Estimating Biomass in a Combined SiB and CASA Model Using Data Assimilation

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Weather and climate dominate inter-annual variability in carbon flux, but whether the land surface model produces a long-term carbon source or sink depends entirely on the assumed initial amount of biomass. Most models assume initial biomass is in climate equilibrium, where biomass input from photosynthesis balances losses due to microbial decay. Essentially, the models start with a completely mature forest, where trees grow and die at the same rate. However, biomass is not in climate equilibrium because of agriculture, timber harvest, and biomass burning, resulting in high uncertainty in the long-term simulated fluxes.

To estimate initial biomass, we used data assimilation of observed CO_2 fluxes from the Ameriflux eddy covariance flux tower network and the Simple Biosphere/Carnegie-Ames-Stanford Approach (SibCasa) model. SibCasa simulates the terrestrial carbon cycle as the flow of carbon from one biogeochemical pool to another. We used the Maximum Likelihood Ensemble Filter ensemble-based data assimilation technique. Data assimilation minimizes the difference between modeled and observed fluxes by iterating initial biomass in various pools.

Our results indicate modeled fluxes are most sensitive to changes in initial wood biomass, as seen by comparing simulated and observed fluxes at Walker Branch, Tennessee (Figure 1). In forest ecosystems, the wood pool has the longest turnover time (35-80 years) and has by far the most carbon. As trees die and decay, the carbon is transferred to the coarse woody debris and other litter and soil pools, which have much shorter turnover times (5 years or less). In young, growing forests typically of the eastern United States, the faster pools reach equilibrium with respect to wood long before the forest matures and the wood pool reaches equilibrium with climate. This means to obtain reasonable model estimates of North American carbon flux, we only need to know the amount of wood rather than a complete carbon budget in all pools.

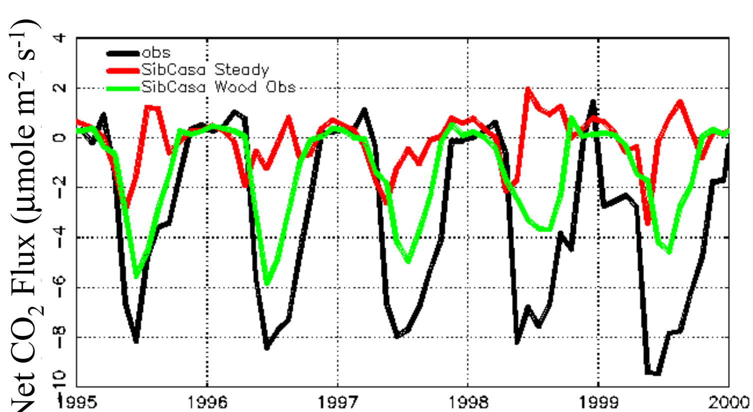

Figure 1. Observed net CO_2 flux (black), equilibrium flux (red), and optimal wood biomass flux (green) at Walker Branch, Tennessee. A positive net CO2 flux indicates a net release into the atmosphere. Walker Branch is a young forest (<50 years old) that clearly shows a net sink over time. Optimizing for wood biomass greatly improves the simulated fluxes from SibCasa.