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Separation of gross primary production and ecosystem respiration of a Japanese forest using atmospheric O2/N2 ratio

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The atmospheric O2/N2 ratio (δ(O2/N2)) has been observed globally since the early 1990s to elucidate the global CO2 budget (e.g. Manning and Keeling, 2006). To apply this method, the global average terrestrial biospheric O2:CO2 molar exchange ratio is needed. Keeling (1988) estimated the - O2:CO2 exchange ratio (hereafter referred to as ER) of 1.05 by surveying the results from various elemental abundance studies. Severinghaus (1995) revised the ER to be 1.10±0.05, which has been used for the global average terrestrial biospheric ER in recent studies. However, Seibt et al. (2004) and Ishidoya et al. (2013) observed the ER values associated with respiration and photosynthesis in forests and reported that the ER for net turbulent O2 and CO2 fluxes between the forest ecosystem and the atmosphere above the canopy (hereafter referred to as ER_F) could be different from 1.1 significantly, based on one-box canopy O2/CO2 budget model analyses. Moreover, the ER_F reported by Seibt et al. (2004) is quite different from that by Ishidoya et al. (2013); the former is larger than 1.1 and the latter is smaller than 1.0 under the condition of uptake of CO2 from the atmosphere to a forest. Therefore, direct observation of the ER_F at various forests is expected to validate the global average terrestrial biospheric ER. In addition, such the observation of the ER_F will lead to estimate the gross primary production (GPP) and the ecosystem respiration (RE) of the forest separately.

In this study, we present the average daily mean ER_F at Takayama deciduous broadleaf forest site in central Japan (36○09′ N, 137○25′ E, 1420 m a.s.l.; designated as TKY in the Asia Flux site code database) for the period May 24 – August 28, 2013, observed firstly based on an aerodynamic method (Yamamoto et al., 1999). The observed average daily mean ER_F is 0.79±0.08, which is not only smaller than 1.0 as predicted by Ishidoya et al. (2013) but also significantly smaller than the assumed global average terrestrial biospheric ER (1.10±0.05). We also separate the average daily mean NEP for the corresponding period observed by the eddy covariance method (Saigusa et al., 2005) into average daily mean GPP and RE, by using the observed average daily mean ER_F in this study as well as the ER_A (the ER for GPP) and ER_R (the ER for RE) at TKY reported by Ishidoya et al. (2013). Then, the separated average daily mean RE is compared with that estimated from an empirical function of air temperature (Saigusa et al., 2005) and the soil CO2 efflux observed using soil chamber experiments (Mo et al., 2005), to discuss the validity of the observed ER_F and its implication to the forest and global carbon cycle (Ishidoya et al., in manuscript in prep.).

Reference

Ishidoya, S., Murayama, S., Takamura, C., Kondo, H., Saigusa, N., Goto, D., Morimoto, S., Aoki, N., Aoki, S., Nakazawa, T. (2013) O2:CO2 exchange ratios in a cool temperate deciduous forest ecosystem of central Japan. Tellus 65B, 21120, http://dx.doi.org/10.3402/tellusb.v65i0.21120.

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