

***Interactive comment on* “Linking global terrestrial CO₂ fluxes and environmental drivers using OCO-2 and a geostatistical inverse model” by Zichong Chen et al.**

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In this work, the authors use a geostatistical inverse modelling approach to infer surface fluxes from observations of column CO₂ by the Orbiting Carbon Observatory 2 (OCO-2). Using these estimates, the authors make claims about the environmental drivers of the spatiotemporal variability of surface fluxes. However, their evaluation against independent data (sometimes coarsely defined as "validation") is not sufficient to support these claims.

Inferring surface carbon fluxes from observations of atmospheric CO₂ is an inherently ill-defined problem. Its solution, in any form, requires a number of assumptions that

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Discussion paper



are often poorly constrained by existing scientific knowledge. The authors do a commendable job of explaining that despite erroneous claims in the existing literature to the contrary, geostatistical inverse models do in fact use prior information, just in a different form than more common approaches. What the authors fail to do is support that their surface flux estimates are fit for the scientific purpose at hand. Typically, this is accomplished through comparisons to other independent data products. While pedantic, it seems more and more necessary that we remind ourselves that inferred surface fluxes fall into the prediction step of the Scientific Method. Between that and the analysis step, is the all important testing step. The testing step cannot be shortcut – it is the only thing separating science from plausible guesswork.

In order to make claims about the spatiotemporal variability of surface fluxes, the authors must first evaluate the fidelity of their surface fluxes' spatiotemporal variability. While this reviewer admits that there is no ideal method of evaluating global surface fluxes of CO₂ on horizontal scales greater than a few tens of kilometers, a greater effort must be made to demonstrate the product is appropriate for the analysis in the text. In particular, the only evaluation of their surface fluxes is that of long-term time mean regional budgets (Figure 6) and simulated CO₂ at just a handful of aircraft profiling sites (Figures S5 and S6). If one is to make claims about seasonal cycles, for example, then the seasonal cycle of the inferred fluxes must be evaluated as well. Given the assumptions necessary to make these inferences, it is entirely possible that their long-term time mean budgets are reasonable and their seasonal cycles are not. This is especially important given the documented impact (Basu et al., 2013, ACP; Crowell et al., 2019) that very small seasonal and regional biases from satellite retrievals can have on inferred fluxes. Unless the authors are able to demonstrate the skill of their product in reproducing variations over the same spatiotemporal scales as the scientific analysis, this review does not see how their claims can be supported.

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