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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 , O_2/N_2 , O_2/N_2 , and their O_2/N_2 0 and O_2/N_2 0 and O_2/N_2 1 and O_2/N_2 2 and their O_2/N_2 3 and O_2/N_2 4 and their O_2/N_2 5 and O_2/N_2 5 and O_2/N_2 6 and O_2/N_2 6 and O_2/N_2 6 and O_2/N_2 7 concentrations of O_2/N_2 8 and O_2/N_2 9 and O_2/N_2 9 and their O_2/N_2 9 and O_2/N_2 9 and O_2/N_2 9 and their O_2/N_2 9 and O_2/N_2 9 and their O_2/N_2 9 and O_2/N_2 9 a

Innovative observations network of atmospheric constituents Stratosphere south Pacific Advanced inversion system Simulation of gravitational separation Midlatitude O₂ Low-to-upper R/V Mirai troposphere Subtropics Taiki (balloon Sanriku (balloen) Ochiish JAL (aircraft) Tsukuba Forest tationa M/V New Century 2 Arctic R/V Hakuho M/V Trans Future 5 Ocean heat content Global carbon and COS Atmospheric circulation oxygen cycles Minamitorishima Ground-based stations Antarctica * Balloon observations wa station (ground + balloon) Standard gases Comparison with existing methods Southern ocean Evaluation of global warming based on original methods 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.

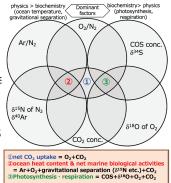


Figure 2. Image of the combined analyses using multi species

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 COS. We also try to detect changes in COS 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 COS 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.

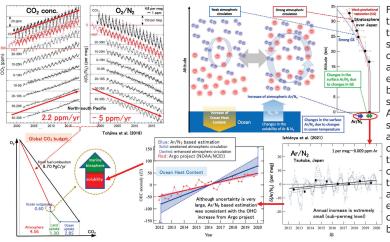


Figure 3. An example of the combined analysis in this research. Left figure shows long-term observation of O₂/N₂ and CO2 and the estimated global CO2 budget. Right figures show mechanism of Ar/N2 change due to airsea heat flux and GS, and long-term observation of Ar/N2 and the estimated OHC change. By 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.

Homepage Address, etc. Homepage for this research project is in preparation. E-mail address of the principal investigator is "s-ishidoya@aist.go.jp".