

Observed long-term change and variability in the global upper-ocean stratification

*Ryohei Yamaguchi¹, Toshio Suga^{1,2}

1. Graduate School of Science, Tohoku University, 2. Japan Agency for Marine-Earth Science and Technology

With the progress of global warming, enhanced upper-ocean thermal stratification from the 1970s has been reported by IPCC AR5. Many studies on future climate projection using CMIP climate models also point out that upper-ocean stratification will strengthen in this century. The strengthened stratification will reduce vertical nutrient supply from the subsurface by further stabilizing the upper-ocean water column, and then the primary production of the whole ocean is concerned to decrease.

However, large uncertainties in the observational estimate of the long-term change in the upper-ocean stratification still remain. Strengthening trend of the upper-ocean thermal stratification due to the surface intensification of the warming signals has been detected from estimation using globally-averaged sea surface and subsurface temperature time series. On the other hand, some observational studies focusing on some specific regions or using relatively short time series demonstrate that the upper-ocean stratifications are weakening in recent decades, rather than strengthening associated with global warming.

We investigated globally the long-term change and variability in the upper-ocean stratification defined here as the difference between the surface and subsurface density. To resolve spatial patterns of the trends and superposed decadal variability, we used temperature and salinity observations with as spatial and temporal coverage as wide as possible from World Ocean Database 2013. As a result, strengthening trends of the upper-ocean stratification associated with global warming were detected over the global ocean, except for the Arctic Ocean. In the global average, the increase in density stratification corresponds to a 6.6–11.8% of the mean stratification from the 1960s. In addition to the well-documented cause, that is the surface intensified warming, the subsurface temperature changes and haline stratification changes also have significant impacts on the long-term changes in the upper-ocean stratification. The decadal/interannual variabilities in the upper-ocean stratification associated with each particular climate mode are also detected in some ocean regions: The density stratification is correlated with the Niño 3.4 index in the tropical Pacific, negatively lagged correlated with the North Atlantic Oscillation (NAO) index in the North Atlantic, and shows correspondences with SST variations associated with the Pacific Decadal Oscillation (PDO) in the North Pacific.