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Parameter estimation in the Community Land 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. The National Ecological Observatory Network (NEON) is a continental scale facility that will collect biogeochemical and biogeophysical data from 60 sites in the continental US, Alaska, Hawaii, and Puerto Rico over 30 years. Data will include 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 at small spatial scales but estimates of these fluxes at the regional and continental scale are required to diagnose, understand and predict the response of the global water and carbon cycles to a changing climate. In order to perform both spatial extrapolation from flux tower sites and temporal forecasting on decadal timescales we are developing a model-data fusion framework in which NEON data can be combined with the Community Land Model, which features a fully coupled carbon and nitrogen cycle (CLM-CN). Our goal is to produce optimal solutions for model states, fluxes and parameter values, with their associated uncertainties, at regional to continental scales. We have developed the Community Earth System Model (CESM) infrastructure to allow an ensemble of multiple instances of CLM to work simultaneously. This has allowed us to implement a coupling of CLM with the National Center for Atmospheric Research's Data Assimilation Research Testbed (DART) ensemble Kalman filter. Here we first describe the methodology developed for DART/CLM assimilation. We then discuss some initial results from an observing system simulation experiment in which we have attempted to optimize a limited subset of CLM parameters that a sensitivity analysis has shown strongly affect vegetation dynamics and land-atmosphere fluxes. We selected a suite of synthetic observations of carbon, water and energy fluxes and carbon and water pools available at different temporal frequencies for assimilation based on those that are currently available from FLUXNET eddy covariance tower sites and which will be made at NEON sites in the future. Finally, we present some preliminary results from assimilating actual, observed fluxes from a single FLUXNET site and identify a number of remaining challenges.