Role of tidal mixing on biogeochemical cycling in the northwestern North Pacific

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The northwestern North Pacific is one of the regions with the highest net primary production and the largest seasonal variation in pCO_2 due to carbon uptake by marine phytoplankton. The northwestern North Pacific is adjacent to marginal seas such as the Sea of Okhotsk and the Bering Sea, where strong vertical mixing is caused by breaking internal waves generated by tidal currents and rough submarine topography. It is speculated that the vertical mixing in the straits drives the large pCO_2 variation in the northwestern North Pacific by pumping up nutrients abundant below the surface water, but the quantitative relationship between the tidal mixing and pCO_2 variation is still unclear.

In this study, a marine ecosystem-biogeochemical cycle model was developed targeting on the northwestern North Pacific to investigate the effects of tidal mixing on the primary production in the northwestern North Pacific. ROMS (Regional Ocean Modeling System) was used for the ocean model, and BEC (Biogeochemical Elemental Cycling) model was used for the ecosystem-biogeochemical cycle model. The resolution of the physical model was set to 1/12° to realistically reproduce the marine physical characteristics of the northwestern North Pacific: the subtropical and subarctic circulations, the Kuroshio-Oyashio confluence zone and the formation of the North Pacific Intermediate Water. The BEC model incorporates the five nutrient cycling (nitrate, ammonia, phosphate, silicate, iron) and carbonate system geochemistry, and can simulate the dynamics of large and small phytoplankton. The vertical mixing due to tide was calculated by converting the energy conversion rates calculated by a tide model into vertical diffusion coefficients by a parameterization.

The results of the cases where the vertical mixing due to tide was not considered (Tmix OFF) and considered (Tmix ON) showed a clear difference in the concentrations of phytoplankton biomass in the northwestern North Pacific (Figure: monthly mean phytoplankton biomass concentrations on April, units are in mmolC/m^3, the while line represents 10 mmolC/m^3 and colors above it are filled in log scale). The increase in phytoplankton biomass was remarkable in the straits, suggesting that vertical mixing due to tides increased the net primary production locally by pumping nutrients up. In addition, the increase in the biomass was also observed periphery of the straits and the Kuroshio-Oyashio confluence zone. The increase in the periphery of the straits is likely attributed to horizontal transport of biomass and/or nutrients by eddies, while the increase in the confluence zone is likely because tidal mixing changed a large-scale vertical structure of nutrient, which increased nutrient entrainment by the surface boundary layer mixing.

Keywords: Diapycnal mixing, Net primary productivity, Nutrients, Iron

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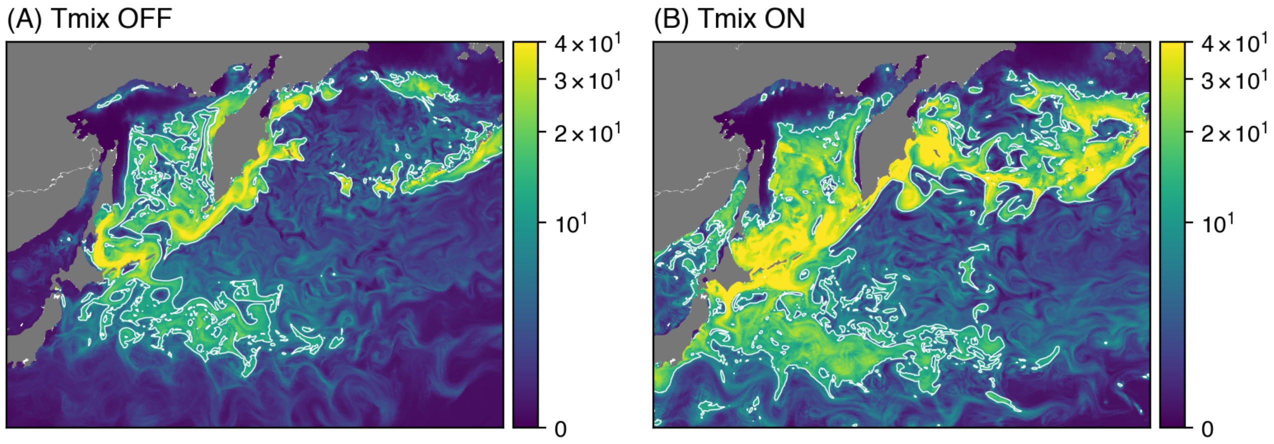

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