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Interactive comment on "Modelling dynamic interactions between soil structure and the storage and turnover of soil organic matter" *by* Katharina Hildegard Elisabeth Meurer et al.

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Summary

The study contributes a new model on the dynamical between feedback soil organic matter (SOM) decomposition and soil aggregate structure. Like other models it employs the concept that the addition of low-density organic matter modifies both, the soil layer thickness, porosity, and the bulk density, but is the first study to my knowledge to explicitly discuss this feedback. It explicitly models retardation of of SOM decomposition by aggregation and associated micropores. The approach is demonstrated using a simple parsimonious SOM model at pedon scale with a sensitivity analysis and

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a model calibration to a long-term field study. It will be a welcome contribution to the SOM modeling community. I enjoyed reading the manuscript. It is well written and the logical flow is clear to me. The study could be made stronger by including a simulation/calibration without the feedback and comparing the improvements between the two versions.

General comments

I missed a discussion on implications and results on whether the presented feedback is important for understanding or prediction of SOM dynamics or model structure. The authors showed that the relatively simple model could already predict differences in SOM and soil structure by different inputs. However, to what extent could this also be modeled without SOM influencing the soil structure? Although the paper holds enough new insights to be published, I encourage the authors to take the extra work to compare to a model version where the feedback is switched off. For example by calibrating time-constant bulk densities and parameters to the three input-scenarios.

The conclusions currently read more like a discussion. They could be sharpened to what readers should "take home" for their work from this study. What are the most important parameters and feedbacks that you think they need to consider in their experiments and studies?

There are already models that let SOM decomposition affect soil structure. For example in the model of Ahrens et al. 2015 (see also Yu 2020 eq. S28a) SOM dynamics affects bulk soil density and soil volume and this in turn affects modeled concentrations, changes in soil volume, and transport processes. They applied the same concept of Federer 1993 as in the current manuscript, but incorporated many more processes so that this feedback was not explicitly discussed. The present manuscript additionally partitions micro- and mesoporosity and models protection by aggregation. A little comparison in the discussion or introduction would be nice.

P4L103: The authors argue that macropores probably are only a minor balance of

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SOM balance. Contrary, some researchers think, that macropores are a hot spot of SOM turnover and together with the rhizosphere are the most important places to study. Especially for systems with active earth worms this has been shown (e.g. Don et al. 2008).

eq. 7 and 11 seem to both add volume and additional pore space with addition of OM. In an alternative mind model putting dissolved organic matter or root exudates into soil would partly fill up existing pores. Please, add some explanation of assumptions to this part.

I miss a paragraph how the model was integrated in time. I assume an explicit time (Euler forward) step much lower than the 5 years of distance between observations. How did you track the changes in soil depth (eq. 12) in the comparison to data?

Minor comments.

The discussion at p3L55 argues about soil structure affecting SOM dynamics. If one could show that it is not only affecting fast pools, then this argument could be made even stronger to affecting SOM stocks and soil carbon sequestration.

The font sizes in the figures are often very small, which makes it difficult to read the print-version.

eq.5 and 6: Why is there a factor of 1/2?

Please, check consistency of mathematical symbols. E.g. delta.z_min is sometimes written with min as subscript and sometimes with parenthesis (Table 1) denoting density gamma_o and gamma_m or gamma_org and gamma_min. F_text_mic or F_mic_text (fig. 6).

p6L165: Parameter f_agg is introduced here. To my reading its quite an important parameter. I recommend explaining it (here or somewhere) in more detail. Does it correspond to the porosity of the volume occupied by organic matter?

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eq 21-24: please, use a different symbols at the left hand side than in (19) and (20) to denote the quantities to use assumption of f_som = 0 r f_som = 1.

Sect 3.2: Given the 5 years interval of SOM measurements the non-identifyability of the fast turnover pool is expected. Could you think of additional observations or sub-experiments that could inform the shorter time scale?

Sect 3.2. The mixing ratio was quite influential in Table 1. I assume in the identifyability analysis it correlated strongly with other parameters - which ones? Could this lead to potential model simplifications?

P11L335: "root litter input was distributed uniformly across depth". What do you expect to be the effect of distribution root litter input with an exponentially decreasing profile? How do you treat partitioning of given total root input to the modeled top soil and the non-modeled lower depth?

Fig 1: The dotted regions were not visible in my printout. Please adapt the pattern.

Fig 2: The placing of the braces confused me. Vor micropores its at the maximum pore diameter for mesopores the lower boundary of the upper brace coincides with the blue line. To my understanding it should instead coincide with he red line at the upper diameter.

Fig 3: Cannot read the subscripts in this figure. Please, adjust the font sizes. (Also in the other figures)

Fig 8: I had to search for the difference between left and right panel. Please describe in the legend or make the font of the years 1997 or 2019 more prominent.

Fig 9: Figure headings (bare fallow, manure) in addition to the legent would help the reader.

References

Ahrens B, Braakhekke M, Guggenberger G, Schrumpf M & Reichstein M (2015)

Contribution of sorption, DOC transport and microbial interactions to the 14C age of a soil organic carbon profile: Insights from a calibrated process model.Soil Biology and Biochemistry, Elsevier BV, 88 , 390-402 10.1016/j.soilbio.2015.06.008 suppl: https://ars.els-cdn.com/content/image/1-s2.0-S0038071715002138-mmc1.pdf

Yu L, Ahrens B, Wutzler T, Schrumpf M & Zaehle S(2019)Jena Soil Model: a microbial soil organic carbon model integrated with nitrogen and phosphorus processes.Copernicus GmbH, 10.5194/gmd-2019-187

Don A, Steinberg B, Schöning I, Pritsch K, Joschko M, Gleixner G & Schulze E(2008)Organic carbon sequestration in earthworm burrows.Soil Biology and Biochemistry, Elsevier BV, 40 , 1803-1812 10.1016/j.soilbio.2008.03.003

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