Atmospheric pressure and winds

Atmospheric pressure and wind are both significant controlling factors of Earth's weather and climate.

1. Atmospheric pressure

Pressure is the force exerted on a unit area, and atmospheric pressure is equivalent to the weight of air above a given area on Earth's surface or within its atmosphere.

Atmospheric pressure is an indicator of weather. When a low-pressure system moves into an area, it usually leads to cloudiness, wind, and precipitation. High-pressure systems usually lead to fair, calm weather. Pressure varies from day to day at the Earth's surface because the Earth is not equally heated by the Sun. Areas where the air is warmed often have lower pressure because the warm air rises. These areas are called low pressure systems. Places where the air pressure is high, are called high pressure systems.

1.1. Low pressure system

A low-pressure system has lower pressure at its center than the areas around it. Winds blow towards the low pressure, and the air rises in the atmosphere where they meet. As the air rises, the water vapor within it condenses, forming clouds and often precipitation.

Because of Earth's spin and the Coriolis Effect, winds of a low-pressure system swirl counterclockwise north of the equator and clockwise south of the equator. This is called cyclonic flow.

1.2. High pressure system

A high-pressure system has higher pressure at its center than the areas around it. Winds blow away from high pressure.

Swirling in the opposite direction from a low-pressure system, the winds of a high-pressure system rotate clockwise north of the equator and counterclockwise south of the equator. This is called anticyclonic flow. Air from higher in the atmosphere sinks down to fill the space left as air is blown outward.

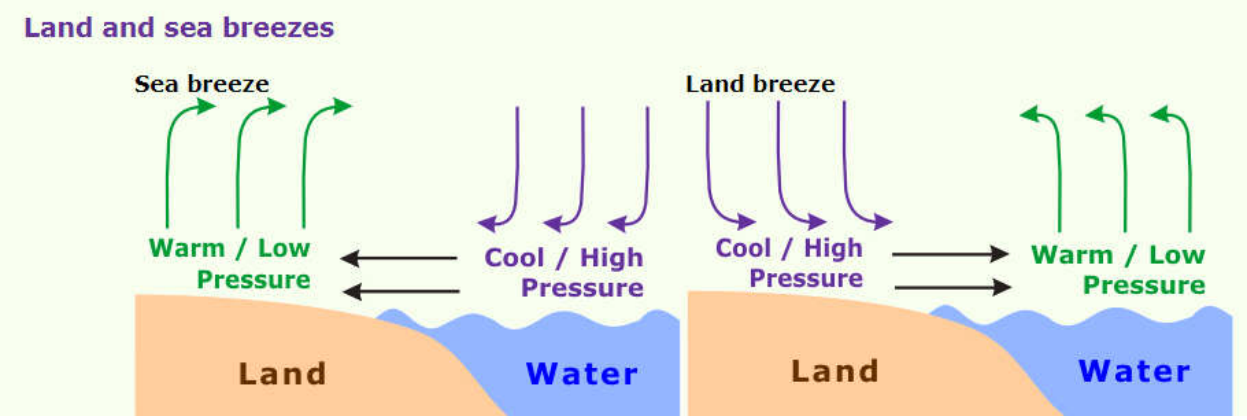

Figure: Low- and high-pressure systems

2. Variations in atmospheric pressure

2.1. Vertical variations in pressure

Air pressure decreases with elevation, at the higher altitude, the more diffused, and more widely spaced the air molecules become. The increased intermolecular space results in lower air density and lower air pressure.

As the pressure decreases, the amount of oxygen available to breathe also decreases. At very high altitudes, atmospheric pressure and available oxygen get so low that people can become sick and even die.

2.2. Horizontal variations in pressure

Thus, during the day, as Earth's surface heats the air in contact with it, the air expands in volume and decreases in density. Such air tends to rise as its density decreases. When the warmed air rises, there is less air near the surface, with a consequent decrease in surface pressure. The equator is an area where such low pressure occurs regularly.

In an area with cold air, there is an increase in density and a decrease in volume. This causes the air to sink and pressure to increase. The poles are areas where such high pressures occur regularly. Thus, the constant low pressure in the equatorial zone and the high pressure at the poles are thermally induced.

Most gas molecules in the atmosphere are pulled close to Earth's surface by gravity, so gas particles are denser near the surface. With more gas particles in a given volume, there are more collisions of particles and therefore greater pressure.

Example

Higher air pressure at the surface in column 1 and lower air pressure at the surface in column 2 causes the surface air to move from city 1 towards city 2 (Fig. 1). As the surface air moves out away from city 1, the air aloft slowly sinks to replace this outwardly spreading surface air. As the surface air flows into city 2, it slowly rises to replace the depleted air aloft. In this manner, a complete circulation of air is established due to the heating and cooling of air columns.

Heating and cooling columns of air can establish horizontal variations in air pressure both aloft and at the surface.

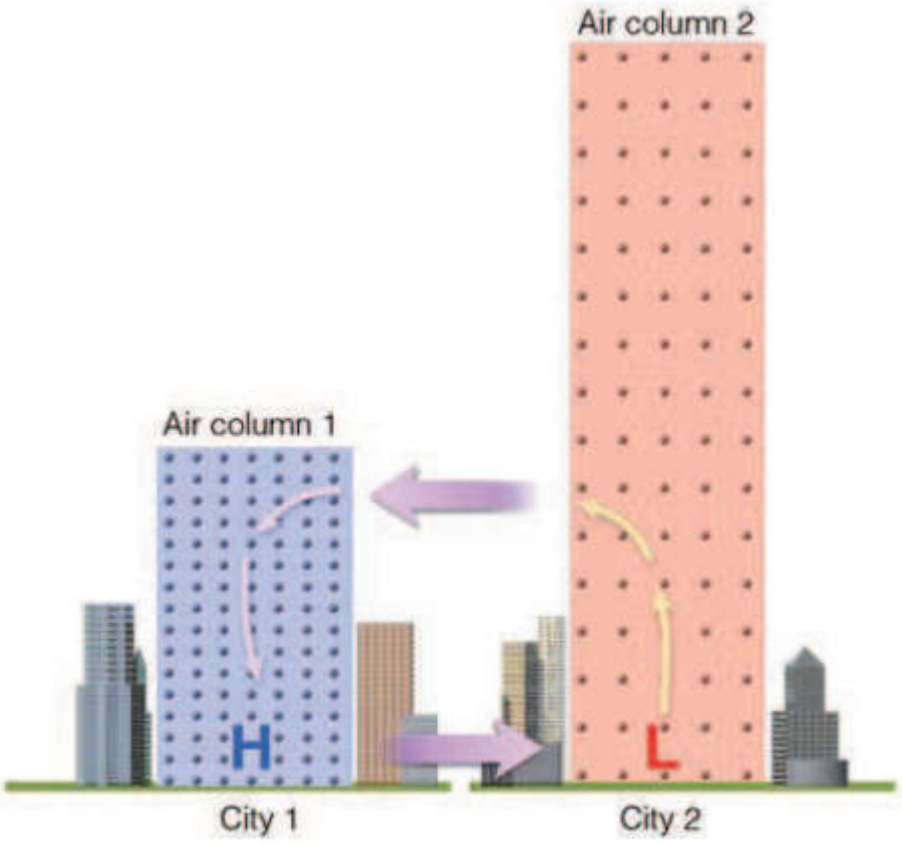

Figure: The heating and cooling of air columns causes horizontal pressure variations aloft and at the surface

3. Winds

Winds occur

1. When air masses move from regions of higher pressure to regions of lower pressure.
   - Equatorial region is hotter, and the air above expands, becomes less dense and rises. This produces a low-pressure belt at this latitude. Generally, the equatorial region has a warm, rainy climate.
   - Polar regions are colder, and air above contracts, becomes denser, and subsides, producing a high-pressure region at this latitude.
2. Wind results from a horizontal difference in air pressure and since the sun heats different parts of the Earth differently, causing pressure differences, the Sun is the driving force for most winds. The wind is a result of following forces acting on the atmosphere:

i. Pressure-gradient force

The pressure-gradient force is the force that results when there is a difference in pressure across a surface. In Earth's atmosphere, for example, air pressure decreases at altitudes above Earth's surface, thus providing a pressure-gradient force which counteracts the force of gravity on the atmosphere.

ii. Coriolis force

an apparent **force** that as a result of the earth's rotation deflects moving objects (such as projectiles or air currents) to the right in the northern hemisphere and to the left in the southern hemisphere.

iii. Friction

Friction is most important near the ground and less important higher in the atmosphere.