

Interactive comment on “How does the terrestrial carbon exchange respond to interannual climatic variations? A quantification based on atmospheric CO₂ data” by Christian Rödenbeck et al.

Anonymous Referee #1

Received and published: 8 February 2018

This paper quantified the sensitivity of the terrestrial carbon exchange to interannual climatic variations using a new formulation of atmospheric CO₂ flux inversion. Instead of optimizing terrestrial carbon exchange directly as in classical CO₂ flux inversion, this study optimized the sensitivity of terrestrial carbon exchange interannual variability (IAV) to temperature, which itself has been used as an emergent quantity to constrain the predictions of future terrestrial biosphere carbon accumulations. They found that the sensitivity changes with latitudes and seasons. The results over the NH extratropics are more robust and agree better with independent sensitivity calculated from eddy covariance observations from flux towers. The paper is well written, and the proposed method is quite interesting. I recommend this paper for publication after minor revision.

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Here are my detailed comments:

1. I would recommend adding more details about the inversion system. In describing the standard inversions in the first paragraph in section 2.1, it would be easier for readers to follow if they can add a cost function equation, and then describe how they define each term in that cost function. Currently, it is hard to understand the sentence: “The cost function additionally brings in a-priori information to regularize the estimation, in particular spatial and temporal smoothness constrains on the flux field”. I have to guess from that the authors are talking about the prior error covariance structure.
2. The details of sensitivity experiments described in section 2.3 are lacking, which make it hard to judge whether the uncertainties calculated from these sensitivity experiments are realistic. It would be helpful to describe the first three sensitivity experiments quantitatively. How much longer are the spatial correlations and temporal correlations in the sensitivity experiments? and how much have the a priori uncertainties been reduced in these sensitivity experiments?
3. Besides the sensitivity of terrestrial carbon exchange (NEE) IAV, the atmospheric CO₂ inversion described in this study also optimized the long-term trend and the seasonality trend of NEE. Since only CO₂ observations were assimilated, the sum of these three terms should agree with observed CO₂. Therefore, these three quantities mathematically have intrinsic correlations. It would be helpful to discuss the dependency of the estimated IAV sensitivity to the a priori assumptions of the other two terms in equation (2). Also, I would suggest adding a few sentences discussing whether the estimated trends are realistic, though this study focuses on the sensitivity of IAV.
4. Figure 1 used 40 gC/m²/yr as a threshold for robustness of the calculated sensitivity. Where did this number come from? What is the basis?
5. The unit in Figure 1 should be gC/m²/yr.
6. In the first paragraph in the introduction, “the response of NEE on. . .” should be “the

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response of NEE to . . .”

Interactive comment on Biogeosciences Discuss., <https://doi.org/10.5194/bg-2018-34>, 2018.

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