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Uncertainty Analysis of Gross Primary Production Separated from Net Ecosystem Exchange Measurements at Speulderbos Forest, The Netherlands

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Gross primary production (GPP), separated from the flux tower measurements of net ecosystem exchange (NEE) of CO_2, is used increasingly to validate process-based simulators and remote sensing-derived estimates of simulated GPP at various time scales. Proper implementation of validation requires knowledge of the uncertainty associated with the separated GPP at different time scales so that the propagated uncertainty can be determined. We estimate the uncertainty in GPP at half-hourly to yearly time scales. Flux tower measurements of NEE results from two major fluxes GPP and ecosystem respiration (R_{eco}) as NEE = GPP – R_{eco} and therefore GPP can be separated from NEE. We used a non-rectangular hyperbola (NRH) model to separate half-hourly GPP from the three years of continuous flux tower measurements of half-hourly NEE at the Speulderbos forest site, The Netherlands. NRH includes the variables that influence GPP, in particular radiation, vapor pressure deficit, and temperature. In addition, NRH model provides a robust empirical relationship between radiation and GPP by including the degree of curvature of light response curve. NRH was fitted to the measured NEE data on a daily basis. Variation in the parameters of this model was studied within each year. We did not obtain a single optimized value of each parameter of NRH model, instead we defined the prior distribution of each parameters based on literature search. We adopted a Bayesian approach, which was implemented using Markov chain Monte Carlo (MCMC) simulation to update the prior distribution of each parameter on a daily basis. This allowed us to estimate the uncertainty in the separated GPP at the half-hourly time scale. The results of this approach generated the empirical distribution of GPP at each half-hour, which are a measure of uncertainty. The time series of empirical distributions of half-hourly GPP values also allowed us to estimate the uncertainty at daily, monthly and yearly time scales.

Our research provided a robust integration of numerically efficient NRH model and MCMC method to estimate uncertainty in GPP at different time scales. This will provide relevant and important information for the validation of process-based simulators.