TEMPORAL VARIATIONS OF CO_2 AND ITS CARBON AND OXYGEN ISOTOPIC RATIOS IN A COOL-TEMPERATE DECIDUOUS FOREST IN CENTRAL JAPAN

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ABSTRACT

Using discrete air sampling, atmospheric CO_2 and its stable carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) isotopic ratios have been measured since 1994 in a cool-temperate deciduous forest in central Japan influenced strongly by the Asian monsoon. In this paper, the results are shown and the temporal variations on different time scales are discussed.

INTRODUCTION

For a better understanding of the global carbon cycle, worldwide systematic measurements of CO_2 concentration are made. Its $\delta^{13}C$ and $\delta^{18}O$ measurements that give us useful information about respective contributions of the terrestrial biosphere and the ocean in the carbon cycle and those of photosynthesis and respiration in the biospheric flux, have also been made at some of the stations. However, systematic measurements at sites influenced strongly by terrestrial biospheric activities are still insufficient, especially in the monsoon Asian region. Therefore, we have been measuring atmospheric CO_2 and its $\delta^{13}C$ and $\delta^{18}O$ in a cool-temperate deciduous forest in central Japan since 1994. In this paper, we will present temporal variations of the concentration and the isotopic ratios at the site.

MEASUREMENT

Our observation site is located in a mountainous area in the central part of the main island of Japan (36°08'N, 137°25'E, 1420 m a.s.l.) and is situated about 15 km east of Takayama City. The main tree species at the site are deciduous broad-leaf trees such as birch and oak, whose average height is about 17 m. Budding and defoliation occur in May and October respectively, and the ground surface is usually covered with snow from December to April. The rainy season is strongly influenced by the Asian Monsoon and occurs in early summer.

Continuous measurements of atmospheric CO_2 and meteorological parameters, as well as the CO_2 flux between the atmosphere and the forest, have been made on a 27-m tower since 1993 (Saigusa et al., 2002; Murayama et al, 2003). Air samples used for the isotopic measurement have been collected monthly or biweekly during daytime and nighttime since 1994. The air is drawn from different heights on the tower into flasks after passing through a desiccant column. CO_2 for the isotopic measurement is extracted from the flask samples using a cryogenic method at our laboratory after concentration analysis. The $\delta^{13}C$ and $\delta^{18}O$ of the CO_2 samples are analyzed by a mass spectrometer. Measurements of $\delta^{18}O$ of precipitation have also been made since 2002.

RESULTS AND DISCUSSION

Figure 1 shows temporal variations in the CO_2 concentration and its $\delta^{13}C$ and $\delta^{18}O$ observed above the canopy in the daytime, together with their best-fit curves, long-term trends and the rates of change of the trends. The diurnal variations and height-dependent difference in the variations will be shown in our poster presentation. The $\delta^{13}C$ data show a prominent seasonal cycle with a maximum in late summer and a minimum in early spring, a cycle that is in opposite phase with that of the CO_2 concentration. The rate of change of $\delta^{13}C$ with respect to the concentration is about -0.06 per-mil ppm^{-1}, reflecting the seasonally-dependent biospheric processes near the site. Compared with the concentration and $\delta^{13}C$, the $\delta^{18}O$ data are more scattered and the seasonal variation is not so prominent because the variation in $\delta^{18}O$ is governed by complicated biological and hydrological processes. However, the average seasonal variation over the period shows high values in spring and early fall, and low values in early summer and winter, showing some similarity with $\delta^{18}O$ of CO_2 equilibrated with precipitation but different from those in the concentration and $\delta^{13}C$ (Fig. 2). Such a rapid decrease of $\delta^{18}O$ in early summer is not seen in the reference marine boundary layer at 36^{o}N provided by the GLOBALVIEW-CO_2, while it is observed at Tae-ahn Peninsula in South Korea. This phenomenon therefore may be attributed to the Asian monsoon.

In Fig. 1, a secular decrease of $\delta^{13}C$ is also seen, characterized by a noticeable inter-annual variability, with rapid decreases in 1997-1998 and 2002-2003, corresponding to globally-observed rapid CO_2 increases associated with the ENSO events. The rate of change of the $\delta^{18}O$ trend also shows similar inter-annual variation with that of $\delta^{13}C$. On the other hand, the year-to-year change of the annually averaged $\delta^{18}O$ show significant positive and negative correlations with early spring temperature and the occurrence of the seasonal downward zero crossing of CO_2 at Takayama, respectively, while not correlated significantly with the observed annually-integrated gross primary productivity and ecosystem respiration at the site. These findings might suggest that the inter-annual change of $\delta^{18}O$ is governed not only by the $\delta^{18}O$ of source water and biological activities near the site in the springtime which is dependent on spring temperature, but also by biological activities and hydrological processes occurring at regions far away from Takayama.

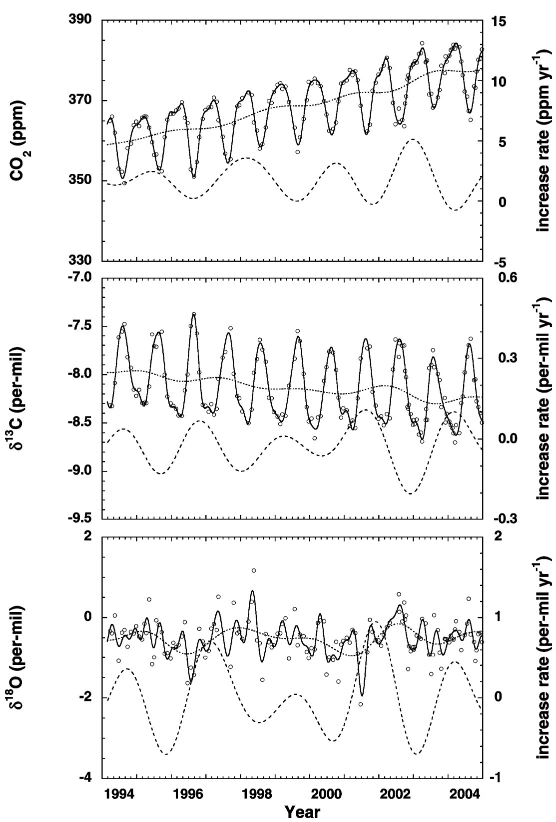

Fig. 1. (left) Variations in the CO_2 concentration (top) and its $\delta^{13}C$ (middle) and $\delta^{18}O$ (bottom) observed above the canopy in the daytime. Their best-fit curves (solid lines), long-term trends (dotted lines) and the rates of change of the trends (broken lines) are also shown.

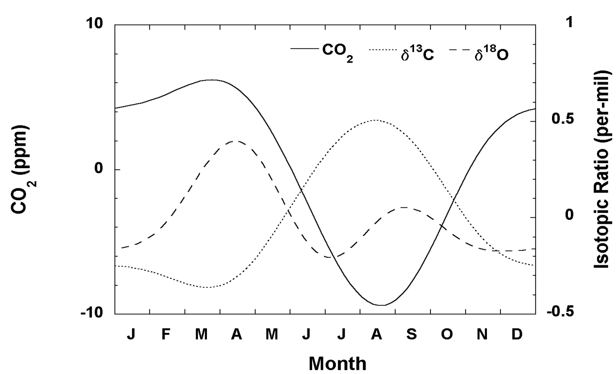

Fig. 2. Average seasonal variations in the CO_2 concentration and its $\delta^{13}C$ and $\delta^{18}O$ over the observed period.

REFERENCES

Murayama, S., N. Saigusa, D. Chan, S. Yamamoto, H. Kondo, and Y. Eguchi (2003), Temporal variations of atmospheric CO2 concentration in a temperate deciduous forest in central Japan, *Tellus 55*B, 232-234.

Saigusa, N., S. Yamamoto, S. Murayama, H. Kondo, and N. Nishimura (2002), Gross primary production and net ecosystem production of a cool-temperate deciduous forest estimated by the eddy covariance method, *Agric. For. Meteorol., 112*, 203-215.