Ocean Biogeochemistry and Climate Feedbacks
The Ocean is a key player in the climate system, buffering changes in the atmospheric composition. Changes in the ocean can modify the Earth's radiation budget, modulate the water cycle, and affect weather patterns. Our research line focuses on ocean biogeochemical processes and the effects of their alteration on the climate system.

**Summary**

Atmospheric levels of CO$_2$ and other greenhouse gases (CH$_4$ and N$_2$O) have increased substantially above preindustrial levels due to human activities. Carbon dioxide is continuously removed from the atmosphere by the ocean. This process is of fundamental importance in the global carbon cycle and the global climate system. Carbon dioxide entering the surface ocean immediately reacts with water to form bicarbonate (HCO$_3^-$) and carbonate (CO$_3^{2-}$) ions by means of the physical and the biological pump. These two pumps maintain a vertical gradient in CO$_2$ regulating the exchange of CO$_2$ between the atmosphere and the ocean. The strength of the solubility pump depends globally on the strength of the MOC, which can be affected by climate-driven changes in the ocean circulation such as the slowing down of the Thermohaline Circulation.

Climate-driven changes in the ocean circulation and the ocean-atmosphere system can impact the biological pump by altering the vertical exchange of CO$_2$ with the atmosphere. The main impacts include changes in the ocean stratification, marine productivity, and ocean solubility:

**Changes in CO$_2$ solubility:**

- CO$_2$ solubility is a function of the temperature, therefore as the ocean's temperature increases the solubility of CO$_2$ decreases and consequently the uptake of the CO$_2$ is reduced.

**Changes in the ocean stratification:**

- Increased sea surface temperatures (SST) and increased precipitation at high latitudes lead to an increase in the ocean stratification. This causes a shallower mixing layer and a reduction in the vertical exchange and transport of anthropogenic CO$_2$ to the deep ocean. The stratification reduces the supply of DIC and nutrients, which are needed for biological activity.

**Changes in the marine productivity:**

- Warming and other environmental changes (e.g., ocean acidification) can lead to further changes in marine productivity.

**Changes in the ocean circulation:**

- On centennial time scales the ocean carbon sink may also be affected by climate-driven changes in the ocean circulation such as the slowing down of the Thermohaline Circulation.

**Objectives**

- To study the ocean biogeochemical impacts due to climate change and climate variability.
- To quantify feedbacks between ocean biogeochemistry and the climate system.
- To understand the impacts on the marine ecosystem due to the changes of the main ocean biogeochemical cycles in a changing climate.

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