In-situ continuous observations of atmospheric O_2/N_2 ratio and CO_2 concentration on-board "SHIRASE" in the Southern Ocean

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Atmospheric O_2/N_2 ratio (O_2 concentration) and CO_2 concentration are closely related to each other through terrestrial biospheric activities and fossil fuel combustion. However, they are independently fluctuated when their exchanges occur between the atmosphere and the ocean. For a better understanding of the global carbon cycle, atmospheric O_2/N_2 ratio has been observed around the world since 1990s (e.g. Manning and Keeling, 2006). Until recently, most of O_2/N_2 ratio observations have been conducted at fixed stations on land, and a few of them have been on-board vessels (e.g. Tohjima et al., 2005). In particular, O_2/N_2 observation data are very sparse in the Southern Ocean. In this study, we have developed a continuous measurement system for atmospheric O_2/N_2 ratio and CO_2 concentration and conducted in-situ observations on-board the icebreaker "*SHIRASE*" in the Southern Ocean on her JARE-59 cruise. The measurement system consists of a differential fuel cell oxygen analyzer (Sable Systems, Oxzilla) and a non-dispersive infrared CO_2 analyzer (LI-COR, LI-6252), together with a precise pressure and flow-rate control system. Repeatability of the O_2/N_2 ratio and CO_2 concentration measurements was estimated to be ±4.1 per meg (corresponding to about 0.9 ppm) and ±0.04 ppm for 10-minute averages and ±1.6 per meg (0.3 ppm) and ±0.02 ppm for 1-hour averages. The measurements were started at Fremantle, Australia (FRM: 32°03'S, 115°45E) on December 1, 2017, and stopped at Sydney, Australia (SYD: 33°52'S, 151°12'E) on March 18, 2018. Between FRM and Syowa Station (SYO: 69°00'S, 39°35E), latitudinal gradients were observed in the O_2/N_2 ratio and CO_2 concentration and their gradients showed negative correlation; the O_2/N_2 ratio and the CO_2 concentration became lower and higher, respectively, towards southern latitudes. In addition, the atmospheric potential oxygen (APO ~ O_2 +1.1CO_2) ~~also~~ showed similar latitudinal gradient as the O_2/N_2 ratio. Considering that the APO signal is mainly produced by oceanic O_2 flux, it is suggested that the spatial distribution of the O_2/N_2 ratio is affected by O_2 outgassing from ocean surface in the southern middle latitudes. Similarly, negative correlation between the O_2/N_2 ratio and the CO_2 concentration was also found in their short-term variations observed on December 9. The variation ratio of the O_2 concentration with respect to the CO_2 concentration ($-\Delta O_2/\Delta CO_2$) for the short-term variation is calculated to be 5.5 ppm/ppm. This number is much larger than that expected for fossil fuel combustion (1.4 ppm/ppm) and for terrestrial biospheric activity (1.1 ppm/ppm). Since O_2 and CO_2 exchange between the atmosphere and the surface ocean occurs independently and the exchange rate is much faster in the O_2 exchange, it is suggested that the observed short-term variation of the O_2/N_2 ratio is mainly produced by O_2 exchanges between the atmosphere and the surface ocean. In the presentation, we will show the details of our measurement system and the latitudinal and longitudinal distributions of the observed O_2/N_2 ratio and the CO_2 concentration.

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References

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