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Uncertainty analysis of net ecosystem fluxes over the Iberian Peninsula

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We followed a model data-assimilation approach to evaluate the impacts of the commonly considered carbon-cycle steady state assumption (CCSSA) in biogeochemical modeling. A set of eddy-covariance sites representing ecosystems present in the Iberian Peninsula (IP) was selected for conducting an inverse model parameter optimization study, comparing net ecosystem production (NEP) measurements with NEP estimates from the Carnegie Ames Stanford Approach (CASA) model. The CASA model was driven by local weather station climate and remotely sensed derived fraction of photosynthetically active radiation absorbed by vegetation (fAPAR) and leaf area index (LAI). The model parameter optimization focused on the main parameters governing net primary production (NPP) and heterotrophic respiration (Rh) responses to temperature and water availability. In addition we identified a parameter (η) that relaxed the CCSSA in the model, allowing site level simulations to be initialized either as net sinks or sources. Overall, the robust relationships observed between modeled and observed NEP supports the CASA model structure for net ecosystem fluxes simulations. Furthermore, significant improvements in model performance and parameter optimization results were observed in relaxed (CCSSA_r) against fix (CCSSA_f) CCSSA conditions. Significantly lower parameter uncertainties were observed under CCSSA_r, and differences between maximum light use efficiency and Q_{10} estimates under CCSSA_r and CCSSA_f conditions suggest parameter compensation effects in steady state approaches.

Long term forest net ecosystem fluxes for the IP were estimated with the CASA model driven by spatially explicit climate fields and remotely sensed vegetation properties. Uncertainties were propagated following a Markov approach using the optimization parameter and covariance matrices estimated under CCSSA_r and CCSSA_f. These were attributed on a plant functional type basis, to compute and analyze spatially distributed ecosystem carbon fluxes and uncertainties for the IP region. Consequently, vegetation type strongly contributes to the spatial distribution of ecosystem fluxes and their respective uncertainties. Differences in inter-annual variability and seasonal C fluxes and uncertainties between CCSSA_r and CCSSA_f results reveal significant reductions in uncertainties in error propagation under relaxed steady state assumptions. Uncertainties introduced by wrong model assumptions (e.g. CCSSA) clearly exceed the purely statistical uncertainties that come out of conventional data-assimilation schemes. Our results hence emphasize the importance of model structure evaluation in model-data synthesis approaches.