温暖化に対する海洋炭素循環の応答の再検討
Revisiting response of oceanic carbon cycle to global warming

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Climate warming tends to reduce oceanic uptake of CO_2 from the atmosphere thereby accelerating the rate of CO_2 accumulation in the atmosphere and global warming. Most previous studies have shown that the physical effects, decrease in CO_2 solubility and increased stratification, are major contributors to this reduction in oceanic CO_2 uptake [Sarmiento et al., 1998; Plattner et al., 2001]. In those previous studies, changes in the biological pump associated with ocean circulation change were regarded as a second-order process even though biological effects on the natural carbon cycle can be very important. However, the contributions of both physical and biological effects to the reduction in oceanic CO_2 uptake are not evaluated directly in the recent generation of coupled atmosphere–ocean general circulation models (AOGCMs) and ocean biogeochemical models. To address this we reevaluate the individual mechanisms contributing to the reduction in oceanic CO_2 uptake using a series of multi-centennial global warming simulation conducted with AOGCM and an offline ocean biogeochemical model. The uptake reduction of 13% due to global warming at 140 years is consistent with the same simulation using models in the CMIP5 [Arora et al., 2013]. Sensitivity studies show that changes in the biological pump and gas solubility are the dominant processes for this reduction in oceanic carbon uptake, which is opposite to most of the previous studies: changes in ocean circulation and solubility are the dominant processes. Decrease in new production caused by lower nutrient supply and enhanced remineralization from seawater warming increase dissolved inorganic carbon at the surface, thereby substantially preventing oceanic CO_2 uptake. The weaker Atlantic meridional overturning circulation reduces oceanic CO_2 uptake, while weaker equatorial upwelling and increased mixing due to enhanced westerly winds in the Southern Hemisphere enhance CO_2 uptake. As these effects cancel each other out, the effect of circulation change becomes a second–order process. Our results demonstrate that the biological pump plays a significant role in not only natural carbon cycle but also anthropogenic carbon cycle.

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