

Biogeosciences Discuss., referee comment RC1
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Comment on bg-2022-36

Anonymous Referee #1

Referee comment on "Consistent responses of vegetation gas exchange to elevated atmospheric CO₂ emerge from heuristic and optimization models" by Stefano Manzoni et al., Biogeosciences Discuss., <https://doi.org/10.5194/bg-2022-36-RC1>, 2022

This study is a theoretical analysis of the effects of elevated CO₂ on carbon and water fluxes at the leaf and canopy level. The authors use four different models describing carbon water relations, one heuristic (PETA) and three optimality based, and run these under different CO₂, soil moisture and VPD conditions. Results show that all models predict relatively constant canopy scale transpiration and implicitly an increase in water use efficiency. The paper is well written and the models clearly explained.

The question of how plants will respond to future increased atmospheric CO₂ and dryer conditions remains one of the critical questions in plant ecophysiology, so in principle this study is highly timely and relevant. However, in practice, it is in my opinion a purely theoretical exercise that largely uses pre-existing models and knowledge and has some pretty big assumptions. I find that the assumption that most affects the results is that related to the increase in leaf area with increased CO₂. The logic behind this assumption is that as photosynthesis increases, there is more carbon available for growth and therefore the leaf area increases in turn. However, from observations and elevated CO₂ experiments we know that often there is a shift in allocation and while overall growth goes up, leaf area might not, as resources get allocated belowground to deal with other resource limitations. This has implications not only for the ΔL quantity in the model, but also for soil moisture limitations, in particular in the OPT3 formulation. The authors themselves acknowledge this limitation in the discussion and state that optimizing both carbon-water relations and allocation would lead to a too complex model. But surely there are some intermediary options between no belowground allocation and fully optimal allocation. For example, the parameter w_0 could be varied as it is a function of rooting depth and it could be a trade off between rooting depth and ΔL . Although I am sure the authors know their models better than I do and come up with the best way of doing this.

Also related to the biomass growth and leaf area question, I find the α parameter somewhat confusing. It is meant to represent resource availability. What this appears to mean in the model, if I understand correctly, is that for a low resource availability (α close to zero), there is a strong increase in leaf area. This is because at high resource availability the canopy would be already almost closed and there is no room to grow while conversely at a low availability the canopy is open and the plants can grow more. But if

the resource in question is for example nutrients, at low availability we would in reality see no growth response whatsoever, as we do at, for example, the EucFACE experiment. This would make the ΔL dependency on α more like a bell shape. I think this part of the model formulation needs some further explanation and discussion.