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Geoscientific Model Development Discussions

Interactive comment on "A multi-species data assimilation system to retrieve information on land-atmosphere exchange processes" *by* Ivar R. van der Velde et al.

Anonymous Referee #1

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General comment: I read this manuscript with much interest. The authors did a good job in using atmospheric 13C data in a global data assimilation system for its additional information in partitioning land and ocean fluxes. Four assimilation experiments are logically designed to demonstrate the improvements in the global carbon cycle estimation brought by the use of the 13C data. The finding of the impact of drought on 13C discrimination is also interesting and convincing to a large extent. The manuscript is well written. However, the following issues need to be addressed before its publication. 1. Figures 10 and 11 show large (>0.5 permil) changes in the optimized plant 13C discrimination rate from the prior value, indicating that Eq. 2 for estimating the prior values does not perform well at least under drought conditions. The equation is based

on Suits et al. (2005) and includes full discrimination processes from free air to the photosynthetic site inside chloroplasts. However, there are various ways to implement the equation. It is not clear how Ci and Cc in the equation are estimated. Usually, stomatal conductance and mesophyll conductance are used to estimate them. In previous research, mesophyll conductance is often simply scaled to stomatal conductance. Chen et al. (2017, GMD) used a mesophyll model of Harley et al. (1992, Plant Physiology), and found it to be effective in improving the sensitivity of the modeled 13C discrimination rate to environmental conditions and in removing abnormal values caused by scaling mesophyll conductance to stomatal conductance. I am not requesting the authors to further develop their prior model for this paper, but they should make it clear how the equation is implemented and discuss issues associated with photosynthetic discrimination modeling. Perhaps they should also estimate the errors in their modeled discrimination rate. These errors would have implication on the partition between land and ocean fluxes, seasonal variability of the fluxes and the drought effect found in the manuscript. 2. I appreciate very much that both land and ocean discrimination rates are optimized in their data assimilation systems, and it is interesting to see that it is possible that these rates can be optimized with currently available measurements. The authors also make it clear that these optimizations are based on the assumption that the prior disequilibrium fluxes of land and ocean have no bias errors. We understand that these disequilibrium fluxes are large and nearly equivalent to discrimination fluxes in size and that their estimates are quite involved and inaccurate. I wonder what is the justification to optimize discrimination but not disequilibrium. Since the disequilibrium rates over both land and ocean are difficult to estimate accurately, I wonder what are the impacts of their errors on the optimized fluxes and discrimination rates. The authors qualitatively discussed these impacts in Discussion, but the discussion is not useful for assessing the reliability of optimized results of their data assimilation systems. It would be useful to do a quantitative assessment of these impacts. 3. The word "multi-species" in the title is a bit misleading because there are only two gas species, CO_2 and $^{13}CO_2$, considered in their data assimilation systems, while multi-species would imply at least three species. Although the systems are intended for more than two species, the current study only uses two species. I suggest changing it to duel-species or some other phrases.

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