Influence of enhanced deep circulation due to geothermal heat on biogeochemical cycle in the Pacific Ocean

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There exists heat conduction from the oceanic lithosphere to the abyssal ocean. Its heat flux amounts to about 0.1 W m^{-2} in the global average. It is much smaller than the heat exchange between the atmosphere and ocean in the order of 10 W m^{-2}. However, it is known that this geothermal heat significantly enhances the deep circulation especially in the Pacific Ocean. For example, Adcroft et al. (2001) conduct numerical experiments with/without geothermal heating using an ocean general circulation model and report that constant heat flux at the sea bottom by 0.05 W m^{-2} results in enhancement of the Pacific meridional overturning circulation (PMOC) by 25 %. Other studies also report that the geothermal heat significantly enhances the oceanic deep circulation (e.g., Emile-Geay and Madec, 2009; Urakawa and Hasumi, 2009; Downes et al., 2016). The importance of the geothermal heat seems to be robust from the viewpoint of ocean dynamics but it has not been investigated to what extent the geothermal heat influences the biogeochemical cycle of the ocean. Here, we conduct two numerical experiments with/without the geothermal heat using an ocean general circulation model developed for the CMIP6 and investigate the effect of the geothermal heat on the biogeochemical tracer fields.
The geothermal heating enhances PMOC at 30º S by 17 % in this model, which leads to stronger ventilation in the North Pacific Ocean. This stronger ventilation results in increase of delta ^{14}C by more than 10 per mille, which means younger water masses, at the bottom of the North Pacific. The stronger PMOC also results in higher dissolved oxygen in the abyss especially in the eastern tropical Pacific. The geothermal heat leads to dissolved oxygen increase by more than 10 micro mol L^{-1} there, which corresponds to 10–70 % of hypoxic water in the control experiment without geothermal heating. This oxygenation near the sea bottom affects the oxygen-deficient water in the surface of the eastern tropical Pacific. Its thickness becomes thinner by around 100 m. The geothermal heat also plays an important role in the biogeochemical cycle in the Pacific Ocean.

