【Grant-in-Aid for Scientific Research (S)】

Development of parameterization techniques for next-generation Southern Ocean oceanographic observations

Principal Investigator	Hokkaido University, Faculty of Environmental Earth Science, Associate Professor WATANABE Yutaka Researcher Number:90333640
Project Information	Project Number : 22H05003 Project Period (FY) : 2022-2026 Keywords : Southern Ocean, parameterization, Changes in ocean dynamics

Purpose and Background of the Research

Background The Antarctic deep water, which accounts for as much as 40% of all seawater, is a huge reservoir of heat and material that largely controls global climate and marine ecosystem variability. Therefore, estimating the variability of this biological production in the Southern Ocean is one of the most important research topics in understanding global climate change. However, the spatiotemporal scarcity of observation data due to the severe weather and oceanographic conditions in the Southern Ocean has caused great uncertainty in the study of the ecosystem and material cycle in the region. Even with the recent development of satellite observations and automated ocean observation robots (ocean floats), a seamless observation data set in spatiotemporal direction has not been established for the above researches.

Global warming is currently weakening the ocean circulation by reducing seawater density and causing the melting of ice sheets to produce fresh water. As a result, nutrients brought to the ocean surface from the deep sea will decrease, and phytoplankton is feared to decrease dramatically. In order to clarify the actual situation, it is necessary to obtain spatiotemporal high-resolution data and to comprehensively clarify the ocean circulation and the ice sheet melting.

However, the key factors that determine the Earth's climate, such as "How is ice sheet melting in the Southern Ocean currently progressing? What are the spatiotemporal impacts of ice sheet melting on marine ecosystems and material cycles? How do ice sheet melting and ocean ecosystems and material cycles contribute to global warming? These questions are not well understood at all. This is one of the major bottlenecks in climate change prediction.

Purpose To overcome these problems, this research aims to deeply understand ice sheet melting in the Southern Ocean through novel parameterization techniques, ideas, and observations, and to open the door to this elucidation by pioneering the world's first comprehensive clarification of the actual conditions of the interaction between the ice sheet melting and the ocean ecosystem and material cycles (Figure 1).

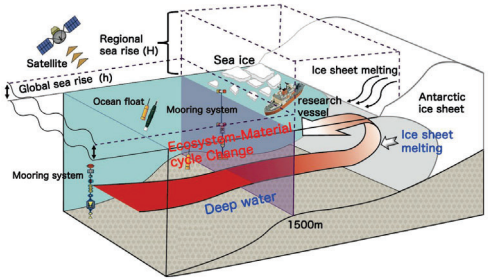


Figure 1. Interaction among deep ocean, ice sheet melting, ocean ecosystem in the Southern Ocean

Research Methods To achieve the goals of this research, the following four research items will be addressed (Figure 2).

(1) Develop parameterizations of carbonates and nutrients that can be applied to the entire Southern Ocean, using data other than oceanic carbonates and nutrients (water temperature, salinity, oxygen, and pressure) (Figure 3).

(2) Develop a new method for estimating the amount of ice sheet melting in the Southern Ocean based on changes in carbonates.

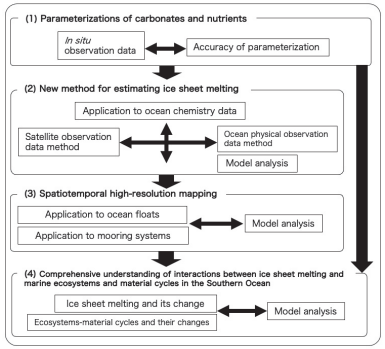


Figure 2. Outline of this research

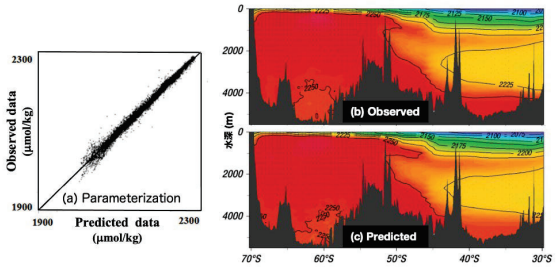


Figure 3. Comparison between parameterization estimates and observed data: e.g., Carbonate

(3) Apply a new estimation method of ice sheet melting amount by carbonates to ocean floats, and conduct real-time spatiotemporal high-resolution mapping of ice sheet melting amount in the Southern Ocean in cooperation with model studies to elucidate the actual state of ice sheet melting in the Southern Ocean in detail.

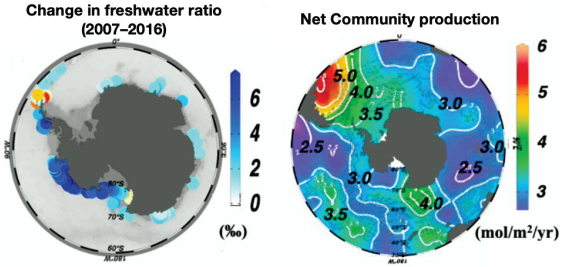
(4) Apply nutrient parameterization to data from ocean floats to construct a spatiotemporal high-resolution image of the ocean ecosystem-material cycles and clarify its variability, aiming to comprehensively elucidate the interaction between ice sheet melting and ocean ecosystem-material cycles in the Southern Ocean.

Expected Research Achievements

Scientific Significance This research is the world's first attempt to gain a concrete and quantitative understanding of the actual state of Antarctic ice sheet melting, which is the bottleneck in climate change projections, and to explore the details of the interaction between Antarctic ice sheet melting and ecosystem and material cycles in the Southern Ocean (Figure 4: preliminary results).

The results will lead to a breakthrough in the study of climate change in the entire ocean and its associated changes in material cycles, as well as future projections. This application is not simply a participation in a project led by the U.S. and Europe, but is a unique and world-leading oceanographic research project originating in Japan to get to the core of the actual interactions between ice sheet melting and desalination and marine ecosystem-material cycles, which is an important factor in determining the global climate. How is ice sheet melting progressing in the Southern Ocean?, "What is the actual impact of ice sheet melting on marine ecosystems and material cycles? and How do ice sheet melting and ocean ecosystems and material cycles contribute to global warming? ; This research approaches the biggest global environmental problem that no one has been able to answer so far.

Figure 4. Are ice sheet melting and marine ecosystem material cycles linked? (Preliminary results)



Homepage Address	https://kakens-sopara.jimdofree.com