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Interactive comment on "Dynamic modelling of weathering rates – Is there any benefit over steady-state modelling?" *by* Veronika Kronnäs et al.

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We would like to thank the reviewer for your comments, too. They were very helpful and we think that we now have made the manuscript more clear and understandable. Below we give our answers to the questions the reviewer had.

GENERAL COMMENTS Comment: "The study presents soil weathering rates for two sites in Sweden. It is concise and well written, and the subject is within the scope of SOIL." Answer: Thank you! Comment: "However, I would urge the authors to rethink the focus of the manuscript; the comparison of output from a weathering sub-model within a steady-state model to output from the same weathering sub-model in a dy-

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namic model is somewhat trivial, and the results are unsurprising." Answer: ForSAFE consists of many more parts than just the weathering part and they interact with one another. Soil moisture, for example, are not modelled at all in PROFILE and is a very important parameter for the weathering. The weathering sub model is also not exactly the same, since it is dynamic in ForSAFE. For us it was not obvious that the results would be so similar to each other. The models are different enough that one cannot just be switched to the other without studying if the newer one gives reasonable results, which is what we have done by comparing with PROFILE weathering. See also our answer to the first reviewer's general questions. We included text in the discussion clarifying how much the models differ. We also expanded the second objective to refocus the paper somewhat. Comment: "Similarly, it is also unsurprising that a dynamic model provides more temporal data compared to a steady-state model. The current aims of the manuscript are trivial. There is merit in presenting the dynamics of weathering; the Title and presentation could be refocused to 'Dynamic modelling of weathering rates – the benefit over steady-state modelling'." Answer: We agree with the change of title. We think there is merit also in comparing the results of a new (with regards to weathering calculations) model with a previously used model, to examine if the new model would make very different critical load or acidification sensitivity assessment than the old assessment – and if the new assessment would have been very different – how this can be explained and if it is to be believed. Comment: "Secondly, the discussion somewhat repeats the results, there are few references to literature, and overall it feels more like a report." Answer: We have restructured the discussion somewhat, expanded it and put in more references. SPECIFIC COMMENTS Comment: "P1L10. Do not mention SWETHRO in the abstract." Answer: We have removed it. Comment: "P1L20. The results / discussion of scenario's does not fit with the objectives or title of the manuscript." Answer: We expanded the description of objective number two somewhat, see comment P2L127. Comment: "P1L23. This is not a result of this study." Answer: What is not a result of the study? ForSAFE has not been used for weathering calculations before this study, but we show that weathering rates

calculated by ForSAFE are similar to weathering rates from the previously used model PROFILE and thus that ForSAFE can be used for weathering calculations too. Comment: “P2L23. Given the importance of weathering (Title / objectives), it is surprising that weathering is given limited attention in the introduction.” Answer: We have focused on why knowing the rate of weathering is important, rather than the weathering chemistry. The process understanding of chemical weathering, which is used in the models, has been described thoroughly in previous papers, some of which we refer to. Comment: “P2L27. I recommend that you remove the first objective and expand (refocus) the second.” Answer: We don′t agree on removing the first objective. Weathering from the ForSAFE model has never before been investigated and compared to other, well used, ways of calculating weathering. The fact that the process is in the model and the model gives reasonable other output does not necessarily mean that the weathering estimates are robust and useful. This study shows that the weathering estimates from ForSAFE are of the same size as estimates from the previously often used model PROFILE, and this we did not know before. We expanded the description of second objective to explain the scenarios: “. . .scenarios, representing important ecological issues: acidification, climate change and nutrient removal through land use.” The scenarios are included to illustrate what kinds of questions dynamic modelling can help answer, using scenarios with relevant questions such as how weathering responds to climate change, changes in forestry practices and changes in acidifying deposition. Comment: “P2L30. What is the objective of the scenarios?” Answer: See answer to the comment above. Comment: “P3L2. What were the models applied to two forests?” Answer: The steady state model PROFILE and the dynamic model ForSAFE, described in the text in chapter 2. Comment: “P3L3. Please provide more background. For the external reader SWETHRO has no meaning or context.” Answer: We provided some more background in chapter 2.3. There is also a reference to a paper describing SWETHRO for the reader who wishes to know details about the monitoring. Comment: “P3L17. Does ‘factors affecting’ mean sensitive parameters? Can you site previous sensitivity studies?” Answer: We meant parameters used to model the weathering, not only

the sensitive parameters. We changed the word factors to parameters, to clarify. We cited two previous sensitivity studies in chapter 4.3. Comment: “P4L14. There is more sand at Hissmossa (Table 2) but more less Quartz (Table 3). How is this?” Answer: Texture and total chemistry have been analyzed separately and show that there are more material in the sand fraction in Hissmossa than in Västra Torup, and more Si in Västra Torup than in Hissmossa. Quartz is not only found in sand and sand does not only consist of quarts, especially not in relatively young till soils, which can explain the observed pattern. We added in the description of the sites that texture has been measured. Comment: “P4L20. It is surprising that a fixed value is used for soil moisture given (a) that soil moisture is an ‘important’ parameter (as noted by the authors), and that (b) the determinants of soil moisture (texture, bulk density and organic matter) are very different between both sites (as noted by the authors).” Answer: A steady state model cannot use a value that varies with time, so in that sense it has to be a fixed value in PROFILE. It does not have to be the same value for all sites though, but there are no measurements of soil moisture for the sites, nor are there usually any for sites that are used for PROFILE modelling. The values used are based on observation of the vegetation on the sites, which gives a “soil moisture class”, which is translated into a soil moisture value that is supposed to represent average soil moisture over a whole forest rotation, for all layers. In this study it happens to be the same for both sites. Yes, it is very crude. Modelling it, as in ForSAFE, should be a lot better. We clarified in the text in chapter 2.3 that it is a site specific value. Comment: “P4L21. The authors need to provide better context (justification) for the scenarios.” Answer: We rewrote the text explaining the scenarios in chapter 2.4 and expanded the second objective to include the scenarios better. Comment: “P5L5. The list of scenarios suggests a study objective different than that presented.” Answer: We expanded the second objective somewhat to include the scenarios better. Comment: “P5L25. Given the importance of soil moisture, why are these data not shown (Figure or Table)” Answer: Good idea, data on modelled soil moisture is included as a new figure 2. Comment: “P5 Figure 1. The difference between PROFILE and ForSAFE in L4 (and L5) at Hissmossa needs

more quantitative explanation / support. It might be soil moisture but this is not clearly shown." Answer: In Hissmossa, there is a very strong relationship for the layers between difference in soil moisture in the two models and difference in weathering. This can be more easily seen now when the soil moisture is shown in a new figure 2. In Västra Torup the differences between soil moisture in the two models are small, except in the organic layer, and differences between weathering rates between the two models are also small, except in the organic layer. There are other differences between the models that affect the difference in weathering rates too, but soil moisture has a large role. See figure attached. Comment: "P6 Figures 2 to 6. Many of the figures forces on magnesium or calcium but the sum of base cations is the focus of the text (primarily)." Answer: We changed figure 2 (now figure 3) to two that show the sum of base cations instead of Mg. Figure 3 (now figure 4) shows sum of base cations. Figure 4 (now 5) and 6 (now 7) show Mg and P since the rates of weathering of these two react in the opposite way to acidification, which was the focus of figure 4 (now 5). Part of the difference between the base scenario and the background scenario shown in figure 6 (now 7) are the lack of acidification in the background scenario. Figure 5 (now 6) shows Ca as an example of one of the base cations. Comment: "P7L10. The discussion has notably few citations. . . it is a discussion?" Answer: See answer to the general question regarding the discussion. Comment: "P9L15–L19. These are not surprising conclusions (and more-or-less were previously known)." Answer: That two different models give comparable results needs to verified before using the new, previously untested model (with regards to this process), which is what we have done. For us, the results were not at all self-evident. We rephrased the conclusions somewhat, since yes, it is quite self-evident that the ForSAFE model provides more results, but not necessarily that they are useful. Comment: "Table 3. It appears that surface area is estimated for Clay, Silt and Sand. How are areas for the O horizon estimated?" Answer: For the mineral part of the soils in the organic layers, mineralogies and texture analyses from the second layers are used, since there are no texture analyses for the organic layers and the total chemistry analysis of them include the ash of the organic part and thus

aren't useful for calculating mineralogy. The surface areas of the mineral part of the organic layers are calculated from the texture in the second layers, but adjusted for how much less mineral matter there is in the organic layers (about 10% of the matter). We clarified this in the text in chapter 2.3.

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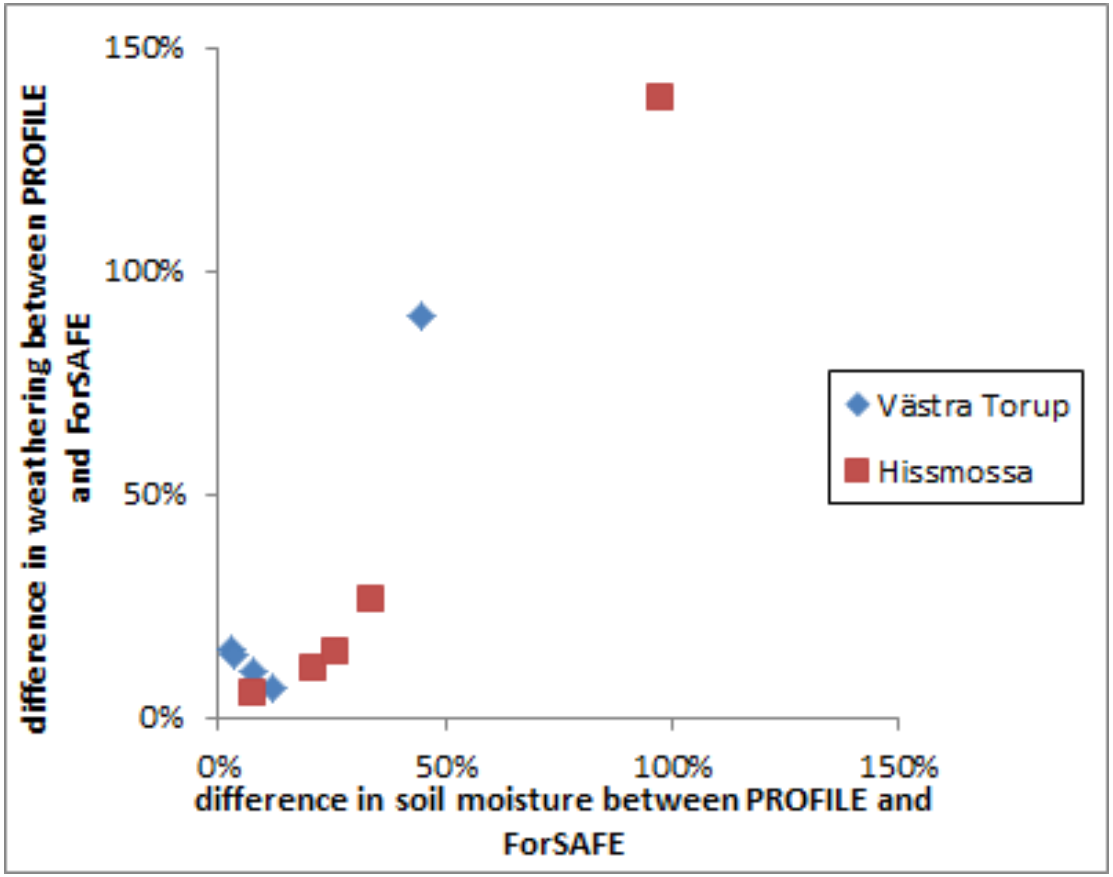

Fig. 1.

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