Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., referee comment RC2
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Comment on gmd-2021-202

Anonymous Referee #2

Referee comment on "A dynamic local-scale vegetation model for lycopsids (LYCOm v1.0)" by Suman Halder et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-202-RC2, 2021

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.

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 th 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.

Specific points:

Lines 11-14. Poor grammar, please revise.

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.

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.

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.

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.

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

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

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

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?

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.

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

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?

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

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.

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.

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

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