

The Basics of Climate

Weather is the state of the atmosphere at a given place and time. For example, as Mr. Stonebraker is writing this sentence the weather by OSU campus is partly cloudy and warm with no precipitation. **Climate**, on the other hand, is a long-term average of weather conditions. Usually this average is taken over 30 years or more to make sure the random variations from year to year are smoothed out.

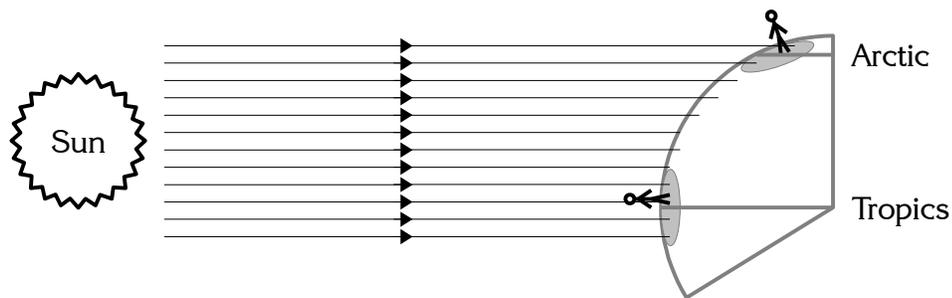
Just like weather, there are many factors that go into determining an area's climate, but there are three geographic factors responsible for most of the climate differences found on Earth:

- latitude
- nearby water
- nearby mountains

Latitude

All the weather on Earth is driven by energy from the Sun. You probably already know that heating from the Sun is stronger in the tropics than in Ohio, and very weak in the Arctic. Depending on how close you are to the equator, the Sun's rays might be very strong or very weak. This is because of the spherical shape of the Earth.

In the picture below, part of the Earth is shown along with a person living in the tropics and someone in the Arctic. They both live on the same amount of land, represented by the ovals. It could be one acre, for example. The Sun's rays reach the Earth moving in the same direction and equally spaced out, but the land in the tropics is being hit by more rays of sunlight than the oval in the Arctic. This means the land in the tropics absorbs more radiant energy and will be warmer!



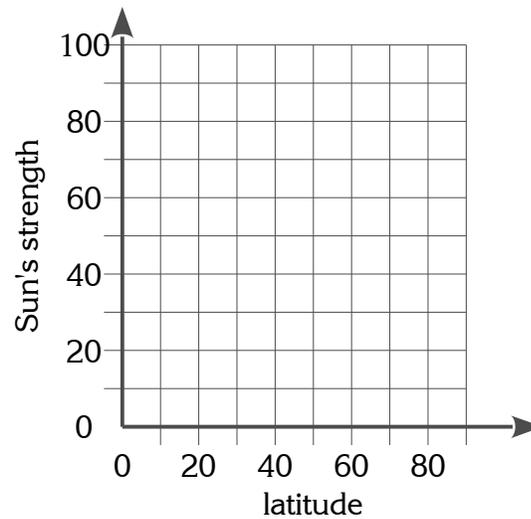
Remember, **latitude** is a measurement of how far north or south you are from the Earth's equator. The equator has a latitude of 0° . The North Pole has a latitude of 90°N . Columbus' latitude is about 40°N , about halfway between the equator and the pole.

Basically, the latitude of a city determines what angle the sunlight comes in at. Steeper angles give more energy and lower angles give less, just like the difference between 9 AM when the sun is low and Noon when it's at it's highest.

- 1) How many of the Sun's rays in the picture are hitting the land in the tropics? And, how many are hitting the land in the Arctic?

- 2) Below to the left is a table showing the average strength of sunlight at different latitudes. On the grid to the right, make a graph of these data and draw in a smooth, curved line to show the trend of the data.

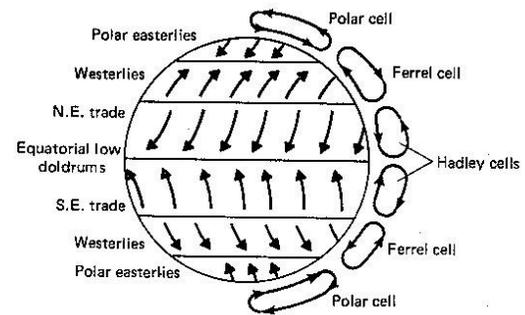
Latitude	Sun's strength
0°	100%
10°	98.5%
20°	94.0%
30°	86.6%
40°	76.6%
50°	64.3%
60°	50.0%
70°	34.2%
80°	17.4%
90°	0%



- 3) If latitude were the only thing that had an effect on a city's climate, which of these cities would have the warmest weather?
- A) Casablanca (33°N) or Timbuktu (17°N)?
 - B) Alamogordo (33°N) or Albuquerque (35°N)?
 - C) Miami (26°N) or Miami University (39°N)?
 - D) Intercourse, Pennsylvania (40°N), or Climax, Pennsylvania (41°N)?

So, the tropics are heated by the Sun much more strongly than other parts of Earth. The warm air in the tropics expands and rises as a result. We call this **convection**. When air in the tropics rises up it creates a Low pressure zone at those low latitudes.

All that rising air spreads out and eventually comes back down again further to the north and south, creating High pressure zones at those latitudes. The rising and sinking air creates a gigantic convection current called a **Hadley Cell**. Differences in heating at other latitudes create two other large convection currents in each hemisphere (the Ferrel Cells and Polar Cells).



In the northern hemisphere, high-level winds carry air away from the equator and surface-level winds bring air back. But, the **Coriolis effect** causes the direction of these winds to bend or turn, so instead of going directly north/south, they flow northeast/southwest.

The USA lies mostly within the northern Ferrel Cell, shown on the diagram. Surface winds here try to move north, but are deflected east by the Coriolis effect. Because they end up blowing largely from the west, they are called **westerlies**. *This is why most of our weather moves west-to-east!*

- 4) Between the Ferrel Cell and Polar Cell, air is rising. Would you expect to see High pressure zones or Low pressure zones along that boundary? Why?
- 5) The diagram shows the directions of prevailing surface-level winds in each Cell. In the northern Hadley Cell, the high-level winds try to take air north, away from the tropics. When the Coriolis effect bends them to the right, which direction will those winds end up flowing?
- 6) In the northern Ferrel Cell, high level winds try to move air south. When those winds are deflected by the Coriolis effect, which direction will they flow?

Water

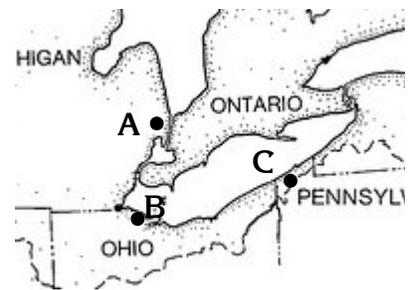
Water has a very large **specific heat**, which means that a lot of thermal energy is needed to change water's temperature. Land – which is made mostly of soil, sand, and rock – has a much smaller specific heat, so its temperature changes more quickly and easily. Water's large specific heat also means that it can “store” or hold a great deal of thermal energy.

Because water takes a long time to heat up and cool down, it tends to reduce and slow down temperature changes nearby. This is true for bodies of liquid water and even for air masses: a humid, maritime air mass will heat and cool much slower than a dry, continental air mass.

Because the water keeps temperatures more moderate, we call this **temperature moderation**.

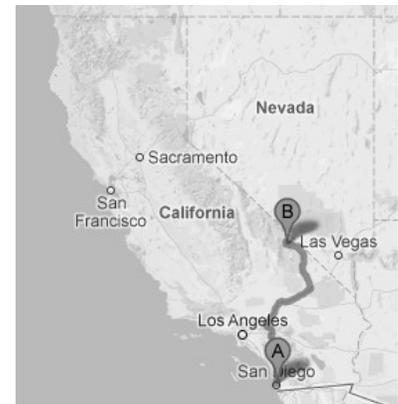
When winds blow across lakes or oceans, the air picks up moisture from the water. If that air is later cooled or lifted, it will produce much more precipitation than air that hasn't picked up a bunch of extra water vapor. This is known as the **Lake Effect**, named after the enormous snowstorms that occur along the Great Lakes in cities like Cleveland and Buffalo.

- 7) Look at the map of Lake Erie to the right. If a cold front moves across the region going directly east, in which city (A, B, or C) would you expect the heaviest snow to fall? Explain why!



- 8) On this map, “A” is San Diego, and “B” is Death Valley. Over the course of a year, the temperatures in San Diego vary from an average low around 49°F to an average high around 77°F. In Death Valley, the temperature ranges from about 38°F to 134°F.

- A) How many degrees of difference is there between the high and low in San Diego?
- B) How many degrees of difference is there between the high and low in Death Valley?



- C) Why is there such a big difference between these two places?

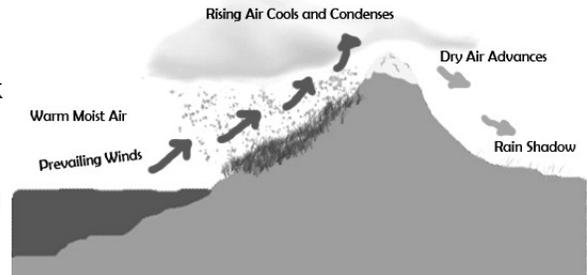
- 9) Consider these three cities: Columbus (in the middle of Ohio), Toledo (on the shore of Lake Erie), and Detroit (sandwiched between Lake Erie and Lake Huron).

- A) Which of the three would you expect to have the most variation in temperature? Why?
- B) Which of the three would you expect to have the least variation in temperature? Why?

Mountains

Cloud formation and precipitation are closely tied to rising air. When air rises, it expands and cools off, which leads to condensation. In central Ohio, rising air is usually caused by either convection (warm air expanding and rising up on its own) or by weather fronts “pushing” the air up and causing storms. However, mountains can force air to rise just like a weather front does.

When winds blow against a mountain range, air is forced to go uphill. This can lead to condensation and precipitation. After the air reaches the peak, it has already lost most of its moisture. As the air moves back downhill it warms up again and any clouds that are left usually evaporate away. As a result, the **windward** side of a mountain range gets a lot of rain and the sheltered or **leeward** side gets very little. The dry area next to a mountain range is called a **lee rain shadow**.



10) To the right is a map of South America. Along the entire west coast you can see the Andes Mountains, a chain of very tall mountains caused by a convergent plate boundary. Three locations in the southern section of the continent have been marked.

A) Locations A, B, and C are all far enough south to lie in the Earth's southern Ferrell Cell. From what direction will the prevailing winds blow there?

B) One of these three locations will be very rainy because of the influence of the mountains. Which is it? Explain why it will rain a lot there.

C) The Patagonian Desert is one of the largest and driest deserts in the world. Which of the marked locations is the most likely desert? Explain why.

