

Interactive comment on “Model–data fusion across ecosystems: from multi-site optimizations to global simulations” by S. Kuppel et al.

S. Kuppel et al.

sylvain.kuppel@lsce.ipsl.fr

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The authors would like to thank D. Schimel for his comments and the profound perspective suggested. It has been taken into consideration in the revised manuscript.

General comments

This is a very nice contribution and a significant advance in the practice of ecosystem carbon data assimilation. The work is well done, conforms to the state of practice, advances the field and is clearly presented for the most part.

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I have one perspective to add. The approach taken is directly analogous to similar estimation approaches in meteorology, and is useful but in a sense not informative. Consider the actual situation being modeled. Ecosystems, far from being a continuous field of "green slime" are in fact made of up of billions of individual plants, and even more bazillions of leaves and microbes etc. Within a single model plant functional type that can be up to tens of thousands of species, each with slightly or significantly different parameter values for the model equations. The goal of assigning PFTs and biomes is to reduce the unmanageable dimensionality of this variation to a reasonable degree, and the study presented here shows that using replication of flux sites –even though they do not systematically or randomly sample this variability– helps improve overall model performance.

However, this analysis does not take into account any covariance structure associated with the underlying structure of parameter variation associated with species or functional variation. Treating parameter variation as a random field is a reasonable first assumption but is almost certainly not true. It would be interesting to consider or speculate on how such an analysis would be done if more detailed information on plant parameter distributions were available to weight extrapolation from a limited set of towers. In any case, adding a description of the conceptual situation in which this assimilation is taking place would be useful. As ecosystem data assimilation progresses, making a transition to a more biologically sophisticated underlying model will be critical.

This comment is indeed very accurate. As the long-term aim of model-data fusion is here to assess the structural limits of ecosystem models based on the PFT concept and to guide later conceptual developments, ignoring parameter covariances will ultimately bias the results and could for example wrongly attribute model deficiencies. In the revised manuscript, the conclusions have been completed to include this idea, as

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follows:

'[...] maximize this improvement. In parallel, by using a diagonal prior covariance matrix for parameter error, within a same PFT and across PFTs, we implicitly assumed that all parameters could in principle be efficiently corrected as independent random distributions. It ignores the fact that a covariance structure interlinking the optimized parameterization would be necessary to translate the interconnectedness of ecophysiological processes within a given PFT. For instance, the allocation of carbon within the plant reservoirs depends on specific allometric relations and on photosynthesis rate; these relations would need to be embedded in the prior parameter error covariance matrix. Additionally, the influence of nearby individuals of other PFTs (e.g., the understory) should be accounted for when correcting parameters of a given PFT. Together with a simultaneous optimization of several PFTs, building standard spatialized parameter covariance tables from databases of plant traits and soil characteristics (e.g., (Kattge et al., 2011)) and 'preliminary' posterior multi-site parameter error covariance matrices (e.g., supplementary material of (Kuppel et al., 2012)) might soon become necessary to consistently apply model-data fusion to more sophisticated mechanistic ecosystem models.'

References

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