Response of deep ocean circulation and dissolved oxygen to climate change on millennial time-scales

*Akitomo Yamamoto[1], Tomohiro Hajima[1], Manabu Abe[1], Tokuta Yokohata[2], Ayako Abe-Ouchi[3], Michio Kawamiya[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. National Institute for Environmental Studies, 3. Atmosphere and Ocean Research Institute, The University of Tokyo

It is well established that the ocean is currently losing dissolved oxygen (O_2) in response to ocean warming. CMIP5/6 models show that deoxygenation will continue through the end of the century. However, it is not understood quantitatively how much dissolved oxygen will eventually decrease. For example, could ocean anoxic events that occurred during past warm periods also be caused by anthropogenic climate change?
In this study, we conducted simulations until year 4000 AD using MIROC-ES2L, one of the CMIP6 earth system models. Under SSP585 scenario (maximum CO_2 concentration of about 2200 ppm), AMOC and AABW decreased to about 2 Sv and 4 Sv, respectively, by year 2300. This weakening continued until year 4000, with no recovery of AMOC or AABW as reported in previous multi-millennial simulations.
Globally averaged O_2 concentrations continued to decrease during the simulations, eventually decrease to less than half the current levels. This is a significant decrease compared to previous multi-millennial simulations in which oxygen recovered as AMOC or AABW recovered. The decrease in oxygen supply from the surface to the interior due to the weakening of the deep ocean circulation and the accumulation of oxygen consumption due to increased residence time reduced O_2 to less than one-third, especially in the deep ocean. The average concentration at depths below 2000 m is below 60 μmol/L, which is not habitable for fish and other organisms.
Our results suggest that anthropogenic climate change may cause shutdown of deep ocean circulation and large-scale ocean hypoxia on a 1000-year scale. It should be noted that our results are from a single model and could be model dependent. In the presentation, we will also compare our results of changes in deep ocean circulation with previous millennial simulations conducted with other models.

Keywords: Climate change, AMOC, AABW, Deoxygenation

