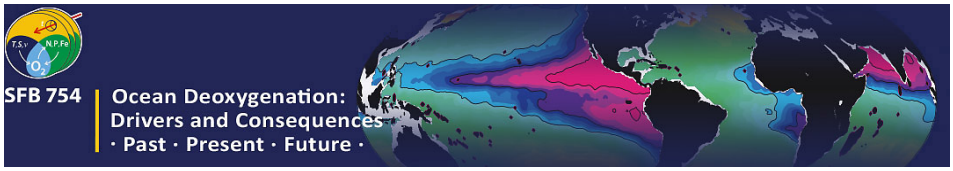

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Variability of dissolved oxygen over the last millennium and the 21st century in an Earth System Model.

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Oceanic dissolved oxygen has been observed to decrease over the past decades. Yet, the exact mechanisms leading to these changes and the relative role of natural and forced variability are not completely understood. Similarly, the time of emergence (ToE) of anthropogenic O2 trends from the "noise" caused by chaotic internal variability as well as naturally-forced variations, e.g., in response to volcanic eruptions and solar irradiance changes, awaits further investigations.
We analyze results from a simulation from 850 AD to 2100 forced by solar irradiance changes, explosive volcanic eruptions and anthropogenic greenhouse gases and of a corresponding control simulation performed with the NCAR-CESM climate model. Results from the preindustrial period are used to define the natural variability (internal and external forcing) of the climate system and to compute ToE for oxygen and temperature as well as for apparent oxygen utilization and the O2 solubility component. In contrast to earlier work on ToE, we consider both forced and internal variability of the pre-anthropogenic period as contributing to the background noise. We find that the global mean oxygen concentration in the ocean is decreasing under anthropogenic forcing and becomes smaller than the pre-industrial range as early as around 1900 AD. Focusing on the thermocline, where oxygen concentrations are particularly relevant for biological processes, the simulated oxygen decrease is detectable before the increase in ocean temperature in some regions such as the North Pacific and the Southern Ocean and as indicated by an earlier time of emergence of the anthropogenic signal of O2 than of temperature. Physical and biogeochemical processes, influence dissolved O2. The role of these processes, their magnitude and timescales of simulated responses in marine O2 will be discussed in the context of ToE of anthropogenic signals.

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