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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Low and contrasting impacts of vegetation CO_2 fertilization on terrestrial runoff over the past three decades: Accounting for above- and below-ground vegetation-CO_2 effects" *by* Yuting Yang et al.

Anonymous Referee #2

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The manuscript by Yang et al. aims at quantifying the impact of physiological and structural vegetation adaptations induced by elevated atmospheric CO2 concentration (eCO2) on mean annual runoff (Q). The vegetation-mediated eCO2 effect on Q is complex and involved several processes with sometimes opposite effects. Also, the link of below-ground processes to eCO2 is still not entirely clear. For these reasons, the effect of eCO2 on Q is a source of uncertainty in simulation models. This paper uses an attribution framework, based on the previously applied BCP model, to quantify the net vegetation-mediated eCO2 effect on Q. This is a highly topical subject, the choice

of methods seems appropriate and the inclusion of a link to below-ground processes constitutes a substantial novelty, which makes this manuscript of interest to HESS. However, my concerns relate to the presentation of the material: I find the manuscript difficult to follow and think that its value could be greatly increased by improving the description of methods. I therefore recommend a minor revision before the paper gets published.

I find the presentation of the methods somewhat unclear and found it difficult to understand how the different methodical steps are linked together, particularly Sections 2.3 and 2.4. Are the responses of stomatal closure and L to eCO2 integrated in the BCP model? If so, please make the links explicit. If not, please clarify how these different steps work together in the attribution framework. Also, it seems to me that the step of extending the analysis from the study catchments (l. 196 states that the analysis is limited to those) to a global raster map (e.g. Fig. 7) is not described in sufficient detail in the Methods.

In the presentation of the results, it is not immediately clear if the Q-eCO2 response refers to the net effect of increased CO2 concentration on Q (through all the known effects on e.g. meteorological forcing, plant physiological and structural adaptations to CO2 and climate etc – this seems to be the case in the first paragraph of Section 3.3 and Fig. 5), or the net effect of eCO2-induced plant physiological and structural adaptations (this seems to be the case in the second paragraph of Section 3.3 and Fig. 6). Then again, in the first paragraph (l. 270 ff.) the authors discuss the relative importance of physiological and structural effects of eCO2 on vegetation before the corresponding evidence has been presented.

The authors conclude by stating that the analyses provide insightful guidance for the development of climate models. It would be helpful to describe how exactly the findings from this analysis can be used in climate model development. In general, if this is where the value of the paper lies, it would greatly benefit from connecting the different steps (methods and discussion) to the current state of research in climate and earth system

modeling (including the significance of these feedbacks and their uncertainty for earth-system modeling, e.g. Hickler et al. 2015 https://doi.org/10.1007/s40725-015-0014-8, Li et al. 2019 https://doi.org/10.5194/bg-15-6909-2018) . For example, how does the CO2 fertilization effect calculated in this paper compare to results obtained in modeling studies? How is the link between Ca and below-ground vegetation dynamics currently represented in models, and how might they benefit from the advances in this study?

Further remarks, some of them minor:

- l. 111: Please indicate the values for root respiration and the Q10 parameters.

- l. 142 ff: This is not necessarily the case. In the Guswa model, the relation of optimal rooting depth to P/EP is nonlinear and non-monotonic, with the greatest optimal depth calculated in conditions where water supply and demand are approximately equal.

- Eq. 15: please define beta.

- l.161: what exactly does “residual” mean in this context?

- Eq. 16: What are the units of S_Q_to_eCO2?

- l. 250: This average value by itself is not very informative, I suggest characterizing the distribution (mode(s) and range) in more detail (including a discussion of Fig. 4 b).

- l. 257 “has resulted”: I suggest making it clearer that this statement describes simulation results, rather than observations (as I understand it).

- l.288: did you mean “other factors including”?

- l. 320: which mechanism?

- l.337: I am not sure if the word “exaggerate” corresponds to the idea expressed by the authors. Maybe “exacerbate”?

- l. 340 “This suggests that the structural response. . .” This causal link is not immediately clear to me, please clarify

- Fig. 4 a,b,d,e: To avoid any confusion I think it is important to make clear that the data shown are the results of simulations, and not (as I understand it) based on observations.

- Fig. 5: What exactly is meant by “Q change induced by eCO2” (see my comment in the 3rd paragraph)?

- Fig. 6: The size of the error bars representing 1/10 suggests a great variability of these quantities among the different catchments. Consider using an alternative visualization method (e.g. boxplots or kernel density plots).

- Fig 6: some sentence of the caption refer to elements that I cannot see (viewing the PDF in Chrome on Windows): values in parenthesis; vertical grey dashed line.

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