OBSERVATIONS OF ATMOSPHERIC CO_2 CONCENTRATION AND ITS CARBON ISOTOPIC RATIO IN CHINA

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ABSTRACT

Systematic measurements of the CO_2 concentration and its carbon isotopic ratio ($\delta^{13}C$) have been carried out at 7 locations in China since March or July 2003. Seasonal cycles of the CO_2 concentration and $\delta^{13}C$ were clearly observable, especially at Longfengshan, Shangdianzi and Fukang. The $\delta^{13}C$ value of source producing the seasonal CO_2 cycle at each site, δ_S, was estimated from the observed CO_2 and $\delta^{13}C$ seasonal cycles. The average value of δ_S derived for the 6 sites was calculated to be -25.6 (±1.8) ‰, which is larger than those observed at mid-latitudes in the western Pacific region, probably due to smaller discrimination of ^{13}C by C_4 plants in the continent of China.

1. INTRODUCTION

Systematic measurements of the atmospheric CO_2 concentration in continental regions are important for a better understanding of the global carbon cycle. The data from those measurements are required especially for numerical carbon cycle studies using 3-D atmospheric transport models. However, the CO_2 measurements at continental sites are rather limited at present, especially in the Asian region. China is one of the most important regions for the cycles of CO_2 and CH_4, due not only to a vast area with forests and agricultural land but also to rapidly growing consumption of fossil fuel. Considering such a situation, we started to collect air samples at 7 locations in China, with subsequent laboratory analyses of CO_2 and CH_4 concentrations and the carbon isotopic ratio, $\delta^{13}C$, of CO_2. In this paper, we report the observed results of the CO_2 concentration and $\delta^{13}C$, and discuss spatial differences of their seasonal cycles and carbon isotopic signatures between China and the western Pacific region.

2. EXPERIMENTAL PROCEDURES

Air sampling has been carried out at 7 locations in China since March or July 2003. Our sampling sites are shown in Fig. 1. In addition to the Chinese GAW site at Mt. Waliguan, we newly established 6 sampling sites at Longfengshan, Shangdianzi, Taishan, Lin-an and Huangshan in the eastern part of China, and Fukang in the northwestern part of China, to cover a wide geographical area. The air sample was collected into a stainless-steel flask weekly or biweekly, and sent to our laboratory in Beijing to determine the CO_2 and CH_4 concentrations by using NDIR and FID-GC, respectively. The standard gases used for this analysis were calibrated by using the standards of Tohoku University. Pure CO_2 was then extracted cryogenically from the remaining air in the flask for isotopic analysis. Details of our mass spectrometry are described elsewhere [*Nakazawa et al.*, 1993].

Fig. 1. Map showing the locations of our sampling sites in China. Triangles represent mountain sites with altitudes of over 1500 m.

3. RESULTS AND DISCUSSIONS

Observed results of the CO_2 concentration and $\delta^{13}C$ are shown in Fig.2. The seasonal cycles of the CO_2 concentration and $\delta^{13}C$ are clearly seen. In order to extract the average seasonal cycle, a digital-filtering technique was applied to the data [*Nakazawa et al.*, 1997a]. The data of CO_2 and $\delta^{13}C$ observed in the western Pacific region [*Nakazawa et al.*, 1997b; *Morimoto et al.*, 2000] were also analyzed to compare with the results in China. The seasonal cycles of both components are especially enhanced at Longfengshan and Shangdianzi in the northeastern part of China. Peak-to-peak amplitudes of 30 ppmv and 1.5 ‰ at Longfengshan are more than twice as large as those observed at similar latitudes in the western Pacific region. Such large seasonal cycles are thought to be caused by active biospheric uptake and release of CO_2. The large seasonal amplitudes were also observed at Fukang. The cause is mainly due to considerably high CO_2 concentrations and low $\delta^{13}C$ values observed in winter. Since high CO_2 concentrations were accompanied by high CH_4 concentrations and low oxygen isotopic ratios of CO_2, it is suggested that CO_2 emitted due to local human activities was gradually accumulated in the strong inversion layer formed near the ground surface in very cold winter. The relationships between the seasonal CO_2 and $\delta^{13}C$ cycles were found to be approximated well with a linear function at all sites. In order to estimate the $\delta^{13}C$ value of source producing the seasonal CO_2 cycle at each site, δ_S, we adopted following mass balance equation introduced by *Miller and Tans* [2003],

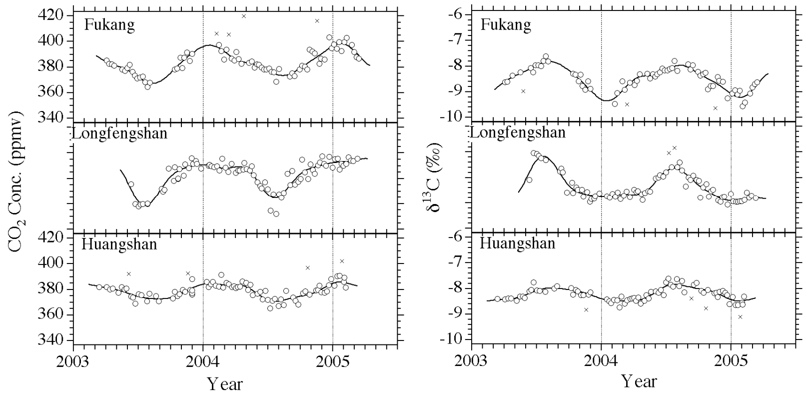

Fig. 2. Temporal variations of CO_2 concentration and its $\delta^{13}C$ at Fukang, Longfengshan, and Huangshan. Solid lines are the best-fit curves of the data.

$$\delta_{obs}C_{obs} - \delta_{bg}C_{bg} = \delta_S\left(C_{obs} - C_{bg}\right). \qquad (1)$$

Here, δ and C denote $\delta^{13}C$ and CO_2, respectively, and subscripts obs and bg mean observed and background values, respectively. The values of δ_{bg} and C_{bg} were determined by using a digital-filtering technique. In order to calculate δ_S as a slope in equation (1), the 'reduced major axis' technique was applied to a linear regression. The δ_S values derived for the Chinese sites are compared in Fig. 3 with those from observations in the western Pacific region during the period from 1984 to 2000. The δ_S values in China range widely from -28 to -23 ‰. In general, the δ_S value depends on the photosynthetic discrimination, the $\delta^{13}C$ values of CO_2 emitted by ecosystem respiration and fossil fuel combustion, and their flux magnitudes. If we assume that the seasonal CO_2 cycles observed in China were governed primarily by terrestrial biospheric activities, δ_S represents an average $\delta^{13}C$ of CO_2 exchanged seasonally between the atmosphere and the terrestrial biosphere. The average value of δ_S for the 6 Chinese sites, excluding Fukang, was calculated to be -25.6 (±1.8) ‰. This value is higher than those (-27.3 (±0.3) ‰ on average) at similar latitudes in the western Pacific region. Physiological studies suggested that C_4 grass dominates over C_3 grass in the eastern part of China (Woodward et al., 2004). Considering that the photosynthetic discrimination of ^{13}C by C_4 plants is smaller than that by C_3 plants, it is thought that the contribution of C_4 plants to the atmospheric CO_2 variations is fairly large in the continent of China.

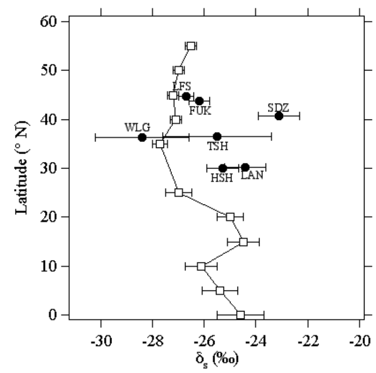

Fig. 3. Latitudinal plots of $\delta^{13}C$ of source producing the seasonal CO_2 cycle (δ_S) for Chinese sites (closed circles). The results obtained by shipboard measurements in the western Pacific region are also shown (open squares).

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