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Ventilation controls of ocean heat and carbon uptake: similarities and differences in the response to carbon emissions

Anna Katavouta and Richard Williams
Department of Earth, Ocean and Ecological Sciences, University of Liverpool, Liverpool, UK (a.katavouta@liverpool.ac.uk)

Ocean ventilation provides the primary control of how the ocean takes up excess carbon and heat supplied to the earth system due to carbon emissions. Ventilation involves an atmospheric source supplying a tracer to the mixed layer, which is then physically transported into the thermocline and deep ocean by the ocean circulation. For this physical transfer of tracer, there are two characteristic timescales: (i) a fast adjustment controlled by the depth of the mixed layer and (ii) a slow adjustment controlled by the rate of mass transfer to the ocean interior. However, this physical transfer is modified for heat and carbon by climate feedbacks and carbonate chemistry respectively. Here, we use a conceptual 2-dimensional ocean model that is designed to address the ocean adjustment to carbon emissions on yearly to multi-centennial timescales. The model includes a source, an ocean mixed-layer and interior adjustments, and a feedback mechanism that includes a surface temperature feedback (such as from clouds) and the effects of carbonate chemistry; the model ignores any seasonality, biological processes and chemical weathering. Using this conceptual model, we reveal the similarities and differences in how ventilation controls the uptake of heat and carbon involving changes in how the fast and slow adjustments are controlled. In summary, despite the physical transfer of fluid being determined by ocean ventilation, the effects of climate feedbacks and carbonate chemistry lead to differences in the ocean thermal and carbon adjustments to an increase in atmospheric CO_2.