Scaling Biospheric CO_2 Fluxes in the Western U.S. From Site to Region Using the Community Land Model

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Forests in mountainous terrain represent a major carbon sink in the Western U.S. These forests are particularly vulnerable to climate change, which is expected to increase the frequency and severity of droughts, wildfires, and insect damage. Such disturbance events could weaken these forests' capacity to sequester carbon or switch them from a net carbon sink to a source. Despite the relevance of these mountain ecosystems, direct carbon flux measurements with eddy covariance towers are sparse, especially due to difficulties associated with complex topography. Land-surface models, constrained by observed atmospheric CO_2 concentrations, emerge as an alternative for quantifying current carbon fluxes and projecting carbon dynamics into the future.

We carried out simulations with the Community Land Model, Version 4.5 (CLM). The model successfully simulated photosynthetic carbon isotope discrimination and surface-atmosphere exchange of CO_2, water, and heat at two AmeriFlux sites in coniferous forests in the Western U.S.: 1) Wind River (Pacific Northwest) and 2) Niwot Ridge (Colorado). In accomplishing this successful comparison against observations we calibrated key parameters controlling plant-physiology and soil processes within CLM.

Here we expand our CLM simulations to the Western U.S. region, using the same successful strategy we implemented for the site-level runs regarding model spin-up and transient simulations, which account for pre-industrial to present-day changes in atmospheric CO_2 and $^{13}CO_2$, nitrogen and aerosol deposition, and land-cover change. In order to evaluate CLM performance we used a time-reversed Lagrangian transport model (Stochastic Time-Inverted Lagrangian Transport Model; "STILT") to link CLM carbon fluxes to atmospheric CO_2 concentrations at 3 in-situ CO_2 observations sites in the Regional Atmospheric Continuous CO_2 Network in the Rocky Mountains (Rocky RACCOON). Meteorological fields from a high-resolution Weather Research and Forecasting (WRF) simulation were used to drive CLM and STILT during the summer of 2012, a period characterized by a severe drought in the Western U.S.

We are currently working on the regional calibration of key plant-physiology parameters in CLM, aiming to minimize the differences between modeled and observed atmospheric CO_2 concentrations at the Rocky RACCOON sites. We present results of this initial calibration effort.