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

Evaluation of climate change and carbon/oxygen cycles based on innovative observations of atmospheric constituents

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Purpose and Background of the Research

●Outline of the Research

Many studies have been conducted to elucidate mechanisms and effects of global warming. For example, ocean heat content (OHC) change has been estimated based on ocean temperature measurements (Argo project), and changes in land and marine biospheric activities have been estimated from in-situ and/or satellite observations. However, there are some issues in the estimated values such as a lack of data at a depth > 2,000 m, spatial restriction of forest observation, and cloud contamination in the satellite data. Therefore, independent validations of the estimations are important task. For this purpose, we propose methods to evaluate changes in ocean heat content, atmospheric circulation, and carbon/oxygen cycles based on innovative wide-area observations of atmospheric constituents; O_2/N_2, Ar/N_2 and their $\delta^{18}O$, $\delta^{15}N$ and $\delta^{40}Ar$, concentrations of CO_2 and COS and its $\delta^{34}S$ (Figure 1). By using the observed multi species, we carry out analyses schematically illustrated in Figure 2.

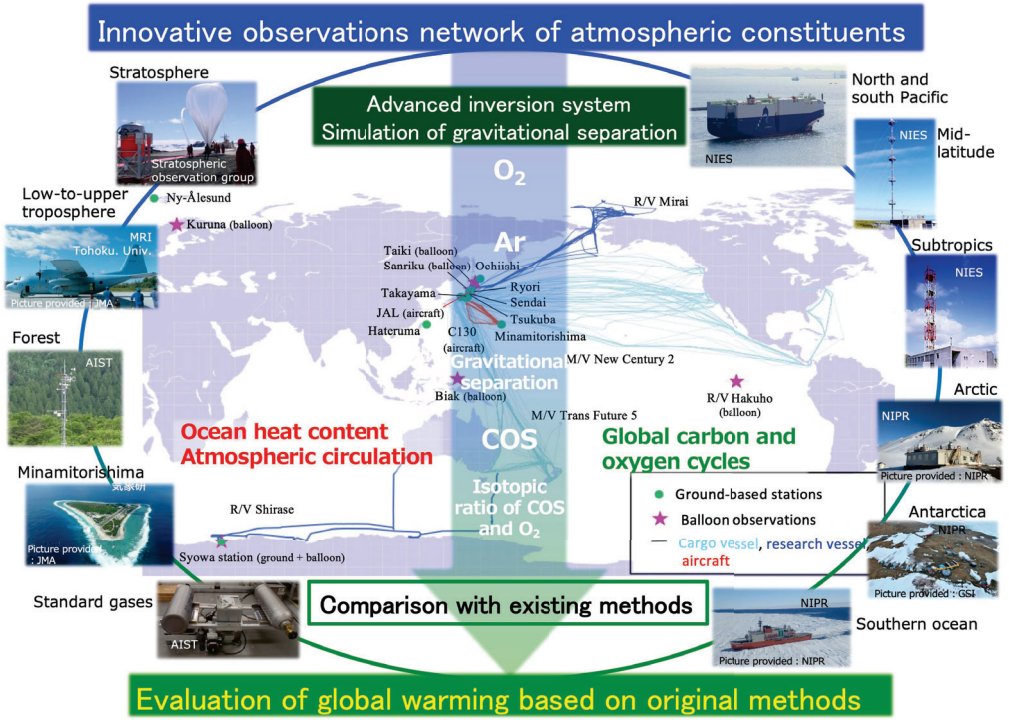

Figure 1. Overview of the research.

O_2/N_2 and Ar/N_2 have information about global CO_2 cycle and air-sea heat flux, respectively, but their variations are quite small. Especially, to derive annual change in surface Ar/N_2 in sub-per meg (10^{-7}), an effect of stratospheric gravitational separation (GS) should also be considered. COS and $\delta^{18}O$ of O_2 have information about photosynthesis and respiration, however, development of stable standard is needed for COS and $\delta^{18}O$ change in the present atmosphere has never been detected. In this regard, all Japanese institutes capable of measuring O_2/N_2, Ar/N_2, GS and COS and its $\delta^{34}S$, and National Metrology Institute participate in this research project. Moreover, modelers capable of carrying out advanced inversion analyses and simulation of gravitational separation also join us. Therefore, we are going to promote this project.

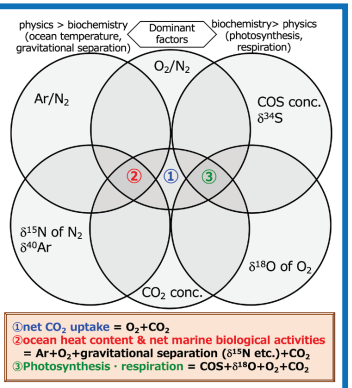

Figure 2. Image of the combined analyses using multi species

Expected Research Achievements

We construct an observation network from both polar regions to north-south Pacific at the surface, and from the surface to middle stratosphere, by integrating the observation networks of respective institutes. We observe O_2/N_2 at all sites and establish its common standard scale among the institutes. We actualize ship-based observation of Ar/N_2 and COS in the north-south Pacific, to evaluate air-sea heat flux and oceanic/anthropogenic sources of COS. For the stratospheric observation, we analyze not only the air sample collected using an improved cryogenic air sampler but also the archived air samples to clarify past 35 years variations in GS. We also try to detect changes in $\delta^{18}O$ of O_2 for diurnal cycle to secular change. To achieve these observations, we introduce new mass spectrometers for atmospheric major components and COS isotopes and a laser absorption spectroscopy for COS concentration. From the observed data and an advanced inversion system, it is expected we obtain information about global average and spatiotemporal variation in the air-sea O_2 and heat exchange (or OHC change), net marine biological activities, and land photosynthesis and respiration. An example of the analyses is shown in Figure 3.

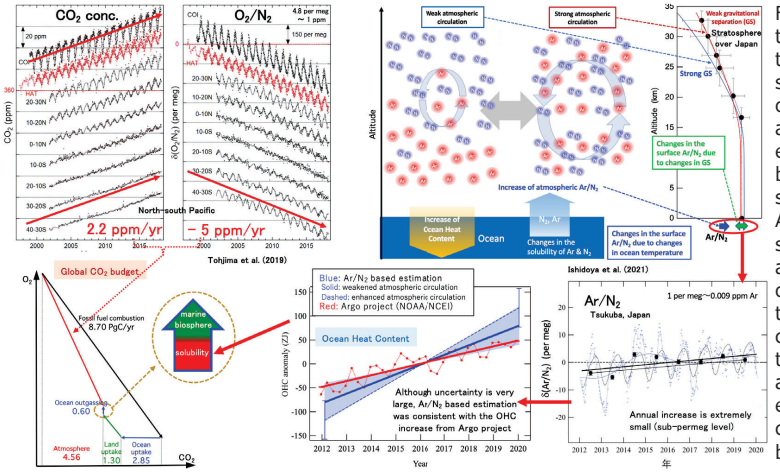

Figure 3. An example of the combined analysis in this research. Left figure shows long-term observation of O_2/N_2 and CO_2 and the estimated global CO_2 budget. Right figures show mechanism of Ar/N_2 change due to air-sea heat flux and GS, and long-term observation of Ar/N_2 and the estimated OHC change. By combining the O_2/N_2, CO_2, Ar/N_2 and GS, it is also expected we can extract contribution of marine biological activities.

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