TEMPORAL VARIATIONS OF THE ATMOSPHERIC CO_2 CONCENTRATION AND ISOTOPE RATIOS IN THE ARCTIC AND ANTARCTIC REGIONS

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ABSTRACT

Systematic observations of the atmospheric CO_2 concentration, and carbon and oxygen isotope ratios of CO_2 ($\delta^{13}C$ and $\delta^{18}O$) have been maintained at Japanese Arctic Observatory in Ny Ålesund (79°N, 12°E) and Antarctic station, Syowa (69°S, 40°E). The interannual variations of the CO_2 concentration and $\delta^{13}C$ in association with the occurrence of ENSO event were clearly observed at the both sites. The $\delta^{18}O$ values observed at Syowa Station showed significant increasing trend after 1999.

INTRODUCTION

To elucidate contributions of the terrestrial biosphere and the surface ocean to the CO_2 cycle on the earth's surface, precise and long-term measurements of $\delta^{13}C$ and $\delta^{18}O$ of atmospheric CO_2 have been required over geographically wide area. We have maintained long-term measurements of the CO_2 concentration, $\delta^{13}C$ and $\delta^{18}O$ at Japanese Antarctic station, Syowa since 1984 and 1995, respectively. It has been also carried out the concentration and the CO_2 isotopes observations at the Japanese observatory in Ny Ålesund, Svalbard, since 1991. In this paper, temporal variations of the CO_2 concentration and the isotope ratios observed at Ny Ålesund and Syowa Station will be presented and discussed.

EXPERIMENTAL PROCEDURES

Our observation sites are shown in Fig.1. In Syowa Station, continuous measurement of the CO_2 concentration was started in 1984 using a non-dispersive infrared analyzer (NDIR) and three kinds of standard gases calibrated by Tohoku University scale [*Nakazawa et al.*, 1991]. Since then, the CO_2 concentration has been determined with a precision of 0.01 ppmv every 5 minutes. In-situ CO_2 extraction has been carried out once every week at the station for the $\delta^{13}C$ and $\delta^{18}O$ analyses since 1995. Weekly air sampling program in Ny Ålesund in cooperation with Norwegian Polar Institute was started in 1991. The air sample pressurized into stainless steel flasks in Ny Ålesund were returned to Japan to determine the CO_2 concentration and to extract CO_2 for the isotope analysis using the similar systems used at Syowa Station. After September 2001, the air samples were cryogenically dried before filled into the flasks to prevent sample deterioration, especially for $\delta^{18}O$. The mass spectrometer used in this study was Thermo Electron MAT-δS. Instrumental reproducibilities of our isotope analyses were within 0.02 and 0.05 ‰ for $\delta^{13}C$ and $\delta^{18}O$, respectively (Nakazawa et al., 1997).

Fig. 1. Location of Ny Ålesund and Syowa Station.

RESULTS AND DISCUSSION

Figures 2 and 3 show the observed CO_2 concentration, $\delta^{13}C$ and $\delta^{18}O$, together with their fitted curves, long-term trends and increase rates, at Ny Ålesund and Syowa Station, respectively. The, $\delta^{13}C$ and $\delta^{18}O$ data obtained with wet air samples at Ny Ålesund are not plotted in Fig.2, since they have now been reexamined on 'storing' effects between air sampling and CO_2 extraction. As seen in Fig.2, the CO_2 concentration, $\delta^{13}C$ and $\delta^{18}O$ show clear seasonal cycles at Ny Ålesund, of which average peak-to-peak amplitudes are 16.2 ppmv, 0.79 ‰ and 1.2 ‰, respectively. The $\delta^{13}C$ value of CO_2 source producing the CO_2 seasonal cycles was calculated to be –26.7 ± 0.1 ‰, which was in the range of $\delta^{13}C$ value of typical C3 plants. The phase of the $\delta^{18}O$

seasonal cycles lagged 1-2 months behind those of the CO_2 and $\delta^{13}C$, reflecting the fact that the $\delta^{18}O$ variations were affected by gross CO_2 exchange between the atmosphere and terrestrial biosphere. Fig. 3 shows the CO_2

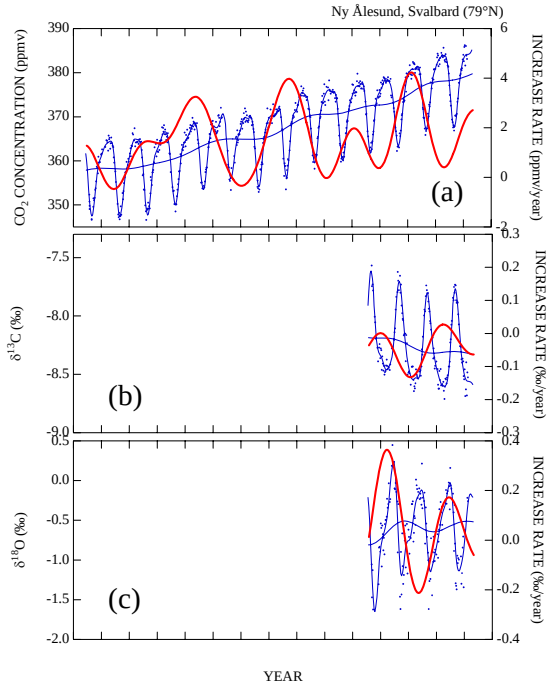

Fig. 2. CO_2 concentration (a), $\delta^{13}C$ (b) and $\delta^{18}O$ (c) observed at Ny Ålesund and their best-fit curves, long-term trends (left axis) and increase rates (broken lines: right axis).

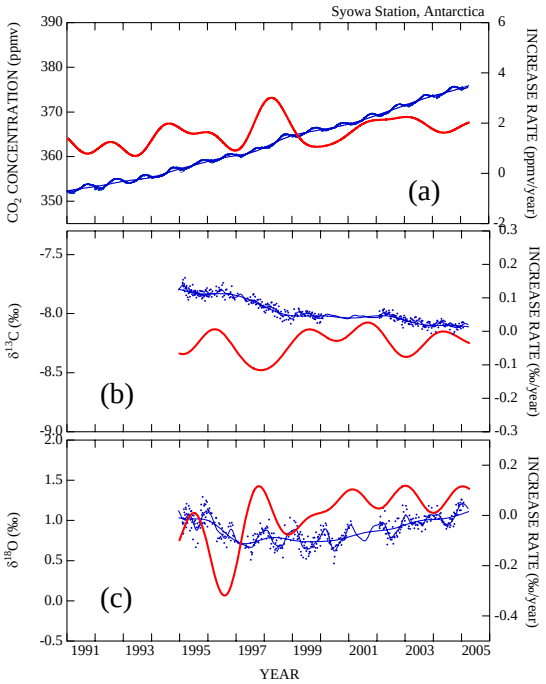

Fig. 3. The same as in Fig. 2, but for Syowa Station.

concentration and the isotope ratios observed at Syowa Station. As already reported [*Murayama et al.*, 1996; *Morimoto et al.*, 2003], clear seasonal cycles in the CO_2 concentration and $\delta^{18}O$ with peak-to-peak amplitudes of 1.1 ppmv and 0.2 ‰, respectively, can be found in Fig. 3. The phase lag of the $\delta^{18}O$ cycles amounted to be 3-4 months against the CO_2 concentration. Rapid CO_2 increases in association with 1997/98 and 2002/03 ENSO events are clearly shown in Fig. 2 and 3. Remarkable decreases of $\delta^{13}C$ were also observed in the ENSO periods, suggesting that the cause of the rapid CO_2 increase could be attributed to the anomalous CO_2 release from terrestrial biosphere and/or by biomass burning. Significant increasing trend of $\delta^{18}O$ at an average rate of +0.064 ± 0.004 ‰/year were observed at Syowa Station after 1999, in contrast to the decreasing trends found at several sites around the world for the period of 1993-1997. It could be indicated that gross CO_2 fluxes between the atmosphere and the terrestrial biosphere have changed after 1999.

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