Comments from Anonymous Referee #2

This very interesting modelling study presented by Maria Eliza Turek and co-workers examines the potential benefits of SOC addition to Swiss maize cultivation on crop transpiration.

The manuscript itself it nicely written and well-structured – the ideas behind the study are reasonable and well explained and the proceeding during the modelling approach is described in a clear way. The outcomes of the study show that there is a (small) benefit of SOC addition on water retention, and that incorporation into depths below 65 cm do not lead to additional gains for the presented Swiss sites.

However, I am a bit doubtful about the scenarios considered in this study. I understand that the addition of SOC in the topsoil is the main focus and certainly what will happen under adapted management practices. The subsoil so far is still kind of a debate and a lot of research is happening at the moment to better evaluate the importance and future of subsoil SOC under future agricultural practices and climate change. Some studies, however, already point out that an SOC enrichment in the topsoil is likely to go along with a (slight) depletion of SOC in the subsoil (and directly below the enrichment layer, respectively). However, this certainly is dependent on the agricultural measure and most studies (and meta-analyses) of recent years have focussed on tillage (e.g. Krauss et al. 2022: *https://doi.org/10.1016/j.still.2021.105262*; Meurer et al. 2018: *https://doi.org/10.1016/j.earscirev.2017.12.015*). Nevertheless, a recent study from Germany (Skadell et al. 2023: *https://doi.org/10.1016/j.agee.2023.108619*) showed that, averaged over a variety of management practices, SOC stocks still increase in the upper and lower subsoil. Still, the variation across the soil profile was very different between different management practices. If I understand the modelling correctly, the management was kept the same during the simulations, while the SOC content in the soil increases. I actually think that the presented scenarios are kept too simple and too optimistic. The authors should consider to extend them towards a potential "subsoil depletion" scenario.

> We appreciate very much the careful revision of our manuscript and the insightful suggestions that helped us to improve our work.

Some minor comments:

Figure 1: I assume that it is minimum and maximum temperature that is shown in the top panel?

> Correct, we added this information at the caption (lines 191-192).

- 249 – 261: do I understand correctly that no calibration and “only” validation was performed?

    Yes, we used the model without a calibration of the soil hydraulic parameters, because we wanted to use directly the results from the PTF’s and create reproducible scenarios.

- 272 – 277: I am not sure if “reduction factors” is a good expression here. My first thought was that the authors assume a reduction in SOC below the enrichment layer (which has also been shown in some studies, see studies above), but from what I understand from Table 4, so was simply the increase reduced. What about the increase of topsoil SOC at the expense of subsoil SOC (see my comment above)?

    We have considered this interesting point of reducing SOC at the subsoil as a consequence of adding SOC to the topsoil and performed a simulation where SOC was increased until 0-25 cm and a reduction of 0.1% was applied at the layer of 25-32 cm. We considered a scenario, where the soil had an 4% addition in the topsoil, while 0.1*4% were reduced in the layer below. The very small initial SOC (Table 2) did not allow much flexibility on the SOC reductions. For this particular soil and PTF, the results on transpiration did not differ notably from the scenario where only an addition of SOC was considered as shown in Figure 1 below. Therefore we elected not to present this as a separate scenario, but we added this point and reference to the targeted model run to the discussion, see lines 507-514:

    “A meta-analysis on effects of tillage on SOC (Krauss et al., 2022) has shown that a common effect is that the increase on SOC at the topsoil can occur with the depletion of SOC in the subsequent layer. With this particular soil and PTF tested, the hydrological effects of reducing SOC at the depth of 25-32 cm (results not shown) were almost identical to the scenario where the same amount of SOC increase in the depth of 0-25 cm was considered without subsoil SOC depletion (**Error! Reference source not found.**). We emphasize that, from the point of view of water availability to plants with deep roots, management strategies should aim for deep SOC increases.”

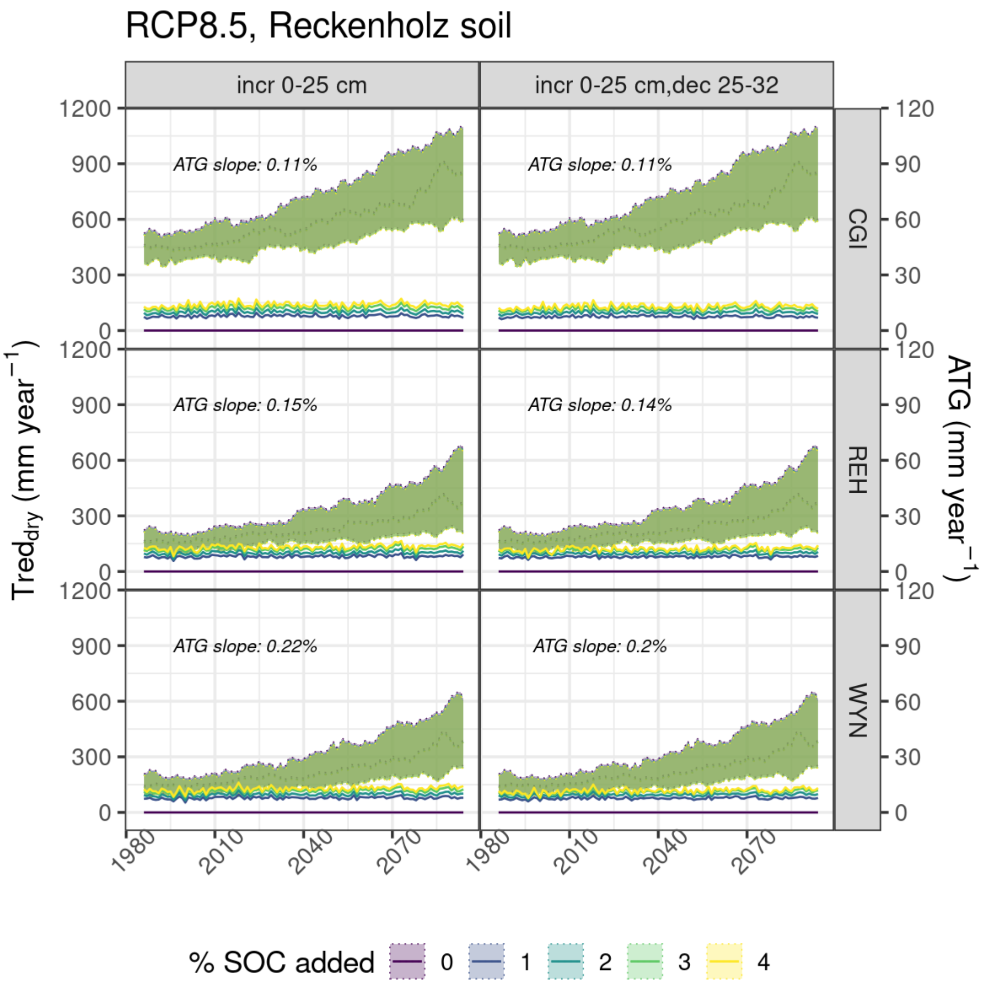

Figure 1: Transpiration reduction due to drought stress ($Tred_{dry}$) (left axis) for actual and future climate conditions considering different levels of SOC increase (left panel) and increase/decrease (right panel) in in the soil at different effective soil depths. Climate projections considering RCP8.5 and averaged for every 10 years. Shaded area refers to the values between (dotted) quantiles $q_{0.05}$ and $q_{0.95}$ of the climate projections. The slope refers to the average transpiration gain, ATG, (right axis; interpretable as average seasonal gain in transpiration with SOC increase) between 0 and 4% addition of SOC. *ATG slope* refers to the slope of the ATG line between 0 and 4% SOC addition.

- 337 ff: these results are interesting. However, does this mean that the authors assumed unlimited access to (ground-)water? What was the reduction if yield given the changes in precipitation (and certainly temperature) patterns?

  Groundwater availability was not considered in our simulations. The lower boundary condition at the soil profile was set as free drainage, which means a soil profile with deep groundwater levels. The bottom flux is driven only by gravity flow and the head pressure gradient equals zero. We added this information at lines 305-307:

"The bottom boundary condition was set as free drainage, representing a soil profile with deep groundwater levels."

About the yield, we added to the discussion at lines 558-567:

"In this study, we focused on transpiration reduction, which is likely to imply biomass reduction, but may not necessarily imply yield reduction – depending on the timing of water stress. Other studies have investigated impacts of CC on yields for grain maize in Switzerland (Holzkämper, 2020; Holzkämper et al., 2015a) and it was found that yield trends differ depending on the choice of varieties assumed to be planted. In our study here, we focus on drought impacts on crop transpiration alone. Subsequent yield formation will be affected by crop transpiration, but also by various other drivers (e.g. temperature & radiation limitations, timing of stresses, heat stress). The multitude of interactive effects would have prevented a clear view on the impacts of SOC increases on crop transpiration."

- 368 – 370: this is not clear to me. From what I understood did the authors rather assume a constant SOC level in the soil, but not a constant SOC addition – the latter would lead to a build-up over time. Or was the SOC level adapted annually within the model?

In this study, we consider generic scenarios of SOC increase without referring to particular management changes to achieve such increases. We assume that management has been successful to increase SOC from the beginning of the simulation period and SOC remains stable over the simulation period. The purpose of choosing these generic scenarios is to investigate which changes can be most beneficial for crop transpiration. We then discuss in section 6.2, which management options may be suitable to increase SOC. We clarified this in the M&M section, lines 282-284:

"We assumed that management improvements have led to increased SOC from the beginning of the simulation period and that SOC remained stable over the simulation period, thereby testing different scenarios of successful carbon sequestration."

- 475 – 477: yes, that´s an important point. How was this handled in the model? Did the roots reach a maximum depth/length?

  The model considers a maximum rooting depth that is allowed by the soil profile (135 cm) but the roots reach a maximum depth depending on the cultivar (100 cm).