Geoscientific
Model Development
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Discussions

Interactive comment on "A user-friendly forest model with a multiplicative mathematical structure: a Bayesian approach to calibration" *by* M. Bagnara et al.

Anonymous Referee #1

Gnerelal comment:

Bagnara et al. present a study that calibrates the parameters associated with Gross Primary Production (GPP) in a Light Use Efficiency (LUE) formulation based forest model. LUE type models are widely by the ecosystem biogeochemistry modeling community. The model performance is largely regulated by how well the model is calibrated. Studies that explore the efficiency and efficacy of model calibration are warranted. This study focuses on Bayesian approach with MC sampling. This study is well designed and smoothly presented in general. However, I still have several major concerns.

Major comments:

Abstract: Abstract is the place to clearly concisely show what you have done, why do you think the work is important. What are your results and why are they significant? The abstract is somehow not clear and concise enough to me; may be also confuse the potential readers. For example, the first paragraph basically says: the Bayesian approach is widely used to calibrate forest model, which has already been well accepted (hundreds of published studies). No need to spend entire paragraph to clarify this point. Please consider reconstruct your abstract to be as concise as possible.

Introduction: The presentation is not complete. For example, the author started the introduction with the definition of GPP and followed by the observation of GPP, GPP modeling and model calibration. Lots of important information are missing, including but not limiting to (1) Besides Eddy Covariance GPP data, MODIS-GPP is another famous GPP product; (2) Eddy Covariance network only measure NEP, GPP is derived from their model; (3) There are several other ways to model GPP besides LUE model (e.g., Farquhar 1980 type model). (4) Dislike LUE model, in Farquhar model GPP associated parameters have physical meaning, thus they are relatively easy to infer from observations. In the second part of introduction, the author presented the idea of Bayesian Calibration. It worth to mention that Bayesian calibration is not necessary rely on MCMC method. Bayesian approach relying on adjoint method is also an effective calibration method (Zhu 2014). Also it worth to mention other important type of ecosystem model calibration method: Kalman filter (Gao 2011). And the author need to justify the reason why they decide to use MCMC methods, given that other two types of calibration methods (adjoint method and kalman filter) could be much more efficient (e.g., adjoint method is a local optimization method, while this study needs a global optimization method? I believe the authors have their own reasons).

Method: The purpose of model calibration is to improve the posterior model predictability. This study only presented the calibrations, but miss the posterior model evaluation. One common approach is that: the model should be first calibrated at one EC tower site and then apply to anther site that has the same plant function type. The cross-

site evaluation is necessary to ensure the efficacy of model calibration. I suggest that the author should apply the posterior model parameters derived by different calibration methods to another tower site, in order to fairly compare the goodness of different calibration methods.

Discussion: Broad impact of this study is not well discussed. It is not clear to me how their findings interest our molding community and facilitate future studies in terms of forest model calibration. Another issue worth discussing is that the parameter calibration could only reduce model parameter uncertainty, however, is not able to constrain model structure uncertainty. There are two LUE models with different model structure used in this study, which might provide insight into the uncertainty in model structure.

Minor comments:

Page 6998 Line 2: Remove in very different forest all over the world. Do you mean different forest functional type? Line 4: "easy to use" is not a rigid scientific term. Define it more appropriately. Maybe "pragmatic"? Line 13: what does "user-friendly" mean? Line 19: this sentence needs to be rephrased. Line 22: calibration did not Page 6999 Line 2: terrestrial ecosystem carbon balance Line 11. Cite paper here Reichstein 2005 Page 7000 Line 13: sentence needs to be rephrased. Line 18: compared with Line 21 daily time step, based on Page 7001 Line 1: The Bayesian model calibration approach Line 15: The efficiency of the MCMC technique highly depends on the model structure. Is it true in general? How about other factors? Page 7002 Line 26: Why only use one year data? Lavarone site has multiple-year data (2000-2006). Perhaps, it is a good practice to use part of the data as calibration dataset, and use the rest for model validation. Page 7005 Line 4: Why do you chose 0.3*GPP as a upper bound of GPP data uncertainty? Any reference or reasons? Page 7011 Line 16: "multiplicative structure of Prelued was probably the main factor responsible for the difficulty in the calibration." Is it true? (1) First of all, photosynthesis (GPP) is a very complex biology process, a certain level of model complexity is needed. The difficulty of model calibration might be simply due to the fact that LUE model is too simple (model structure) to capture

the GPP response to environmental changes. (2) Multiplicative structure is common in other GPP models (such as abovementioned Farquhar model), there is no evidence that the multiplicative structure hinders model calibrations. Page 7013 line 14: Any suggestion of future development of LUE model? At least, based on your findings, the LUE model needs a better mathematical structure? Which structure should it be?

Reference: Farquhar, G. D., S. von von Caemmerer, and J. A. Berry. "A biochemical model of photosynthetic CO2 assimilation in leaves of C3 species." Planta 149.1 (1980): 78-90. Zhu, Qing, and Qianlai Zhuang. "Parameterization and sensitivity analysis of a process‐based terrestrial ecosystem model using adjoint method." Journal of Advances in Modeling Earth Systems (2014). Gao, Chao, et al. "Assimilation of multiple data sets with the ensemble Kalman filter to improve forecasts of forest carbon dynamics." Ecological Applications21.5 (2011): 1461-1473. Reichstein, Markus, et al. "On the separation of net ecosystem exchange into assimilation and ecosystem respiration: review and improved algorithm." Global Change Biology 11.9 (2005): 1424-1439.

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