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Geoscientific Model Development Discussions

# *Interactive comment on* "Constraining DALEC v2 using multiple data streams and ecological constraints: analysis and application" *by* Sylvain Delahaies et al.

**Anonymous Referee #1**

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Review: "Constraining DALEC v2 using multiple data streams and ecological constraints: analysis and application" by Sylvain Delahaies et al.

Summary:

The manuscript by Delahaies et al. describes how to incorporate ecological and dynamic constraints (EDCs) into a 4DVar framework in order to estimate 23 parameters and initial conditions in a simple box model. Further, they show how the constraints can help to estimate otherwise underdetermined components. In their study, multiple data streams are combined, using observations from an Ameriflux site for LAI, NEE, GPP and respiration. Sensitivity analysis is performed to identify the most important parameters. They also introduce the resolutions matrix to diagnose the ill-posedness



of the linearised inverse problem.

The manuscript is well written and the details of the methods are described adequately. However, I am missing a broader discussion and some comments are made below. Nevertheless, I would recommend publications after minor revisions.

Comments:

It has already been shown in previous work that EDCs can be used as a form of regularisation to reject unrealistic parameter combinations in the same simple model. The novel aspect of the study by Delahaies et al. is that they include theses constraints directly in a 4DVar framework, which is really useful.

The 4DVar framework has already successfully been used to constrain terrestrial ecosystem parameters at the global scale in the Carbon Cycle Data Assimilation System (CCDAS) (i.e. Rayner at al., 2005). Kemp et al. (2014) also investigated how to constrain the 4DVar problem in CCDAS through a number of different methods including a constrained optimiser and parameter transformations. This should be included in the discussion.

I would also encourage the authors to comment on the feasibility of applying their framework at the global scale. It is great to see how the additional constraints work at the site level using a simple box model, but ultimately we would like to apply this to more complex global models. The authors argue that 4DVar is much faster than Monte Carlo methods, but it relies on the availability of adjoint code, which is not always easy to generate (i.e. model is not differentiable, etc.) .

Minor and technical comments: P3, L78: CO_2

P4, Table 1: Where to you get the range for the parameters and initial conditions from? Some of them seem to be different to what is stated in Bloom and Williams (2014).

P5, L128-129: You mention that you have 23 inequalities denoted EDC1 to EDC22. That's only 22? Can you provide the EDCS in the same way you provided EDC23 to

EDC25?

P8-P9, L208-211: How good is the Gaussian approximation of the posterior uncertainty? I guess that depends on the non-linearity of the model. You are using simple model and a Monte Carlo simulation should be possible (i.e. just sampling the cost function minimum). This kind of comparison has been done, for example, in Ziehn et al. (2012).

P9, L219 and throughout the manuscript: Your refer to Table 2.1, but this should probably be Table 2?

P10, L243: You refer to EDCs 4 and 6, but the reader does not know what they are. Can you please provide a complete list of the EDCs you are using?

P18, L439: Table 3 instead of Table 5?

P19, L449 Table 4 instead of Table 5? Can you please check references to tables throughout the manuscript?

References:

Rayner, P. J., M. Scholze, W. Knorr, T. Kaminski, R. Giering, and H. Widmann (2005), Two decades of terrestrial carbon fluxes from a carbon cycle data assimilation system (CCDAS), Global Biogeochem. Cycles, 19, GB2026, doi:10.1029/2004GB002254.

Kemp, S., Scholze, M., Ziehn, T., and Kaminski, T.: Limiting the parameter space in the Carbon Cycle Data Assimilation System (CCDAS), Geosci. Model Dev., 7, 1609-1619, doi:10.5194/gmd-7-1609-2014, 2014.

Bloom, A. A. and Williams, M.: Constraining ecosystem carbon dynamics in a data-limited world: integrating ecological "common sense" in a model–data fusion framework, Biogeosciences, 12, 1299-1315, doi:10.5194/bg-12-1299-2015, 2015.

Ziehn, T., M. Scholze, and W. Knorr (2012), On the capability of Monte Carlo and adjoint inversion techniques to derive posterior parameter uncertainties in terrestrial ecosys-



tem models, Global Biogeochem. Cycles, 26, GB3025, doi:10.1029/2011GB004185.

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