Weather and Climate Notes

The Atmosphere

Weather - the condition of the Earth’s atmosphere at a particular time and place

Atmosphere - the layer of gases that surrounds the planet

Earth's atmosphere makes conditions on Earth suitable for living things.

Nearly all the atmosphere is confined to a thin shell surrounding Earth. The atmosphere is a mixture of gases, including nitrogen and oxygen with small amounts of water vapor, carbon dioxide, and other trace gases. The atmosphere is stratified into layers, each having distinct properties. Nearly all weather occurs in the lowest layer of the atmosphere.

Because air has mass, it also has other properties including density and pressure.

Density - the amount of mass in a given volume

Pressure - the force pushing on an area or surface

Air pressure is the result of the weight of a column of air pushing down in an area.

Barometer - an instrument that is used to measure changes in air pressure.

There are two kinds of barometers: mercury barometers and aneroid barometers.

As altitude increases, air pressure decreases. As air pressure decreases, so does density.

Think of the relationship between air pressure and altitude like a stack of books. The book at the bottom has more weight on it than the book on the top. Air at sea level is like the bottom book. It has the pressure of the entire stack of books on it. The books at the stop of the stack have less weight pressing on them. This is like the higher altitudes having a lower air pressure.
The four main layers of the atmosphere are classified according to changes in temperature. These layers are the troposphere, stratosphere, the mesosphere, and the thermosphere.

**Troposphere** - the lowest layer of Earth’s atmosphere, where weather occurs

**Stratosphere** - the second-lowest layer of Earth’s atmosphere; the ozone layer is found in the upper stratosphere

**Mesosphere** - the middle layer of Earth’s atmosphere; the layer in which most meteoroids burn up

**Thermosphere** - the outermost layer of Earth’s atmosphere

  **Ionosphere** - the lower part of the thermosphere, where electrically charged particles called ions are found

    **Aurora borealis** - a colorful, glowing display in the sky caused when particles from the sun strike oxygen and nitrogen atoms in the ionosphere; also called the Northern lights.

**Exosphere** - the outer layer of the thermosphere, extending outward into space

**Weather Factors**

**Energy in the Atmosphere**
Most of the energy from the sun reaches Earth in the form of visible light and infrared radiation, and a small amount of ultraviolet radiation.

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<th>sub-mm</th>
<th>Infrared</th>
<th>visible light</th>
<th>Ultra-Violet</th>
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**LOW wavelengths**

**LOW energies**

**S H O R T wavelengths**

**H I G H energies**

**Red orange yellow green blue violet**
When Earth’s surface is heated, it radiates some of the energy back into the atmosphere as infrared radiation.

The uneven heating of the Earth’s surface is the cause of weather.

*Greenhouse effect* - the process by which gases hold heat in the air

**Winds**

All winds are caused by differences in air pressure.

*Wind* - the horizontal movement of air from an area of high pressure to an area of low pressure

*Anemometer* - a tool used to measure wind speed

[Diagram of an anemometer]

*Wind-chill factor* - the increased cooling that a wind can cause

Local winds - winds that blow over short distances
Local winds are caused by unequal heating of Earth’s surface within a small area.

A wind that blows from an ocean or lake onto land is known as a *sea breeze*.

The flow of air from land to a body of water is called a *land breeze*.

Sea and land breezes over a large region that change direction with the seasons are called *monsoons*.
Global winds - winds that blow steadily from specific directions over long distances

The movement of air between the equator and the poles produced global winds.

Coriolis Effect - (named for a French mathematician) - the way Earth’s rotation makes winds in the Northern Hemisphere curve to the right and winds in the Southern Hemisphere curve to the left

The major global wind belts are the trade winds, the prevailing westerlies, and the polar easterlies. (page 59 in book).

Jet stream - bands of high-speed winds about 10 kilometers above Earth’s surface

Water Cycle - the water cycle is the continuous process by which water moves through the living and nonliving parts of the environment

Humidity - a measure of the amount of water vapor in the air

Relative Humidity - the percentage of water vapor in the air compared to the maximum amount the air could hold
A psychrometer measures the relative humidity.

How do clouds form?
Clouds of all kinds form when water vapor in the air becomes liquid water or ice crystals. The water droplets condense around dust in the air forming clouds.

Dew point - the temperature at which condensation begins

Types of Clouds

Meteorologists classify clouds into three main types: cumulus, stratus, and cirrus

Cumulus - clouds that form less than 2 kilometers above the ground and look like fluffy, rounded piles of cotton

Stratus - clouds that form in flat layers

Cirrus - wispy, feathery clouds made mostly of ice crystals that form at high levels, above about 6 kilometers
Precipitation

Precipitation - any form of water that falls from clouds and reaches Earth's surface.

Common types of precipitation include, rain, sleet, freezing rain, hail, and snow.

Rain - drops of water that are at least .5 mm in diameter. Precipitation made of smaller drops of water is called mist or drizzle.

Sleet - raindrops that freeze into solid particles of ice. Ice particles smaller than 5 mm in diameter are called sleet.
Freezing Rain - raindrops that fall through cold air and freeze when they touch a cold surface. In an ice storm, a smooth, thick layer of ice builds up on every surface.

Hail - round pellets of ice larger than 5 mm. Hail only forms inside cumulonimbus clouds during thunderstorms.

Snow - water vapor in clouds converted directly into ice crystals called snowflakes.

Drought - long periods of unusually low precipitation.
Weather Patterns
Four major types of air masses influence the weather in North America: maritime tropical, continental tropical, maritime polar, and continental polar.

- **Tropical** - warm air masses form in the tropics, low air pressure
- **Polar** - cold air masses from north of 50° north latitude and south of 50° south latitude, high air pressure
- **Maritime** - air masses that form over oceans, very humid
- **Continental** - air masses that form over land (in the middle of continents), dry
Air masses form when air remains nearly stationary over a large section of Earth’s surface and takes on the conditions of temperature and humidity from that location. Weather conditions at a location are determined primarily by temperature, humidity, and pressure of air masses over that location. Most local weather condition changes are caused by movement of air masses.

The movement of air masses is determined by prevailing winds and upper air currents.

The prevailing westerlies are the major wind belts in the Continental United States. The prevailing westerlies generally push air masses from west to east.

Front - the area where the air masses meet and do not mix

Precipitation is likely to occur at a front, or where air masses meet.

There are four types of fronts: cold fronts, warm fronts, stationary fronts, and occluded fronts.

Cold Fronts - Cold fronts move quickly, can cause abrupt weather changes including violent thunderstorms. After a cold front passes through, cool, dry air moves in (clear skies and cooler temperatures).
Warm Fronts - A warm front forms when warm air moves over cold air. If the warm air is humid, showers and light rain will fall. If the warm air is dry, scattered clouds form. Warm fronts move slowly, so it may take several days for the front to pass through an area. After a warm front passes through, the weather is likely to be warm and humid.

Stationary Fronts - A stationary front forms when cold and warm air masses meet, but neither one has enough force to move the other. Warm air will condense to form rain, snow fog or clouds at a stationary front.

Occluded Fronts - At an occluded front, a warm air mass is caught between two cooler air masses. The denser cool air masses move under the less dense warm air mass and push it upward. The two cooler air masses meet and mix. The temperature near the ground becomes cooler. As the warm air is cooled, the weather may turn cloudy and rainy or snowy.

Cyclone - a swirling center of low air pressure (L on weather map), spin counterclockwise in the Northern Hemisphere.

Cyclones and decreasing air pressure are associated with storms and precipitation,

Anticyclones - high-pressure centers of dry air (H on weather map)
**Storms**

Storm - a violent disturbance in the atmosphere

Storm Watch - there is a possibility for the storm

Storm Warning - a storm has been spotted, prepare yourself

**Thunderstorms**

Thunderstorms form within large cumulonimbus clouds, or thunderheads. They usually form when warm air is forced upward at a cold front. As the air rises, it cools, forming dense thunderheads.

During a thunderstorm, areas of positive and negative electrical charges build up in the storm clouds.

Lightning - a sudden spark, or energy discharge, caused when electrical charges jump between parts of a cloud or between a cloud and the ground.

Thunder - the sound made when the air is rapidly heated and expands from lightning causing an explosion

We see the lightning before we hear the thunder because light travels faster than sound.

Safety - During thunderstorms, avoid touching metal objects because they can conduct electricity from lightning into your body. Avoid open spaces outside during a thunderstorm. If you are inside during a thunderstorm you should avoid touching phones, electrical appliances, or plumbing fixtures, because all can conduct electricity into the house.

**Tornadoes**

Tornado - a rapidly whirling, funnel-shaped cloud that reaches down from a storm cloud to touch Earth’s surface.

Tornadoes develop in low, heavy cumulonimbus clouds - the same clouds that bring thunderstorms. There is an area in the central United States known as “Tornado Alley” because that is where most tornadoes occur.
Safety - The safest place to be during a tornado is the basement of a well-built building. If the building you are in does not have a basement, move to the middle of the ground floor. Stay away from windows, get onto the floor under a sturdy piece of furniture.

Hurricanes

Hurricane - a tropical storm that has winds of 119 kilometers per hour or higher (a typical hurricane is about 600 km across)

A hurricane begins over warm water as a low-pressure area, or tropical disturbance. If the tropical disturbance grows in size and strength, it becomes a tropical storm, which may then become a hurricane.
Hurricanes gather heat and energy through contact with warm ocean waters. Evaporation from the seawater increases their power. Hurricanes rotate in a counter-clockwise direction around an "eye." The center of the storm or "eye" is the calmest part.

Safety - If you hear a hurricane warning and are told to evacuate, leave the area immediately. If you must stay, move to the interior of the building away from windows.

**Winter Storms**

Snow falls when humid air cools below 0°C.

Lake-effect snow - as cold air flows over the warm lake water, the relatively warm water heats the air’s bottom layer as lake moisture evaporates into the cold air. Since warm air is lighter or less dense than cold air, the heated air rises and begins to cool. As the air cools, the moisture that evaporated into it condenses and forms clouds and snow begins falling from the cloud if the air is humid enough.

Blizzard - a long-lasting snowstorm with very strong winds and intense snowfall. You need three things to have a blizzard; cold air at the surface, lots of moisture, and lift.

Safety - If you are caught in a snowstorm, try to find shelter from the wind. Cover
exposed parts of your body and try to stay dry.

Predicting the Weather

Meteorologists - scientists who study the causes of weather and try to predict it

Changes in technology have occurred in two areas: gathering weather data and using computers to make forecasts

Weather Balloons

Computer Forecasts

El Nino - an event that occurs every two to seven years in the Pacific Ocean, during which winds shift and push warm surface water toward the coast of South America; it can cause dramatic climate changes.

Reading Weather Maps

Weather maps use symbols to show fronts, high and low pressure areas, and precipitation. Sometimes color bands are used to show different temperatures.

Isobars - lines joining places on the map that have the same air pressure

Isotherms - lines joining places that have the same temperature

Climate and Climate Change

Climate - the average, year-after-year conditions of temperature, precipitation, winds, and clouds in an area

The main factors that influence temperature are latitude, altitude, distance from large bodies of water, and ocean currents.

Latitude - the distance from the equator, measured in degrees
Tropical Zone - the area near the equator, between about 23.5° north latitude and 23.5° south latitude

Polar Zone - the areas near both poles, from about 66.5° to 90° north and 66.5° to 90° south latitudes

Temperate Zone - the area between the tropical and polar zones, from about 23.5° to 66.5° north and 23.5° to 66.5° south latitudes

Altitude

Altitude - elevation above sea level

In the case of high mountains, altitude can affect climate more than latitude. Highland areas everywhere have cool climates. There are snowy mountain tops on the peak of Mount Kilimanjaro which is located near the equator in Africa.

Distance from Large Bodies of Water

Oceans and large lakes can also affect temperatures. This is because water heats up more slowly than land; it also cools down more slowly.

Ocean Currents

Many marine climates are influenced by ocean currents. In general, warm ocean currents carry warm water from the tropics toward the poles. Cold currents bring cold water from the polar zones toward the equator.
Factors Affecting Precipitation

The main factors that affect precipitation are prevailing winds and the presence of mountains.

Prevailing Winds

The prevailing winds in the Continental United States generally push air masses from west to east.

Air masses are moved from place to place by prevailing winds. Air masses can be warm or cool, dry or humid. The amount of water vapor in the air mass influences how much rain or snow will fall.

Mountain Ranges

A mountain range in the path of prevailing winds can influence where precipitation falls

Windward - the side of the mountain that faces the oncoming wind

Leeward - the downside of mountains

Microclimate - the climate characteristic of a small specific area; it may be different from the climate of the surrounding area
Reason for the Seasons

The seasons are caused by the tilt of Earth's axis as Earth travels around the sun.

Climate Regions
Long-Term Changes in Climate

In studying ancient climates, scientists follow an important principle: If plants or animals today need certain conditions to live, then similar plants and animals in the past also required those conditions.

Fossils can serve as evidence as to what type of plant or animal lived in the past, this can give scientists clues as to what the climate was like at that time.

Tree rings can also be used to learn about ancient climates. Thin rings indicate that a year was cool and dry, where a thick ring represents a warm or wet year.

Another source of information about ancient climates can be found in pollen records. By looking at the pollen that is present scientists can infer what type of plant was present at a specific geologic time period and therefore infer what the climate was like.

Ice Ages

During each ice age, huge sheets of ice called glaciers covered large parts of Earth's
Possible explanations for major climate changes include variations in the position of Earth relative to the sun, changes in the sun’s energy output, and the movement of the continents.

- **Sunspots** – darker cooler regions on the surface of the sun; increase and decrease in regular 11 year cycles

- **Continental Movement** – 224 million years ago there was one large continent called Pangaea

**Global Changes in the Atmosphere**

Most changes in world climates are caused by natural factors. However, in the last 100 years human activities have also impacted changes in the climates around the world. Two most important worldwide issues are global warming and thinning of the ozone layer.

- Human activities that add greenhouse gases to the atmosphere may be warming Earth’s atmosphere.

**greenhouse gases** – gases in the atmosphere that trap heat

**global warming** – a gradual increase in the temperature of Earth’s atmosphere
Possible Effects of Global Warming
Areas too cold for farming today could become farmland
Some fertile fields could become “dust bowls”
The number of hurricanes could increase
Sea levels could rise and flood low-lying coastal areas

Chemicals produced by humans have been damaging the ozone layer.

Chlorofluorocarbons - chlorine compounds formerly used in air conditioners, refrigerators, and spray cans; also called CFCs