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Clim. Past, 5, 537-550, 2009
www.clim-past.net/5/537/2009/

Glacial-interglacial atmospheric CO_2 change: a possible "standing volume" effect on deep-ocean carbon sequestration

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Abstract. So far, the exploration of possible mechanisms for glacial atmospheric CO_2 drawdown and marine carbon sequestration has tended to focus on dynamic or kinetic processes (i.e. variable mixing-, equilibration- or export rates). Here an attempt is made to underline instead the possible importance of changes in the standing volumes of intra-oceanic carbon reservoirs (i.e. different water-masses) in influencing the total marine carbon inventory. By way of illustration, a simple mechanism is proposed for enhancing the marine carbon inventory via an increase in the volume of relatively cold and carbon-enriched deep water, analogous to modern Lower Circumpolar Deep Water (LCDW), filling the ocean basins. A set of simple box-model experiments confirm the expectation that a deep sea dominated by an expanded LCDW-like watermass holds more CO_2, without any pre-imposed changes in ocean overturning rate, biological export or ocean-atmosphere exchange. The magnitude of this "standing volume effect" (which operates by boosting the solubility- and biological pumps) might be as large as the contributions that have previously been attributed to carbonate compensation, terrestrial biosphere reduction or ocean fertilisation for example. By providing a means of not only enhancing but also driving changes in the efficiency of the biological- and solubility pumps, this standing volume mechanism may help to reduce the amount of glacial-interglacial CO_2 change that remains to be explained by other mechanisms that are difficult to assess in the geological archive, such as reduced mass transport or mixing rates in particular. This in turn could help narrow the search for forcing conditions capable of pushing the global carbon cycle between glacial and interglacial modes.

Final Revised Paper (PDF, 775 KB) Discussion Paper (CPD)

Citation: Skinner, L. C.: Glacial-interglacial atmospheric CO_2 change: a possible "standing volume" effect on deep-ocean carbon sequestration, Clim. Past, 5, 537-550, 2009. Bibtex EndNote Reference Manager

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