Analysis of future changes in ocean primary production using CMIP5 models

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Due to global warming, changing ocean environment such as stratification, acidification, and deoxygenation is expected to affect marine phytoplankton and its primary production. Multiple modeling studies show that global Net Primary Production (NPP) and Export Production (EP) will decrease in the future because stratification reduces supply of nutrient from the deep ocean (Fu et al., 2015). However, though EP decreases in all CMIP5 models, NPP does not change significantly in a few CMIP5 models, exceptionally (Bopp et al., 2013). The purpose of this study is to clarify the reason why responses of NPP to global warming significantly differ among models.

Because it is found that the tropical ocean mainly contributes to changes of global NPP and EP, we focus on this area. By analyzing NPP and EP simulated in 10 CMIP5 models, we found that the inter-model difference in response of NPP to global warming is attributed to combination of stratification and temperature dependence of remineralization. For a model that shows exceptional response of NPP (GFDL-ESM2G), we suggest the possibility that the temperature-dependent parameter of remineralization is overestimated in this model; global warming promotes remineralization, which tends to increase NPP in spite of decreasing EP. As a further analysis, we investigate response of NPP to El Nino by regressing Nino.3 SST index to NPP. We found that the satellite-based estimate and the other CMIP5 models show decrease of NPP during El Nino, whereas GFDL-ESM2G shows increase of NPP. This result implies that evaluation of models by investigating response of NPP against natural variability such as ENSO is useful for improving the future prediction.

As a next study, we plan to perform sensitivity experiment by using the marine ecosystem models in order to evaluate how ocean primary production affect the changes of carbon cycle in global warming climate.

Keywords: Primary Production, Export Production, CMIP5, global warming

