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Impact of the expanded growing period length on carbon budget in a deciduous broad-leaved forest in future climate

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The growing period length of plants is one of the major interests in studying the current and future carbon cycles in terrestrial ecosystems, since it would directly affect the photosynthetic CO2 uptake and respiratory CO2 release in those ecosystems. In this study, we examined the possible effects of growing period length on forest canopy and understory vegetation ecosystem CO2 budget under future climate conditions, by combining [1] canopy-phenology model based on in-situ canopy observation and its dependency on microclimate and [2] ecosystem carbon cycling model. First, by using daily canopy surface images and air temperature data at the Takayama deciduous broad-leaved forest site (TKY) from 2004 to 2009, we examined the dates of the beginning of leaf expansion, the beginning of autumn leaf color development, and the end of leaf-fall, and their relationships with air temperature. Second, we adapted these relationships between leaf phenology and air temperature to account for the seasonal variation of canopy leaf area index (LAI) under future climatic conditions by referring to the climate projection data based on A1B, A2 and B2 scenarios from CMIP3 Multi-Climate Models. Under the near future condition (2046 ? 2065) as compared to the current condition (2002 ? 2007), the beginning of leaf expansion and the end of leaf-fall were 10-13 days earlier and 7-9 days later. As a result, the potential growing period was predicted to be enhanced by 17-22 days. We also estimated the photosynthetic period of understory evergreen vegetation (i.e., from the end of snowmelt in spring to the beginning of snow cover in late autumn) under current and near future climate conditions using NCAR/LSM model. Under the near future condition (2046 ? 2065) as compared to the current condition (2002 ? 2007), the end of snowmelt in spring and beginning of snow cover in late autumn were 8-12 days earlier and 5 days later. As a result, the potential length of photosynthetic period of understory evergreen vegetation was predicted to be enhanced by 13-17 days. Then we introduced simulated phenology of canopy leaf area index into NCAR/LSM model to examine its possible effects on photosynthesis (GPP), ecosystem respiration (RE) and resulting net ecosystem CO2 budget (NEP) of overstory and understory vegetation in the near future climate. Annual total ecosystem GPP, RE and NEP was greater under the future condition than under the current condition by 9-12 %, 9-13% and 12-17%. The increased GPP, RE and NEP were almost accounted by these increased by overstory vegetation. Our analysis indicates the importance of understanding space-time distributions of canopy phenology dynamics and snow-cover and of their consideration into the mechanistic evaluation of ecosystem functions in the climate studies.

Keywords: Carbon budget, Deciduous broad-leaved forest, Future climate, Global warming, Phenology, Understory vegetation