



EGUsphere, author comment AC2
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Reply on RC2

Ivan Cornut et al.

Author comment on "Potassium limitation of forest productivity – Part 1: A mechanistic model simulating the effects of potassium availability on canopy carbon and water fluxes in tropical eucalypt stands" by Ivan Cornut et al., EGU sphere,
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This work by Cornut et al. developed a K biogeochemical model based on the relative benefits of two processed-based models (i.e. MAESPA and CASTANEA). A lot of work has went into this model development, and the authors splitted the work into two manuscripts, with the current draft focusing on carbon and water fluxes simulations, and the second draft focusing on growth limitation. I appreciate the reason to do so. In this review, I provide my comments specifically to the first part of their work.

We thank RC2 for his review and for approving our choice of splitting the work in two manuscripts.

In this manuscript, the authors described the mathematical formulations of the K cycle, the coupling of MAESPA and CASTANEA, and model parameterization and evaluation, including some sensitivity tests. Here, MAESPA served as the canopy model and CASTANEA served as the ecosystem C model. The rationale as to why to integrate the two models were well described (L143 – 155), but the details on how the two models were merged were quite lacking. For example, it's unclear how the 3-d structure of MAESPA was simplified into the 1-d structure of CASTANEA. It's unclear how leaf photosynthesis and transpiration of MAESPA was integrated with the light interception component of CASTANEA. Etc. Considering the vague information, I can't help but wonder if the authors actually ran both models but used the output of one to feed into the other. I suspect not, but I think the authors should further elaborate details on how the two models were merged.

We integrated the MAESPA model in the CASTANEA model to benefit from the detailed soil water balance on these deep sandy soils including water table dynamics, the hydraulic structure of MAESPA with water potential of roots and leaves, which drives the stomatal conductance, and the leaf photosynthesis model (which was itself very similar to the one in CASTANEA, base on the Farquhar model). On the other hand, light and rain interception, allocation and respiration routines from CASTANEA were conserved. For each 1D layer of the CASTANEA, transpiration and C assimilation was calculated using routines present in MAESPA (where they are used on voxels).

Furthermore, abstract can be improved, as in many places the results are vague. For instance: "Simulations showed that K-deficiency limits GPP by more than 50% during a

6-year rotation, a value in agreement with the literature". What level of K-deficiency limits GPP by more than 50%, and what does the literature say in terms of uncertainty range? Is it the same species and stand? Moreover, "The negative effects of K-deficiency on canopy transpiration and water use efficiency were also reported and discussed". Can you be more specific and describe some key results and implications? Moreover, "Litter decomposition processes were of lower importance". This sparks readers interest to understand why, and I think it's useful to briefly describe your understanding regarding this "lower importance".

Thank you for these suggestions for abstract improvement. We have found no information in literature about the uncertainty range. The level of K deficiency that leads to this reduction is a total omission of K fertilizer in eucalypt stands. This is similar to measured GPP reduction at these stands (Epron et al., 2012). For the low importance of the litter leaching of K this is due to the very fast transfer of K from litter to the soil which means that this process does not immobilize a big quantity of K. This will be clarified in the abstract.

Regarding the K cycle structure, I'm not sure how the mass balance for K was closed. The authors indicated that there are 7 pools of K, splitted into soil, soil fertilizer, litter, xylem, phloem, leaf and other plant organs. Can the authors describe how K was allocated in plants of different organ, and whether that matches with plant K uptake? In particular, I wonder why the authors did not consider allocation into root in their work? Did the authors consider the vertical growth of root and the associated K content at all? Furthermore, how soil K was mineralized and immobilized remains unclear. I suspect CASTANEA has a three soil organic matter pool structure for the soil component of the model, but this was not reflected in Figure 1. The process of plant litter entering soil and the associated biogeochemical processes should be better captured, or explained in the case of not included in this work.

We thank you for your comments. We can assure that the mass balance of K is closed (when considering fertilisation fluxes). This is not immediately visible in this manuscript but the allocation of K uptake to the different organs is described in detail in the companion paper Part 2 (Cornut et al., 2022). Allocation into roots was considered and was based on objective functions similar to the ones used in the G'day model (Marsden et al., 2013). The process of K from the plant litter entering the soil was a leaching process (Cornut et al., 2022). This was chosen due to the highly mobile nature of K (that stands in opposition to N and P dynamics in soils) and what we believe is negligible interaction between K and decomposition processes (Maquere, 2008). This was also one of the reasons (also due to the complexity of a soil K exchange sub-model) why soil K dynamics were very coarsely described in CASTANEA-MAESPA-K. These choices were sufficient for our study but could prove a handicap for genericity.

Furthermore, this work introduces the limitation effect of K on many plant and ecosystem processes. Obviously, as the authors introduced, there are other limiting nutrients as well. In the current model structure, the authors did not consider the interactive effect of the relative limitation of N, P and K. I wonder if it is useful to discuss some of the potential influences on these interactive effects, and the challenges to actually implement them in a cohesive modelling framework?

There is very little information pertaining to interactions between N or P and K. One could hypothesize a lower K demand when limited by N or P. N and P limitation might also lead to lower weathering in the rhizosphere (less enzymes being released, see N and phosphatases). We were also limited by the absence of a strong N or P limitation at our experimental sites. In the absence of these limitations modeling or testing for interaction

between N, P and K is difficult.

Specific comments:

L274" But there is a specific pool for bark, branch, so what K concentration did you assume for them?

This is explained in the companion paper (Cornut et al., 2022) . Briefly, we assumed concentrations from destructive biomass and nutrient dosing measurements conducted at different ages during the rotation.

L276: What do you mean by "very lose K release rates"?

Sorry this was unclear, we will reformulate as "very similar K loss rates".

L280: But K concentration in different plant organs are different, right? But in litter you assume a fixed concentration? How to close the concentration imbalance?

Sorry if this was unclear in the manuscript, the concentration in litter directly depends on the concentration of the falling organs (after remobilisation for branches and leaves). Every day the litter pool is updated by adding the K mass of falling organs (computed as the actual K concentration of the falling organ multiplied by its nbiomass) and removing the losses that take place by K leaching from the litter. This will be clarified in the manuscript.

References

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