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Synthesis of tower-based observed and simulated carbon, water, and energy fluxes across North America

Christopher Schwalm (1), Christopher Williams (1), Kevin Schaefer (2), and the NACP Site Synthesis Team
(1) Clark University, Worcester, MA, United States, (2) National Snow and Ice Data Center, Boulder, CO, United States

Field-scale observations of ecosystem CO2 metabolism provide the backbone for understanding how the terrestrial biosphere interacts with climate. Across North America these interactions are superimposed on large gradients of vegetation, climate, topography, and environmental drivers. Though terrestrial biosphere models are valuable for extending field-scale observations of ecosystem metabolism to regional and continental scales (e.g. North America), formal analysis of uncertainties in both observations and simulations as well as the quantification of model skill are lacking despite increasing need by the broader climate policy community. We address this need through detailed analysis of observed CO2, H2O, and energy fluxes from 58 tower sites across 10 across vegetation types in North America. In addition to these observations 22 state-of-the-art terrestrial biosphere models, with varying structural attributes, were used to hindcast tower-based fluxes. The resulting model-data intercomparisons use consistent datasets and a well-defined simulation protocol to control for possible external contributions to model output. We focus explicitly on the problem of uncertainty estimation in both observations and model results and quantify sources of uncertainty. For the observed fluxes, uncertainly is driven by gap-filling and flux partitioning methodologies, including data-filtering protocols. Within-model and between-model uncertainty estimates are primarily linked to parameter sets, input weather data, and the explicit incorporation of disturbance and site history. Model performance varies based on climatic season, weather extremes, and biome. Overall, our main goal is to answer the question: Are the various measurement and modeling estimates of carbon, water, and energy fluxes at individual sites consistent with each other - and if not, why?