EDDY-COVARIANCE, CHAMBER AND BIOMETRIC BASED ESTIMATES OF ANNUAL CO_2 EXCHANGE ABOVE TEMPERATE DECIDUOUS FOREST IN CENTRAL JAPAN

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ABSTRACT
In a temperate deciduous forest in Japan situated complex terrain, net ecosystem CO_2 exchange (NEE) was estimated using micro-meteorological method, and net ecosystem products (NEP) was estimated by measures of major carbon pools and fluxes using biometric and chamber methods. In this study we evaluate the threshold value of u* for interpolation in case stability was high using estimated NEP acquired by biometric method. And the function which relate temperature to FCO_2 for interpolation was evaluated by the data acquired using automated chamber for soil, CWD, trunk and foliage CO_2 exchanges. Averaged net uptake of CO_2 measured by eddy covariance method from 1999 to 2002 was 3.4 tC yr^{-1} ha^{-1} without compensation of nighttime underreport. Increase of live under and above ground biomass from 1994 to 1999 was 1.56 tC yr^{-1} ha^{-1}. U* threshold values based on biometric and chamber NEP were respectively 0.28 and 0.35 m sec^{-1}

INTRODUCTION
Eddy covariance method has been used commonly to measure CO_2 flux from forest, and estimate the rate of NEE of CO_2 in forest. However, in case stability is high (at night in calm winds), CO_2 flux measured by eddy covariance method underreports respiration caused by effect of local advection especially in case measurement site is not situated in flatland. In such cases, interpolation using relationship between night time CO_2 flux and temperature (soil or air) under appropriate turbulent transfer conditions is commonly used to fill the gap data. And exponential curve is often used as the function that shows the relationship between CO_2 flux and temperature. But in many cases evaluation of this function is difficult because lack of enough data [*Kominami*, 2003]. Therefore evaluation of threshold value and function for interpolation using multilateral methods is necessary for estimating accurate NEE.

SITES AND METHODS
Measurements were conducted at the Yamashito Experimental Forest (YEF) in Kyoto, Japan. The forest is situated at a headwater and plot area is 1.7ha. Forest type is a secondary deciduous broad-leaved forest and *Qercus serrata* and *Irex pedunculosaa* are dominated. Stand density is 3209 ha^{-1}, mean crown height is about 12m, living biomass (DBH≥3cm) is 44.5tC ha^{-1} [*Goto et al*., 2003]. Soil is generally thin, immature and sandy.

CO_2 FLUX OVER THE FOREST
Two meteorological towers, each equipped with an eddy covariance system using a closed-path CO_2 analyzer, were erected in the Yamashiro Experimental Basin to measure the CO_2 flux above the forest and to examine the effects of the complex topography on the measurements. The first tower, 35 m high, was erected in a valley, while the other, 26.5 m high, was situated along a ridge. The eddy covariance sensors were mounted at the top of each tower, and other meteorological variables were measured at various heights. The eddy covariance measurement was conducted with a 3-dimensional ultrasonic anemometer (model DAT-600-3TV, Kaijo, Tokyo, Japan) and a closed-path CO_2 gas analyzer (model LI-6262, LICOR). Vertical profiles of CO_2 concentration were also obtained from air samples taken at 8 different

heights using same gas analyzer. In this study, we used eddy covariance flux data obtained at ridge tower from 1 January 1999 to 31 December 2003

BIOMETRIC METHOD

Above and below ground net primary production were estimated based on allometric relationships and DBH census [*Goto*, 2003, *Dannnoura*, 2002]. Allometric relationships between size parameters and dry weight of stems, branches, leaves and roots were established using 46 and 16 trees for above and blow ground biomass respectively. And DBH census was conducted for all trees (1cm≤DBH) in 1994 and 1999.

CO_2 FLUX USING CHAMBER METHOD

CO_2 flux from foliage was estimated using 4 automated chambers and LAI measurements [*Miyama*, 2005a]. CO_2 flux from soil was estimated by 2 automated and 16 manual chambers [*Tamai*, 2005]. Estimation function for Fs was established using the data of soil temperature (Ts) and soil water content (θ). CO_2 flux from CWD was estimated by 2 automated and 192 manual chamber measurement and CWD census in 2003 [*Jomura*, 2005]. CO_2 flux from stem was estimated by 2 chambers measurements and the data of stem surface area estimated by allometric relation between stem surface area and DBH [*Miyama*, 2005b]. By integrating each CO_2 flux, CO_2 flux from forest was estimated by chamber method.

RESULTS AND DISCUSSION

Averaged net uptake of CO_2 measured by eddy covariance from 1999 to 2003 was 3.4 tC yr^{-1} ha^{-1} without compensation of nighttime underreport. Estimated NEP(=NEE) using biometric measurements from 1994 to 1999 was 1.56 tC yr^{-1} ha^{-1}. U* threshold based on biometric NEP were 0.28 m sec^{-1} and regression function which relate nighttime CO_2 flux and soil temperature at 5cm depth (Ts) was

$$FCO_2=0.02443EXP(0.0912\ Ts)$$

Annual averaged regression function obtained by chamber measurements showed good agreement with the function using the u* threshold as 0.35 m s^{-1} and that obtained by chamber method showed good agreement. Assuming the u* threshold as 0.32 which was mean value of two evaluations, annual NEP obtained by eddy covariance method varied from 1.29 to 1.68 tC yr^{-1} ha^{-1} from 1999 to 2003.

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