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Estimation of terrestrial carbon fluxes over East Asia through AsiaFlux and improved MODIS gross primary production data

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The accurate estimation of carbon fluxes over terrestrial ecosystems provides useful information in studying the global carbon cycle. Estimates of carbon fluxes such as gross primary production (GPP) and net ecosystem exchanges (NEE) have been commonly used as indicators of the global carbon budgets. Eddy covariance (EC) flux towers are operating all over the world, networking each other. The towers provide temporally continuous measurements of carbon, water and energy over terrestrial ecosystems as being the best way to estimate ecosystem fluxes up to date. However, the EC flux towers only cover the scale of footprint, having difficulty in representing fluxes at the regional or continental scale. For upscaling flux tower data, satellite products that cover vast areas at high temporal resolution can be used. While many studies were conducted to estimate carbon fluxes from satellite products using process-based modeling and empirical modeling approaches, there are still great uncertainties in carbon flux estimation due to biases and errors associated with in-situ measurements, spatio-temporal discrepancy between satellite products and in-situ measurements, and relatively less accurate satellite products.

In this paper, NEE and GPP were estimated using machine learning techniques including random forest, Cubist, and support vector regression. Various satellite products were used as independent variables such as land surface temperature, normalized difference vegetation index, enhanced vegetation index, leaf area index, fraction of photosynthetically active radiation, GPP, evapotranspiration, rainfall, normalized difference water index obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS) and Tropical Rainfall Measuring Mission (TRMM). However, MODIS GPP based on the light use efficiency (LUE) model has some uncertainties derived from input data used in this model such as coarse spatial resolution of the Data Assimilation Office (DAO) meteorological data, upstream data of MODIS land cover use, FPAR, LAI, and model parameters. MODIS GPP data was improved using enhanced input variables by using Weather Research and Forecasting (WRF) meteorological data with high spatial resolution instead of DAO data, reflecting topographic characteristics over East Asia. GPP estimated using the enhanced input variables was compared with original MODIS GPP and in situ GPP to analyze the degree of improvements. Finally, improved GPP data were incorporated into the machine learning empirical models to estimate NEE. The spatiotemporal patterns of terrestrial carbon fluxes (GPP and NEE) over East Asia were also examined considering vegetation type and topography.