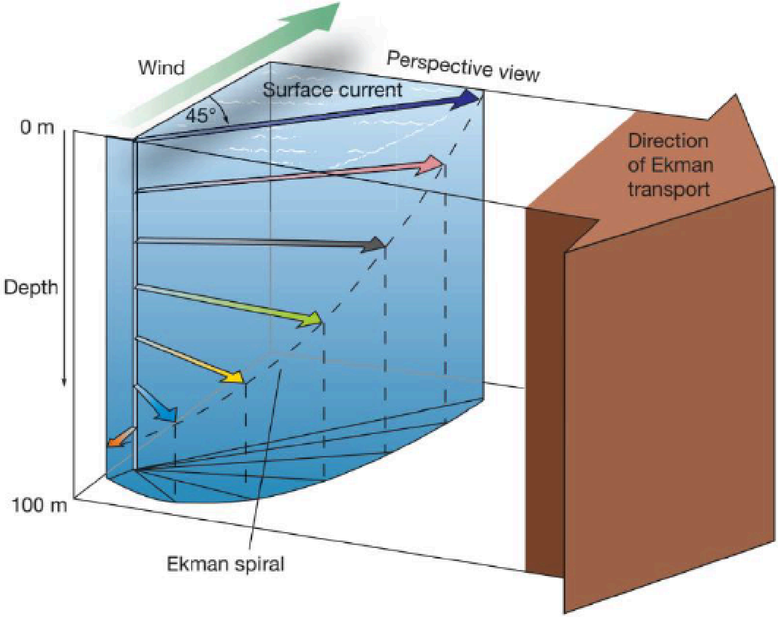
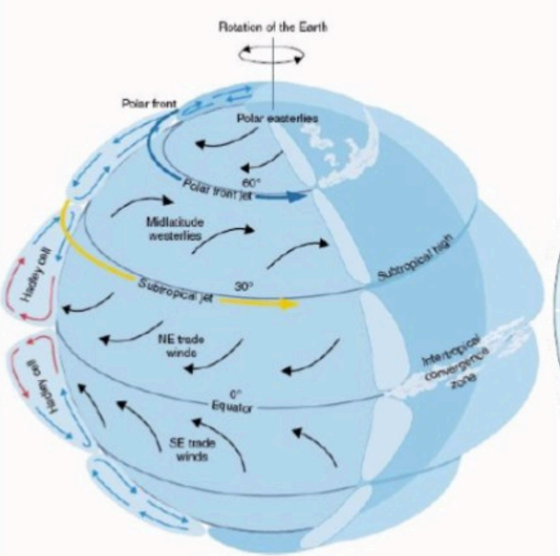
EKMAN TRANSPORT

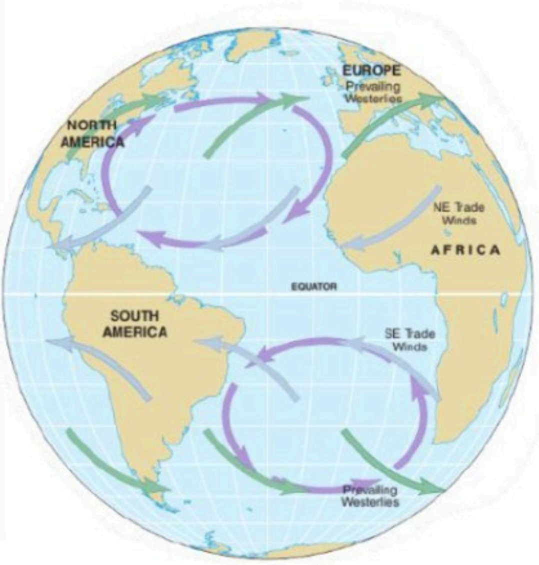


Due to the Coriolis effect, surface currents move at about 45° to the wind: to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. Each water layer is driven by the one above, with decreasing speed and increasing deflection, creating a spiral pattern.

The overall water movement, known as Ekman transport, occurs ideally at 90° from the wind direction and is stronger with higher wind speeds.

SURFACE CURRENT

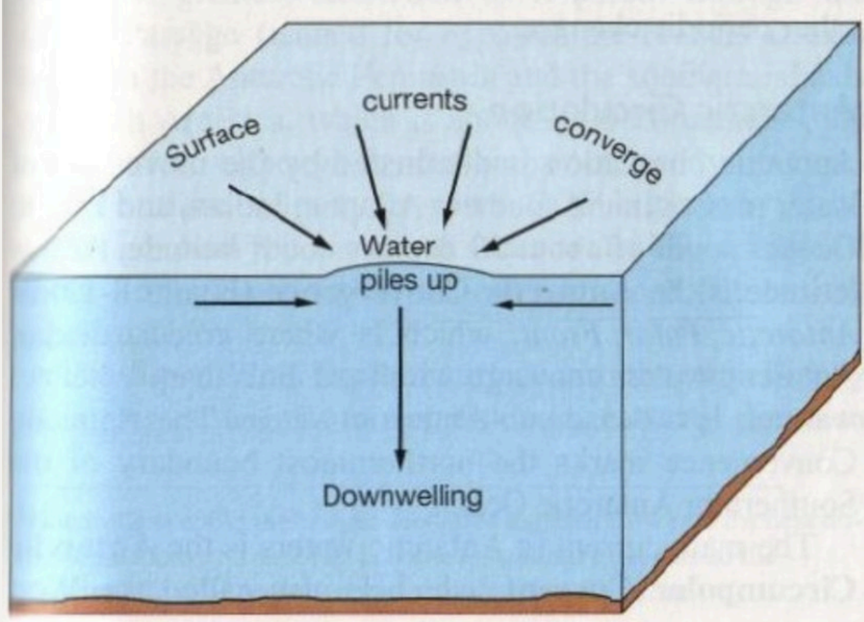




Surface currents born with the wind by friction and Coriolis force (rotation of the Earth). The upper layers are dragged and drag the lower layers.

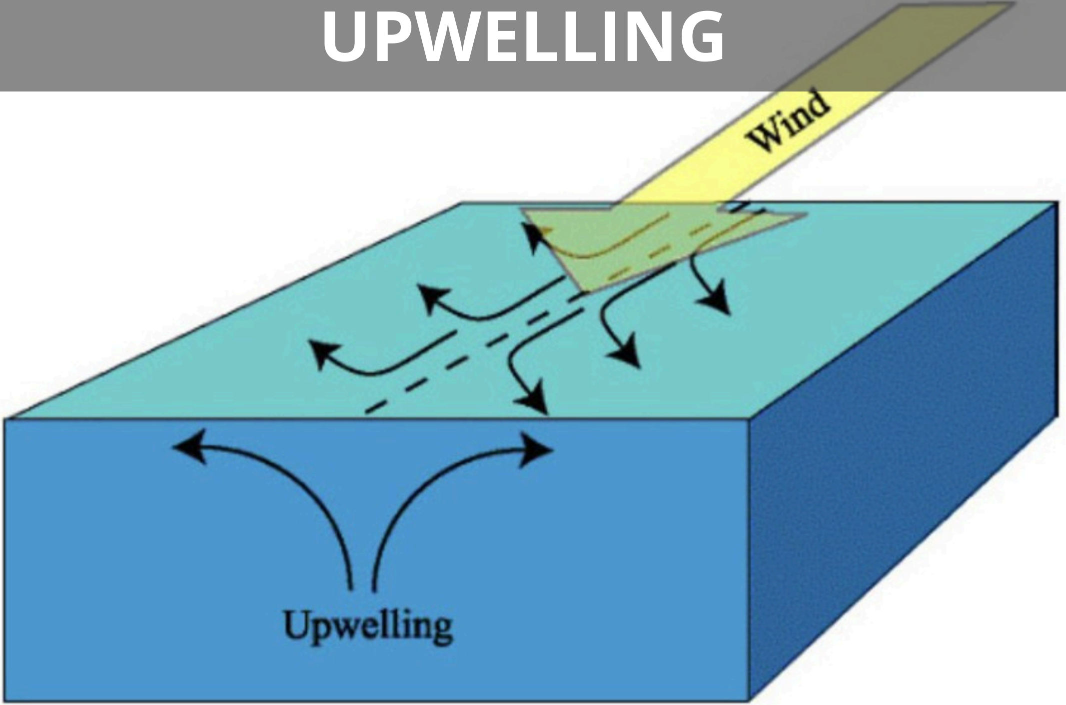
Gyres, large circular-moving water loops, are formed following the main wind belt pattern. The trade winds (blue arrows) together with the prevailing westerlies (green arrows) create circular moving loops of water (purple arrows) at the surface in both parts of the Atlantic Ocean basin.

DOWNWELLING



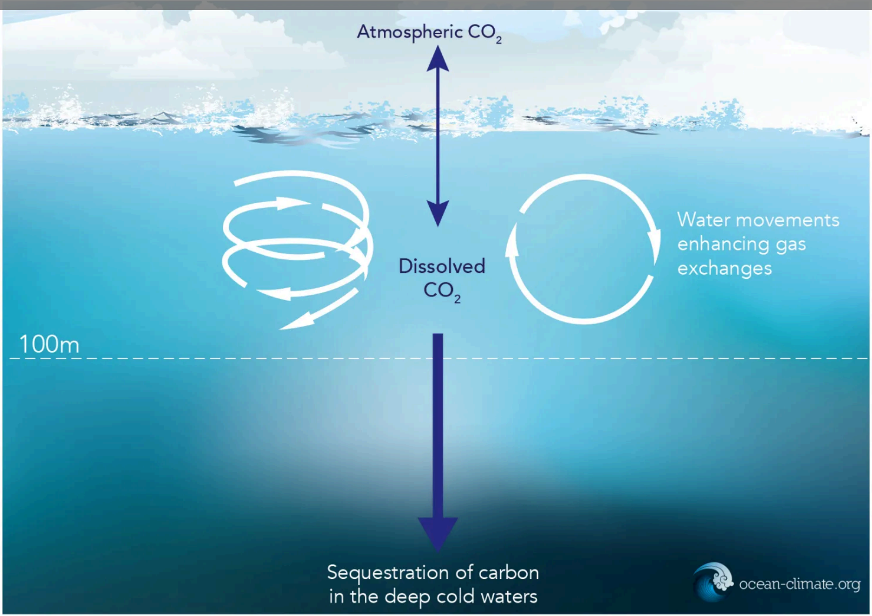
Downwelling is an oceanographic process where surface waters sink into deeper layers of the ocean. This typically occurs in regions where surface currents converge, causing water to pile up and be forced downward. Downwelling can also result from increased water density due to cooling or higher salinity, such as in polar regions where cold, salty water becomes denser and sinks .

UPWELLING



Upwelling is an oceanographic process where deep, cold, nutrient-rich waters rise toward the ocean surface. This phenomenon is primarily driven by wind patterns and the Earth's rotation, which cause surface waters to diverge and allow deeper waters to ascend. The influx of nutrients stimulates the growth of phytoplankton, forming the base of the marine food web and supporting diverse and productive ecosystems.

CARBON SINK



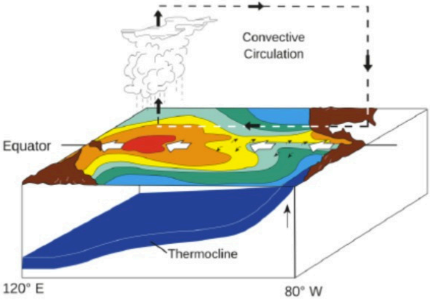
Physical carbon pump

The ocean exchanges CO_2 with the atmosphere. There are two processes : one physical and the other one biological. The physical process leads to sink CO_2 dissolved in water toward the deep cold water.

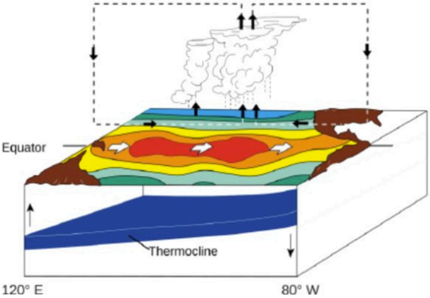
Ocean warming has the effect of exchanging less CO_2 and even to release some CO_2 already captured in the ocean.

EL NIÑO, LA NIÑA

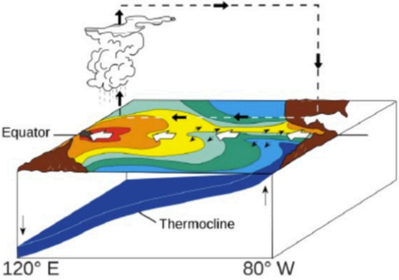
Normal Conditions



El Niño Conditions



La Niña Conditions



El Nino is an elevation of surface water temperature in the central and eastern tropical Pacific Ocean. This phenomenon increases cyclone possibilities but boosts fishing activity too thanks to nutrients more present. La Nina is characterized as a cooler-than-average sea surface temperature.

El Niño and La Niña play a key role in climate variability, influencing weather patterns on interannual to decadal timescales.

CLIMATE CHANGE

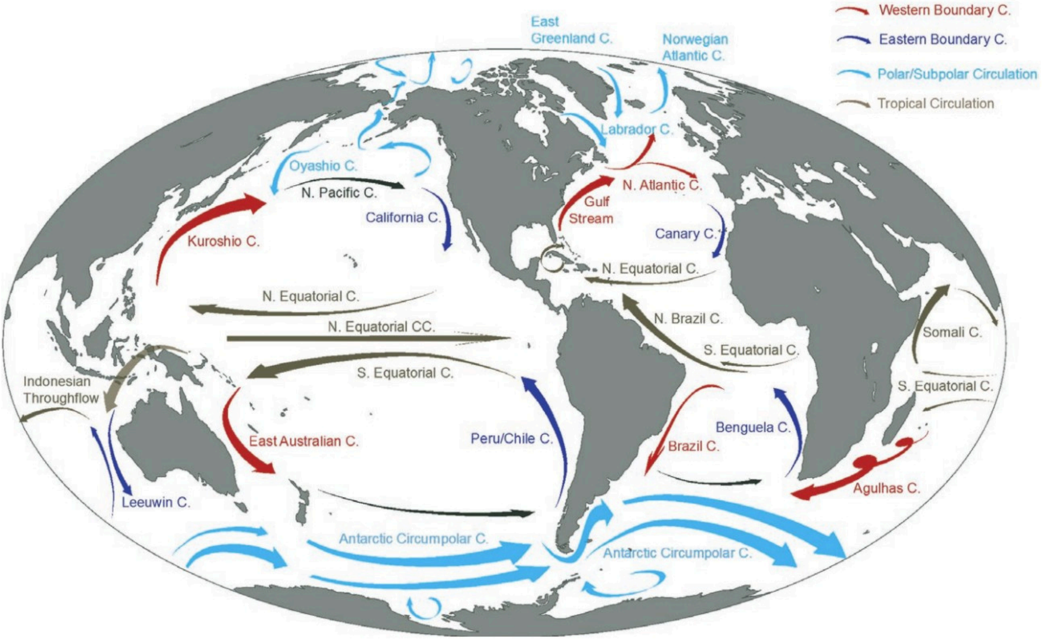
Surface currents, driven primarily by wind patterns and the Earth's rotation (Coriolis effect), play a vital role in regulating global climate by redistributing heat, nutrients, and gases across the oceans.

Some effects due to climate change on the role of surface currents : temperature and salinity shifts, wind pattern changes, sea level rise, increased storm intensity.

ECONOMIC CRISIS

Lack of nutrients in surface water leads to lack of fish which impacts fishing. Countries requiring fishing as food or economic activity are the most impacted creating health problems and inequality.

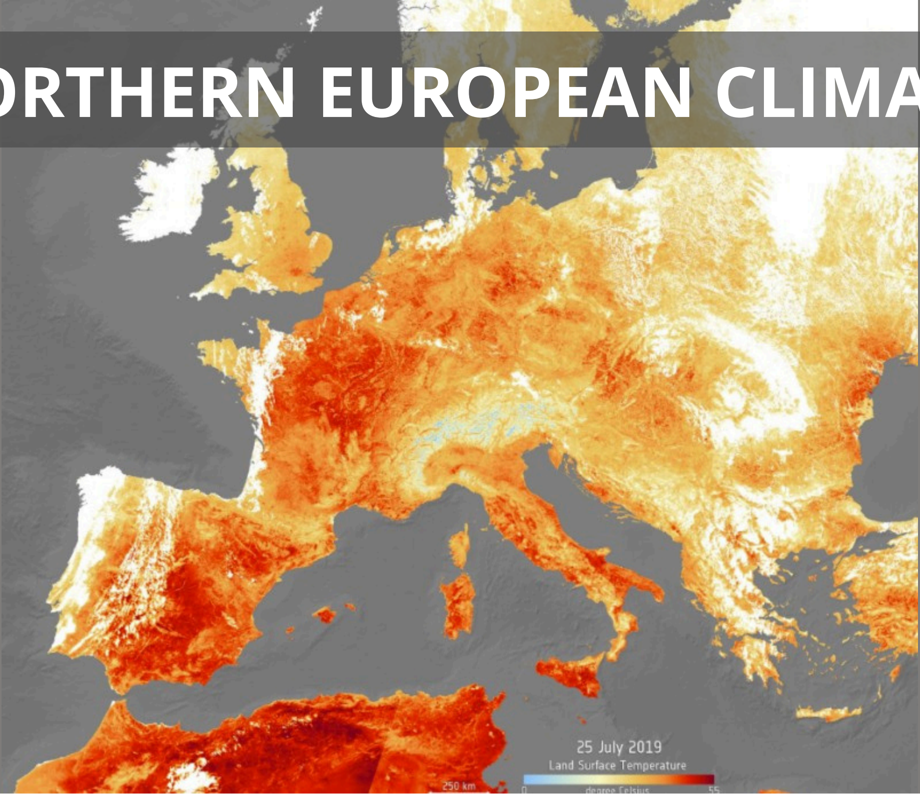
OCEAN CIRCULATION



Ocean circulation consists of fast, wind-driven surface currents and slow, deep-water flows. These currents are essential for regulating Earth's climate. They distribute heat across the globe, help keep equatorial regions relatively cool, and transport nutrients that sustain marine life and biological productivity.

Ocean currents play a key role in the global carbon cycle. The ocean absorbs over a quarter of the CO_2 released by human activities each year, with the Southern Ocean alone accounting for nearly half of this storage. However, as ocean temperatures rise, their capacity to absorb CO_2 decreases. These currents also facilitate the exchange of oxygen and support the natural release and absorption of gases, making them vital to both climate stability and ocean health.

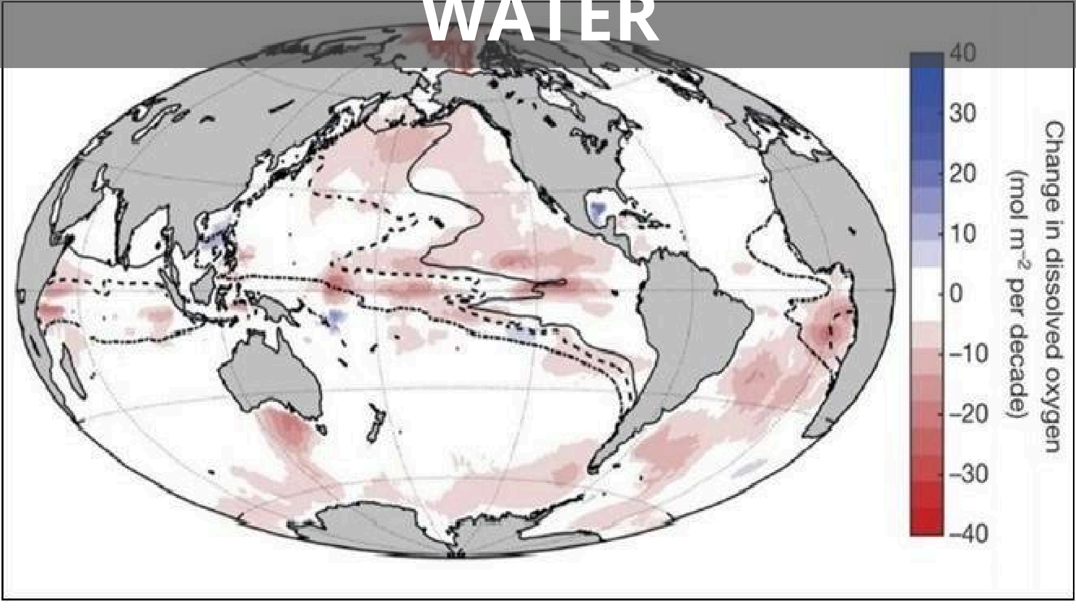
NORTHERN EUROPEAN CLIMATE



The AMOC is weakening due to global warming, as melting ice and increased rainfall make ocean water less salty and less dense, which slows down the sinking process that drives the circulation. As a result, less warm water reaches Northern Europe, potentially leading to cooler temperatures, more storms, increased rainfall, or colder winters.

These changes could partly offset the overall warming expected from climate change in parts of Northern and Western Europe.

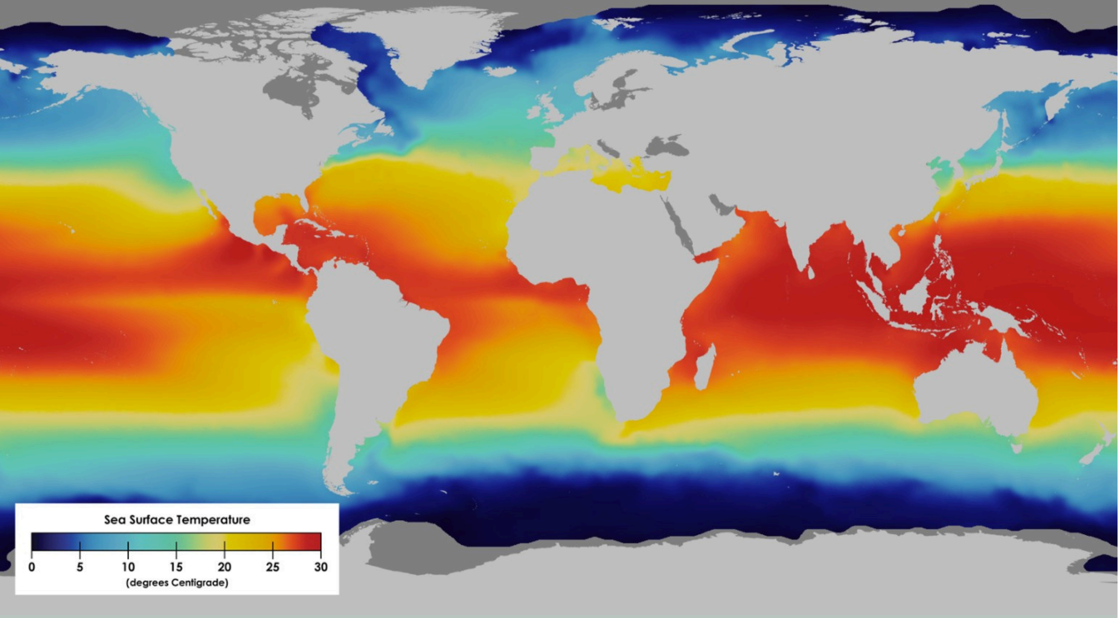
LOW SOLUBILITY OF GASES IN WATER



The ocean absorbs more than a quarter of anthropogenic CO2 emissions each year, almost half of which is absorbed by the Southern Ocean.

Ocean surface warming affects the solubility of gases in water, including greenhouse gases. The weakening of large ocean movements reduces its ventilation and thus decreases exchanges with air, especially oxygen. This reduction in oxygen in the water has serious consequences for marine ecosystems.

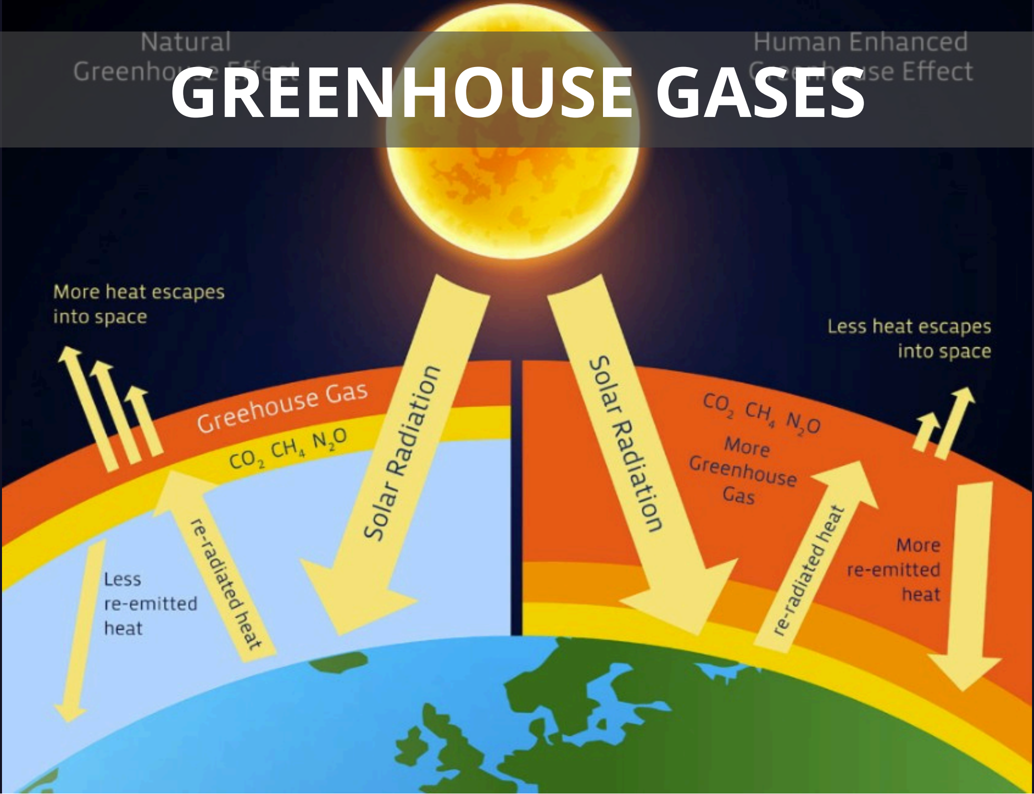
OCEAN HEATING



Oceans tend to warm up due to climate change and the increasing greenhouse effect. In addition, the decrease of large-scale circulations tends to reduce the exchange between hot and cold waters, and thus to favor the divergence of temperatures.

Ocean warming causes a retroactive loop that tends to promote climate change. Indeed, a warmer ocean absorbs less CO_2 than a cold ocean, so unabsorbed gas will increase the greenhouse effect even more, especially knowing that the ocean is one of the largest carbon sinks in the world.

GREENHOUSE GASES



Greenhouse gases are gases in the atmosphere that absorb solar radiation reflected by the Earth’s surface and re-emit it to the Earth, this is called the greenhouse effect. They keep the Earth warm and are essential to our survival. However, the increase in their concentration in the atmosphere is one of the main causes of global warming.

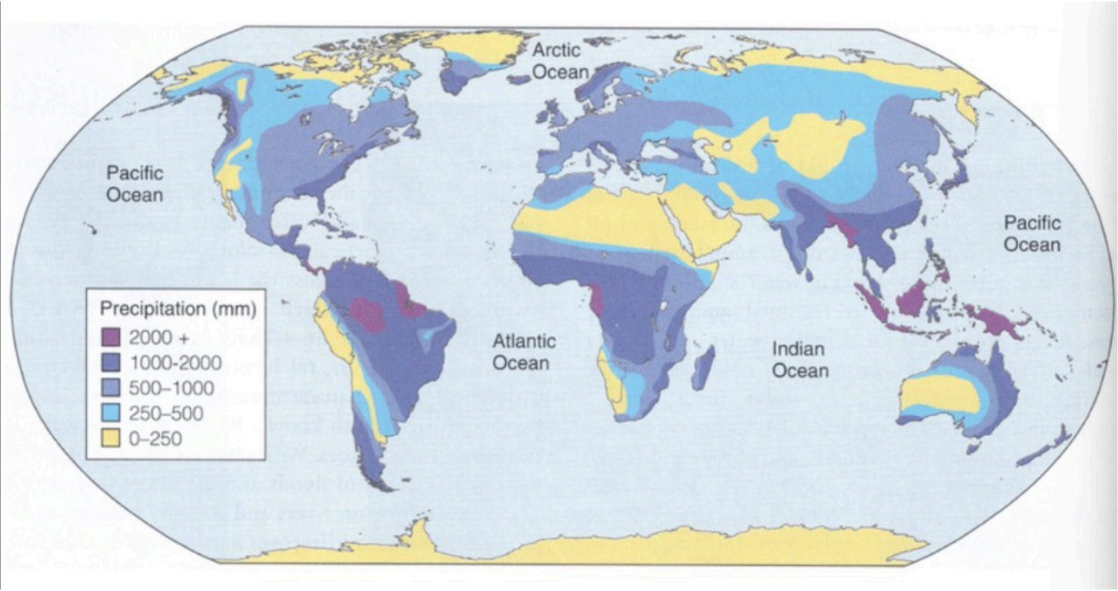

GLACIERS MELTING

In recent decades, global warming due to the increasing greenhouse effect has intensified the melting of glaciers. Between 1994 and 2017, 28 trillion tons of ice melted without regenerating. Polar, Arctic and Antarctic areas are the most affected. All of this fresh water released into the sea has serious consequences such as rising sea levels.

ICE CAPS MELTING

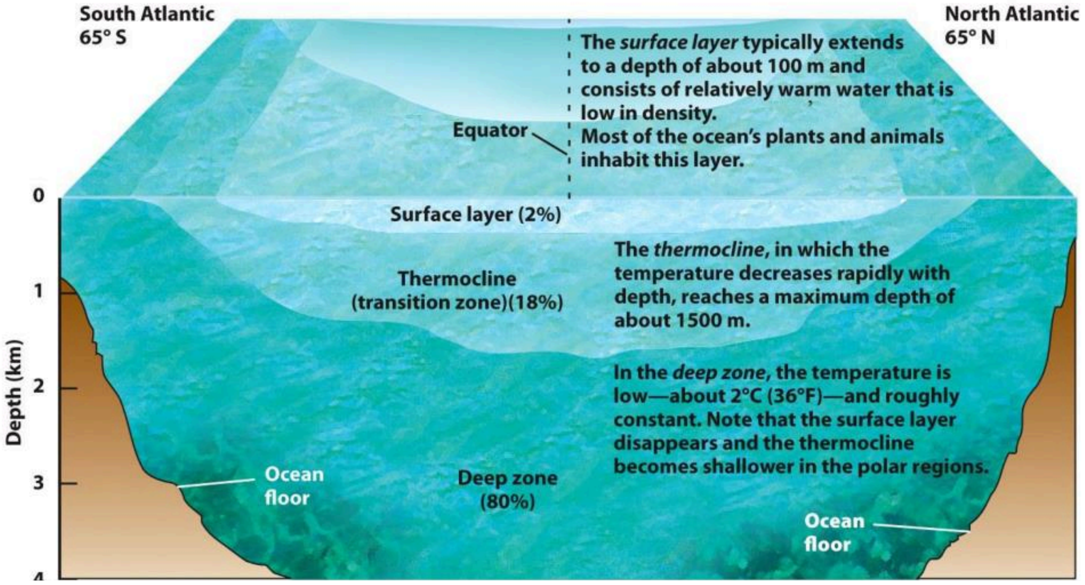
Melting of ice caps continues to increase with climate change. The decrease in upwelling causes a warming of the surface waters which accelerates the melting of these calottes, and which then accelerates the discharge of fresh water into the oceans at the poles.

PRECIPITATIONS RISING



Precipitation is higher in some parts of the world and storms are becoming more severe, and this is due to climate change. Global warming causes an increase in the amount of water vapour in the air, which accelerates the frequency and intensity of natural disasters: storms, tornadoes or floods. This increase is not uniform throughout the world and particularly affects tropical areas.

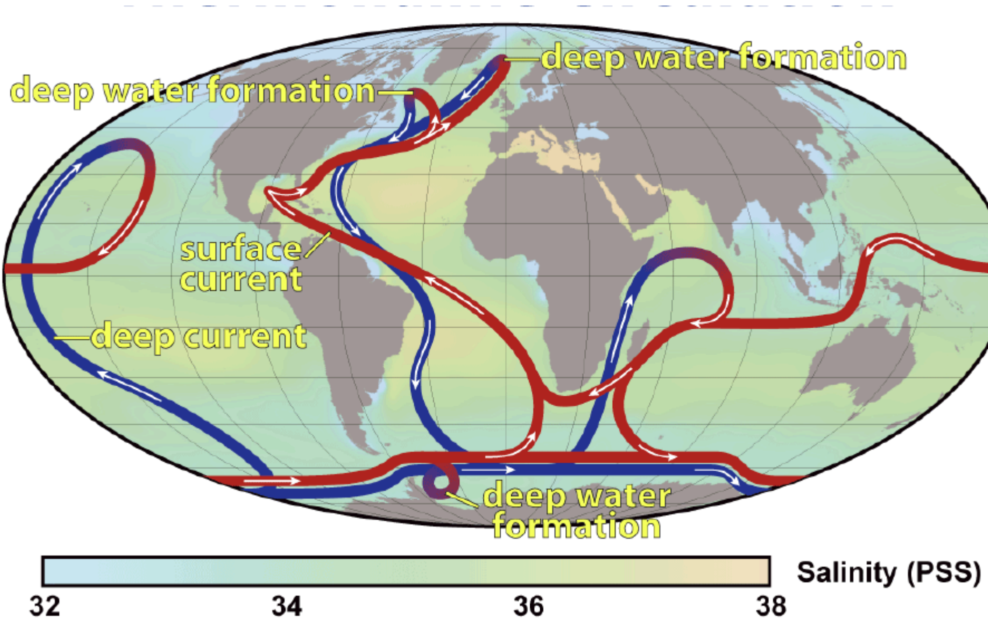
OCEAN STRATIFICATION



The stratification of the ocean is a phenomenon that makes it composed of several layers one above the other which are distinguished by their properties (density, temperature, salinity, oxygenation...).

This stratification is intensifying with global warming, notably due to the arrival of huge quantities of fresh water in the upper layers of the oceans. This results in decreased oxygen and nutrient exchange as it slows down the thermohaline circulation and global currents.

THE AMOC


deep water formation
deep water formation
surface current
deep current
deep water formation
Salinity (PSS)
32
34
36
38

The AMOC (Atlantic Meridional Overturning Circulation) is a large system of surface currents (like the Gulf Stream) and deep ocean currents that begins in the Atlantic but connects to other ocean basins. It is driven by thermohaline circulation, which is circulation caused by density differences (thermo- for temperature and -haline for salt). Warm, low-salinity waters at the surface move toward the poles, where cold, salty waters sink to depth and flow back toward the equator.

This global process ensures that the world’s oceans are continually mixed and that heat and energy are distributed around the Earth.