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Interactive comment on "A new step-wise Carbon Cycle Data Assimilation System using multiple data streams to constrain the simulated land surface carbon cycle" *by* P. Peylin et al.

Anonymous Referee #4

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Comment on P. Peylin et al., "A new step-wise Carbon Cycle Data Assimilation System using multiple data streams to constrain the simulated land surface carbon cycle" by Anonymous Referee 4

General Comments

The manuscript presents a sequence of parameter estimation exercises for the ORCHIDEE Land Surface Model using a CCDAS data assimilation framework. Firstly, NDVI data are assimilated at point scale. Secondly, FLUXNET data are assimilated at point scale. Thirdly, atmospheric CO2 data are assimilated at global scale.

The presentation of the material is excellent, despite some minor inconsistencies.

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Discussion paper

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The novelty of the material is limited.

What the authors present as a step-wise system, are in fact three systems that are operated in a sequence. The interface between these systems is minimal: It consist of selected parameters with error bars but excluding the error covariance that are passed in one direction.

The step-wise approach is not new. It is desribed, for example, by Rayner et al. (2005): They assimilate NDVI in the first step and atmospheric CO2 in the second step.

The system for assimilation of NDVI is described in more detail elsewhere (MacBean et al., 2015).

The system for assimilation of FLUXNET data is described in more detail elsewhere (Kuppel et al., 2012, 2014).

What is left is the system for assimilation of a single data stream, i.e. the atmospheric CO2 data from 2002 to 2004. The description of the assimilation method is provided elsewhere (see above references). The ORCHIDEE LSM, the LMDz CTM and the use of influence functions was also described elsewhere (see references in section 2.3.2). The assimilation of atmospheric CO2 using a combination of an LSM and a CTM and prescribed emissions from other components of the carbon cycle is not new either. It was presented by Rayner et al. (2005) and applied for a time span of two decades.

In summary the manuscript is not suitable for GMD because it fails to present "substantial new concepts, ideas, or methods".

The scientific approach of passing reduced information on the parameters from one assimilation system to the next is questionable. The reviewer agrees with the author's statement: "It is important to note that this is an implementation question. Tarantola (2005) recasts the fundamentals of the approach as the conjunction or multiplication of probability densities. This multiplication is associative so it makes no difference whether it is performed in one step or several." However, an implementation of such a

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step-wise procedure needs to propagate the full Probably Density Function from one step to the next. In the Gaussian framework selected here this requires to propagate the full error covariance matrix and not just the error bars (see comment above). Error correlations are to be expected (see, e.g. Raoult et al., 2016). The change of the parameter space from one step to the next adds a further weakness as well as the dependence of H_∞ on the last iteration of each step. The degradation of the results in the back-compatibility test is no surprise. Another test that has not been performed here would be to operate the sequence of assimilation systems in the reverse order and compare the final parameters and validation results. The computing effort is the same as for the order presented here.

The assimilation of a statistical index, i.e. NDVI, is somewhat beyond state of the art, as assimilation of the related physical variable, FAPAR, has been demonstrated for multiple LSMs (Knorr et al., 2010, Schurmann et al, 2016). The required physical model of FAPAR is available in ORCHIDEE (Naudts et al., 2015).

Specific Comments

p11: 184 parameters is misleading, as none of the three systems estimates that many parameters

Why are K_{soilC} parameters differentiated per region?

p23: Why are the FLUXNET assimilations performed per site and not simultaneously? How is the error of the parameter averaged over PFTs calculated.

Eq.(1) in the manuscript does not correspond with Eq. (1) in Tarantola (1987).

p21: After assimilation of atmospheric CO2 it is no surprise that the trend is close to observations.

p24: Fluxes are calculated from 2000 to 2009. Why are concentrations in Figure 6 not shown over the same time span?

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p41: 36 regions while in text it is 30.

Technical Corrections

p e l 16: "remains"change to "remain"

p 13 l 13: "we did not propagated" change to "we did not propagate"

p 9 l 12: "et al., (1980)" change to "et al. (1980)"

References

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