Dear Respected Referee,

We would like to thank you for reviewing our manuscript. We value the suggestions and will try to address the comments to the best of our ability. A revised version of the article will be uploaded soon.
Here we have addressed the comments and concerns:

Comment 1: I preface this review in that I only have expertise on the fossil plant and geological timescaled environmental, climate and weathering implications of the research; I cannot comment in detail on the methods used to develop the model but these seem appropriate and well thought through. The parameters relating to geological factors such as weathering and soil carbon dioxide match my understanding of the subject. it would be important to get feedback from a climate modeller on the paper.
This is an interesting paper that develops a model for the weathering of lycophytes in modern and ancient environments to interpret their environmental and potentially climatic significance. The approach is novel and appropriate, generating what appear to be important implications. Overall, I like this and think the underlying research is solid, but conclude the paper needs to be revised before it is suitable for publication to address a number of points. The absence of up to data and correct information on the early evolution of Lycophyta in the Paleozoic is a problem that leads to incorrect statements being made in various places in the paper. My feeling is that the paper would benefit dramatically frombeign revised by a palaeobotanist with knowledge of Paleozoic plant in order to correct that aspect of the work as it underpins the rationale for the research. As it is, if the introduction was re-done as outlined below it would be better. It would also benefit from further editing of the language to improve the readability.

Response: The article aims to address the research gap in understanding the effects of Lycopsids for today's climate. Several citations and information will be updated in the upcoming version in order to avoid providing misleading information. We have considered the suggestions in order to provide accurate palaeobotanical evidence.

Comment 2: The principles of the model seem appropriate and these are easy to follow, but some further clarification on specific parameters would be helpful. The results are great as are the conclusions, but both sections could make greater comparisons to the rock record to compare to past conditions. As it is, the paper aims to design a model suitable for the geological past and present, but the results and conclusions only really deal with the present so there is score to expand this. In the Devonian, Lycophyta were key components in terrestrialization and biogeochemical cycles, as well as being geo-engineers. There is ample scope to introduce these concepts to enhance the impact and implications of the research.

Response: It is true that the current article focuses on simulating today's potential effects of Lycopsids on weathering. This is necessary precondition, in our opinion, to provide estimates for the geological past. The application of the model to the past, namely the Devonian, however, requires further comprehensive work and is thus beyond the scope of the paper. We plan to carry out these simulations in a follow-up study.

aims to provide a motivation for the study but delves into effects of the Lycopsids for the present. There will be a following article encompassing their effects for the past namely, Devonian.

Comment 3: Specific points:
Lines 11-14. Poor grammar, please revise.

Response: In the revised version, we will state instead:
‘Hence, as a first step, a process-based model is developed to estimate net carbon uptake by these organisms at the local scale. The model includes key features such as distribution of biomass above and below ground, along with a plausible root distribution in the soil affecting water uptake by plants. The stomatal regulation of water loss and its immediate implications for photosynthesis are considered. Moreover, root respiration plays a crucial role in the model by affecting soil carbon dioxide and weathering rates.’

Comment 4: Line 31. The citation to Foster et al. (2017) is disingenuous to the pioneering works on this topic by R. A. Berner, that should be cited here as this is still widely accepted as correct.

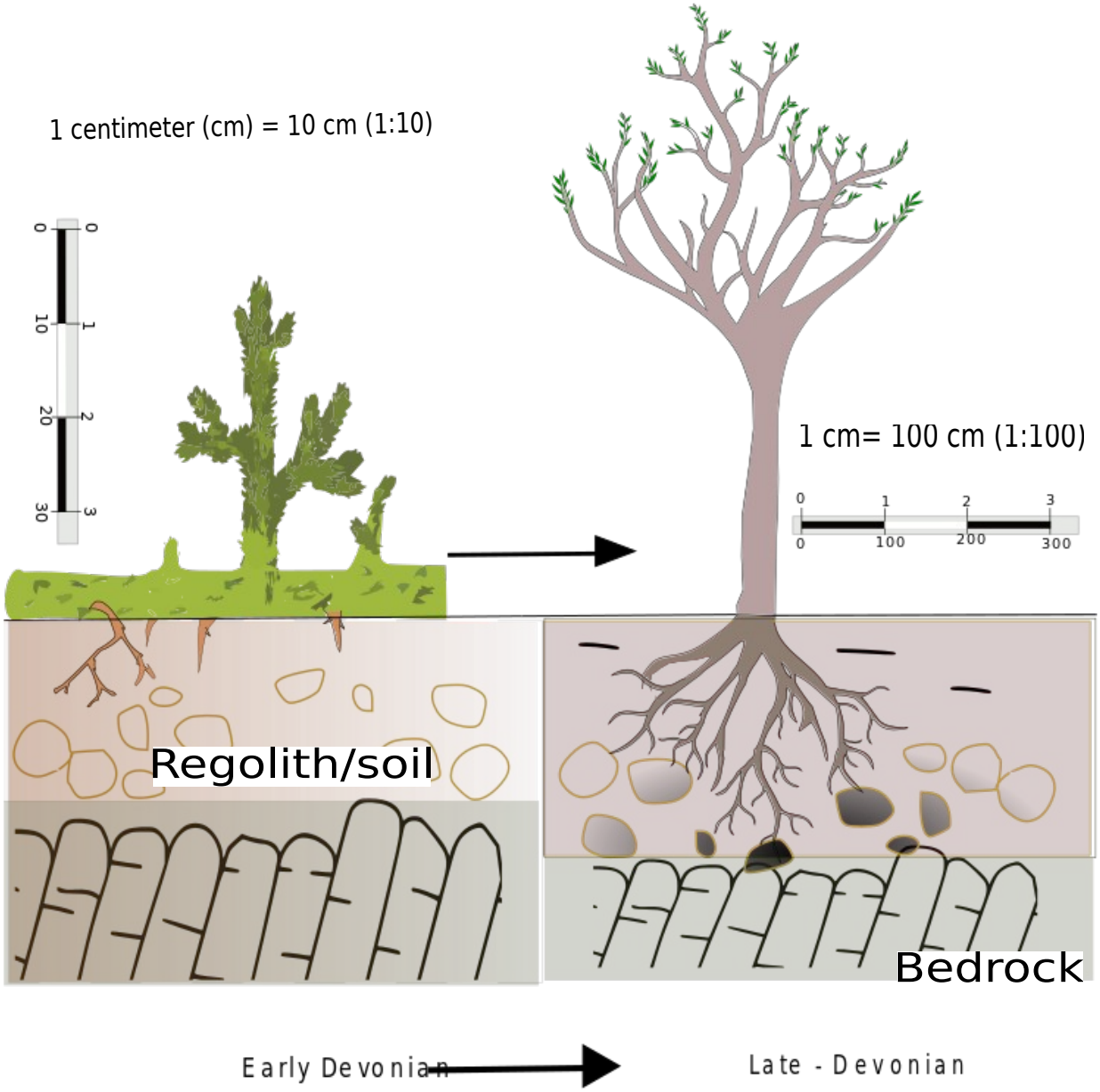
Response: The works of R.A. Berner will be cited in the revised version of the article.

Comment 5: Lines 35-41. Lycophytes are one of the earliest forms of vascular plants and not THE oldest form. Also, there is no macro-fossil evidence for lycophytes dating back as far as you report; the papers by Steemans et al. and Rubinstein et al. are inappropriately synthesized and mis-quoted, with both showing no pre-Devonian evidence of lycophytes. The present authors confuse Embroyphyta or Tracheophyta which have pre-Devonian evidence, with Lycophyta. This section needs fundamentally revising and appropriate references using – see for example Gensel (2017) Fern Gaz. 20(6): 217-242 and Servais et al. 2019 I Palaeogeog., Palaeoclimatol., Palaeogeog., 534: 109280. The conclusions of Qiu et al. and Wicketts et al. presented are based on clade dating approaches that have no substance in the fossil record – these plants do not go back that far in time.

Response : This point has been noted and modified already according the previous posted referee comment. Our primary aim is to provide a broad underlying reasoning for the choice of our parameters in the model. The parameterization of the model uses broad range of plants including Zosterophyllopsida which is considered to be a sister-group to lycopsids. In the model, we look to incorporate a broad range of species that existed around 410 million years ago. This is done to incorporate bio-diversity and include closely-related species. It is with the same reasoning *Embroyphyta* was initially included but have been excluded. This will be looked into in details to avoid any misinformation.

Comment 6: Figure 1 – please put a scale bar that is easy to comprehend with mm and cm clearly shown. This is very confusing. Also in figure 1, what about regolith/soils? Bedrock looks broken up – why not have solid bedrock rather than round lumps floating in nothing? Compare with the rooting model of Algeo and Scheckler (1998) for added context and content.

Response: A revised version of the figure 1 with better scaling system and regolith has been generated. An updated version of the representative figure below will be used for the purpose. Since the detailed root structures are beyond the scope of modelling work, we would like to stress on the fact that these diagrams are representative and are for illustrative purposes only. This illustrative figure is inspired from the works of *Algeo and Scheckler (2012)*



Comment 7: Lines 52-76. This is good but lacks reference and inclusion of key information from Algeo and Scheckler (1988) and Elick et al. (1998) that should be included.

Response: In the latest version the works of Algeo and Scheckler (1988) and Elick et al. (1998) have been incorporated. The close association of weathering by early vascular plants has been well explored in the studies and we would like to thank you for mentioning them.

Comment 8: Lines 65-71 – needs citations to primary sources of information.

Response: The upcoming version will substantiate the information with proper citations making the article robust and reliable.
'Roots were not the only suite of innovations from these kinds of plants, they further developed stomatal control (Kenrickand Strullu-Derrien, 2014; Brodribb and McAdam, 2011) of water loss to be able to photosynthesize under adverse climatic conditions which might have given lycophytes yet another advantage over their contemporaries. The evolution of stomata followed the innovation of roots closely, around 400 million years before the present (Chater et al., 2011; Ruszala et al., 2011). Water loss and NPP are regulated by the opening and closing of stomata (McAdam and

Brodribb, 2013). By changing the aperture of the stomata, plants inhibit water loss to prevent desiccation, at the cost of reduced photosynthetic productivity. The combination of adjustable stomata with an internal water transport system i.e. vascularity, was a turning point in plant evolution that might have enabled vascular plants to invade most terrestrial environments, tolerating water stress and exploiting favorable conditions (Raven, 2002).'

Comment 9: Line 101 – lycophytes were not abundant in the Silurian – see comment above.

Response: Although the lycophytes were not abundant in the Silurian, it is certain that their origin can be traced in the Silurian. The above statement has been revised and rewritten asserting Late abundance of lycophytes in the Late Devonian period.

research and has been duly noted the change in timeline has been implemented.

Comment 10: Line 104 – all Paleozoic lycophyte genera and species are now extinct.

Response: It is without doubt that the extant lycophyte species are different from those which existed in the Paleozoic. It is therefore hard to gather information and this poses a unique challenge to our research. Nevertheless, the impacts of existing lycophytes on biogeochemistry can, in our opinion, be used to approximate the potential impacts of their predecessors on the Devonian climate.

Comment 11: Lines 126 – VPD vs. soil water content and potential evaporation; many lycophytes lived in saturated soils so had abundant aerenchyma in their roots – does this affect your model?

Response: The current article focuses on extant lycophytes under various environmental conditions and hence does not incorporate the special case of the effects of arenchyma tissue. Our current scheme accounts for stomatal control depending on the average climatic condition and atmospheric water demand of the immediate surrounding. This is done for the extant lycopsids under current atmospheric conditions.

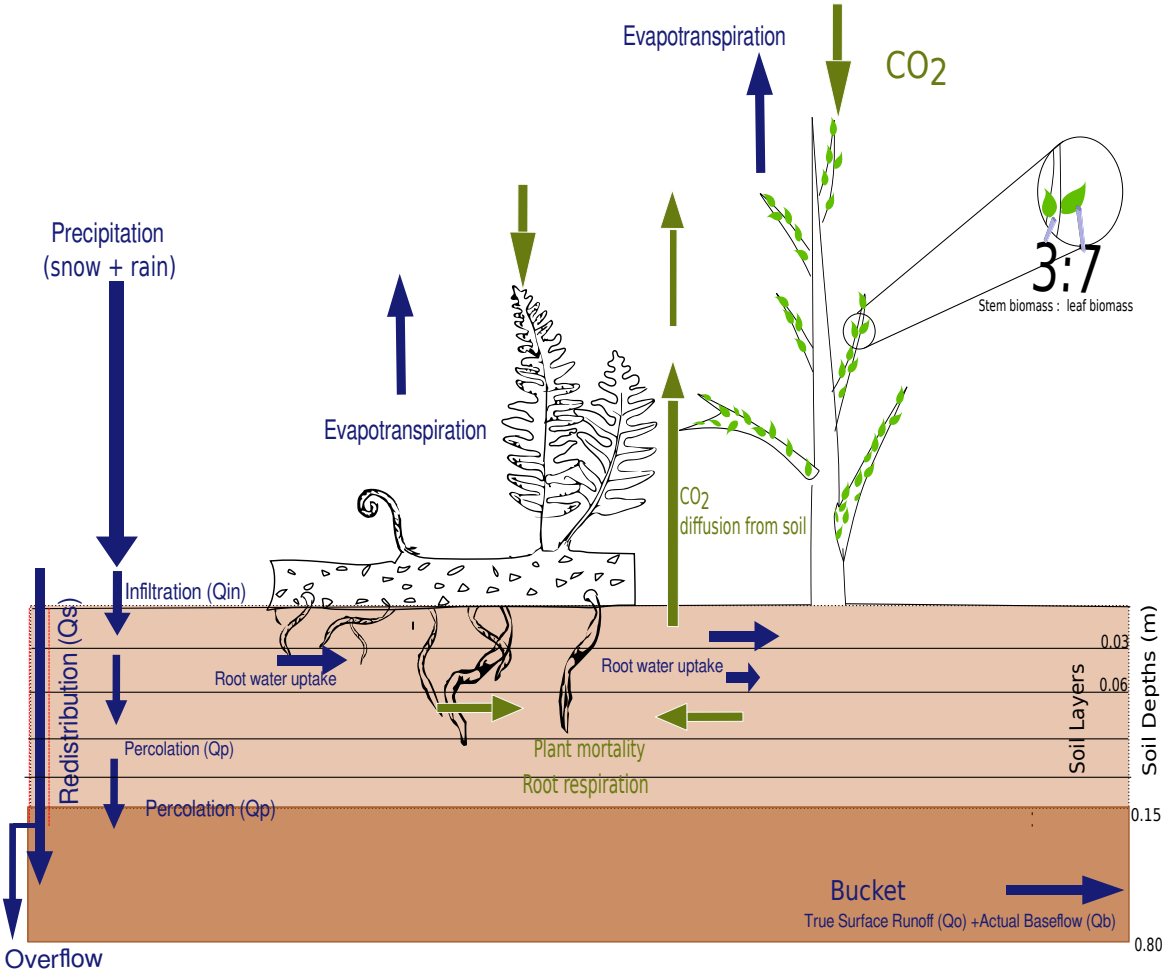
The aerenchyma plant tissue is primarily a feature of plants in stress under hypoxic condition. The implication of such tissue is hard to incorporate in our model since these tissues are primarily responsible for Oxygen transport to the root. This hardly affects the potential evaporation or photosynthesis which is our main focus here and hence does not affect the current model. Oxygen limitation of roots may be incorporated in later versions of the model.

On the other hand, the presence of such tissue would mean a easier release of CO_2 from the soil, which we can incorporate by increasing carbon dioxide diffusion from soil to the atmosphere. The feature will be taken into consideration while simulating for the Devonian and hence a simple scheme of faster diffusion should be enough to capture the implication of such tissues.

Comment 12: Line 128 – there were no lycophytes in the Silurian, so this aim is misguided – no point in reconstructing what wasn't there. Work on the Devonian.

Response: This article primarily lays the foundation for a global version of the model with a motivation to extend it for the past. It is important to focus on the period when the Lycophytes thrived in abundance and hence we shall focus on the time-period around 410 million years ago (Early Devonian).

Comment 13: Figure 2 – nice – but really needs to be two parted showing the horizontal form as in figure 1 as well.



Response : The purpose of the figure is to provide a synopsis of the primary processes devised in the model. The Figure 2 is for pure explanatory purpose. The model does not currently distinguish between an upright or horizontal lycophytes. The updated figure will hopefully provide clartiy and help in a better understanding of the model.

Comment 14: Lines 130-135 – the LYCOm model depicts lycophytes as comprising organogrpahically distinct stems and leaves. See recent paper by Hetherington et al. (2021) that shows the basal lycopsid Asteroxylon had three kinds of axes in the body plan; leafy shoot axes, root-bearing axes, and rooting axes. This information is key to understanding the actual plant and needs to be incorporated into the present manuscript. How do your two organs compare or map onto the three of Hetherington et al?

Response: A model as simple as LYCOm provides us with a limited opportunity to incorporate a detailed structural representation of plants in real life. The most important aspect of the Dynamic Vegetation Model (DGVM) is to try and include the processes impacting the Carbon balance and its products. The current state of the model distinguishes between below and above ground biomass, with further division of above ground biomass into leaves and stem. The allocation of the carbon is subject to limitations in water, CO_2 as well as light. The root allocation with soil depth is in agreement with most terrestrial biomes. The earlier works of Dr. Alexander John Hetherington contributed to the understanding of the rooting structure and key features while implementing it in our LYCOm. The works of Hetherington et al. (2020) is impressive and makes our model assumptions robust, but at the same time does not compromise the model performance or outcome.

Comment 15: Lines 348-353 – readjust to the Devonian period. There were NO lycophytes in the Ordovician.

Response: This point has been noted and will be reflected in the latest version of the manuscript.

Comment 16: Table 1 – please show where individual range values come from for each parameter. This is key to the model, but the sources of data are not explicit for those not referred to an Eq. in the paper e.g. fracTransm, VCm, Vom, EactKc, EactKo, EactKm, EactKj.

Response: The sources of the data will be mentioned in the upcoming version of the manuscript with explicit references.

Comment 17: Results – nice – but figure 4 is missing in the version I reviewed. However, I would like to see comparisons to values for weathering rates in geological time – how do your results correlate to similar conditions in the Palaeozoic, returning to your aim to understand the impact of early lycophytes on climate and environment.

Response: Since the current focus is today we have drawn comparison from the articles exploring the present weathering scenario. The comparison with the Palaeozoic weathering will only be fair when we run the model for Devonian. The model isunder constant development and will be extended for a global paleo-simulation soon.

Comment 18: Conclusions – no mention of relevance or implications to the fossil record. Great for the model, but otherwise disappointing.

Response: The LYCOm model draws in information from fossil records as it helps in setting the physiological limitations of the extinct species. Modern lycophytes, such as terrestrial lineages of the Lycopodiaceae, maintain some degrees of functional and morphological conservatism with respect to Early Devonian herbaceous lycopsids and their fore-runners. On this basis, modern lycophytes can be used as a suitable analog system for widespread elements of Early Devonian plant communities. This model therefore can be applied toward investigations targeting weathering dynamics in early terrestrial ecosystems. This implication of the model to the fossil record is imminent and we therefore try to explore the past using information from such records.

Comment 19: Missing key references
Algeo, T. J., Scheckler, S. E., 1998. Terrestrial-Marine Teleconnections in the Devonian: Links between the Evolution of Land Plants, Weathering Processes, and Marine Anoxic Events. Royal Society of London Philosophical Transactions (B): Biological Sciences, 353: 113–130
Algeo and Scheckler (2012) Land plant evolution and weathering rate changes in the Devonian. Journal of Earth Science 21, 75-78.
Elick et al., 1998. Very Large Plant and Root Traces from the Early to Middle Devonian: Implications for Early Terrestrial Ecosystems and Atmospheric P(CO2). Geology 26: 143-146.
Hetherington and Dolan (2017) The evolution of lycopsid rooting structures: conservatism and disparity. New Phytologist 215: 538-544.

Hetherington et al. (2020) An evidence-based 3D reconstruction of Asteroxylon mackiei the most complex plant preserved from the Rhynie Chert. 2021;10:e69447 DOI: 10.7554/eLife.69447

Response: These key citations have been compiled in the latest version.

We look forward to hearing from you in due time regarding our submission and to respond to any further questions and comments you may have.

Yours Sincerely,
Suman Halder