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Impact of ocean ventilation on the ocean carbon pumps in 21st century climate change simulations

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Under increasing atmospheric CO2 concentrations the expected changes in the Earth's radiative balance will influence the ventilation of the deep and intermediate layers of the ocean with consequences for the ability of the ocean to absorb and store CO2. To a first degree of approximation the ocean's carbon uptake can be separated between solubility-driven and biologically-driven pumps. The impact of the changes in ocean ventilation on these two pumps is still unclear though a strong relationship between the evolution of atmospheric CO2 and the biological pump efficiency has been suggested. The objective of this study is to assess the different impact of ocean circulation changes on the two carbon pump components. To this end, we design a suite of model experiments to quantify the difference in the ocean carbon storage between a preindustrial steady state and an evolving state with atmospheric carbon concentrations rising according to historical (1880-2009) and projected (IPCC scenario) emissions. All experiments are carried out in CM2Mc, a coarse version of one of the leading ocean-atmosphere coupled climate models (the GFDL CM2) used in the IPCC Fourth Assessment report. Embedded in the physical model is the Biology-Light-Iron-Nutrients-Gas (BLING) ocean biogeochemical model with a set of novel biogeochemical tracers which allow the separation between biological and solubility contributions to the dissolved inorganic carbon (DIC). Our simulations allow us to quantify the changes in biological and solubility-driven ocean carbon storage as a consequence of the wind-driven increases in Circumpolar Deep Water (CDW) upwelling and changes in Southern Ocean and North Atlantic intermediate and mode waters formation.