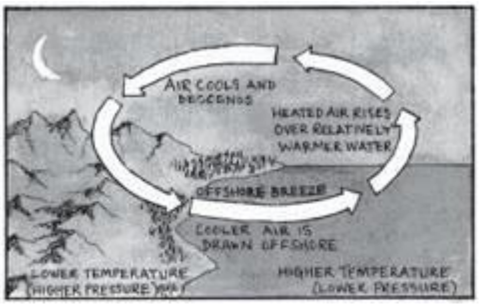
Atmospheric Circulation

Atmospheric circulation is the large-scale movement of air, and together with ocean circulation is the means by which thermal energy is redistributed on the surface of the Earth.

Atmospheric circulation is a complex and fascinating system of movements that profoundly affects life around the world. One consequence of this complex atmospheric circulation is that the composition of air stays well-mixed, so that plants and animals always have access to the gases they need. The atmosphere also moves energy from the equator to the poles to help alleviate the imbalance in incoming energy from the Sun. The air also carries particles, and atmospheric circulation determines how they are dispersed on a global level. Particles generated in one place can literally be transported around the world.

There are 5 major factors affecting global air circulation : - uneven heating of earth's surface, seasonal changes in temperature and precipitation, rotating of earth on its axis, properties of air and water and long term variation in the amount of solar energy striking the earth.

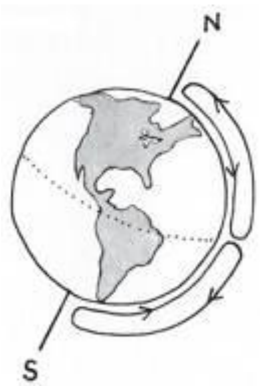
1. **Temperature, Density, and Pressure**

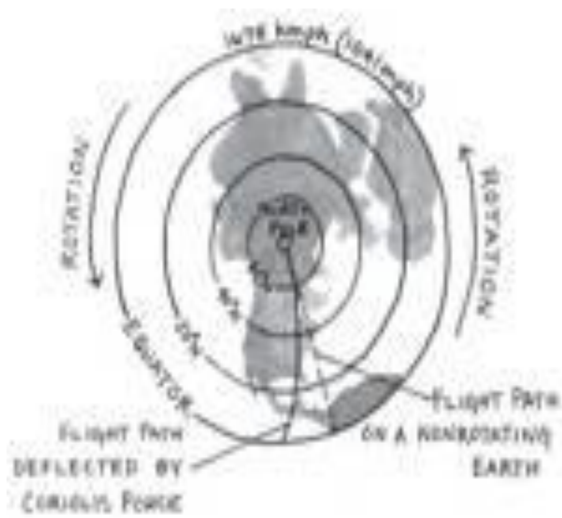


This statement describes one aspect of atmospheric circulation, but the reality is much more complicated...and interesting. Temperature, density (a measure of how many atoms and molecules there are in a given space), and pressure (the weight of the air above a given point per unit of area) are highly interrelated factors. When one factor changes, at least one other factor changes as well. Mathematically, this relationship is known as

The Perfect Gas Law

P = kT(N/V) with P = pressure k = a known constant (Boltzmann 's constant) T = temperature N = number of gas atoms and molecules V = volume = density





This means that when the Sun unevenly heats the Earth 's surface and atmosphere, the resulting changes in temperature create changes in pressure and density. And these changes lead to air movement or air *circulation.* Atoms and molecules of gas move from areas of high density to areas of low density and from areas of high pressure to areas of low pressure. Consider the temperature difference between the equator and the poles. The warmer air at the equator is less dense than the cold air of the poles. Thus, the air from the poles tends to flow toward the equator (toward the area of lower density).

In other words, if the atmosphere were simple, the warm air at the equator would rise and flow pole-ward to replace the air that would flow toward the equator along the surface of the Earth. The atmosphere is not this simple. The earth also rotates and in its spinning deflects the flow.

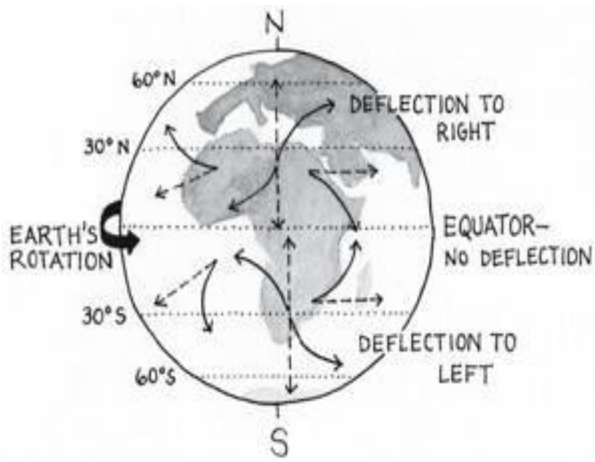
Water vs. Land

The Earth's oceans and continents have very different heating patterns. Oceans, and other bodies of water, moderate temperature, thus keeping the temperature relatively constant. Land, on the other hand, allows temperatures to vary widely, depending on the availability of solar radiation (sunlight). Since temperature differences are an important factor in atmospheric circulation, this difference in temperature regulation is also an important factor. Winds blow from cold, dense areas to warm, less dense areas.

There are many causes of this difference between land and ocean. First, land heats more easily than water; it takes more energy to change the temperature of water than it takes to change the temperature of land. Water is thus slower to warm and slower to cool, and moderates the temperature of the air above it.

Second, water is transparent to light, whereas land is not. So land absorbs much of the solar radiation (light) that reaches it, and its surface increases in temperature. Since only the surface is heated, the heat is rapidly lost to the air at night when the solar radiation is removed. This results in large swings in land temperature depending on the presence or absence of solar radiation. Water, on the other hand, transmits much of the solar radiation (light) that reaches it. Thus not only the surface but an entire layer of water is heated. This heat, which is only exposed to the air at the surface of the water, is not rapidly released. Furthermore, oceans move. The movement of the water further distributes the heat and slows its release. Essentially, water stores heat for longer periods than land.

These land-water temperature differences disrupt the steady decrease in temperature with latitude, affecting the patterns of air movements. On a small scale, these differences cause daily shifts in wind patterns. During the day, land and the air above it heat more quickly than water and the air above it. The warmer air over the land rises, and the cooler air over the water blows in toward the shore. This is called the sea breeze. At night, the process is



reversed. Land and the air above it cool quickly without sunlight, whereas water and the air above it maintain a higher temperature. The warmer air over the water rises, and the cooler air over the land blows out over the water. This is called the land breeze. Thus the different properties of land and water affect atmospheric circulation.

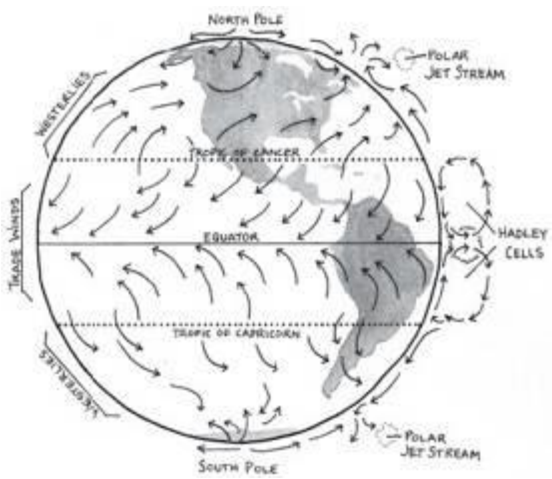
Coriolis Force

The Coriolis force, which results from the Earth rotating on its axis, is an apparent deflection of objects moving in a straight line over the Earth. The Coriolis force causes the winds that flow across the surface of the Earth to curve.

This sounds complicated, but it is simply a matter of perspective. The Earth is rotating; however, we on the Earth's surface are unaware of this rotation. We consider ourselves to be stationary, so when the air is not rotating at the same speed as the Earth upon which we are standing, we say that the wind is being deflected.

In other words, if an object is moving in a straight line over the surface of the Earth, the rotation of the Earth under the object causes the path of the object to appear curved. And indeed, relative to the Earth's surface, the path *is* curved. This is caused by the Coriolis force. This becomes more interesting when you consider that the Coriolis force is not constant across the Earth.

How All the Factors Come Together



These and many other factors come together in a dynamic system of winds. There are overall patterns to where and how these winds blow, but they are complex and ever-changing. Consider the image below. It is a generalized, highly simplified view of the Earth's atmospheric circulation.