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Evaluating assumptions and parameterization underlying process-based ecosystem models: the case of LPJ-GUESS

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Dynamic vegetation models have been widely used for analyzing ecosystem dynamics and climate feedbacks. Their performance has been tested extensively against observations and by model intercomparison studies. In the present study, the LPJ-GUESS state-of-the-art ecosystem model was evaluated with respect to its structure, hypothesis, and parameterization by performing a global sensitivity analysis (GSA). The study aims at examining potential model limitations, particularly with regards to regional and watershed scale applications. A detailed GSA based on variance decomposition is presented to investigate the structural assumptions of the model and to highlight processes and parameters that cause the highest variability in the outputs. First order and total sensitivity indexes were calculated for each of the parameters using Sobol's methodology. In order to elucidate the role of climate on model sensitivity synthetic climate scenarios were generated based on climatic data from Switzerland. The results clearly indicate a very high sensitivity of LPJ-GUESS to photosynthetic parameters. Intrinsic quantum efficiency alone is able to explain about 60% of the variability in vegetation carbon fluxes and pools for most of the investigated climate conditions. Processes related to light were also found important together with parameters affecting plant structure (growth, establishment and mortality). The model shows minor sensitivity to hydrological and soil texture parameters, questioning its skills in representing spatial vegetation heterogeneity at regional or watershed scales. We conclude that LPJ-GUESS' structure and possibly the one of other, structurally similar, dynamic vegetation models may need to be reconsidered. Specifically, the oversensitivity of the photosynthetic component deserves a particular attention, as this seems to contradict an increasing number of observations suggesting that photosynthesis may be a consequence rather than the driver of plant growth.