

Abstract

Evaluation of ecosystem carbon dynamics in North America using hourly to decadal data on local to regional scales

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Suggested start date: 1 September 2006.

There are major uncertainties in the causes and magnitudes of ecosystem CO₂ fluxes, and hence ecosystem carbon storage, in North America. Because of the complexity, and varied spatiotemporal scales, of the key processes, detailed process-based models are needed to understand and predict carbon fluxes and storage. It is crucial that these models are constrained properly, calling for an integrated modeling-data approach utilizing data at a wide variety of scales. The increasing availability of such data for North America could allow fundamental improvements in vegetation models, reducing uncertainties in estimates of current and future carbon fluxes and storage.

We propose to combine two different data sources (eddy flux, forest inventories) to estimate biophysical parameters, with an emphasis on respiration parameters, for the state-of-the-art dynamic vegetation model LM3V. This model has been jointly developed at Princeton and NOAA/GFDL and has been successfully coupled to the GFDL atmospheric and climate models. Eddy flux data provide information on terrestrial carbon fluxes at short (hourly to seasonal) time-scales, whereas the USDA forest inventories measure land carbon over decades to a century, including physiological and ecological changes within ecosystems, which is needed to accurately simulate ecosystem carbon dynamics in the context of climate change. These data will thus mutually constrain model parameters, accounting correctly for the varied spatiotemporal scales of the processes, and leading to a new understanding of how adaptation and acclimation within ecosystems might affect the future of carbon sources and sinks. Following data availability, we will focus on the East of the United States.

Parameters will be estimated using Bayesian MCMC methods, which give posterior probability distributions of model parameters by combining data with prior knowledge of parameter values. A particular attention will be paid to potential sources of uncertainty. Model and parameter validity will be evaluated by: (1) examining posterior distributions; and (2) comparing model predictions with independent observations, including atmospheric CO₂ data. The fitted model will then be used to understand and predict short- and long-term carbon dynamics in North America. The project will benefit from the computing facilities of GFDL.

Expected deliverables include: (1) improved land carbon estimates informed by eddy flux and forest inventory data; (2) new vegetation biophysical parameters, accounting for short- and long-term physiological and ecological change, including new processes such as long-term respiration acclimation; (3) an improvement in understanding the relative importance of key physical and biological processes for land-atmosphere carbon exchange over North America; (4) an improved understanding of how North American carbon dynamics might be affected by climate change; (5) a framework and a set of recommendations for the assimilation of other data.