Scaling approach of ecosystem productivity over black spruce forests in Alaska: a synthesis of the eddy covariance data, and satellite remote sensing data

Masahito Ueyama (1,2), Yoshinobu Harazono (1,2), Kazuhito Ichi (3)

1) Schools of Life and Environmental Sciences, Osaka Prefecture University
2) International Arctic Research Center, University of Alaska Fairbanks
3) Faculty of Symbiotic Systems Science, Fukushima University

Field observations have been conducted to reveal the terrestrial carbon cycle; however, lack of sufficient continuous observation in high latitude ecosystems makes difficult in estimating their spatial and temporal variability. Therefore, scaling up of observed data to regional carbon fluxes is an important issue in the context of the carbon cycle in the Arctic. In this study, we proposed a new model to scale up the eddy covariance data to estimate regional carbon fluxes, by using satellite-derived data. The eddy covariance measurements were conducted at a black spruce forest in Fairbanks, interior Alaska (64°52'N, 147°51'W). The study period was from 2003 to 2006, when the flux data for model validation were available.

Gross primary productivity (GPP) and ecosystem respiration (RE) were empirically calculated by using normalized difference vegetation index (NDVI) and land surface temperature (LST) from moderate resolution imaging spectroradiometer (MODIS) with a spatial resolution of 250 m. Net ecosystem exchange (NEE) was determined by the difference between GPP and RE. At point scale, the satellite-based model could reproduce the seasonal and interannual variations in the carbon exchange in the black spruce forest in Alaska. The parameterized model also reproduced the carbon fluxes at a black spruce forest in Canada. These results suggested that seasonality of NDVI and the temperature played an important role on the carbon fluxes, and that the model is robust within black spruce forests in North America.

We used the model to estimate regional carbon fluxes over black spruce forests in Alaska. The integrated GPP, and RE between 2003 and 2006 were 1.76, and 1.86 kg CO₂ m⁻² y⁻¹, resulting in that black spruce forests in Alaska acted as a small carbon source of 0.10 kg CO₂ m⁻² y⁻¹. According to our model results, the black spruce forests increased the sink strength in spring warming, and decreased it in summer or autumn warming. These results were also consistent with simulation results from a BIOME-BGC model calibrated at the black spruce forest in Alaska.

The methodology of this study is applicable to scale up the observed fluxes to estimate the regional scale, by applying satellite-derived parameters related to observed carbon fluxes. Our future progress in satellite-based empirical modeling to estimate regional carbon fluxes will be realized by their application to other ecosystems.