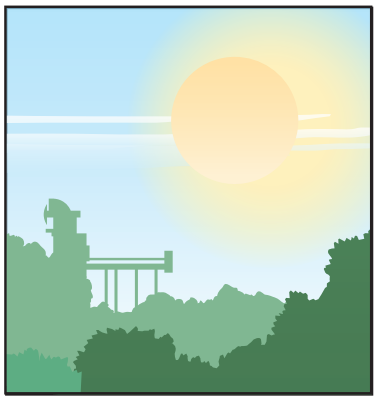
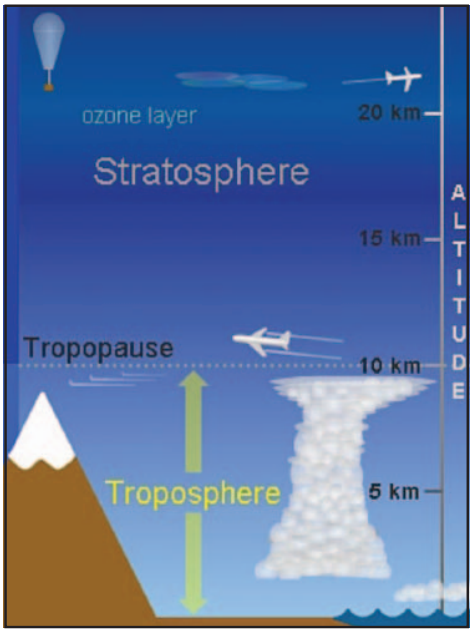
World Wide Weather

Living in Balance



The driving force for all weather is the movement toward balance. The sun heats the Earth unevenly which causes different parts of the atmosphere to have different temperatures. These temperature variations cause changes in pressure, creating instability and movement. Air moves from areas of high pressure to areas of low pressure in an effort to reach balance. The sun is continually altering this balance by heating the equator more than the poles, and the result is movement in the atmosphere which causes weather.

Earth is surrounded by a layer of gases extending over 50 miles above the surface. Beginning from the edge of space to the surface of the Earth, the atmosphere is composed of distinct layers. The thermosphere is the highest and has low density and high temperature at over 3,500°F making it the hottest part of the atmosphere. The mesosphere is below the thermosphere and it is a little denser but much colder at about -225°F. The stratosphere is just above the highest mountains and the tallest clouds, where most planes fly. The ozone layer is part of the stratosphere and it protects us against harmful ultraviolet radiation from the sun. The most turbulent layer is the lowest, the troposphere. It extends from sea level up to about 7 or 8 miles. Even the highest rain forming clouds are within this layer. It is composed of mostly Nitrogen and Oxygen with trace amounts of other gases and solid particles like dust and pollen. The atmosphere also holds an enormous amount of evaporated water, enough to cover the entire planet with one inch of water if it all rained out at once.



Credit: Randy Russell, UCARhttps://scied.ucar.edu/shortcontent/troposphere-overview

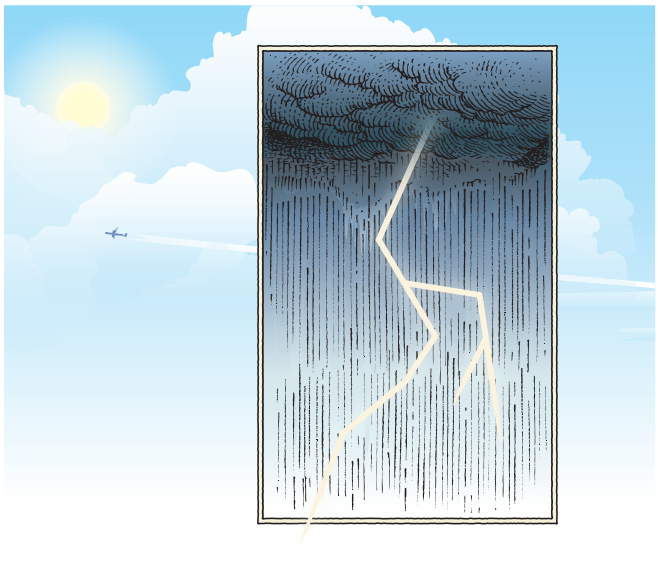
Weather is simply the state of the atmosphere over the short term. Is it raining today? Will it be windy tomorrow? Is it going to be warm for the next few days or weeks? **Climate** is the average of weather over a longer period of time. Since weather affects our lives, it would be useful if we could make accurate predictions of what the weather is going to be like in the future. Scientists do this using observed data and models based on certain physical rules.

The most important rule, which is as basic as the law of gravity, is called the **gas law**. It is a law of nature and states that when you heat a gas it expands and its pressure decreases. When you cool a gas it contracts and its pressure increases. This law drives most weather phenomena. Another important rule relates to the amount of water vapor air can hold, which depends on temperature. Warm air can hold more water vapor than cold air. If you heat up some air and water evaporates into that air, and then later cool that same volume of air, the water will condense out of it and form a cloud of tiny water droplets.

Operating under these and a few other laws, the atmosphere behaves as we expect and observe. Cold dense air sinks down over the poles and moves through the lower part of the atmosphere towards the sunny equator where warm air rises and moves through the upper part of the atmosphere to the poles where it cools and sinks, creating a cycle. There are also other factors that complicate this motion like the Coriolis Effect which makes air deflect to the right in the north and to the left in the south.

This project was funded through a Pennsylvania Department of Environmental Protection Environmental Education grant (EE#:16-186).

The oceans play a large role in the daily changes in the atmosphere. The temperature and pressure changes that set the atmosphere in motion cause circulation in the oceans which we observe as currents. Steady winds blowing east to west at the equator push the water in the same direction. The ocean also moves due to temperature differences between the poles and the equator creating the thermohaline current. Cold salty water sinks at the poles and slowly moves far below the surface towards the equator where that water is heated and rises. Eventually the heated water moves north or south and the process begins again. Circulation in the atmosphere and ocean moves excess heat but the oceans have a large heat carrying capacity. The upper 10 feet of the ocean holds more heat than the entire atmosphere above. That is why changes in ocean currents have such a large impact on the weather. Even a small change in the temperature of surface waters in the oceans can have dramatic consequences.



There is a vast region of the Pacific Ocean that is particularly prone to sudden changes in current flow due to changes in winds at the surface. When the winds blow harder the water moves across the Pacific west from South America. That westward movement of water draws up cold waters from deep below the surface. When the winds are weak, the water moves slowly retaining heat from the sun without mixing with colder deep waters. This phenomenon is called **El Niño** or **La Niña** – in El Niño years the waters off the coast of South America are warm, in a La Niña they are cold. These temperature changes in part of the ocean affect the atmosphere of the entire planet. The Gulf Stream is another example of the ocean's ability to influence weather conditions. It is the warm current of water that flows along the east coast of the United States before moving across the North Atlantic to warm Europe.

Air also moves up and down powered by the sun's uneven heating of the atmosphere. Sunlight passes through the upper atmosphere without heating it. As light is absorbed at the surface, air in contact with it is heated from the bottom up. Since hot air is less dense than cold air, it is lifted by its low density into the upper troposphere. That warm air often holds water vapor especially if it formed over water. As it rises it cools and the water condenses into droplets that clump together forming larger and larger droplets that fall to the surface as rain, or if it is cold enough snow. Thus, to get rain we only need to lift warm wet air high into the atmosphere. This happens almost daily at the hot sunny equator, but outside of the tropics there isn't enough energy to do that all the time except for the hot days in summer. Since air can't rise high enough to cool and condense water, it is normally left to a passing front moving across the surface to provide the necessary temperature change. Fronts form where cold and warm air masses collide and can produce large violent storms.

Cold fronts form when cold dense air sweeps in and quickly pushes warm air up and out of the way. This can produce sudden downpours and the powerful thunderstorms we see mostly in the summer months.

Warm fronts form when warm air slides on top of cold air. The warm air has a hard time displacing the cold air, so these storms often move slowly, producing a light amount of rain over a long period of time. When it rains and rains for days it is due to a passing warm front.

Occluded fronts form when a warm front is caught between two cold fronts. This pushes the warm air straight up very quickly producing incredibly violent downpours. These form in the spiral arms of a hurricane and other spinning storm systems.

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Name:_____

Our planet is surrounded in layers of gases that we call the atmosphere. The layers are called the thermosphere, mesosphere, stratosphere, and troposphere. The atmosphere gets thicker and denser as we get closer to the surface.

1. The thermosphere is the highest layer of the atmosphere and the closest to outer space. How dense is it compared to the other layers. Circle your answer

More dense

Just as dense

Less dense

Weather is the state of the atmosphere at one point in time and refers to the temperature, wind speed, air pressure, cloudiness, and the presence of precipitation. Climate is the average of weather conditions over long time periods. If someone asks if it's snowing they are asking about weather. If someone asks how much snow a region gets per year they are asking about climate.

2. Circle statements about weather, underline statements about climate.

It is raining today

Clear skies are expected this weekend

July and August are normally the hottest months

The hurricane will make landfall in 6 hours

Snow is rare in the southern United States

It was windy three days ago

The British Isles are known for being cloudy most of the year

Rain is rare in Nevada

We can predict weather because we understand the fundamental rules that govern the behavior of our atmosphere. Hot air expands and has lower air pressure. Cold air contracts and has higher air pressure. Areas of high pressure move towards areas of low pressure. This movement of air from high to low pressure areas is the cause of wind. It also drives the movement of air that leads to precipitation of rain and snow.

3. Air over the North Pole is cold and at high pressure compared to air at the equator which is warm and at low pressure. Which way does the air move from the North Pole? Circle your answer.

High pressure cold air moves out of the North Pole towards the equator.

Low pressure warm air moves away from the equator towards the North Pole.

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Our oceans play a vital role in the weather. The ocean currents are driven by temperature differences just like the weather in the atmosphere above.

4. Cold polar waters move along the bottom of the ocean towards the equator. How do you think the warm water moves at the equator? Circle your answer.

Warm water sinks down to the bottom of the ocean and moves with the cold water.

Warm water flows along the surface towards the North Pole.

Warm water stays in place as cold water accumulates at the equator.

Because we know how air responds to changes in temperature we can predict what the weather will be like in the near future. The more accurately we can measure current weather conditions, the better our chances of predicting future conditions. Meteorologists measure current conditions with instruments at ground based weather stations, floating weather stations at sea, weather balloons, weather plans, and even satellites.

5. Try to match the weather instrument with the property of the atmosphere it measures. Use the word bank.

Thermometer	Wind Speed
Barometer	Accumulated Rainfall
Hydrometer	Humidity
Anemometer	Temperature
Rain gage	Barometric air pressure

Meteorologists need to warn the public when they think that a severe weather event is likely to occur. Severe weather events might include heat waves, cold spells, flooding, strong winds, thunderstorms, hail, tornadoes, hurricanes, and droughts. Extreme weather warnings can be issued on TV, over radio, on the internet, or by text message. If you see a severe weather warning you should do your best to stay safe and follow the instructions given in the warning.

6. Match the severe weather event with the correct responses below.

Event:

a. Temperatures above 95 degrees
b. Temperatures below 10 degrees
c. Hurricane
d. Tornado
e. Flooding
f. Thunderstorms

Responses:

____ Get to higher ground if you are in a flood prone area. Avoid driving in flooded road ways.
____ Stay away from windows and get to higher ground if you are in a flood prone area.
____ Stay away from doors and windows. Try to shelter in the lowest part of your home.
____ Stay indoors and wear insulating clothing if you must go outdoors.
____ Stay indoors and away from windows. If you are caught outdoors, avoid tall structures or metallic objects. Stay away from bodies of water.
____ Stay out of the sun, avoid outdoor work or activities and drink lots of water.