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Addressing the carbon cycle steady state assumption: learning from multiple constraints approaches

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Models represent conceptual abstractions bonded to particular and general simplifications on functional ecosystem dynamics. Within the context of the terrestrial component of the carbon cycle, the steady state assumption represents a routine initialization method that develops ecosystem pools until fluxes reach equilibrium. Previously, the implications of these spin-up routines in inverse model optimization exercises showed significant biases in parameter estimations and increasing uncertainties. Building on empirical approaches, we develop a set of experiments where different site level historical dynamics are prescribed in the CASA model aiming at simulating net ecosystem production fluxes. The set of experiments entail different dynamics behind observed non-equilibrium conditions following both empirical and more mechanistic approaches. Although the prescription of non-equilibrium conditions reveals significant improvements in model performance and parameter uncertainties, relying solely on eddy-covariance data constraints is insufficient in differentiating the varying prescribed dynamics, resulting in an equifinality problem. The addition of biometric constraints in the cost function enables a positive distinction of different model structures through overall improvements in model performance. Our results emphasize the need to challenge modeling assumptions and the relevance of multiple constraints approaches in addressing equifinality issues.