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Calibration of two complex ecosystem models with different likelihood functions

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The biosphere is a sensitive carbon reservoir. Terrestrial ecosystems were approximately carbon neutral during the past centuries, but they became net carbon sinks due to climate change induced environmental change and associated CO_2 fertilization effect of the atmosphere. Model studies and measurements indicate that the biospheric carbon sink can saturate in the future due to ongoing climate change which can act as a positive feedback. Robustness of carbon cycle models is a key issue when trying to choose the appropriate model for decision support.
The input parameters of the process-based models are decisive regarding the model output. At the same time there are several input parameters for which accurate values are hard to obtain directly from experiments or no local measurements are available. Due to the uncertainty associated with the unknown model parameters significant bias can be experienced if the model is used to simulate the carbon and nitrogen cycle components of different ecosystems. In order to improve model performance the unknown model parameters has to be estimated.
We developed a multi-objective, two-step calibration method based on Bayesian approach in order to estimate the unknown parameters of PaSim and Biome-BGC models.
Biome-BGC and PaSim are a widely used biogeochemical models that simulate the storage and flux of water, carbon, and nitrogen between the ecosystem and the atmosphere, and within the components of the terrestrial ecosystems (in this research the developed version of Biome-BGC is used which is referred as BBGC MuSo).
Both models were calibrated regardless the simulated processes and type of model parameters. The calibration procedure is based on the comparison of measured data with simulated results via calculating a likelihood function (degree of goodness-of-fit between simulated and measured data). In our research different likelihood function formulations were used in order to examine the effect of the different model goodness metric on calibration. The different likelihoods are different functions of RMSE (root mean squared error) weighted by measurement uncertainty: exponential / linear / quadratic / linear normalized by correlation. As a first calibration step sensitivity analysis was performed in order to select the influential parameters which have strong effect on the output data. In the second calibration step only the sensitive parameters were calibrated (optimal values and confidence intervals were calculated). In case of PaSim more parameters were found responsible for the 95% of the output data variance than is case of BBGC MuSo.
Analysis of the results of the optimized models revealed that the exponential likelihood estimation proved to be the most robust (best model simulation with optimized parameter, highest confidence interval increase). The cross-validation of the model simulations can help in constraining the highly uncertain greenhouse gas budget of grasslands.