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Decomposition of climate change effects on ocean natural and anthropogenic carbon uptake.

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The ocean has been the only net sink of anthropogenic CO_2 over the last 200 years, removing more than 30% of emitted anthropogenic carbon [Sabine et al., 2004]. The Southern Ocean accounts for up to half of this sink through the formation of various bottom, intermediate and mode water masses [Gruber et al., 2009]. Therefore, understanding the full range of global warming's possible consequences for the Earth system hinges on an understanding of the Southern Ocean's continued ability to serve as a carbon sink in the future. Many of the physical processes that are crucial to ocean carbon uptake and storage are expected to change under warming conditions, with consequences that are difficult to predict. The recent observed increase in the strength of the Southern Ocean Westerlies might enhance the anthropogenic carbon uptake through a more vigorous vertical mixing. However, this could also cause a decrease in natural carbon storage with a compensating effect. On the other hand, projected changes in buoyancy fluxes are expected to work in the opposite direction leading to a reduction of the vertical mixing. Finally, CO_2 solubility at the sea surface will be affected by changes in temperature and salinity. We use a coupled atmosphere-ocean model (CM2Mc, Gallbraith et al., 2011) to perform a series of modeling experiments aimed to quantify the separate impact of these mechanisms on the various processes responsible for the functioning of the ocean carbon pumps. The experiments are based on the IPCC rcp8.5 scenario for the 21st century climate and consist in a combination of perturbations in which only one of the forcing factors is varying. This approach allows us to evaluate the relative importance of each process on the ability of the ocean to store carbon through the solubility and biological pumps. We also discuss the future climate projected changes in the relative importance of the Southern Ocean with respect to the global Ocean, for the total carbon uptake.

References

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