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Effect of a dynamic mixed layer scheme on ocean carbon storage in the GENIE Earth-Sytem Model

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In order to improve our understanding of the Earth's past, present and future climates we must better understand the controls on the partitioning of carbon dioxide between the atmosphere and ocean, particularly the relative and interacting contributions to the ocean-atmosphere CO_2 flux of physical chemistry (the 'solubility pump') and biological activity (the 'biological pump'). Whilst these two processes are closely connected through various interactions and feedbacks it is possible to separate the purely physical (solubility pump) component of the ocean uptake of carbon from the net total effect of physics plus biology within the GENIE (Grid ENabled Integrated Earth-system model) modular framework, by switching off the biological model.

In this work we compare pre-industrial spin-ups of GENIE, with and without a newly-developed dynamic mixed layer scheme, and with and without a biotic component. We find that in abiotic runs the Atlantic overturning circulation is increased and surface-ocean DIC is elevated when the mixed layer scheme is turned on. Biotic runs demonstrate enhanced primary productivity and phosphate utilisation and consequently a substantial (almost 10%) decrease in atmospheric CO_2 in the presence of the mixed layer scheme. This appears to be due to much stronger communication between the surface and deep oceans at mid latitudes where the original static mixed layer scheme fixed the thermocline at the bottom of the first layer of the ocean (80m).

We also present data from runs simulating the rise of pCO_2 from the pre-industrial to the present-day where we show that the influence of a dynamic mixed layer scheme is to enhance the biological pump and increase the proportion of emitted CO_2 that is drawn down into the ocean. The effect of the dynamic mixed layer scheme on future CO_2 emissions scenarios and in spin-up runs using boundary conditions from the last glacial maximum will also be presented and discussed in the context of past and future ocean carbon storage.