

## ***Interactive comment on “Bayesian calibration of terrestrial ecosystem models: A study of advanced Markov chain Monte Carlo methods” by Dan Lu et al.***

### **Anonymous Referee #2**

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Bayesian calibration of terrestrial ecosystem models: A study of advanced Markov chain Monte Carlo methods.

This paper describes the testing of the performance of the Differential Evolution Adaptive Metropolis (DREAM) MCMC algorithm versus the Adaptive Metropolis (AM) algorithm in two benchmarking exercises and with the Data Assimilation Linked Ecosystem Carbon (DALEC) model using Harvard Forest flux tower data.

The manuscript is clear and well written, and highlighting the good performance of the DREAM algorithm is of interest to others addressing the issues associated with parameterizing ecosystem models.

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This is a highly technical manuscript, detailing the implementation of two algorithms, and I note the interactive comments of Vrugt and Laine, both far more qualified than me to assess the technical aspects of this study. Therefore, I'll concentrate on my concern that this manuscript is too technical, or at least focused in the wrong area, for the scope of Biogeosciences.

For publication here, I would suggest some major revisions are required, shifting the focus of the manuscript to make it more relevant to this audience. This would involve: (i) relying more on referencing previous work when discussing the technicalities of the algorithms and their implementation and testing; (ii) bringing in an observing system simulation experiment (OSSE) approach; and (iii) concentrating more model and ecological insights these implementation of DREAM/AM and DALEC provide.

Addressing the following points would go a long way towards revising the manuscript successfully along these lines.

1. Given the large literature and other information there is already available describing DREAM, and the DE-MC Section 2.4 is overly long, and repetitive of much existing work.
2. For the benchmarking exercises described in Sections 3, similar tests have been carried out in the extensive existing literature on both DREAM and AM, and it doesn't seem that further benchmarking like this is relevant to the Biogeosciences audience.
3. Section 4, the application of the MCMC algorithms to an ecosystem model seems to be more pertinent. Given the nature of the comparison between algorithms, I would perhaps prefer to see an OSSE-type experiment using the model with known parameters to generate pseudo-observations with realistic uncertainties that are then used to try estimate the (known) values, rather than the more standard benchmarks described in Section 3.
4. This is in part motivated by being a little surprised NEE alone has allowed all the

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parameters to be “successfully” determined when using flux tower data from Harvard Forest. This seems to run counter to many (most?) studies that suggest constraining slow turnover rates and large pool sizes from NEE data alone is problematic. With such an experiment you might hope to both demonstrate that this result is feasible (in the absence of model structural and initial condition error) and provide a tool to enable a more detailed analysis of why this seems to be case – simply saying the model is simple enough/doesn’t have many parameters is insufficient. For example – how important are the data themselves to this conclusion? Is the length of the record and quality of the observations important?

5. Post et al, 2017 JGR-Biogeosciences used DREAM to optimize a set of parameters in the Community Land Model, an ecosystem model massively more complex than DALEC, using flux tower data. Given the similarities, you should draw analogies and make comparisons as appropriate.

6. Parameter estimation using MCMC techniques remains very challenging for complex ecosystems models such as CLM for many practical reasons, including computational costs. Again, focusing on the readership of Biogeosciences, it would be useful to provide a comparison of the algorithms not just in terms of intrinsic performance given unlimited resource, but also most importantly their efficiency and also their ease of use and set up.

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