

Numerical simulation of silicate supply process to thermocline in the North Pacific

*Kazuhiro Misumi¹, Jun Nishioka², Tsubono Takaki¹, Daisuke Tsumune¹

1. Sustainable System Research Laboratory, Central Research Institute of Electric Power Industry, 2. Institute of Low Temperature Science, Hokkaido University

1. Introduction

The North Pacific is known to be a unique oceanic region where the silicate concentrations are higher than the nitrate concentrations in the thermocline. The richness of silicate is represented by Si^* (Sarmiento et al., 2004) that is defined as $Si^* = Si(OH)_4 - NO_3$, and, in the thermocline, the Si^* values are positive in the North Pacific while they are negative in the other oceanic regions. In the deep water below the thermocline of the Pacific, the Si^* values exceed $100 \mu\text{mol/L}$. This is because the longer dissolution length scale of silicon than mineralization length scale of nitrogen elevates the Si^* values during water flowing in the deep Pacific. Sarmiento et al. (2004) hypothesized that the positive Si^* in the Pacific thermocline is mainly formed by vertical Si transport from the deep water by locally enhanced vertical-mixing caused by interaction of tidal flow and rough bathymetry. In this study, to test this hypothesis, we used an ocean model coupled with marine biogeochemical cycle model and conducted experiments with tidal vertical mixing turned on and off.

2. Numerical model

We used the ROMS (Regional Ocean Modeling System) model coupled with the BEC (Biogeochemical Elemental Cycling) model simulating marine biogeochemical cycles (Misumi et al., 2021). The computational domain was the entire North Pacific, with a resolution of $1/12^\circ$ for the northwestern part around Japan and a resolution of $1/4^\circ$ for the outer part. To represent tidal vertical mixing, we used a parameterization of the near-field mixing (Oka and Niwa, 2013) with conversion rates of baroclinic tide energy calculated by a tide model (Niwa and Hibiya, 2014). We conducted a case with tidal vertical mixing (ON) and a case without it (OFF). Each simulation was conducted for 60 years, and the results for the last 10 years were compared.

3. Results and discussion

Silicate concentrations in the thermocline were simulated better in the ON case than in the OFF case. However, Si^* in the thermocline was positive in both the cases and the difference was small. Comparison of the silicate tendency caused by vertical mixing showed that silicate was mainly supplied to the thermocline by background vertical mixing and the tidal vertical mixing only has secondary effect. Because the dissolution length scale of silicon is longer than the mineralization length scale of nitrogen, the vertical gradient of silicate concentration reaching below the thermohaline, which makes silicate to be supplied from deeper water more efficiently than nitrate.

Keywords: Nutrients, North Pacific, Tidal mixing