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Using remote sensing to account for disturbance history in process-based, carbon cycling models

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To project future carbon dynamics in fire-prone watersheds, we must account for processes that interact across multiple scales of space and time. Simulation modeling is a powerful tool for bridging scales; however, model projections are limited by uncertainties in the initial state of plant carbon and nitrogen stores. Models typically use one of two methods to initialize these stores. Spin-up involves running a model until vegetation reaches steady state. The steady-state approach, however, assumes the vegetation across the entire watershed is both mature and even-aged. Alternatively, remote sensing can provide data for initializing heterogeneous and non-steady state conditions. Methods for assimilating remote sensing into model simulations often rely on empirical allometric relationships between a single vegetation parameter and modeled carbon and nitrogen stores. However, allometric relationships are species- and region-specific and do not account for the effects of local resource limitation, which can influence carbon allocation (to leaves, roots, etc.). To address this problem, we developed a new approach using the ecohydrologic model RHESSys. In the new approach, we use remote sensing to define spatially explicit targets for one (or several) vegetation variables across a watershed (e.g. leaf area index). Then, the model simulates the growth of all carbon and nitrogen stores until the defined target values are met for all locations. We demonstrate the utility of this approach in two fire-prone watersheds in the western U.S. The target-driven approach increases correspondence between observed and modeled streamflow, showing promise for improving projections of biogeochemical and hydrologic dynamics in non-steady-state systems.