Comment on bg-2022-210

Anonymous Referee #2

Referee comment on "Technical note: Novel estimates of the leaf relative uptake rate of carbonyl sulfide from optimality theory" by Georg Wohlfahrt et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2022-210-RC2, 2022

The study by Wohlfahrt et al. (2022) proposes a new way to constrain the variability of OCS leaf relative uptake (LRU) ratio across plant functional types (PFTs) and climatic gradients by fusing an LRU model to the eco-evolutionary optimality framework (Maire et al., 2012, *PLoS ONE*; Prentice et al., 2014, *Ecol. Lett.*). LRU is a key parameter to translate leaf OCS uptake into constraints on gross photosynthesis. However, there are limited observations to inform LRU variability with climate and across species. This study leverages the optimality theory to bypass the data gap, allowing LRU to be predicted in hitherto unobserved biomes. If the prediction holds against future observations, the results can help calibrate land surface models and provide the LRU input for atmospheric inverse modeling of regional and global OCS fluxes. The study will be of interest to the OCS community as well as the broader photosynthesis research community.

While I do not question the validity of the main conclusions, there seem to be a few assumptions involved in deriving the "optimal" LRU, which need to be articulated and examined. A few technical issues also need to be addressed to make the results more robust. Given that the other reviewer has commented extensively on the P-model, here, I focus on other aspects.

- Electron transport limitation: The Prentice et al. (2014) optimality model assumes photosynthesis is Rubisco-limited. This assumption may not hold for shoulder seasons and high-latitude sites (e.g., boreal forests) in which photosynthesis is often light (electron transport) limited. The latter case, as pointed out by Prentice et al. (2014), may be examined by substituting ξ with the electron transport-limited value given by Medlyn et al. (2011) *Global Change Biol*.
- The model validation shown in Fig. 1 is too broad-brush to be useful. Looking at this figure, we can tell the direction of the mean bias, but we have no idea how well the simulated LRU values capture the variability in the observed values. I recommend showing a scatter plot and reporting the mean bias, RMSE, and R^2 for each data set.
- The internal conductance of OCS (g_i), which includes components of mesophyll conductance and carbonic anhydrase activity, is not constrained by the optimality

framework. Thus, g_i may contribute greatly to the uncertainty in LRU. Although the authors attempted a sensitivity test by varying this parameter by 10%, it is not enough, given that Kooijmans et al. (2021) find that optimized $g_i/V_{c,max}$ ratios can deviate a lot from the original Berry et al. (2013) parameterization. My suggestion to mitigate the problem of g_i uncertainty would be to test the sensitivity of LRU to g_i over a wider range of $g_i/V_{c,max}$ ratio, from 600 to 3000, encompassing the range shown in Fig. 4 of Kooijmans et al. (2021).

Minor comments

- L11: I would leave out "alternative" because readers may not have known other tracers of GPP.
- L12: "LRU" -> "light-saturated LRU" - Given that the prediction focuses on light-saturated LRU, I would make the distinction early on so that readers know what they should be comparing the LRU values to.
- L14: "0.5–1.4" - What is the statistical distribution of LRU values across all grid cells? How does it compare with Fig. 2 in Whelan et al. (2018) *Biogeosci.*?
- L56: "the lack of a suitable theoretical framework" + "to predict LRU *a priori*"
- L96: Are the temperatures reported here mean annual temperatures or averaged over the campaign periods?
- L100: Using midday hours to determine the optimal values may create a bias, because photosynthesis is often suppressed around midday due to stressed conditions under high light or high vapor pressure deficit. Why not use data at the hour of peak photosynthesis (whenever it is) to determine these parameters?
- Fig. 2: Not the best color scheme because it does not have a strong contrast between the minimum and maximum values. On the right panel, consider adding the observed values from Sun et al. (2018) and Kooijmans et al. (2019) for visual comparison.
- Fig. 3 does not seem to compare apples to apples. Seibt et al. (2010) did not limit LRU to light-saturated values, hence showing higher values. LRU values in Maignan et al. (2021) are modeled, and should not be treated as observations. These caveats should be noted in the figure caption.
- Fig. 4: Same as Fig. 2, the color scheme lacks contrast.