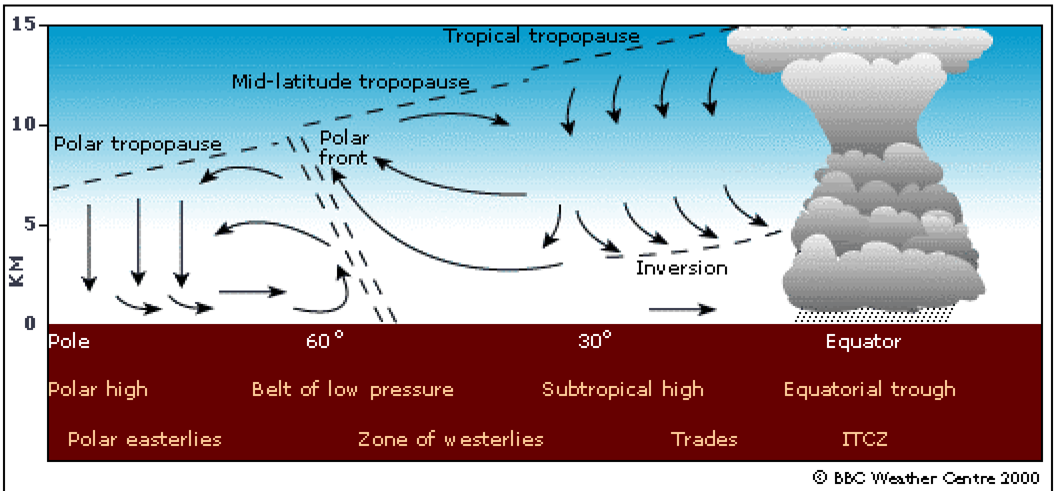
4. Global Circulation

The average amount of energy the earth absorbs from the sun each year is equal to the average amount of energy the earth loses to space. This energy balance, however, is not maintained for each latitude. Tropical regions gain more energy from the sun than they lose, while polar regions lose more energy to space than they gain. The tropics do not continuously grow warmer and the polar regions do not continuously grow colder, however, because the atmosphere transports warm air toward the poles and cold air toward the equator. The oceans do the same with water. The wind pattern generated by the unequal heating of the earth's surface produces the major wind belts over the globe. This average wind flow is called the general circulation of the atmosphere.

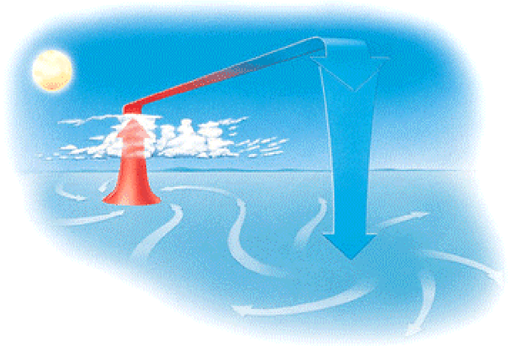
If the Earth was stationary, these winds would be fairly direct; but they are affected by the Earth's rotation, size and geography, as well as by seasonal changes in solar heating. In the northern hemisphere, moving objects such as air and water are deflected to the right as a result of Earth's rotation. They are deflected to the left in the southern hemisphere. This is called the Coriolis effect. Prevailing winds (those following a regular pattern) are arranged in a series of belts around the globe. The prevailing winds encountered in the British Isles are the mid-latitude westerlies. These blow from the south-west.

The cross section of this global circulation is in principle the same in both hemispheres, but in practice is slightly different. This is mainly because of the different distribution of land and sea. There is more land in the northern hemisphere and this pushes the "meteorological equator" to about 5 degrees North of the actual equator.



Cross Section of the Atmospheric General Circulation from Pole to Equator

Meteorological models make simplifying assumptions about the earth, its atmosphere, and its winds, and meteorologists have developed a simple model, called the three-cell model, to describe the average wind flow of the general circulation. The three-cell model assumes that the earth is covered with water and that the sun is always over the equator. With these assumptions, the model makes the following predictions, each of which matches the average surface wind patterns observed, but not the winds at high altitudes called jet streams.



In the tropics, the intense sunlight heats the surface, which warms the air, causing it to rise. This reduces the air pressure at the surface, forming a broad region of low pressure. As the warm, humid air rises, it often condenses into huge thunderstorms. Near the top of the troposphere, the rising air branches and moves toward the North and South poles. As the air moves toward the poles, it gradually cools. At the same time, the air slowly squeezes together and becomes denser.

Near 30° latitude, the air aloft becomes dense enough to produce high-pressure areas at the surface, called the subtropical highs. As the surface air moves outward from the surface highs, the air aloft sinks to replace it and warms by compression, which tends to evaporate any clouds in it. Cloudless skies and little rainfall characterise the region around 30° latitude. Many of the world's deserts are found near this latitude. At the surface, some of the sinking air moves back toward the lower pressure at the equator. This flow of air toward the equator is known as the trade winds. Due to the Coriolis force, a force that results from the rotation of the earth, the trade winds are deflected to the west. In the northern hemisphere, the trade winds blow from the north-east, and in the southern hemisphere, they blow from the south-east. The trade winds complete a thermally driven convection cell, called a Hadley Cell, that begins with the sun warming the tropics, air rising above the equator, flowing toward the poles, then sinking near 30° latitude and returning to the equator. At the equator, the trade winds from the northern hemisphere meet the trade winds from the southern hemisphere forming a boundary called the intertropical convergence zone (ITCZ).

Another cell occurs in the polar latitudes. At the poles, cold air sinks into an area of surface high pressure. As the cold surface air flows toward the equator, it meets milder middle latitude air near 50° to 60° latitude. Here, the converging air rises for the return trip to the poles. The rising air also cools and often condenses into clouds. Hence, plentiful rainfall characterises the region between 50° and 60° latitude. In this region, where the rising air moves toward the poles, regions of surface low pressure often form.

The third cell of the three-cell model occupies the mid-latitudes between the other two cells. Some of the rising air between 50° and 60° latitude begins the journey aloft back toward the equator. At about 30° latitude, this air begins to sink in the vicinity of the subtropical highs. The surface winds tend to blow from the high-pressure region at about 30° latitude toward the low-pressure region between 50° and 60° latitude. The Coriolis force deflects these surface winds, producing the prevailing westerlies of the middle latitudes.

Further towards the poles of the prevailing westerlies, cold, polar air moves toward the equator, and the Coriolis force deflects this air, producing a polar wind belt called the polar easterlies. Near 50° to 60° latitude, the polar easterlies meet the prevailing westerlies. Here the winds are blowing in opposite directions along a boundary called the polar front. It is along the polar front that middle latitude storms often develop.

It is the fact that the British Isles lie close to the polar front that produces many of the main characteristics of its variable weather. The pattern is also complicated even further by the great land mass of Europe to the south and east and the close proximity to the Atlantic ocean.