gov/crp/?n=education-airmasses

Common North American air masses are shown in Figure 1 and described below:

- Maritime tropical (mT) air mass – forms over tropical water. It is warm and moist.
- Continental polar (cP) air mass – forms over a cold land. It is cold and dry.
- Maritime polar (mP) air mass – forms over cold water. It is cold and moist.
- Continental tropical (cT) air mass – forms over warm land. It is warm and dry.

AIR MASSES [FIGURE 1]



Source: National Oceanic and Atmospheric Administration/ Department of Commerce.

Fronts

A front is the boundary between two air masses. Fronts are classified by the type of air mass (cold or warm) that is replacing the other type of air mass.

NOAA, www.srh.noaa.gov/crp/?n=education-airmasses

The Cold Front

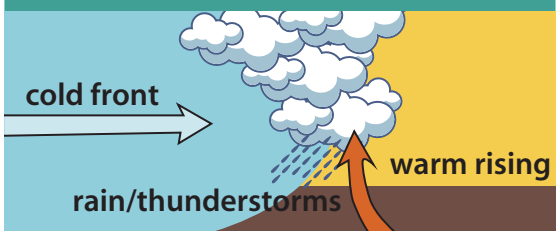
A front is called a cold front if a cold air mass is replacing a warm air mass. The air behind a cold front is colder and typically drier than the air ahead of it, which is generally warm and moist. There is usually a shift in wind direction as the front passes, along with a change in pressure tendency — pressure falls prior to the front arriving and rises after it passes. A cold front has a steep slope, which causes air to be forced upward along its leading edge. This is why a band of showers and/or thunderstorms sometimes lines up along the leading edge of the cold front. Cold fronts are represented on a weather map by a solid blue line with triangles pointing in the direction of its movement.

DID YOU KNOW? The United States has more tornadoes than any other country in the world and four times as many as all of Europe.

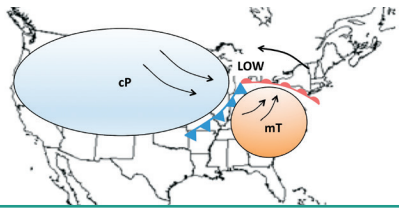
Source: NOAA, www.srh.noaa.gov/crp/?n=education-airmasses

Differences in air pressure cause air masses to move. When a cold air mass moves into an area of warmer air, as shown in Figure 2, the denser cold air forces the warmer air to rise at the frontal boundary. Towering cumulus and cumulonimbus clouds form in a cold front. The density difference between the two air masses and the amount of moisture in the warm air determines how severe the weather in the front will be. Cold air is denser than warm air, and dry air is denser than moist air, so cold, dry air is denser than warm, moist air. Density differences between different air masses result in very little mixing of the air.

COLD FRONT [FIGURE 2]



COLD FRONT AIR MASSES [FIGURE 3]



In the Midwest, warm air masses are usually southwest winds, and cold air usually blows in from the northwest, as shown in Figure 3. It is common to experience a change in wind direction from southwest to northwest after a cold front moves through. The cold air mass moves faster and at a slightly different angle than the warm air. As the cold air moves, friction against the ground slows the air near the surface, causing the upper winds to tumble downward at the frontal boundary. A rapid rise in the warm air causes cloud formation; and the moister the warm air, the more clouds develop.

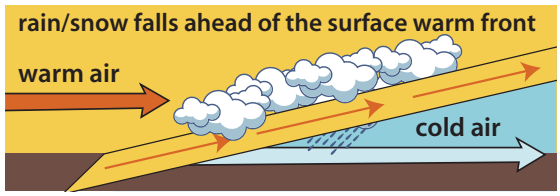
Warm air can be lifted rapidly in advance of a cold front, creating vertical shear winds. Vertical shear winds occur when there is a quick change in vertical direction as the cold front air rises in the warm air and sinks in the cold air.

Weather along a cold front is generally stormy and sometimes severe. In the spring, the continental polar (cP) air masses are extremely dry and cold. These air masses form cold fronts as they move from Canada to the United States and drive into the warm moist air from the Gulf of Mexico. This creates severe cold fronts that can produce damaging storms and tornadoes. Most tornadoes form in the Great Plains, where no landforms disturb airflow. During the winter when the air is cooler in the Midwest, not much moisture is in the air and the cold fronts are not as severe.

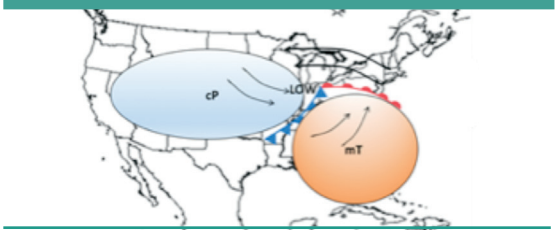
The Warm Front

When a warm air mass moves into an area of cooler air, a warm front forms, as shown in Figure 4. Because the warm air is less dense than the cooler air, it cannot push the cooler air out of the way. As a result, the angle of the frontal boundary is not as severe as with a cold front. The warm air climbs slowly over the cooler air, producing layered clouds like stratus and nimbostratus clouds.

WARM FRONT [FIGURE 4]



WARM FRONT AIR MASSES [FIGURE 5]



Far in advance of the front, cirrostratus and cirrus clouds form. Warm fronts form clouds that cover a large area and create rain or snow events that can last for days. When we are experiencing warm front-produced weather, the warm air is aloft, and we are in the cooler air. The moist, warm air from the Gulf provides the moisture for the clouds and precipitation. Warm fronts produce heavy snow and ice storms in the Midwest, as the weather produced wraps around to the northern section of the low pressure system, as shown in Figure 5.

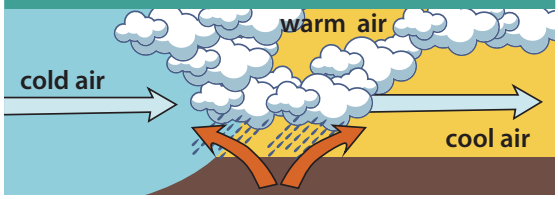
Warm fronts produce overcast skies and steady precipitation that may last for long periods. In the winter, warm fronts can produce blizzard conditions; in the spring, they can produce prolonged rain that can cause flooding. The heaviest snow and most severe ice storms occur when the winds are out of the east and northeast as moist air from the Gulf is lifted and pulled around the low-pressure zone.

Other Fronts

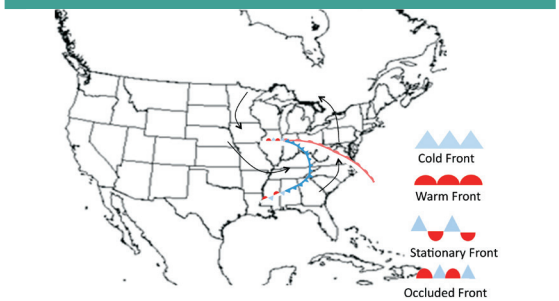
Stationary and occluded fronts are variations of cold and warm fronts. A stationary front, as you might guess, is a cold or warm front that comes to a standstill. The warmer air continues to rise over the cooler air, but the position of the front on the earth moves very little. In a stationary front, the cold air normally flattens out, and the resulting front resembles a warm front with stratus and nimbostratus clouds. Stationary fronts form away from the influence of the primary low and are influenced by other factors in the atmosphere. They often lead to flooding. Stationary fronts are represented on a weather map by alternating red and blue lines, with blue triangles and red semicircles facing opposite directions.

COLD FRONT ADVANCING TOWARD A WARM FRONT [FIGURE 6]

OCCLUDED FRONT [FIGURE 7]



OCCLUDED FRONT FORMATION [FIGURE 8]



The boundary between two cold air masses is called an occluded front. Occluded fronts form because cold fronts usually advance faster than warm fronts and catch up to a warm front. A cold front is shown advancing toward a warm front in Figure 6. When the cold front overtakes the warm front, the warm air is lifted between the two cooler air masses. The coldest air mass undercuts the others. Occluded fronts are represented on weather maps by a solid purple line with alternating triangles and semicircles, pointing in the direction of its movement.

The several different types of occluded fronts are based on their interactions due to the density of the two cooler air masses. Figure 7 shows an approaching cold air mass denser than the warm air mass that created a front with another cold air mass. The cold air mass will lift the cool air mass as well as the warm air mass. Occluded fronts form near the center of low pressure systems, as indicated in Figure 8. The weather in an occluded front depends on the location within the front. As the front passes, you can expect stratus and nimbostratus clouds followed by towering cumulus and cumulonimbus clouds.

Questions:

AIR MASSES

Match the air masses to their characteristic (each letter is used twice):

AIR MASS	LETTER	CHARACTERISTIC
A. Maritime Tropical (mT)		Dry and warm
		Moist and cold
B. Continental Tropical (cT)		Moist and warm
		Dry and cold
C. Continental Polar (cP)		Forms over warm land
		Forms over warm water
D. Maritime Polar (mP)		Forms over cold water
		Forms over cold land

THE COLD FRONT

What causes the movement of air masses?

_____

_____

What causes the warm air ahead of a cold front to rise?

_____

_____

What kind of clouds usually form in a cold front?

_____

What wind direction change usually occurs as a cold front moves through an area?

_____

Where do vertical shear winds form?

_____

What kind of weather is usually expected in a cold front?

_____

THE WARM FRONT

What cloud types are typically associated with a warm front?

_____

Which air mass provides the moisture that produces the clouds and precipitation?

_____

What severe events can warm fronts produce?

_____

What kind of weather is usually expected in a warm front?

_____

How does an occluded front form?

_____

Within the low, where do occluded fronts form?

_____

How do stationary fronts form?

_____

Within the low, where do stationary fronts form?

_____

ISAAC'S STORM

How might a weather event affect the people living through it?

intro

Meteorological observations in the United States were the responsibility of the U.S. Army Signal Corps from 1861 to 1891. Congress, at the request of President Benjamin Harrison, passed an act transferring the meteorological responsibilities of the Signal Corps to the newly created U.S. Weather Bureau in the Department of Agriculture on October 1, 1890.

Isaac's Storm is the story of Isaac Monroe Cline, chief meteorologist at the Galveston, Texas, office of the U.S. Weather Bureau from 1889 to 1901. The book describes the early workings of the Weather Bureau and how a lack of scientific knowledge about hurricanes resulted in the greatest loss of life in U.S. weather history.

OBJECTIVE: Discuss how weather can change people's lives.

Weather Tote

☐ Book: Larson, Erik. *Isaac's Storm*. New York: Vintage Books, 2000. (ISBN: 0-375-70827-8)

do it

1. Read *Isaac's Storm* by Erik Larson.
2. Discuss the Chat questions with a parent or other adult helper.

Chat

SHARE WHAT HAPPENED:

- Why was Galveston an important city in Texas?
- What was the general opinion about Galveston's safety from a hurricane in 1900?
- How did Isaac Cline come to be the head of the Galveston weather station?
- Why did the Weather Bureau ignore reports from Havana, Cuba?
- What is the significance of the ring on Isaac's finger in his photograph?
- What part of this book was most interesting to you? Why?

APPLY: How would a hurricane like this be handled differently today?

GENERALIZE TO YOUR LIFE: Can you think of weather events, either positive or negative, that have changed things in your life or the lives of your family members? Explain your answer.

Fly Higher

- Identify another hurricane event. Learn more about it and share your findings with a parent or friend.
- Learn more about the history of the U.S. Weather Bureau at:

  www.lib.noaa.gov/collections/imgdocmaps/weather_annual_reports.html

  www.weather.gov/timeline

NOTES