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Estimation of carbon cycle of atmospheric carbon dioxide in forest by stable isotopic ratio

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1. Introduction

Forest is an important reservoir of organic carbon where atmospheric CO_2 is exchanged through photosynthesis and respiration processes. Thus, its ability of absorption of atmospheric CO_2 should be decided by balance of activities of these two processes. Precise quantitative evaluation of the cycle of atmospheric CO_2 is required to make reliable numerical targets for actions against the global warming. In this study a methodology of evaluation of carbon cycle in a forest has been discussed, which adopts carbon isotopic analysis.

2. Observation

Mixing ratios and stable carbon isotopic ratios of CO_2 sampled in forest canopy layers and flux densities of soil respiration CO_2 were measured in Japanese larch forest in Inabu, Toyota, Aichi Pref. (35.2N, 137.4E, 1010 m a.s.l., 23 m mean tree height) from May 2004 to Nov. 2006, and an intensive measurement were undergone in a deciduous broadleaf tree forest in Takayama, Gifu Pref. (36.13N, 137.42E, 1420 m a.s.l., 14 m mean tree height) on 2 Aug. 2006. The samples of forest air were collected at 6 heights in Inabu site and at 12 heights at Takayama site. Soil respiration CO_2 samples were collected by a closed chamber over the ground surface. Mixing ratios of CO_2 were measured with a NDIR gas analyzer (LI-820, Li-Cor), and stable carbon isotopic ratios were with an isotopic ratio mass spectrometer (Finnigan MAT252, Thermo Electron).

3. Results and Discussions

Seasonal variations in vertical profiles of CO_2 mixing ratio and stable isotopic ratio has been observed at Inabu site. Especially characteristic profiles were obtained in summer, which has high mixing ratio near the ground in the morning with the largest range of diurnal variation. This would be attributed to soil respiration and implies increasing of CO_2 production by activated decomposition of organic matter due to high temperatures. Decreasing of stable carbon isotopic ratios with increasing of CO_2 mixing ratios were observed. This result is consistent with delta-^{13}C of soil respiration CO_2 lower than that of atmospheric CO_2. At upper heights in the forest, lower mixing ratios were observed in summer, but their range of seasonal variation was smaller than at the lower height. Increasing soil respiration CO_2 and rapid exchange with air over the forest canopy would be almost balanced by the decreasing CO_2 due to photosynthesis.

In Takayama site mixing ratios at most of all measured heights decreased from 10 to 14 o'clock. As oppose to it, their delta-^{13}C values increased. A minima of mixing ratios and maxima of delta-^{13}C were observed at heights of 14-16m, suggesting active photosynthesis at these height because it results from higher delta-^{13}C of CO_2 due to isotopic fractionation of photosynthesis. As is the case in Inabu site, CO_2 at the lowest measured height (0.5 m) showed high mixing ratios and low delta-^{13}C. At heights of 1.0 m and 1.5 m in understory layer, which are just above the lowerst height, temporal decrease of mixing ratios and increase of delta-^{13}C were obtained as occured at the upper heights, suggesting activity of photosynthesis by the understory.

By using these results of the observation, a methodology of quantitative evaluation of CO_2 transport in a forest canopy layer with mass balance of $^{12}CO_2$ and $^{13}CO_2$ has been discussed, and its precision and requirements on observation for its application will be reported.