

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

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1. Introduction

Strong vertical mixing around straits and islands with rough topography is caused by the breaking of internal waves generated by tidal currents. Recent accumulation of observational data suggests that the strong vertical mixing around supports high primary production in the subarctic North Pacific by supplying nutrients to the surface layer (Nishioka et al., 2020). In this study, we used a numerical model to investigate the effects of tidal vertical mixing on primary production and nutrient cycling in the North Pacific by conducting experiments with and without tidal vertical mixing.

2. Method

We used ROMS (Regional Ocean Modeling System; Shchepetkin and McWilliams (2005)) coupled with the BEC (Biogeochemical Elemental Cycling) model (Moore et al., 2013). The simulation domain was the entire North Pacific Ocean (15°S-65°N, 110°E-75°W). The horizontal resolution of the model was 1/12° in the northwestern part of the North Pacific and it was gradually coarsened to 1/4° towards the outside. To represent vertical mixing due to tides, a vertical mixing parameterization (Oka & Niwa, 2013) and the conversion rate of baroclinic tide energy calculated by a tidal model (Niwa & Hibiya, 2014) were used. To prepare the model initial condition, we calculated ROMS (w/o coupling BEC) for 40 years from an observation-based dataset. The initial condition for the biogeochemical variables were obtained from a coarse resolution ROMS-BEC simulation (Misumi et al., 2021). We conducted simulations with and without tidal mixing (ON and OFF cases respectively) for 30 years and results of the last 5 years were analyzed.

3. Results and Discussions

In the ON case, the simulated primary production in the North Pacific increased by 36% (5.5 PgC/yr) compared to the OFF case. The increase was mainly observed around the straits and islands, where the tidal energy conversion rate is high. Modest increases in the production were also observed where tidal mixing is not strong in the ON case. This is because vertical mixing by the tide enhanced local basic production by pumping up nutrients and iron in the deeper layers, and unused nutrients and iron are transported horizontally in the surface layer. This horizontal transport likely enables to form nutrient- and iron-rich water masses during winter, which supports large blooms during spring.

Keywords: Ocean Model, Nutrients, Iron