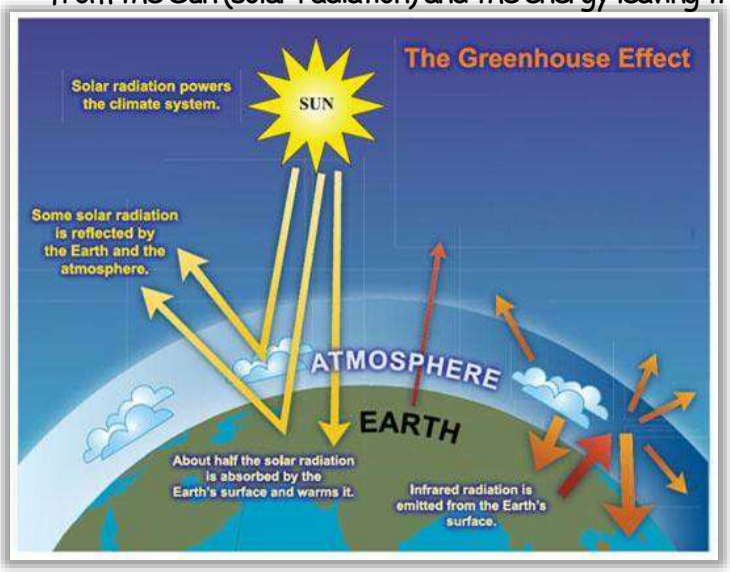
TEACHER BACKGROUND:
THE CLIMATE CONNECTION

What Is Climate? : At the simplest level, the ***weather*** is what is happening in the atmosphere at any given time and the ***climate*** can be considered as the "average weather. In a broader sense, climate is the status of the climate system which comprises the ***atmosphere***, the hydrosphere, the ***cryosphere***, the surface ***lithosphere*** and the ***biosphere***. These elements all determine the state and dynamics of the Earth's climate.

What Determines Climate?

All the factors of the Earth's climate (wind, rain, clouds, temperature…) are the result of energy transfer and changes within the atmosphere at the Earth's surface and in the oceans. Over time, the Earth's climate remains largely stable because the energy received is equal to that lost (the energy budget is balanced). The temperature of the Earth results from a balance between energy coming into the Earth from the Sun (solar radiation) and the energy leaving the Earth into outer space. About half the solar radiation striking the Earth and its atmosphere is absorbed at the surface.



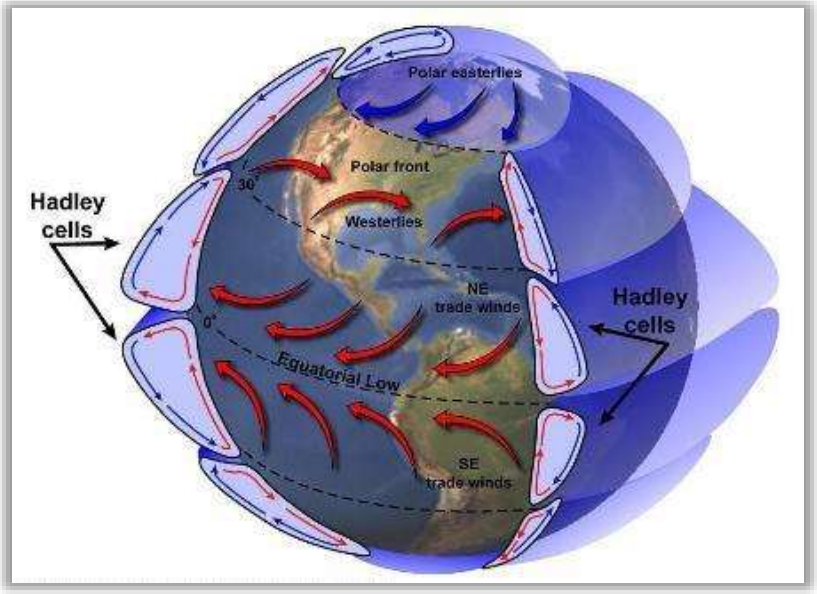
The other half is absorbed by the atmosphere or reflected back into space by clouds, small particles in the atmosphere, snow, ice and deserts at the Earth's surface. Part of the energy absorbed at the Earth's surface is radiated back to the atmosphere and space in the form of heat energy. The temperature we feel is a measure of this heat energy.

In the atmosphere, not all radiation emitted by the Earth reaches outer space. Part of it is reflected back to the Earth's surface by the atmosphere (the greenhouse effect) resulting in an global average of around 14°C, well above the -19°C which would be felt without the natural greenhouse effect.

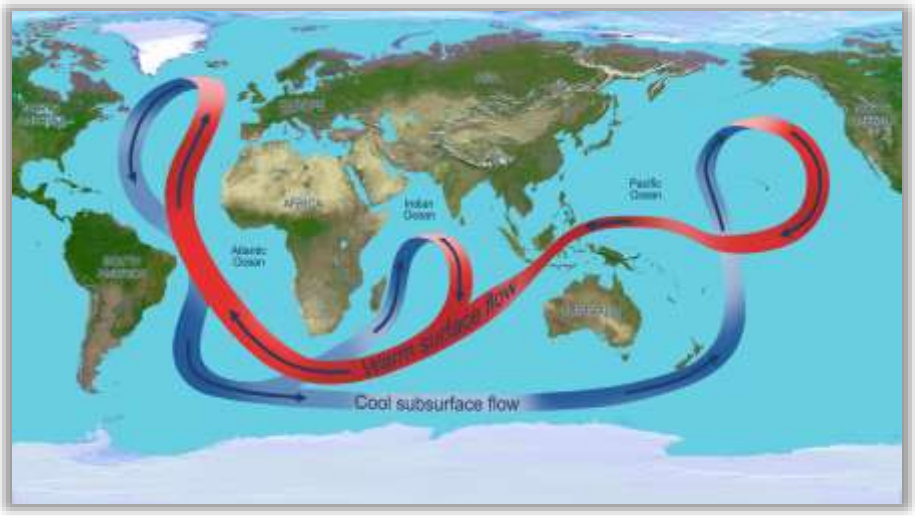
Because the Earth is round and its position in the solar system, more solar energy is absorbed in the tropics creating temperature differences from the equator to the poles. Atmospheric and oceanic circulation contributes to reducing these differences by transporting heat from the tropics to the mid-latitudes and the polar regions. These equator to pole exchanges are the main driving force of the climate system. The energy budget of the Earth can be changed, which then affects the Earth's temperature. An increase in the greenhouse effect, feedbacks in the climate system, or other changes can alter the energy budget of the Earth.

How Is Energy Distributed?

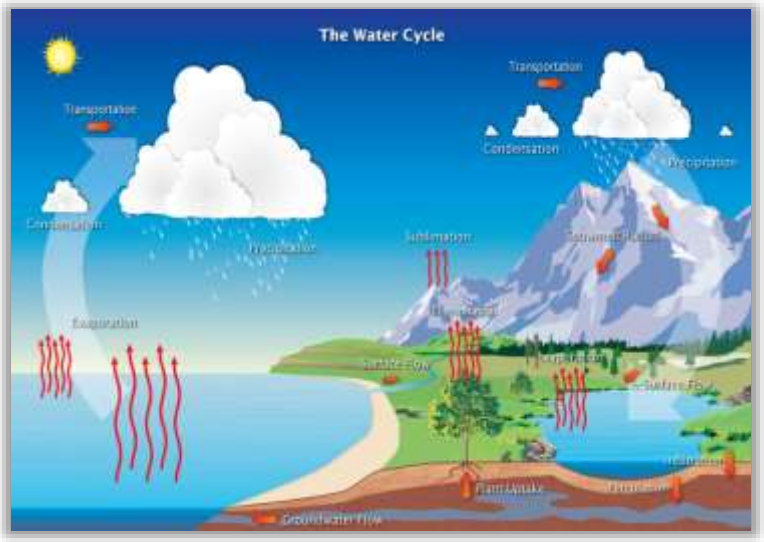
- **Atmospheric circulation**- The circulation of wind in the atmosphere is driven by the rotation of the earth and the incoming energy from the sun. Wind circulates in each hemisphere in three distinct cells which help transport energy and heat from the equator to the poles. The winds are driven by the energy from the sun at the surface as warm air rises and colder air sinks.



- **Ocean circulation**- The oceans play a critical role in storing heat and carbon. When the earth's surface cools or is heated by the sun, the temperature change is greater and faster over the land than over the oceans. Because it is a fluid, the ocean diffuses the effects of a temperature change for great distances via vertical mixing and convective movements. The solid land cannot, so the sun's heat penetrates only the thin, upper crust. One consequence of the ocean's ability to absorb more heat is that when an area of ocean becomes warmer or cooler than usual, it takes much longer for that area to revert to "normal" than it would for a land area. This also explains why "maritime" climates tend to be less extreme than "continental" ones, with smaller day-night and winter-summer differences.



- **Hydrological cycle-** The continual recycling of water between the oceans, land surface, underground aquifers, rivers and the atmosphere (the hydrological cycle) is an essential part of the climate system. Ice requires much energy to melt and water needs even more energy to evaporate, so the cycling of water through the atmosphere by evaporation and its subsequent precipitation is a significant mechanism through which energy is transported throughout the climate system.



How Do The Earth's Spheres Influence Climate?

- **Atmosphere-ocean interactions-** Covering some 71 per cent of the Earth's surface, the oceans are a fundamental component of the climate system. Interactions between the rapidly mixing atmosphere and the slowly changing ocean basins are largely responsible for the natural climatic variations. The high heat capacity of the oceans dampens the much higher temperature changes that would

otherwise occur each day, each season and each year — both in coastal areas and often farther inland. The oceans are the birthplace of all tropical cyclones and most mid-latitude storms. Half the heat transported to the poles is carried by ocean currents, which is why Western Europe, for example, is such a hospitable place. The oceans are also the single most important sink for carbon dioxide produced by human action. The oceans can hold 50 times more carbon than the atmosphere and, when there is equilibrium between these reservoirs, the oceans can absorb up to 85 per cent of any additional carbon released into the atmosphere.

- **Land surface-atmosphere interactions**- Within the first few tens of meters above the ground there are many complex physical processes at work. Understanding these processes is an essential part of improving our knowledge of climate, developing better climate forecasting models, estimating the impact of human activities on climate, and understanding how a changing climate might affect us. On a hot day, it is cooler within a canopy of leafy trees than where the soil or grass is exposed to direct sunlight. In winter, ground frost develops first on exposed grass rather than under trees.

Until recently, the representation of the land surface in computer models of weather and climate was somewhat inadequate. Most coupled models now employ some representation of how vegetation controls evaporation and most can estimate river runoff for the ocean component of the model. Freshwater runoff and local rainfall affect the salinity distribution of the oceans and together are an important part of the development of the latest climate models.

- The feedback process whereby climate-induced changes in vegetation affect the climate system, which further affects vegetation, potentially has large climatic implications. So far, however, it has proven difficult to incorporate this feedback process adequately in the coupled-model experiments used to estimate climate sensitivity. Also, the amount of carbon that is either extracted from the soil or stored in it by decaying vegetation is another source of considerable uncertainty. Snow, with its high reflectivity, is an important component of the land surface. Current climate models have some capability in simulating the seasonal cycle of snow extent but tend to underestimate ***interannual variability***. These weaknesses limit confidence in the details of changes, particularly at middle and high latitudes, simulated by current climate models and goes to show how much the land surface influences climate.