Biogeosciences Discussions

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Reply on RC2

Georg Wohlfahrt et al.

Author 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-AC2, 2022

We thank reviewer #2 for his/her comments - please find out reply to each comment below starting with "R: ...":

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.

R: while the reviewer is correct in that the Prentice et al. (2014) model assumes photosynthesis to be Rubisco-limited, the P-model in the version by Mengoli et al. (2022), which is used here, does not so as it additionally adopts the co-ordination theory, which results in co-limitation by both Rubisco and electron transport over the time scale on which plants acclimate to the prevailing environmental conditions; on short (instantaneous) time scales photosynthesis is thus either limited by electron transport or Rubisco

- 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.

R: Figure 1 will be updated according to the reviewer comment by including the underlying raw data – following a comment by reviewer #1, data of chamber #2 from Kooijmans et al. (2019) will be added; the requested statistical metrics will be added to the text

- 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).

R: the sensitivity analysis regarding the gi parameter will be improved accounting in a more realistic fashion for the uncertainty of gi

Minor comments

- L11: I would leave out "alternative" because readers may not have known other tracers of GPP.

R: will be changed as suggested

- 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.

R: will be changed as suggested

- 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) ?

R: to address this question we will add the data from Figure 2 in Whelan et al. (2018) to our Figure 2

- L56: "the lack of a suitable theoretical framework" + "to predict LRU a priori"

R: will be changed as suggested

- L96: Are the temperatures reported here mean annual temperatures or averaged over the campaign periods?

R: these are averages of the measurement campaigns – will add corresponding clarification to the text

- 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?

R: this is a very interesting comment as it addresses the issue of the time scale over which plants would acclimate to the prevailing environmental conditions, which is not a priori apparent; since this paper is about the application of the P-model for estimating LRU rather than improving the P-model, we believe this comment however to be out of scope

- 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.

R: the colormap will be changed to one in the package recommended by the journal's guide for authors; following a comment by reviewer #2 we will add the LRU distribution from Whelan et al. (2018) to Figure 2, which is better suited to put our results into perspective

- 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.

R: correct – because Seibt et al. (2010) and Whelan et al. (2010) did not explicitly filter for PAR, their values must be expected to be higher – this will be included in the discussion; the fact that LRU values from Maignan et al. (2021) are modelled and represent canopy-integrated values will also be discussed in the revised text

- 4: Same as Fig. 2, the color scheme lacks contrast.

R: see reply to comment above