Assimilating Biogeochemical and Biophysical Observations into a Land Surface Model Using the Data Assimilation Research Testbed

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Interactions between the climate system and vegetation exhibit a number of complex feedbacks. Climate dynamics control many aspects of ecological function, whilst changes in vegetation influence carbon, water and energy budgets directly affecting local and global climate. This role is recognized by the inclusion of complex land surface schemes in Earth System Models.

The National Ecological Observatory Network (NEON) is a National Science Foundation funded, continental-scale facility that will collect biogeochemical and biophysical data from 60 sites across the USA over 30 years. Data will include: (i) observations from eddy covariance flux towers which provide direct measurements of the ecosystem exchange of water, carbon and energy between the land surface and atmosphere; (ii) profiles of soil moisture and temperatures; and (iii) air-borne platform derived measurements of vegetation height, leaf area and biomass.

Such observations, along with comparable observations from space-borne satellites, can be used to inform land surface schemes in a variety of ways, but most directly through a data assimilation (DA) system. As with atmospheric or ocean DA systems, the goal with a land surface model is that it will update model states to make them more similar to the true state of the land surface, and this will then improve the model's forecast ability.

Here we describe how we are using the recently developed support for the Community Land Model (CLM) provided by the Data Assimilation Research Testbed, a community tool for ensemble data assimilation developed and maintained at the National Center for Atmospheric Research, in the development of prototype continental-scale data products for NEON.

In the early stages of this project we have concentrated on investigating methodologies for assimilating Ameriflux network observations of carbon and water fluxes and assessing the impacts of this on modeled carbon and water state variables describing vegetation and soil. As a next step we have assimilated MODIS satellite measurements of leaf area index, which is linked to modeled leaf carbon through a simple relationship describing leaf area per unit of leaf carbon.

Using both real observations and observing system simulation experiments (OSSEs) we have developed tools to preprocess these observations for use with DART and have tested different update time steps and approaches to aggregate different observations that are available at contrasting time intervals (half hourly, weekly, annually).

These early results suggest that ensemble DA is potentially a powerful tool for informing many different state variables in a land surface model, constraining the water and carbon pools and their interaction with the atmosphere. Whilst land surface models are not as sensitive to initial conditions on the same timescales as the atmosphere, we demonstrate that the impact of DA is long lasting, effecting land surface model forecasts over a number of years.