【Grant-in-Aid for Specially Promoted Research】

Response of biogeochemical cycle and lower trophic ecosystem to the environmental change in the Southern Ocean, East Antarctica

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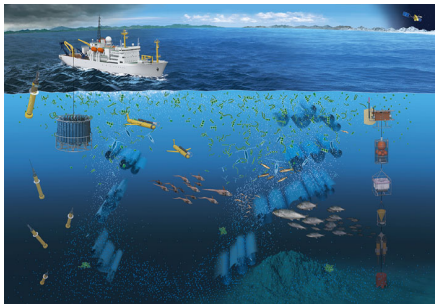
Project Information	Project Number : 23H05411　　Project Period (FY) : 2023-2027 Keywords : Southern Ocean, Marine Production, Eddy, Timeseries observation

Purpose and Background of the Research

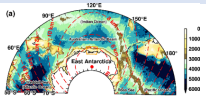
●Outline of the Research

The Southern Ocean in East Antarctica is a blank area for in-situ data, and the response of marine ecosystems to global warming is not well understood. Therefore, we will elucidate the processes linking the physical environment (e.g., water temperature), biogeochemical cycles (e.g., nutrients), and primary production responses. The future of the Southern Ocean marine ecosystem will also be predicted according to CO2 emission scenarios.

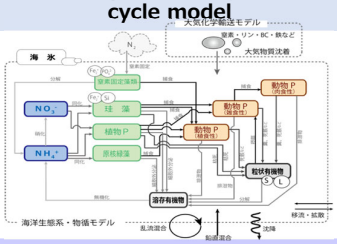
hypotheses inferred from observational data



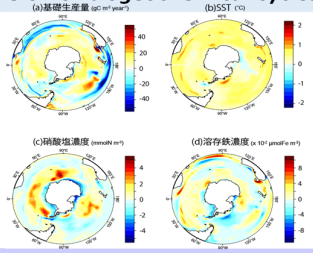
High resolution physical model



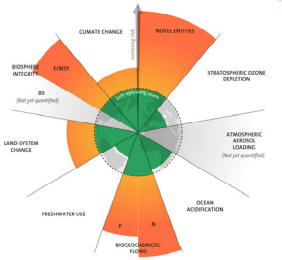
Marine ecosystem – biogeochemical cycle model



Marine ecosystems according to CO2 emission scenarios - a future vision of biogeochemical cycles



Southern Ocean version of "Planetary boundary"



Modify from Persson et al., 2022 Environ. Sci. Etchnol., doi:10.1021/acs.est.1c04158; Steffen et al., 2015, Science, doi:10.1126/science.1259855

Figure 1. Fig. 1 Upper left: Understanding the current situation from observation data; Upper right: Building an integrated model of sea-ice, ocean physics, biogeochemical cycle and marine ecosystem; Lower left: Future vision of biological production, etc.; Lower right: The Planetary boundary. The Southern Ocean version of planetary boundary will be created.

●Scientific Background "Why the Southern Ocean"?

The Southern Ocean is famous as a high nutrient and low chlorophyll (HNLC) area with abundant fisheries resources. In East Antarctica, where the Showa Station is located, the influence of global warming was not considered to be in progress, but recently, Japanese observations have revealed that the melting is in progress, especially in the Totten ice sheet. The melting of the Antarctic ice sheet is thought to have a significant impact on the surrounding physical environment, biogeochemical cycles, and marine ecosystems by supplying large amounts of fresh water, but the links between the three are still unknown at all.

● Two questions

Q1: What are the characteristics of the Southern Ocean in East Antarctica as an HNLC region? What hypotheses can we make about the mechanisms linking the physical-chemical-biological processes?

Q2: To what extent do the model simulation outputs describe the hypotheses linking the physical-chemical-biological processes provided by the observations? Furthermore, how is the lower-trophic level marine ecosystem in the Southern likely to change in the future?

Expected Research Achievements

●**Q1:** The driving force of the transport of sea-ice, water masses, and materials in the study area is stationary mesoscale eddies (approximately 100 km in diameter, Figs.2 and 3). In the eddy, a time-series mooring system (Fig.4) equipped with water temperature (T), salinity (S), and event-based vision (EVS) sensors, current profiler, and sediment trap will be deployed. Biogeochemical (BGC) floats equipped with T, S, DO, pH, nitrate, and Chl.*a* sensors (Fig.5) will also be strategically deployed around the mooring system. Using the integrate physical, chemical, and biological observation data from the mooring system and the BGC floats, we will understand the physical and chemical environments and biological production, capturing seasonal features and will also suggest hypotheses for missing links of physical-chemical-biological processes.

● **Q2:** We will develop an integrated physical-material cycle-biological model by linking an Earth system model with high temporal and spatial resolution. This model will be run to describe the relationship between the physical and chemical environment and the response of lower-trophic level ecosystems in the Southern Ocean.

● **Integration of Q1 and Q2:** We will present a future vision of the marine ecosystem-biogeochemical cycle according to CO_2 emission scenarios.

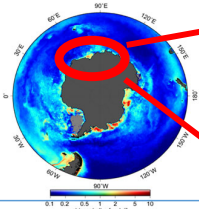


Fig.2 Chl.*a* concentration in 2002-2017 and this study area (red circle).

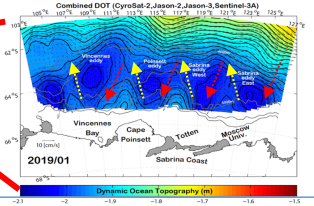


Fig.3 Enlarged location map of this study. Red and yellow direction allows are directions of lateral transportation of water mass and materials.

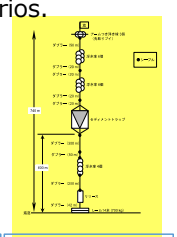


Fig.4 Time-series mooring system with sediment trap.

Fig.5 BGC float (from surface to 500m).

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