

CORE CONCEPTS WEATHER AND CLIMATE

Key Prior Knowledge (from the 5th Grade Matter and Energy Units)

- Thermal energy can be transported through radiation, conduction, and convection.
- The transfer of enough thermal energy (heating) in and out of matter will cause matter to change states. (Evaporation, condensation, freezing, melting)
- Matter that is less dense will rise in a medium that is more dense, and vice-versa.

CORE CONCEPTS for Weather & Climate:

- The Earth's seasons occur because of a combination of the Earth's rotation on a tilted axis, and its orbit around the sun. The resulting seasons cause unequal heating of the Earth and are responsible for much of the planet's weather.
 - Earth / Sun system motions
 - Time zones
 - Direct and indirect sunlight
 - Seasons(SC.E.1.2.1)
- The Water Cycle is the result of the evaporation and condensation of water that is transported through the process of convection in the Earth's atmosphere, powered by the uneven heating of the Earth's surface.
 - Evaporation and Condensation
 - Relative humidity
 - Effects of temperature and pressure on relative humidity(SC.D.1.2.3)
- Ocean Currents are caused by the uneven heating of the oceans' surface. Deep water currents transport warmer water from the equator to the poles, balancing the heat in the oceans. Surface currents bring warm water from the center of the equatorial oceans to the continents, warming the land near the coast.
 - Ocean convection
 - Surface currents
 - Common named surface currents(SC.D.1.2.2)

- Atmospheric currents, both large and small scale, transport air from warmer regions to colder regions and vice versa through the process of convection. The direction of these currents is affected by the Earth's rotation.
 - Large Scale (Equator to Poles) motion
 - Smaller Scale motion, curved due to Coriolis effect

 - The Earth's seasons, the movement of water in our atmosphere due to the water cycle, atmospheric currents, and ocean currents all combine to cause the weather we experience on Earth. Weather can be recorded, and to some extent predicted, using our knowledge of all of these systems. The cause of all weather can be traced back to the uneven heating of the Earth's land, water, and air.
 - Day and night wind patterns (seabreeze)
 - Fronts and air masses
 - High and low pressure systems
 - North American air masses
 - Climate

 - Climates are classified according to two major factors: temperature and precipitation.

 - Factors that influence temperature and precipitation of an area, and therefore climate, include latitude, elevation, distance from sea, oceanic currents and global winds.

 - There are six* main climate regions: tropical rainy, dry, temperate marine, temperate continental, polar, and highlands.

 - Climate influences the processes that shape the landscape of a region and the type of soils that form there. It also determines what type of plants and animals live in that region.
- (SC.G.1.2.2, SC.G.1.2.7)

TEACHER BACKGROUND INFORMATION

CLIMATE

CHAPTER'S BIG IDEAS

- Climates are **classified** according to two major factors: **temperature** and **precipitation**.
- Factors that affect temperature and precipitation of an area, and therefore climate, include **latitude, elevation, distance from sea, ocean currents** and **global winds**.
- There are **six* main climate regions**: tropical rainy, dry, temperate marine, temperate continental, polar, and highlands.
- Climate influences the **processes that shape the landscape** of a region and the **type of soils** that form there. It also determines what type of plants and animals live in that region.

* Number and names of climates varies from textbook to textbook.

CLIMATE CHARACTERISTICS:

Climate is the long-term weather of an area averaged over at least 30 years. This includes the region's general pattern of weather conditions, seasons and weather extremes like hurricanes, droughts, or rainy periods. The earth's climate varies from place to place, creating a variety of environments. Thus, in various parts of the earth, there are deserts; tropical rain forests; tundra (frozen, treeless plains); coniferous forests (cone-bearing trees and bushes); prairies; and coverings of glacial ice.

Climates also change with time. Scientists believe that changes in the Earth's orbit have affected Earth's climate in the past. Between 1000 and 7000 years ago, temperatures in the northern hemisphere were, overall, warmer than they are today. The warmer climate enabled Vikings from Iceland to settle on the southern coast of Greenland. But the colder climate that developed over the following centuries wiped out the settlements.

One major environmental concern is that human activity may be changing the **global climate**. The burning of fossil fuels--coal, oil, and natural gas--to power motor vehicles, heat buildings, generate electric energy, and perform various industrial tasks is increasing the amount of

carbon dioxide gas released into the atmosphere. Fossil fuels contain carbon, and burning them produces carbon dioxide. This gas slows the escape of heat released by the earth into space. Thus, an increase in atmospheric carbon dioxide may cause **global warming**--a rise in the temperature of the air next to the earth's surface. Global warming could change rainfall patterns, leading to shifts in plant and animal populations. If not prevented it could also melt enough polar ice to raise the sea level, and increase the frequency and severity of tropical storms.

Global warming is also affected by deforestation. Plants need carbon dioxide for photosynthesis and destroying them results in less carbon dioxide being “soaked up” out of the atmosphere. This in turn, results in warmer temperatures since less heat is able to escape the atmosphere – hence, global warming.

Two of the most important factors determining an area's climate **are air temperature** and **precipitation**. These factors are in turn influenced by five main factors: (1) **latitude** (distance from the equator), (2) **altitude** (height above sea level) and **topography** (surface features), (3) **distance from oceans** and large lakes, and (4) **ocean currents** and **global winds**.

1. **Latitude:**

The sun continually sends **electromagnetic radiation** into space. Most of the radiation is visible light, and it also includes infrared (heat) rays and ultraviolet rays. About 30 percent of the radiation that reaches the earth's atmosphere is reflected back into space, mostly by clouds.

The remaining 70 percent is absorbed by the atmosphere and the earth's surface, heating them. The intensity of the solar radiation reaching the atmosphere decreases with increasing latitude. The intensity depends on how high in the sky the sun climbs. The closer a place is to the equator, the higher the climb.

In **tropical latitudes** (those near the equator), there is little difference in the amount of solar heating between summer and winter. Therefore, average monthly temperatures do not change much during the year.

In **middle latitudes** (temperate), from the Tropic of Cancer to the Arctic Circle and from the Tropic of Capricorn to the Antarctic Circle, solar heating is considerably greater in summer than in winter. In these latitudes, summers are therefore warmer than winters.

In **high latitudes** (polar), north of the Arctic Circle and south of the Antarctic Circle, the sun never rises during large portions of the year. Therefore, the contrast in solar heating between summer and winter is extreme. Summers are cool to mild, and winters are bitterly cold.

The sun's rays hit the equator at a **direct 90° angle** between 23 ° N and 23 ° S latitude. Radiation that reaches the atmosphere here is at its most intense. In all other cases, the rays arrive at an angle to the surface and are less intense. The closer a place is to the poles, the smaller the angle and therefore the less intense the radiation.

Seasons also affect the amount of radiation received in an area. The Earth rotates about its axis, which is tilted at 23.5 degrees. The Earth's tilt and its revolution around the sun, as well as the sun's radiation result in the Earth's seasons. The sun emits rays that hit the earth's surface at different angles. When they strike the earth at a right angle (90 °), the rays transmit the highest level of radiant (electromagnetic) energy. Temperatures in these areas tend to be the hottest places on earth. Other locations, where the sun's rays hit at **lesser angles**, tend to be cooler. As the Earth rotates on its tilted axis around the sun, different parts of

the Earth receive higher and lower levels of electromagnetic energy. This creates the seasons.

2. **Elevation and Topography:**

The higher a place is, the colder it is. Air temperature drops an average of about 3.5 Fahrenheit degrees per 1,000 feet of altitude (6.5 Celsius degrees per 1,000 meters). The temperature of the air determines how much precipitation falls as snow, rather than rain. Even in the tropics, it is not unusual for mountaintops to be snow-covered.

The surface features of the earth influence the development of clouds and precipitation. As humid air sweeps up the slopes of a mountain range, the air cools, causing clouds to form. Eventually, rain or snow falls from the clouds. Some of the rainiest places on earth are on windward slopes, those facing the wind. As winds blow down the opposite slopes, known as the leeward slopes, the air warms, and clouds thin out or vanish. Therefore, leeward slopes of mountain ranges are dry. In addition, a rain shadow (dry area) may stretch hundreds of kilometers downwind of a mountain range (Fig.1).

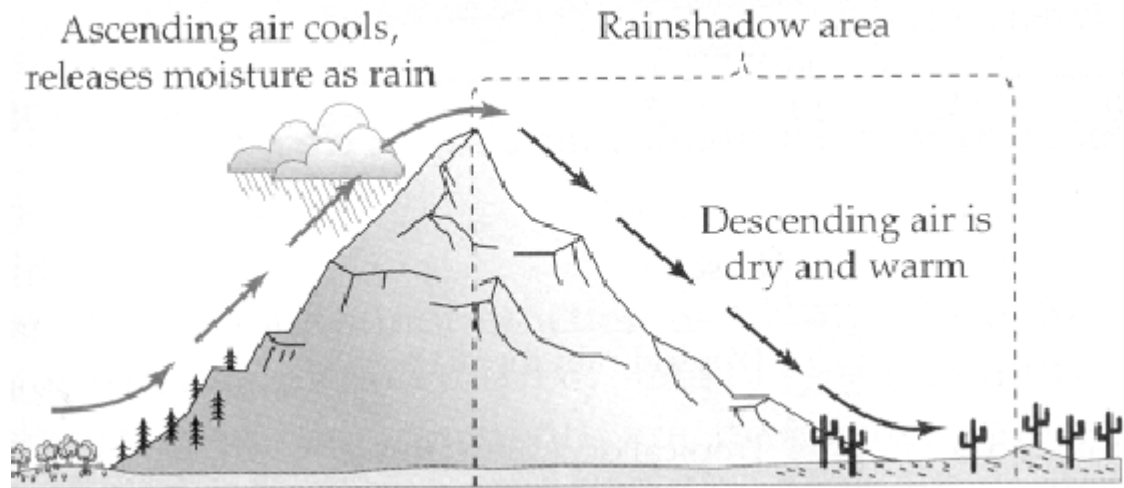


Figure 1 – Affects of elevation on precipitation. (<http://www.chariho.k12.ri.us>)

3. **Distance to Water:**

Oceans and large lakes make the air temperature less extreme in places downwind of them. An ocean or lake surface warms up and cools down more slowly than a land surface. Thus, between summer and winter, the temperature of the water varies less than the temperature of the land. The temperature of the water strongly influences the temperature of the air above it. Therefore, air temperatures over the ocean or a large lake also vary less than air temperatures over land. As a result, places that are immediately downwind of the water have milder winters and cooler summers than places at the same latitude but well inland.

San Francisco and St. Louis, for example, are at about the same latitude and therefore receive about the same amount of solar radiation during the year. But San Francisco is immediately downwind of the Pacific Ocean, and St. Louis is well inland. Consequently, San Francisco has milder winters and cooler summers.

4. **Ocean Currents:**

Proximity to water is not the only factor involved in regulating temperatures. The type of ocean current nearby (warm or cold) has an affect too. Ocean currents are wide bands of water, like rivers that flow in the world's oceans. They sweep around the oceans, moving around water between hot and cold places. Heat from the Sun causes the movement of water in the form of currents. However, in the oceans, the temperature difference between the poles and the Equator is greater than it is on land. Near the Equator, the Sun's rays penetrate far below the ocean's surface. At the poles, the Sun's rays hit the water at a shallow angle. This causes the water to act more like a mirror, reflecting rather than absorbing the Sun's rays.

Currents vary in temperature and move at different speeds. If a current is much warmer or cooler than the surrounding water, it can

dramatically affect the climates of the nearby coastal areas. A warm current called the Gulf Stream, which runs between the Gulf of Mexico and Europe, brings a mild climate to northwest Europe. Large bodies of water and ocean currents are as important in influencing the temperature of a location as latitude is. For example, Bergen, Norway, is a coastal city located 2,000 km north of Omaha, Nebraska. Bergen's latitude is $60^{\circ} 23' N$, while Omaha's latitude is $41^{\circ} 15' N$. Judging only by latitude, one would assume that Bergen's climate would be colder than Omaha's climate. However, the average January temperature in Bergen is higher than that of Omaha, and on average Bergen is cooler than Omaha in July. The seasonal temperatures in Bergen are directly influenced by its proximity to the ocean and the North Atlantic drift (relatively warm current, Fig.2). Because of its great depth and volume and its ability to absorb large amounts of solar radiation, the ocean acts as a huge reservoir of thermal energy.

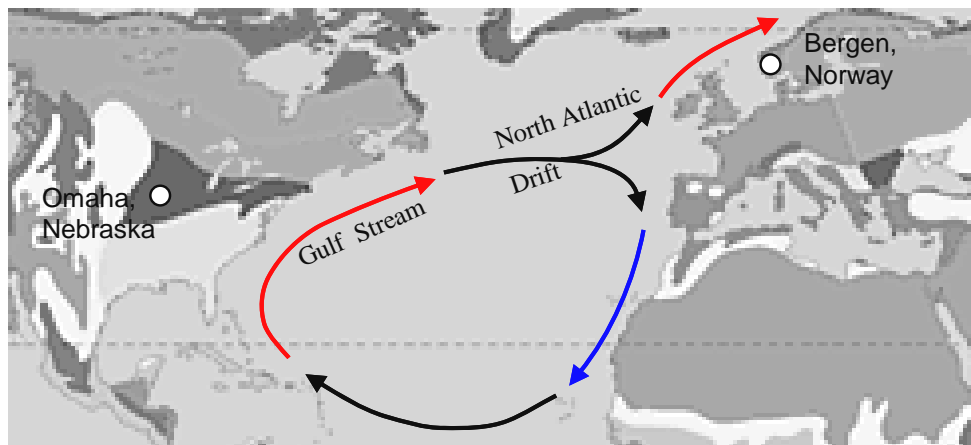


Figure 2- Ocean currents in the Atlantic. (www.nationalgeographic.com)

Cold currents are depleted of that thermal energy, such as the current off West Africa. Within these cold currents, very little evaporation takes place and whatever rain is created, is then blown offshore by the trade winds. The combination of cold currents and winds blowing the rain offshore creates a desert climate, such as the Sahara desert, off the West coast of Africa (Fig.2).

5. **Global winds:**

The air around us is constantly pushing in every direction (molecular motion). The force that the air exerts is known as **atmospheric pressure**. The movement of air is affected by temperature. The sun heats up the land and oceans, which in turn heats the air directly above them. As the air is heated, it rises and leaves behind an area of **low pressure** (an area with less air molecules pushing in every direction). When the air cools, it sinks down on the Earth's surface in a different area, causing **high pressure** (an area with more molecules pushing in every direction).

Because the Sun does not heat up the world evenly, there are differences of pressure. Where there is a difference, **air flows from high to low pressure areas** in order to even out pressure. This

moving air is **wind**. As the air moves, the spinning of the Earth causes it to be deflected sideways. This deflection is known as **Coriolis Effect**. Wind is deflected to the right in the northern hemisphere and to the left in the southern hemisphere, the same goes for surface ocean currents.

Air is constantly circulating between the tropics and the poles as **global winds**. Warm air flows from the tropics and displaces the cold air at the poles, which then flows back toward the tropics. Global winds form near the Equator as it receives more heat from the Sun than other areas. As the air is heated, it rises and spreads out. When it cools, it sinks at around 30° north and south of the Equator. This increases pressure at the Earth's surface and air at the base of the atmosphere is forced outward in direction of both the Equator and the poles.

Atmospheric circulation influences climate by producing winds that distribute heat and moisture. Six belts of wind encircle the earth: (1) trade winds that blow between 30 degrees north latitude and the equator, (2) trade winds that blow between the equator and 30 degrees south latitude, (3) westerlies (winds from the west) that blow between 30 degrees and 60 degrees north of the equator, (4) westerlies blowing between 30 degrees and 60 degrees south of the equator, (5) polar winds

north of 60 degrees north latitude, and (6) polar winds south of 60 degrees south latitude.

Trade winds north of the equator blow from the northeast and south of the equator blow from the southeast. The trade winds of the two hemispheres meet near the equator, causing air to rise. As the rising air cools, clouds and rain develop. The resulting band of cloudy and rainy weather near the equator is called the doldrums.

Prevailing winds called Westerlies blow from the southwest in the Northern Hemisphere and from the northwest in the Southern Hemisphere. Westerlies steer storms from west to east across middle latitudes.

Westerlies and trade winds blow away from the 30 degrees latitude belt. Over broad regions centered at 30 degrees latitude, surface winds are light or calm. Air slowly descends to replace the air that blows away. Any moisture the air contains evaporates in the intense heat, so the descending air warms and becomes dry. The tropical deserts, such as the Sahara of Africa and the Sonoran of Mexico, occur under these regions of descending air.

Polar winds blow from the northeast in the Arctic and from the southeast in the Antarctic. In the Northern Hemisphere, the boundary between the cold polar easterly winds and the mild westerly winds is known as the polar front. A front is a narrow zone of transition, usually between a mass of cold air and a mass of warm air. Where the air masses overlap, storms can develop and move along the polar front, bringing cloudy weather, rain, or snow.

As the seasons change, the global wind belts shift north and south. In the spring, they move toward the poles. In the fall, they shift toward the equator. These shifts help explain why some areas have distinct rainy seasons and dry seasons. Parts of Central America, North Africa, India, and Southeast Asia have wet summers and dry winters. Southern California and the Mediterranean coast have dry summers and wet winters.

TYPES OF CLIMATES:

The earth's surface is a patchwork of climate zones. Climatologists (scientists who study the climate) have organized similar types of climates into groups based on two major factors: temperature and precipitation. They use a classification system introduced in 1918 by Wladimir Koppen, a German climatologist. Koppen based his system on a region's vegetation,

average monthly and annual temperature, and average monthly and annual precipitation. This system identifies broad climate regions, each of which has smaller subdivisions.

There are **six main climate regions**: tropical rainy, dry, temperate marine, temperate continental, polar, and highlands. These climate regions are shown in Figure 3.

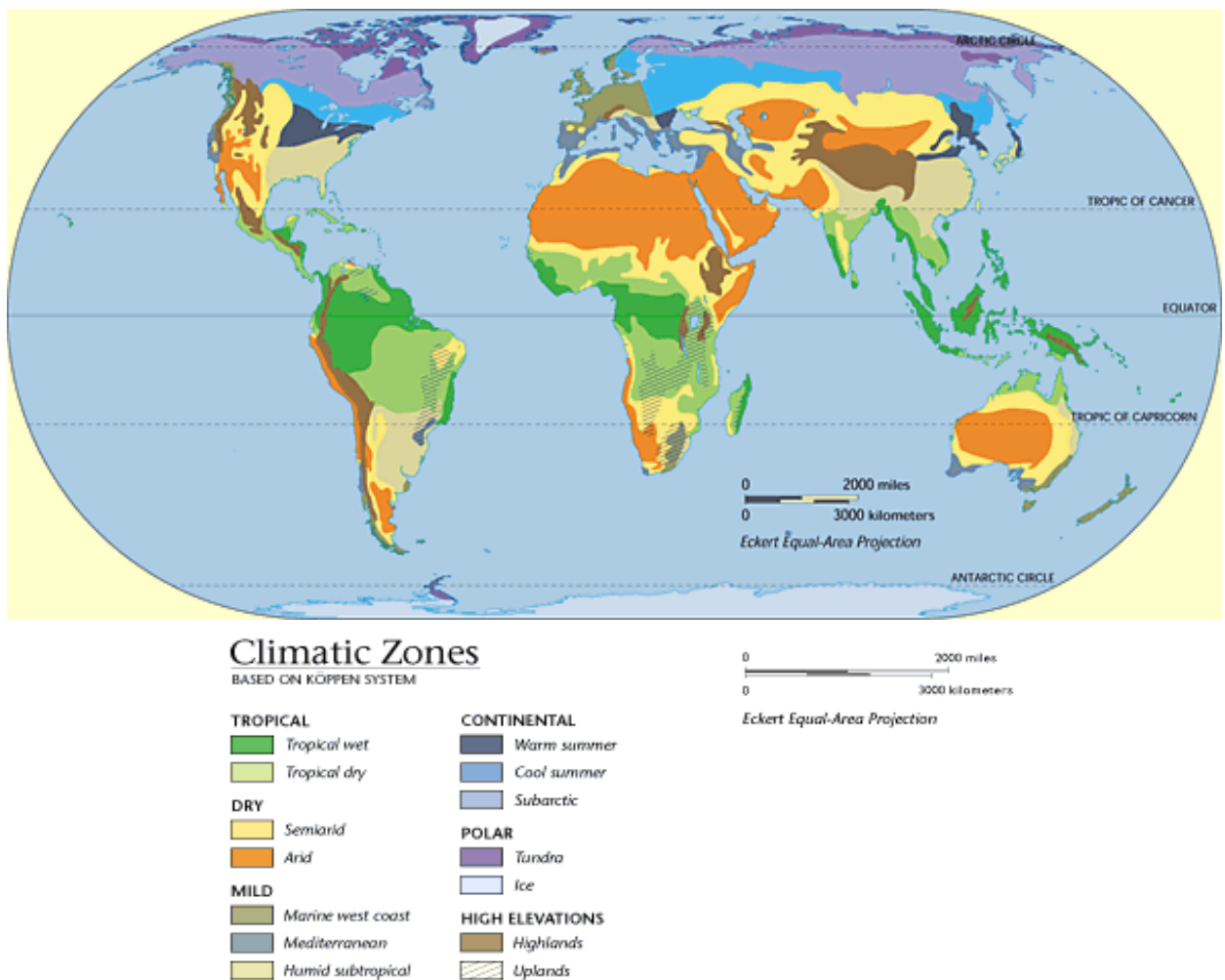


Figure 3 – Map of world climates (www.nationalgeographic.com)