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Impact of ocean circulation changes on ocean carbon and heat sequestration.

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The increase in atmospheric CO_2 concentrations over the pre-industrial level has caused changes in current climate system, both as a result of elevated global temperatures and chemical interactions in the atmosphere and ocean. Both these factors affect the ocean sequestration of the anomalous heat and carbon. Ocean circulation is a main driver of ocean heat and carbon uptake and transport. The main mechanisms are, firstly, gyre transport, which advects warm waters polewards where the cooling results in elevated partial pressures of CO_2, so causing an imbalance of air-sea equilibrium and the uptake of carbon by the ocean. Secondly, the overturning circulation in the North Atlantic and Southern Ocean transports surface waters to the deep ocean and deep carbon-rich waters to the surface, resulting in the uptake and release of carbon respectively.

Using the HadGEM2-ES general circulation model, we investigate the response of the ocean dynamics and thermodynamics to an abrupt doubling and quadrupling of atmospheric CO_2 levels. Using this set of numerical experiments, we investigate changes in the rate and variability of air-sea carbon exchange. In addition, we examine the changes in ocean heat and carbon content integrated throughout the water column and as function of depth. This is done both globally as well as in 6 distinct regions: North Atlantic, North Pacific, Tropical Pacific, zonal bands north of the Southern Ocean and in the Southern Ocean, and in the south Pacific section of the Southern Ocean. For both carbon and heat content, we observe a peak in the amplitude of the change at the bottom of the oceanic mixed layer. In particular regions, such as the tropical Pacific, there is another maximum at the bottom of the basin, dependent on the degree of atmospheric CO_2 levels.

In the study, we aim to identify the cause of the vertical structure of change of heat and carbon with depth in the step experiments and to what extent changes in the ocean circulation induced by the atmospheric CO_2 forcing are responsible.