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Impact assessment of the Seto-Inland Sea Water Profile Based on CMIP5 Model Ensemble

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1.Introduction

This study uses the Regional Ocean Modeling System (ROMS) to project environmental changes of the Seto-Inland Sea in Japan based on the Coupled Model Intercomparison Project Phase 5 (CMIP5) ensemble. The IPCC-AR5 WGI (referred to as AR5) was published in September 2013 and made great progress in impact assessment for future climate changes. Uncertainty of these future projections can mostly be attributed to either greenhouse gas emission scenarios or the precision of the projection model (e.g. GCM). Emission scenarios such as Representative Concentration Pathways (RCP) have been considered and the uncertainty in the model is assessed by the model ensemble mean, which assumes that results are scattered around the true value (IPCC, 2013). Although there are many impact assessments on global or large scale changes in the coastal ocean environment, there are few studies on smaller scale changes, for example in Japan. Further, examination of local scale change has not been consistently discussed in the AR5 large scale impact assessment.

This study analyzed CMIP5 for near-sea surface global and local ocean areas. It also examined the projection of physical environmental changes of the Seto-Inland Sea in Japan by numerical downscaling with CMIP5 forcing.

2.Analysis of CMIP5

CMIP5 was analyzed for present climate named historical, future climate named RCP 4.5W/m^2 scenario (RCP4.5) and RCP8.5. It focused on ten ocean areas, including global areas and locations in east Japan (E125 degrees-E136 dgrees, N27 degrees-N35 degrees). The objective variables of CMIP5 are atmospheric temperature, cloud fraction, humidity, wind speed, sea level pressure, shortwave radiation and longwave radiation, which were analyzed by a 61 GCMs ensemble. Spatial distribution of sea surface temperature (SST) showed a consistent increase overall, with local non-homogeneity; for example, analysis projects an increase greater than 4 degrees increase in the northwest Pacific. The monthly mean of SST in west Japan was projected to change with a maximum increase of 3.5 degrees in June and 2.8 degrees in January. The projected increase is higher than that of the global annual mean. While a constant cloud fraction is projected on the global scale, the model projects a decrease in cloud fraction in west Japan.

3.Future Change of Water Profile in the Seto-Inland Sea

This study calculated the long-term analysis as 2093 using ROMS as downscaling model with forcing variables from CMIP5 results to project future environmental changes in west Japan's Seto-Inland Sea. The projection results in present climate condition were compared with observed results (Tanaka et al., 2013) similarly calculated in 2004. Topography data was taken from Japan GSI, with 1km resolution. Lateral boundary conditions were obtained from FRA-JCOPE. The atmospheric conditions were implemented using hourly results of CMIP5 analysis for temperature, SLP, short wave radiation, cloud fraction and wind speed. In the summer, the SST shows a remarkable increase of about 1.6 degrees. An increase of the same kind of water profile was projected in both shallow and deep areas of Hiuchinada and Kitan straits. A difference between the areas is increasing trend near the sea surface. Remarkable warming near sea surface in Hiuchinada contrasts with constant warming over all layers in Kitan straits.

4.Conclusions

CMIP5 analysis projected a decrease in cloud fraction in the western part of Japan despite projecting a constant cloud fraction on the global scale. Furthermore, although results project an increase in short wave radiation in west Japan. They project a global average decrease.

Using ROMS with forcing from CMIP5 analysis projected an SST increase of 1.6 degrees in the summer. Finally, the water profile tends to remarkably increase in shallow water, such as in Hiuchinada.

Keywords: the Seto-Inland Sea, water profile, ROMS, CMIP5, cloud fraction, short wave radiation