Sensitivity of Community Land Model land-surface fluxes and biomass to carbon-cycle parameters

Daniel M. Ricciuto[1,*], Jiafu Mao[1], Xiaoying Shi[1], Peter Thornton[1]

[1]Environmental Sciences Division and Climate Change Science Institute, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA

[*]Author to whom correspondence should be addressed; E-Mail: ricciutodm@ornl.gov; Tel.: +1-865-574-7067; Fax: +1-865-574-9501.

Incomplete knowledge about ecological processes contributes to substantial uncertainties in climate change projections. Global land surface models and Earth system models used to make climate projections are computationally expensive and contain large numbers of parameters representing ecological processes, limiting the feasibility of uncertainty quantification (UQ) studies that require large model ensembles. Fortunately, even relatively small model ensembles can yield useful information about key model parameter sensitivities. Model parameters are often linked to key ecosystem traits. Knowledge about how these traits are distributed and how they drive carbon and water cycles is of key importance to not only the modeling community, but also the measurement community as this knowledge can inform observation strategies targeted at reducing prediction uncertainties. In this study, we determine the ranking of parameter importance by applying the Morris method on Community Land Model (CLM) model parameters at AmeriFlux sites. We then perform a variance-based analysis to provide a way of analyzing the contributions (linear and non-linear) by each parameter and its interactions with other parameters to the variance of the model output. Particular model outputs of interest are biomass, net carbon fluxes and energy fluxes.

We find that the ranking of parameter importance strongly depends on the plant functional type and environmental drivers. The parameterization of mortality, rooting depth, photosynthesis and stomatal conductance is particularly important and regulates total biomass and seasonal patterns of carbon exchange in these ecosystems. We also evaluate the performance of the model against measured eddy covariance data and determine which combinations of parameters are most likely given the observations.