4.2 Pressure and Air Masses (6.3.2)

Explore This Phenomena

Everybody loves a picnic. Your friends and you are headed up the canyon to enjoy the mountains. While driving you feel a slight discomfort in your ears which goes away as soon as your ears “pop”. What happened? Why were your ears hurting?

Write an explanation for why your ears were hurting as you drove into the mountains and stopped hurting once they “popped”.

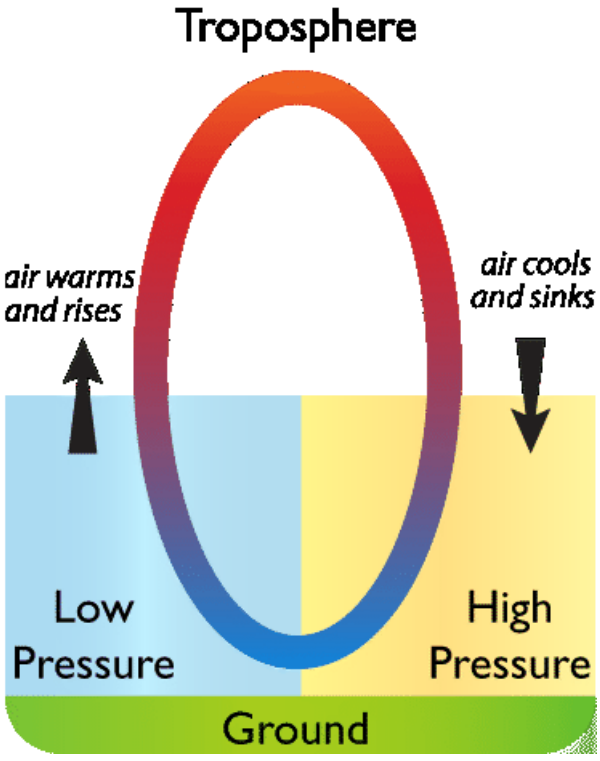
6.3.2 Air Pressure

Investigate the interactions between air masses that cause changes in weather conditions. Collect and analyze weather data to provide evidence for how air masses flow from regions of high pressure to low pressure causing a change in weather. Examples of data collection could include field observations, laboratory experiments, weather maps, or diagrams.

In this section, focus on cause and effect. Analyzing cause and effect relationships help us to predict natural phenomena, such as changes to the weather.

Air Pressure

Pressure in the atmosphere is created by the weight of the atmosphere pushing down on the surface. Air heated at the surface rises, creating a low pressure zone. Air from the surrounding area is rushes into the space left by the rising air. As air cools it sinks back to the surface. When the air reaches the ground, it creates a high pressure zone. Air flowing from areas of high pressure to low pressure creates winds. The greater the pressure difference between the pressure zones, the stronger the wind blows.



Warm air rises, creating a low pressure zone; cool air sinks, creating a high pressure zone

Warm air can hold more moisture than cool air. When warm air rises and cools in a low pressure zone, it may not be able to hold all the water it contains as vapor. Some water vapor may condense to form clouds and precipitation. When cool air descends, it warms. Since it can then hold more moisture, the descending air will evaporate water on the ground.

Gases at sea level are also compressed by the weight of the atmosphere above them. The force of the air weighing down over a unit of area is known as its atmospheric pressure, or air pressure. Why are we not crushed? The molecules inside our bodies are pushing outward to compensate. Air pressure is felt from all directions, not just from above.

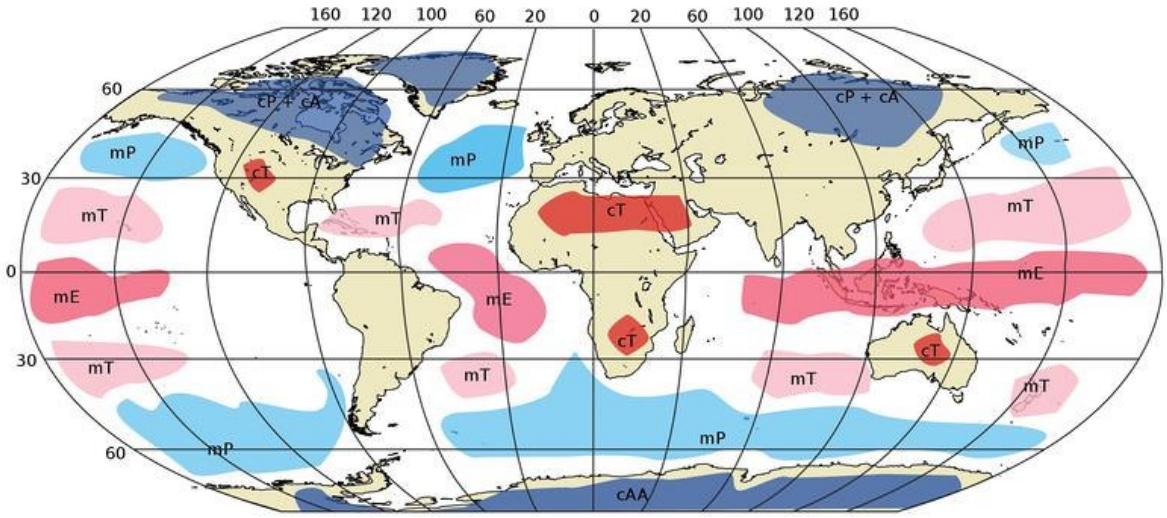
This bottle was closed at an altitude of 3,000 meters where air pressure is lower. When it was brought down to sea level, the higher air pressure caused the bottle to collapse.

At higher altitudes the atmospheric pressure is lower and the air is less dense than at lower altitudes. That's what makes your ears pop when you change altitude. Gas molecules are found inside and outside your ears. When you change altitude quickly, like when an airplane is descending, your inner ear keeps the density of molecules at the original altitude. Eventually the air molecules inside your ear suddenly move through a small tube in your ear to equalize the pressure. This sudden rush of air is felt as a popping sensation.

Air Masses

An air mass is a body of air that has nearly the same temperature and humidity. When the air mass sits over a region for several days or longer, it picks up the distinct temperature and humidity characteristics of that region.

Air masses form over a large area. They can be 1,600 km (1,000 miles) across and several kilometers thick. Air masses form primarily in high pressure zones, most commonly in polar and tropical regions. Temperate zones are ordinarily too unstable for air masses to form. Instead, air masses move across temperate zones, so these areas are prone to having more varied weather.



This picture shows where different types of air masses form. Some form over land and some form over water. They are also named for the area they form.

Air masses are slowly pushed along by high-level winds. When an air mass moves over a new region, it shares its temperature and humidity with that region. So the temperature and humidity of a particular location depends partly on the characteristics of the air mass that sits over it.

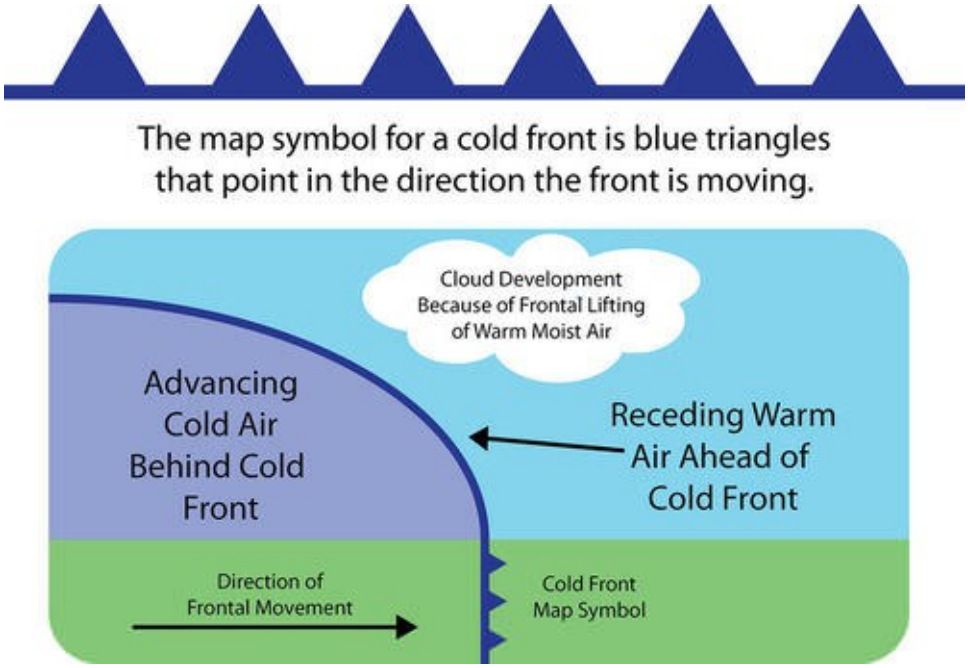
Fronts

Two air masses meet at a front. At a front, the two air masses have different characteristics and do not easily mix. One air mass is lifted above the other, creating a low pressure zone. If the lifted air is moist, there will be condensation and precipitation. Winds are common at a front. The greater the temperature difference between the two air masses, the stronger the winds will be. Fronts are the main cause of stormy weather.

There are four types of fronts, three moving and one stationary. With cold fronts and warm fronts, the air mass at the leading edge of the front gives the front its name. In other words, a cold front is right at the leading edge of moving cold air and a warm front marks the leading edge of moving warm air.

Cold Fronts

When a cold air mass takes the place of a warm air mass, there is a cold front (Figure below).



The cold air mass is slides beneath the warm air mass and pushes it up.

Imagine that you are standing in one spot as a cold front approaches. Along the cold front the cold air pushes up the warm air, causing the air pressure to decrease (Figure above). If the humidity is high enough clouds will develop. High in the atmosphere, winds blow ice crystals from the tops of these clouds. At the front, there will be a line of rain showers, snow showers, or thunderstorms with blustery winds. Behind the front is the cold air mass. This mass is drier, so precipitation stops. The weather may be cold and clear or only partly cloudy. Winds may continue to blow into the low pressure zone at the front.

A developing thunderstorm

The weather at a cold front varies with the season.

- Spring and summer: the air is unstable so thunderstorms or tornadoes may form.
- Spring: if the temperature variation is high, strong winds blow.
- Autumn: strong rains fall over a large area.
- Winter: the cold air mass is likely to have formed in the frigid arctic, so there are frigid temperatures and heavy snows.

Warm Fronts

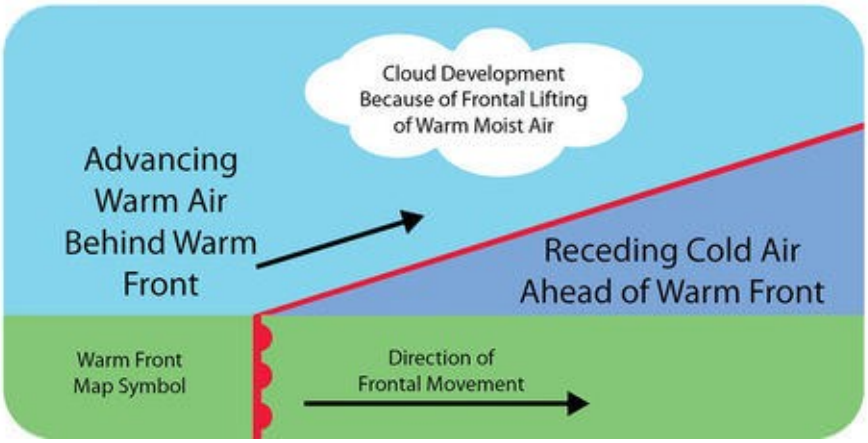
At a warm front, a warm air mass slides over a cold air mass (Figure below). When warm air moves over the colder air the atmosphere is relatively stable.

Imagine that you are on the ground in the wintertime under a cold winter air mass with a warm front approaching. The transition from cold air to warm air takes place over a long distance, so the first signs of changing weather appear long before the front is actually over you. Initially, the air is cold: the cold air mass is above you and the warm air mass is above it. High clouds mark the transition from one air mass to the other.

Over time, the clouds become thicker. As the front approaches clouds appear and the sky turns gray. Since it is winter precipitation falls as snow. Winds grow stronger as the low pressure approaches. As the front gets closer, the cold air mass is just above you but the warm air mass is not too far above that. The weather worsens. As the warm air mass

approaches, temperatures rise and snow turns to sleet and freezing rain. Warm and cold air mix at the front, leading to the formation of clouds and fog.

The map symbol for a warm front is red half-circles that point in the direction the front is moving.



Warm air moves forward to take over the position of colder air.

Stationary Fronts

At a stationary front the air masses do not move (Figure below). A front may become stationary if an air mass is stopped by a barrier, such as a mountain range. A stationary front may bring days of rain, drizzle, and fog. Winds usually blow parallel to the front, but in opposite directions. After several days, the front will likely break apart.

The map symbol for a stationary front has red domes for the warm air mass and blue triangles for the cold air mass.

Occluded Fronts

An occluded front usually forms around a low pressure system (Figure below). The occlusion starts when a cold front catches up to a warm front. The air masses, in order from front to back, are cold, warm, and then cold again.

The map symbol for an occluded front is mixed cold front triangles and warm front domes.

The weather at an occluded front is especially fierce right at the occlusion. Precipitation and shifting winds are typical. The Pacific Coast has frequent occluded fronts.

Focus Questions

1. Describe how the air masses move.
2. What type of weather is associated with a warm front?
3. Look for patterns in the weather map from NOAA. What type of weather would you expect around low pressure areas? Why?