

Reply on RC1

Marijn van der Meij

Author comment on "Evolutionary pathways in soil-landscape evolution models" by W. Marijn van der Meij, SOIL Discuss., <https://doi.org/10.5194/soil-2021-133-AC1>, 2022

Dear reviewer,

Thank you for your extensive review of my manuscript and suggested points for improvement. I especially appreciate the concept of inherent and manageable soil properties, that you address in your first comment. This distinction helps me to indicate how soil-landscape models (SLEMs) can support current-day soil management. This is not only valuable for this paper, but also for other works that I have planned.

I respond to your comments below. Your comments are printed in italic and with bullet points.

- *This short manuscript compares mechanistic soil landscape evolution modelling (SLEM) to the theoretical evolutionary pathway approach and discusses the complementarity of the two approaches with as initial idea that evolutionary pathways could be an efficient tool to summary the modelling results and thus better communicate. The demonstration is made on modelling results from an already published study (van der Meij et al., 2020) that are reinterpreted here in term of evolutionary pathways for two soil characteristics: the depth of the Bt-horizon and the soil organic matter (SOM) stock. The work demonstrates that evolutionary pathways of these two soil characteristics differ due to differences in dynamics of these two characteristics. This idea could however have been pushed forward clearly introducing another concept of the soil sciences: the inherent and manageable soil characteristics as defined by Dominati et al. (2010) among others; depth of the Bt-horizon representing the inherent characteristics and SOM the manageable ones.*

Response: Distinguishing between inherent and manageable soil properties is indeed valuable when comparing different soil properties, especially in the context of ecosystem services. SLEMs are able to simulate the development of inherent properties, such as soil texture, soil depth and slope profiles, as well as some manageable soil properties, such as carbon stocks. I will introduce this distinction in a few sentences in the Introduction and elaborate on the use of evolutionary pathways for evaluating inherent and manageable properties in the Discussion.

- *In addition, the potentiality of evolutionary pathways to be used as a communication tool should be specified, notably by clarifying toward which community this*

communication is thought to. Indeed evolutionary pathways are a convincing tool to sum up the SLEM results but they are not easy to understand and thus probably not suitable to communicate with most of the soil end-users.

Response: As you rightly point out, I indeed didn't specify to which audience the SLEM output should be communicated, while I do mention in the abstract that evolutionary pathways are promising tools to communicate soil model output.

The work in this paper, where I use evolutionary pathways for analysing soil and landscape evolution, is probably most interesting for the scientific community that wants to get a better understanding of soil development and soil-landscape variability. Evolutionary pathways can also be used to analyse the results of other soil models, for example models that evaluate the effect of different soil and land management strategies on manageable soil properties. In that case, the results will also be of interest to policy makers and designers of soil and land management strategies.

I will briefly elaborate on the target audience in the Discussion of the manuscript and link this Discussion to the point raised above, about inherent and manageable soil properties.

Out of these two main comments, the manuscript is very well written and easy to read and follow. I added detailed comments below to be addressed. Once these comments addressed, I think that this manuscript is worth publishing in SOIL.

Detailed comments

Method section

- *Model study. This is the summary of a study published elsewhere. The presented model does not contain weathering processes at all, which can be a severe limitation when used over 15 000 years. I recognised that the aim of this manuscript is not to discuss the model. I nevertheless think that this limitation should be mentioned in this section and discussed in the evolutionary pathway section of the discussion line 153.*

Response: In the modelling study, we decided to adopt a simplified advection-diffusion equation for the clay translocation process, that matched the reduced complexity of the model. This process description was able to reproduce measured clay-depth profiles and did not require the simulation of weathering processes. For future modelling studies, we will reconsider including weathering processes, because weathering can indeed be an important process for generating clay particles through breakdown of particles or clay neoformation, especially over such long timescales.

I will elaborate in Section 2.1 on the processes that were and were not included in the model, also following comments from Referee #2, and I will mention the possible effects of leaving out weathering in the Discussion.

- *Evolutionary pathway. Please add the units used in the different equations*

Response: The units of the equations are the change in the property units over time. For the SOM stocks, this means the units are $\text{kg m}^{-2} \text{a}^{-1}$ and for the depth to Bt the units are m a^{-1} . I will add a sentence at the end of Section "2.2 evolutionary pathways" where I mention the units.

Results

- *Page 5 line 119, replace "the complexity" by "it" to avoid useless repetitions.*

Response: I will change the wording following your suggestion.

- *Page 7 lines 133-137, these statements seem to be true mainly for the depth of the Bt-horizon.*
- *Same page, lines 137-138, on the opposite, this statement seems to be true mainly for SOM.*

Response: Based on your comments and the comments of Referee #2, I will rewrite this Section. I will better explain the differences between the natural and agricultural phase for both soil properties.

- *Same page, sentence lines 142 to 145, please refer to figure 2 (more appropriate than figure 3).*

Response: I will add a reference to Figure 2 for the first sentence of this comment. For the second sentence, I believe Figure 3 better illustrates the point that I want to make. Moreover, I will move this sentence to the Discussion, based on comments of Referee #2.

- *Same page, lines 145-146, add "for SOM" after "new steady state" and "for the depth to Bt" after "a steady rate of change".*

Response: I will add the text you suggested.

Discussion

- *Page 8 line 161. A reference to results found in van der Meij et al. (2020) is made. This should be extended to be clearer to the reader as I had to go to that paper to understand. It presents semi-variogram and when the statement seemed clear to be for SOM, it is not so much the case for the depth of the Bt horizon.*

Response: I will remove the reference to the Figure in the accompanying paper and rephrase the sentences, so that they are now based on the results from this study.

- *Same page lines 172-173, this statement mainly apply to manageable soil characteristics according to the present study. See comment above.*

Response: I will address the effect of humans on manageable and inherent soil properties after this sentence.

Figures

- *1. Please don't use the acronym in the figure title so it can be understood by itself*

Response: I will write the acronym SLDS in full in the Figure caption.

Reference cited

Dominati E, Patterson M, Mackay A (2010) A framework for classifying and quantifying the natural capital and ecosystem services of soils. Ecological Economics 69, 1858-1868. doi:10.1016/j.ecolecon.2010.05.002