【Grant-in-Aid for Transformative Research Areas（A）】

Habitable Japan: Sustainability of atmospheric and oceanic environment as a survival basis of island country Japan

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Project Information	Project Number : 24A203　　Project Period (FY) : 2024-2028 Keywords : Integrated atmosphere and ocean science, global warming, areas around Japan, understanding and prediction, basic processes

Purpose and Background of the Research

●Outline of the Research

Extreme heat in Japan in summer 2023 is still fresh in our memory. It was caused by global warming, meandering westerlies, and unusually high seawater temperature. Since 1 year ago, marine heat waves have existed over the Pacific Ocean off Tohoku with a temperature 5-6ºC higher than the average year, due mainly to the northward shift of the Kuroshio Extension. On the other hand, the Oyashio, which brings colder water from the north, has retreated greatly to the north since mid-2010s. The Japan Sea was also anomalously warm in summer 2023, while the Kuroshio south of Japan has took a large-meander path since 2017 for the longest period observed. Together with ocean warming with a speed 2 times faster than the global average, ocean currents around Japan have begun to show totally different aspects, affecting not only weather but also fisheries. In recent years, the catch of Pacific saury and squid has been dropping drastically, while yellowtail has expanded its habitat greatly northward.

The area around Japan is characterized by the world's largest ocean heat release to the atmosphere in winter and recognized as a "climatic hotspot" representative of the western boundary regions of the world oceans. At the same time, the area is unique due to the existence of the Japan Sea between Japan and the continent. Through the previous Climatic Hotspot 1&2 projects (2010-14, 19-23) supported by MEXT Grant-in-Aid for Scientific Research on Innovative Areas, we have investigated mid-latitude air-sea interaction and its change under global warming. In Habitable Japan project, we will expand our domain to atmosphere/ocean (A/O) chemistry, marine ecosystems, and fisheries, aiming to answer the question "Will mild climate and water/fisheries resources as a survival basis for us living in Japan persist in the future?"

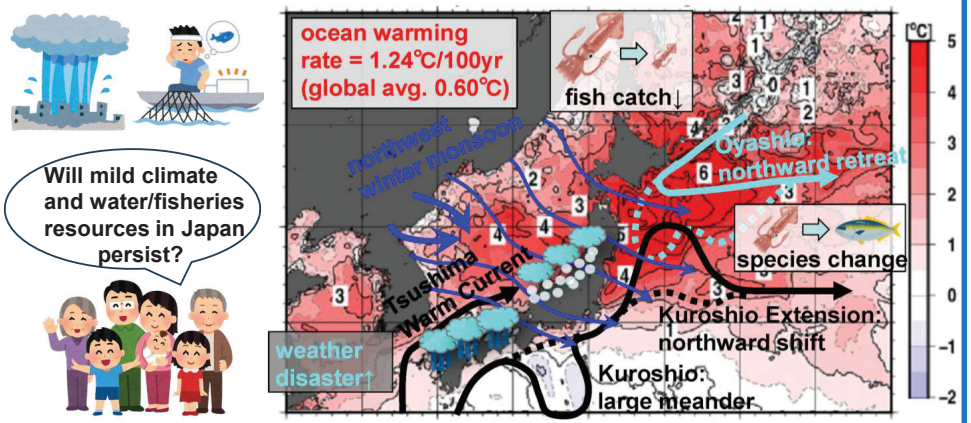

Figure 1. Atmospheric and oceanic changes in recent years around Japan. The background shows sea surface temperature on August 23, 2023 (Anomalies from the average year. Unit: ºC. JMA).

●Observation and numerical simulation

These are the two wheels of our Habitable Japan project. The observations include intense shipboard surveys in the Japan Sea and Pacific off Tohoku and in the East China Sea southwest of Kyushu, deployment of autonomous profiling floats with biogeochemical sensors around the Kuroshio Extension, and monitoring of aerosol particles at 2 islands in the Japan Sea and Pacific. We will also diagnose and predict A/O phenomena by multiply using numerical models with different spatiotemporal scales and parameters, from regional models to global ones.

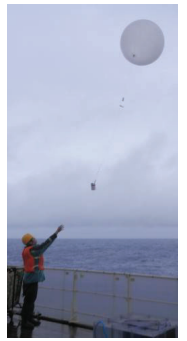

Figure 2. Release of radiosonde

Figure 3. Profiling float for ocean observation

Expected Research Achievements

●Understanding of mid-latitude A/O variability under global warming

We clarify variations/changes of ocean currents around Japan and their impact on coastal marine heat waves and marine ecosystems. We also conduct intensive shipboard surveys to explore the influence of oceanic fronts and coastal marine heat waves on heavy rain/snow fall, and clarify the mechanism of A-O heat and cold waves over the East Asia and North Pacific.

●Development of new methods and identification of basic processes

We clarify biological production/decomposition processes at the ocean surface by float observations and the influence of aerosol particles generated from wave spray on A-O heat and material exchanges by monitoring on islands. We also create a new data assimilation method that allows us to incorporate observation data into models smoothly to reproduce A-O-marine ecosystems coupling processes in the models.

●Prediction and sustainability evaluation of mid-latitude A/O variability

We evaluate predictability of events such as the Kuroshio large meander and marine heat waves, and clarify their impacts on marine ecosystems including fisheries. We also assault prediction of monsoon modulating under global warming and extreme weather inherent in monsoon. We further clarify climate variability and future changes in mid-latitudes from a global perspective.

●Creation of integrated A-O Science

Through the above research across atmosphere, ocean, and fisheries by using in-situ observations and state-of-the-art models, we build a foundation for future predictions and projections.

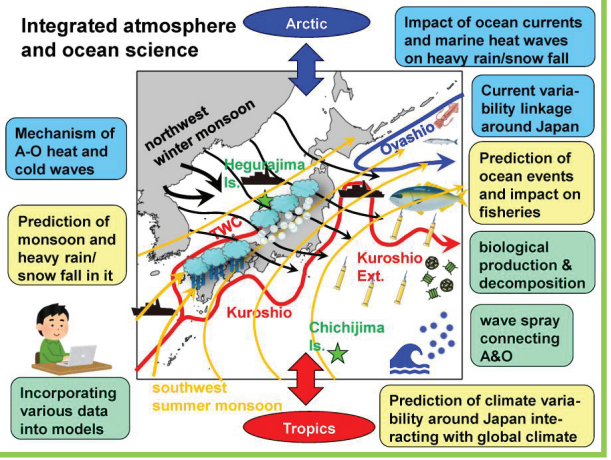

Figure 4. Our research targets

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