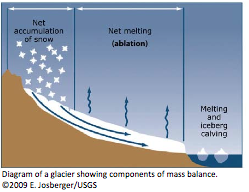


Gases that trap heat in the atmosphere are called greenhouse gases. This section provides information on emissions and removals of the main greenhouse gases to and from the atmosphere.

* Carbon dioxide (CO2): enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste trees, and wood products; through volcanic activity; and as a result of some chemical reactions (example: manufacturing of cement). Carbon dioxide is removed from the atmosphere when it is absorbed by plants during photosynthesis.
* Methane (CH4): enters the atmosphere during the production and transport of coal, natural gas, and oil; raising livestock (examples: cows, pigs, chickens) and other agricultural practices; volcanic activity; and by the decay of organic waste in solid waste landfills. There are currently large quantities of frozen methane on Earth.
* Water vapor (H20): enters the atmosphere through evaporation and volcanic activity. Is removed from the atmosphere through precipitation and formation of ice.
* Nitrous oxide (N2O): enters the atmosphere during agricultural and industrial activities; burning of fossil fuels (coal, natural gas, and oil); and burning of solid waste.
* Fluorinated gases: hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic (humanmade) and powerful greenhouse gases that enter the atmosphere through a variety of industrial processes (example: air conditioning). These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes called High Global Warming Potential Gases (high GWP gases.)

--EPA (2012). “Greenhouse Gas Emissions”

GLACIERS  
Average global sea level rises and falls in response to climate change. When global surface temperatures are low, more snow and ice build up on land, and sea level drops. A warmer climate increases melting of glaciers and ice sheets, raising sea level.   
  
Remember the marine terminating outlet glaciers from Greenland that you watched calving? When marine terminating outlet glaciers calve (break at the edge), large pieces of ice are sent into the ocean, melt, and raise sea level. Mountain glaciers are also melting. For example, the Arapaho Glacier in the Rocky Mountains has shrunk dramatically since it was photographed in 1898. Measurements collected since 1960 suggest that the glacier has thinned by at least 40 meters (~120 feet). Thinning between 1898 and 1960 is unknown but probably considerably greater than 40 meters.   
--Wiscombe, W. (2005). “Glaciers, Climate Change, & Sea Level Rise”. NASA Earth   
Observatory

**OCEANS**The atmosphere transports heat through a complex, worldwide pattern of winds. Blowing across the ocean surface, these winds drive corresponding patterns of ocean currents. But the ocean currents move more slowly than the winds, and water stores heat much more efficiently than air. Therefore, the ocean is the thermal memory of the climate system.

The ocean impacts the Earth’s climate system by using its heat to stabilize the temperature of the Earth. As you know, the Earth’s surface is heated unequally. Ocean circulation (which is driven by atmospheric circulation) plays a role in redistributing the heat on Earth.

Climate is also influenced by the “biological pump”, a biological process in the ocean with which you are already familiar. The biological pump happens when phytoplankton do photosynthesis and convert carbon dioxide and nutrients into glucose, a sugar that contains carbon. A little bit of this carbon sinks to the bottom of the ocean, gets buried in the sediment at the bottom of the ocean, and stays buried for potentially millions of years. (That’s where oil comes from!!) Through photosynthesis, carbon gets removed from the atmosphere and stored in the ocean.

You also know that carbon dioxide is dissolved in the seawater. Carbon dioxide is gets removed from the atmosphere and incorporated into the seawater as the wind mixes the surface of the ocean. The dissolved carbon dioxide gets distributed throughout the water column, and the deep water of the ocean can store carbon dioxide for hundreds of years. Centuries later, this deep water will make it to the surface of the ocean (remember thermohaline circulation?). At that time, the warm surface water releases the carbon dioxide back into the atmosphere. The conveyer belt described above carries carbon dioxide into the deep ocean and releases carbon dioxide at the surface of the ocean back into the atmosphere. Therefore, the temperature of the ocean helps regulate the amount of carbon dioxide that is released into the atmosphere (warm water) or absorbed into the ocean (cold water).

Finally, remember that various environmental processes can cause sea level changes. For example, warming of the ocean water will cause the water to expand, meaning that the water is taking up more space, and sea level will rise. During periods of Earth’s history where there is a great deal of ice, sea levels are lower. During periods of Earth’s history where there is less ice, sea levels are higher because the water is in the ocean, rather than tied up in ice.

--Netting, R. (2010). “Ocean and Earth System”. NASA Oceanography

AIR TEMPERATURE  
Temperature is a fundamental component of climate, and it can have wide-ranging effects on human life and ecosystems. For example, increases in air temperature can lead to more intense heat waves, which can cause illness and death in vulnerable populations. Temperature patterns also determine what types of plants and animals can survive in a particular place. Changes in temperature can disrupt a wide range of natural processes, particularly if these changes occur abruptly and plant and animal species do not have time to adapt.

As greenhouse gases trap more energy in the Earth’s atmosphere, average temperatures at the Earth’s surface are expected to rise. However, because climate change (both natural and human-driven) can shift the wind patterns and ocean currents that drive the world’s climate system, some areas might experience more warming than others, and some areas might experience more cooling.

Changes in air temperature can also causes changes in sea surface temperature, precipitation patterns, and other aspects of climate. For example, changes in air temperature will influence the amount of ice and Earth. As another example, changes in air temperature will influence the amount of evaporation that takes place. Greater evaporation rates might lead to more rainfall, which will allow more land vegetation (plants) to grow.

--Samenow, J., (2010). “Climate Change Indicators in the US”. EPA Climate Change Division.

VEGETATION (PLANTS)  
The amount of vegetation that covers the Earth’s surface has major implications for climate because plants are exchanging gases with the atmosphere, which in turns exchanges gases with the oceans. As you know, plants produce energy through photosynthesis. During photosynthesis, land plants absorb carbon dioxide from the atmosphere, thereby removing CO2, a greenhouse gas, from the atmosphere. The same process occurs in the ocean when phytoplankton engage in photosynthesis and remove CO2.

When thinking about how plants influence climate, it is also important to consider the impact of vegetation on albedo. Remember that albedo refers to the reflectivity of a surface. The presence of plants lowers the albedo of a particular area because plants absorb solar radiation.

Just like vegetation influences climate, climate influences vegetation. There are several environmental and human factors that influence the amount of vegetation in a particular area. Some examples include:  
(1) Global temperature. When global temperatures are relatively warm, there is generally increased evaporation, rainfall, and ability for plants to grow. In contrast, colder global temperatures lead to decreased evaporation rates, less rainfall, and fewer plants. As you know from class, most plants do not do particularly well in cold conditions found at high elevations (example: tall mountain ranges like the Peruvian Andes) and high latitudes (example: Greenland).  
(2) Precipitation rates. In land areas where precipitation is high, adequate moisture in the soil exists for plants to grow. In extremely arid (dry) land regions, there is not enough moisture for plants to thrive.

(3) With regard to human activities, the removal of forests to make room for farmland, houses, businesses, etc., is called deforestation. At the same time, agriculture (farming) introduces more plants over large areas.

