Functional consequences of differences in canopy phenology for the carbon budgets of two cool-temperate forest types: simulations using the NCAR/LSM model and validation using tower flux and biometric data

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Cool-temperate evergreen coniferous and deciduous broad-leaved forests are major Japanese forest types. Because these forests experience broad seasonal and annual environmental fluctuations under a range of geographical conditions, analyses of the functional consequences of their different canopy characteristics for ecosystem carbon gain would provide deeper insights into the possible influence of climate change. We quantified the sensitivity of carbon budgets in two mature forests to variations in microclimate in NCAR/LSM model simulations under two climatic conditions: the relatively warm end of the cool-temperate zone (i.e., 800 m a.s.l., annual average temperature of 9.4 ° C, annual average precipitation of 1700 mm), and the relatively cold end of this zone (i.e., 1420 m a.s.l., 7.2 ° C, and 2400 mm). The model was validated using *in situ* CO_2 flux data such as gross primary production (GPP), ecosystem respiration (RE), net ecosystem production (NEP), and net primary production obtained from tower flux and biometric measurements at two AsiaFlux sites near Takayama City, Japan. The seasonal patterns and annual cumulative values predicted by the model agreed well with field measurements at the two sites. Under both climatic conditions, the NEP peaked between April and June in the evergreen coniferous forest, and between July and September in the deciduous broad-leaved forest (Fig.1 (c, f)). The different seasonal patterns of NEP between the two forest types were determined primarily by differences in GPP from April to June (Fig.1 (a, d)). The annual values of GPP, RE, and light-use efficiency were clearly greater in the evergreen coniferous forest than in the deciduous broad-leaved forest (Fig. 2). Our findings suggest that the mature evergreen coniferous forest has higher metabolic activity than the mature deciduous broad-leaved forest in the cool-temperate regions of Japan.

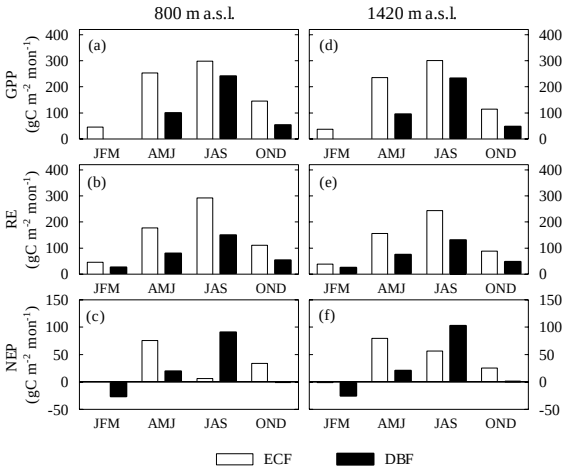

Figure 1: Comparison of the carbon budget between the evergreen coniferous forest (ECF) and the deciduous broad-leaved forest (DBF) under the different meteorological conditions at two altitudes for four periods during the year. GPP is gross primary production, RE is ecosystem respiration, and NEP is net ecosystem production. JFM, AMJ, JAS, and OND indicate the average values from January to March, April to June, July to September, and October to December, respectively.

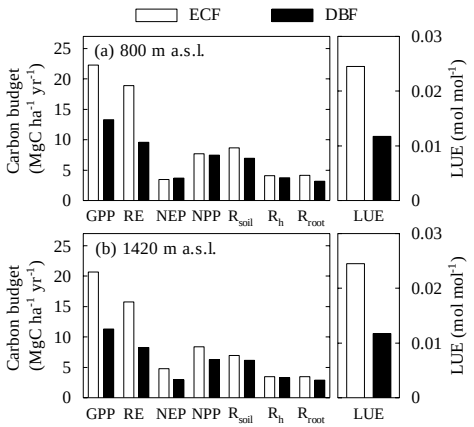

Figure 2: Comparison of the annual carbon budget and light-use efficency (LUE) between the evergreen coniferous forest (ECF) and the deciduous broad-leaved forest (DBF) under the different meteorological conditions at two altitudes. GPP is gross primary production, RE is ecosystem respiration, NEP is net ecosystem production, NPP is net primary production, R_{soil} is soil respiration, R_h is heterotrophic respiration, and R_{root} is root respiration.