Evaluating ocean physical biogeochemical interactions in ESM large ensembles

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State-of-the-art Earth System Models (ESMs) disagree in the sign of dissolved oxygen changes in the tropical oceans under global warming. Unlike heat or carbon dioxide, atmospheric oxygen has a very weak anthropogenic trend, thus the long-term change of oceanic oxygen reflects ocean circulation and biochemical changes induced by the warming and stratification increase. These model disagreements imply fundamental differences in the sensitivity of physical and biogeochemical processes that impact not only oxygen cycling but also other important elements such as nitrogen, phosphorus and carbon with implications to ecosystem health. The growing collection of historical datasets is finally allowing the direct comparison of simulated and observed dissolved oxygen over the last several decades. On one hand, natural climate variability influences oxygen changes as recorded in historical datasets, and on the other a correct diagnosis of anthropogenic trends requires an understanding of background natural climate variability. ESM simulations offer a powerful tool to examine underlying mechanisms of observed biogeochemical changes. We examine the simulated physical and biogeochemical changes under the Representative Concentration Pathway (RCP) 8.5 scenario in two large ensembles of ESMs; 34 member CESM-LENS and 100 member MPI-GE, exhibiting significantly different patterns of ocean deoxygenation. The results are interpreted in terms of the relationship between the ocean oxygen inventory and the heat content, and linking the physical climate modes to the pattern of biogeochemical variability. Water mass displacement often results in positive relationship between oxygen and heat. In contrast ocean stratification and ventilation changes typically result in negative relationship. The representation of physical climate modes and atmospheric teleconnections are essential for reproducing the biogeochemical properties and their spatio-temporal patterns.

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