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Estimation of carbon cycle in a cool-temperate coniferous forest by continuous monitoring of carbon isotopic ratio

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In recent years, carbon assimilation has been estimated at various vegetation and forests are expected as carbon reservoir for the future climate changes. In a forest ecosystem, gas-exchange processes are complicated and difficult to estimate carbon flows because leaf, trunk, root and soil have distinctive gas-exchange characteristics and are interactively affected by environmental factors within a canopy. Fluxes and concentrations of $^{12}CO_2$ isotope compositions provide information about ecosystem physiological processes and their response to environmental variation. We continuously measured the concentrations of $^{12}CO_2$ and $^{13}CO_2$ inside the automated closed dynamic soil chambers and the surrounding atmosphere of a cool-temperate coniferous forest near Mt. Fuji in Japan (AsiaFlux site code:FJY) using a tunable diode laser spectrometer (TDLS: G2101i, Picarro Inc.). The δ13C of the atmospheric CO_2 were fluctuated according the changes of CO_2 concentration and fluctuations of the carbon isotope signal from soil respired CO_2 ($\delta^{13}CR_s$) was not detected, although Keeling plots to estimate $\delta^{13}CR_s$ were very sensitive and the results were very scattered.

To understand carbon flows in a tree, we carried out in situ ^{13}C pulse-labelling experiments for a mature pine tree (*Pinus densiflora*, Tree height: 20m) at the FJY site. The experiments were carried out September 2012, December 2012, and July 2013, covering the canopy of the tree by a plastic film chamber and introducing $^{13}CO_2$ into the labelling chamber. The internal $^{12}CO_2$ and $^{13}CO_2$ was monitored by the TDLS to calculate a carbon assimilation by the tree during the labelling experiments. Carbon efflux from a trunk surface were monitored by the TDLS using four closed dynamic trunk chambers installed in different heights (15.5, 11.1, 7.3 and 3.8m height) of the tree. The carbon flow speed were estimated from the arriving time of $^{13}CO_2$ pulse to the trunk chambers. The pattern of labelled $^{13}CO_2$ efflux in winter was different from other seasons. The speeds ranged from 0.04 to 0.24 m/hr and relatively slow in winter. The amount of carbon respired from the trunk surface were ranged 14-20% of the assimilated carbon. In winter, the tree respired carbon from relatively upper trunk surface and lower in other seasons.

Keywords: forest, carbon cycle, isotope, laser spectrometry, carbon dioxide, respiration