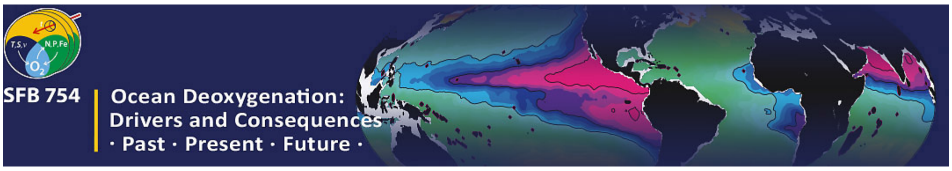

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Robust millennial-scale recovery of deep ocean ventilation and oxygenation with global warming?

Tuesday, 4 September 2018 15:00 (15)

Coupled climate model simulations consistently project for the 21st century reduced ventilation of the deep ocean and a loss of oxygen in response to global warming, yet the warming at the end of the last ice age – similar in amplitude to the warming projected for the end of the century – resulted in a better ventilated deep ocean. Here, we use multi-millennial global warming simulations with the comprehensive Earth system model GFDL ESM2M under a 1% yr-1 atmospheric CO2 increase to 2xCO2 and constant forcing thereafter scenario to show that this counterintuitive result may be a consequence of different rates of ocean warming. After full equilibration of the model with the doubling of atmospheric CO2, achieved after ~4000 years, the deep ocean is actually better ventilated and oxygenated, consistent with paleo-proxy records and intermediate complexity model simulations. We suggest that this millennial-scale ventilation recovery is initiated by the Atlantic Meridional Overturning Circulation, which rejuvenates after atmospheric CO2 has stabilized thereby enhancing the transport of salty waters originating from the subtropical Atlantic Ocean to the Southern Ocean. The upwelling of these anomalous salty waters in the Southern Ocean gradually erodes the freshwater cap (halocline) that usually prevents convection. After approximately 700 years, the onset of deep water formation in the Ross Sea mainly drives the acceleration of Antarctic Bottom water formation and the oxygenation of the deep ocean. The exact timing of the deep water formation onset in the Ross Sea is driven by stochastic processes. Atmosphere-ocean interactions, such as changes in Southern Hemisphere westerly winds and surface density fluxes can be excluded as potential main drivers of the deep ocean ventilation recovery. Such millennial-scale increase in Southern Ocean deep-water formation under global warming may increase the ocean inventory of preformed nutrients and ultimately decreases the carbon uptake capacity of the ocean. To test the robustness of our results, we also use multiple coupled Earth system model simulations that are integrated for more than thousand years and are part of the new model intercomparison project LongRunMIP.

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