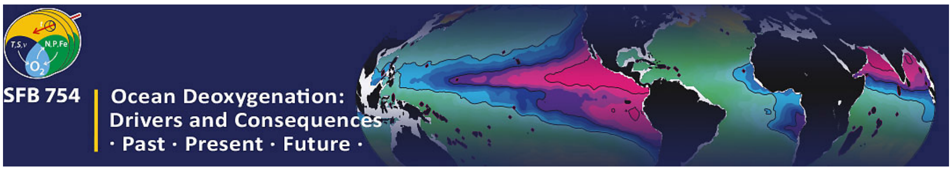

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Mechanisms of future equatorial upwelling change: CMIP5 inter-model analysis

Equatorial upwelling play an important role in oxygen via advection of oxygen and transport of nutrient to the euphotic zone used by biological production. Previous studies showed that climate models project the weakening of equatorial upwelling in the Pacific and Atlantic Oceans, and the main suggested responsible mechanisms are Ekman pumping near surface and equatorial undercurrent (EUC) change at depth. The latter may be associated with flattening of the zonal slope of EUC. Both changes are presumably caused by weakening of the trade wind. However, how much of upwelling reduction was not explained by each mechanism quantitatively. Therefore, in order to understand better the mechanisms of upwelling change, we analyze output data from 24 CMIP5 models in the equatorial Pacific and Atlantic until 2100 under RCP8.5.
In order to obtain better physical explanation, we divide total upwelling into isopycnal upwelling (vertical velocity component of current velocity parallel to isopycnal surfaces) and diapycnal upwelling (difference between total and isopycnal upwelling). The total upwelling decreases in the equatorial Pacific and western Atlantic about 50-200m depth until 2100. The maximum decrease in the Pacific (it is located in the eastern Pacific) is about 30% of its climatology, and it is three times larger than that in the Atlantic. Three-fourths of total upwelling reduction in the eastern equatorial Pacific at 100m depth, where there is a boundary of euphotic zone which is important for biological production, is explained by the isopycnal upwelling change. Further division indicate that 71% (47%) of isopycnal upwelling change there is caused by the zonal isopycnal gradient change (zonal velocity change). Thus, about a half of equatorial upwelling reduction in the eastern Pacific is induced by the EUC flattening. It is shown that weakening of trade wind can explain 95% of EUC flattening without enhanced stratification.
In the Atlantic, however, the mechanism is unclear because contributions of isopycnal and diapycnal upwelling differ among models and they are not statistically significant in contrast to the Pacific. Notes that zonal wind stress change and stratification are not independent in the Atlantic, whereas they are almost independent in the Pacific. It is thus possible that the mechanisms of upwelling change are different between Pacific and Atlantic.

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