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A Study of Decadal Ocean Deoxygenation and Heat Uptake from a suite of OMIP Simulations

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Observational studies reveal substantial ocean deoxygenation and increased heat uptake in the past decades. These two properties are known to be tightly connected. The Earth System Models (ESMs) struggle to simulate the observed trends in oxygen inventory (O_2-Inv) and the tight global O_2-heat relationship. One possible reason is the role of decadal climate variability. The past decadal changes in oxygen inventory and tight global O_2-heat relationship cannot be fully explained by changes in solubility alone, indicating the important role of changes in ocean circulation and biology. Climate variability could modulate O_2-Inv and heat uptake on decadal timescales but the observed climate variability is not necessarily simulated in the ESMs historical simulations due to the fact that the models have their own internal climate variability, which vary in magnitude and phase, in the coupled climate system. Here we address the question how the observed decadal climate variability modulates O_2-Inv and heat uptake using a suite of OMIP simulations.

We will present results from the comparison of state-of-the-art ocean model simulations driven by the atmospheric reanalysis forcing. The main focus is to understand decadal changes in global and regional upper ocean O_2-Inv and OHC based on the results from four different model simulations (NorESM-OC, SMHI-NEMO-PISCES, CNRM-ESM2, and MPI-OM-HAMOCC), and observations. The model structural differences result in different physical and biogeochemical mean states, which lead to different decadal variability of O_2-Inv and OHC. The regional O_2-heat relationship among the models and observations would be presented to discern the biases in the simulated ocean circulations and biological processes. Our study will provide first indications of the importance of decadal climate variability on determining changes in O_2-Inv and OHC. Hence, it will also provide guidance on accuracy and uncertainty of future deoxygenation and warming projected in the ESMs. We aim on stimulating the discussion on near term strategy of how we analyze upcoming OMIP simulations within the context of climate variability and changes in ocean physics and biogeochemistry based on our multi-model analysis.