Dear Editor,

We the authors would like to thank the anonymous Referee #2 for the critical and valuable review of our manuscript "Evaluating sensitivity of silicate mineral dissolution rates to physical weathering using a soil evolution model (SoilGen2.25) ". We have gone through all the comments and taken into account most of the suggestions. We have replied to each of the comments (see below) and some of the suggestions/corrections were directly made to the manuscript. We hope that our responses and the revised manuscript will address some of the issues that seemed unclear.

Anonymous Referee #2
Received and published: 20 October 2015

The m/s "Evaluating sensitivity of silicate mineral dissolution rates to physical weathering using a soil evolution model (SoilGen2.25)" by Opolot and Finke addresses the impact of various soil-forming processes, specifically the physical weathering, on the silicate mineral dissolution. The authors have followed up their previous work Finke (2012) and presented the sensitivity analysis in this m/s. Despite some interesting results from the sensitivity analysis, the overall contribution of the m/s is limited. Some results and figures have directly been lifted from Finke (2012).

Remark: Additionally, authors claimed to assess the impacts of intrinsic (mineral composition, mineral surface area) and extrinsic factors (climate, physical weathering, clay migration, plant uptake, hydrology) on silicate mineral dissolution rates, but they have evaluated only the effect of parent materials and soil texture. I feel that this m/s has a potential for getting published in Biogeosciences, but more work is needed.

Reply: This statement is not entirely correct. The timespan covered by the simulations (15000 years) covers a range of climates and associated vegetation types. Physical weathering, clay migration and plant uptake respond to the changes in climate and thus affect silicate mineral dissolution rates via effects on pH and texture. The parent material was varied independently because it was a constant at the Zonian forest site and this was undesirable. So we claim that the integrated effects of all soil forming factors are taken into account in model B.

Remark: I suggest that authors should demonstrate the validity of their assumptions and model in a chronosequence site, before describing the sensitivity analysis.

Reply: In Sauer et al (2012) the SoilGen model was applied onto chronosequences (start of soil formation between 11050-2100 BP). The conclusion was drawn that model quality was fairly good, although with differences between output parameters, and that quality was not decreasing with older soils. Thus, the suggestion was already implemented.

Sauer, D., Finke, P., Sørensen, R., Sperstad, R., Schülli-Maurer, I., Høeg, H., and Stahr, K.: Testing a soil development model against southern Norway soil chronosequences, Quaternary Int., 265, 18–31, 2012. http://dx.doi.org/10.1016/j.quaint.2011.12.018

Some specific comments are as follows:

1. Line 18, page 13890 – what are other soil forming processes?

Reply: 'Other soil forming processes" will be changed in the revised manuscript to "physical weathering, clay migration, carbon cycling and plant uptake"

2. Line 1, page 13891 – change asses to assess

Reply: "asses" will be changed to "assess" in the revised manuscript

3. Line 15-17, page 13891 – "the measured soil data (Finke, 2012; van Ranst, 1981) and other reconstructed model input data (Finke and Hutson, 2008) were readily available for this site." Then, why authors did not test their model on this soil?

Reply: we did, and also referred to the test results in the text. See also fig. 4b with simulated versus measured results for clay content.

Why did they resort to random sample textures from the USDA textural triangle? I wonder if authors let their model spin up with no clay and no silt (as initial conditions) what will happen? Will their model come to any of textures selected from USDA textural triangle?

Reply: starting with 100% sand will produce silt- and clay sized fragments. We could do such run, excluding processes that move finer particles, thus with model A, to demonstrate that this is possible. But we wonder why this would be interesting to do?

4. Line 19, page 13891 – change to - objectives (1 and 2) of this study are

Reply: this will be changed in the revised manuscript

5. Line 3, page 13895 and Line 6, page 13896 – Eqs 3 and 6, do they have different notations for i?

Reply: Line 6 pg 13896 is Eq. 5 and i in this equation denotes element in the mineral and this equation is not related to equation 3.

Eqs. 3 (Line 3, page 13895) and 6 (Line 17, page 13896) indeed do have a relationship. In eq. 6 only the texture classes clay-silt-fine sand-coarse sand are used; in eq. 3 the class boundaries are (in micrometers): 2-4-8-16-32-64-128-256-512-1024-2048. Thus several "i" in equation 3 combine into each one of the classes in eq.6.

6. Lines 11-15, page 13891 – "pH is generally higher in basalt and peridotite parent materials than granite but only in the first 5000 years of simulation (i.e., up to 10 000 years BP). The trends are however reversed in the subsequent years especially in Model A." What do authors mean by reversed trends? Does it mean pH is higher in granite after 5000 years?

Reply: Lines 11-15, page 13891 should be Lines 11-15, page 13900 I suppose according to the statement referred to by the reviewer.

Yes, for model A it does mean that pH in granite becomes slightly higher. For model B this is hardly the case.

7. Lines 2-4, page 13891 – "The higher dissolution rates (especially in the beginning) of albite and K-feldspar observed in granite compared to basalt and peridotite could therefore be due to lower pH observed in granite than in Basalt and Peridotite at that point in time" These two statements (above) contradict each other.

Reply: Lines 2-4, page 13891 should be Lines 2-4, page 13903 based on the statement referred to by the reviewer.

No, the statement referred to in comment 6 concerns 10000 BP and more recent, the one in comment 7 refers to the beginning of the simulation period.

8. Section 3.3.4 – It is not clear how interactive effects of selected soil forming processes on chemical weathering rates were evaluated. Was it done – one factor (process) at a time? Which period was chosen to evaluate the effect for each soil forming process?

Reply: the soil forming processes cannot been seen in isolation. For instance, clay migration can only occur if clay is present. This clay needs to be produced by physical weathering. Thus, not 1 process was added at a time but difference was made between "physical weathering only" and "all soil formation processes included". We define these two cases as model A and model B (Line 7-16, page 13892). So in model A, we deactivated clay migration, bioturbation and carbon cycling processes and only kept physical weathering active. While in model B, we kept all the three processes active. Both models were then run with the same input data and for the same period of time (15000 years). The difference between the two models would then illustrate the effect of physical weathering. Model B is actually meant to explain the interactive effect of all these processes.

9. Page 13916, Table 1 – provide names of the classes selected from the USDA textural triangle. Also, provide a reference for the USDA classification.

Reply: OK, good suggestion.
Names of the texture classes and a reference for the USDA classification will be provided in Table 1 of the revised manuscript

10. In Table 1, how do you justify clay % more than 44, 67, 80 at the beginning of the simulations? It seems a fully developed soil, which may be at quasi-steady state. It may be interesting for readers to know the texture at the end of simulations (after 15,000 years).

Table 1 (page 13916) has no Clay % more than 44, 67, 80 as indicated by the reviewer, perhaps the reviewer meant to say Sand or Silt % which actually has these values mentioned by the reviewer. Thus the comment is not valid. Additionally, it is possible to extract the texture at the end of the simulations from the model output, but the soil formation model produces a texture distribution with depth and so not one texture value can be given at final stage.

11. Page 13917, Table 2 needs references.

Reply: Harris et al., 1967; Hartmann et al., 2013 were referred to in the text. We will add these references to Table 2 in the revised manuscript.

12. Page 12919, Fig 2Âa T this figure has directly been lifted from Finke (2012). May be this figure can be replaced by a table.

Reply: We agree that Fig. 2a is from Finke (2012) and we even reference Finke (2012) as the source. However replacing this figure with the table would result into a very large table because climate data were used for 100-year intervals over 15000 years.

I have some questions out of curiosity regarding these boundary conditions. For example, why bioturbation is constant after 7000 years?

Reply: bioturbation values are not widely accessible and documented for past situations. We reconstructed values per vegetation type from literature and modified according to climate (moisture and temperature). The last 7000 years the changes in vegetation were absent and in temperature and moisture relatively small.

What is the % OC during these years?

Reply: These simulation results are available and would range between less than 0.5% to maximally around 5 % in the upper 5 cm of the soil.

13. Page 13920, Fig. 3, pH fluctuates in the range 4 to 7 for Basalt? Does it ever come to steady state?

Reply: during the last 5000 years of the simulations, changes in pH for basalt are not large both in model A and model B. We are not sure if such thing as a steady state really exists when boundary conditions fluctuate, but the model appears to converge.

14. Figure 4(a) is also not original finding from this study. Either remove it or change it to a table or so.

Reply: Figure 4(a) is original from this work, the reviewer perhaps means to say Figure 4(b) which indeed is taken from Finke (2012) not as a finding of this study but because we found it useful to to show a graph to indicate that a Bt-horizon is present in the field as well as a result of the simulations. This also partly answers comment 3 in which the question of model testing/validation is raised.

15. For flow simulations, what are the parameters used in Richards' equation for hydraulic conductivity (or permeability). How was the change in the texture during the simulation (during the soil forming process) was handled?

Reply: the Van Genuchten parameters were used to characterize the water retention and hydraulic conductivity relations. Every simulation year, these parameters are estimated by a pedotransfer function (Hypres; Wosten et al., 1999) using texture, Organic matter content and bulk density; these are all predicted by the simulation model. Such a statement will be added to section 2.3 in the revised manuscript

Wosten, J.H.M., Lilly, A., Nemes, A. & Le Bas, C. 1999. Development and use of a database of hydraulic properties of European soils. Geoderma, 90, 169‑185.