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SOIL Discussions

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Interactive comment

Interactive comment on "Beneath the arctic greening: Will soils lose or gain carbon or perhaps a little of both?" *by* Jennifer W. Harden et al.

Anonymous Referee #2

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Harden et al. used the space for time approach in order to get insights on the critical question about the fate of permafrost soil carbon under climate change. The authors combined physico-chemical fractionation of soil C pools with radio carbon dating and exponential equation fitting with soil depth. The results showed depth distributions of organic C were related mainly to depths of rooting and changes in bulk density. According to the study, thawing of PF will cause changes in specific C pools. The first period until the year 2100 will result in net C loss of unprotected pools, while mineral protected pools will gain C. Further warming beyond 2100 will cause losses from the mineral protected C pools, while deeper rooting stimulate the gain of light fraction materials. These results are of strong importance for the scientific community. Not only for permafrost research, but also for general information about changes in

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stabilization mechanisms of soil C under a future climate. The authors did a great job evaluating 14C in different SOM pools, which is crucial in order to understand SOM stabilization mechanisms. The study is written in excellent scientific English and well organized.

I found, however, some drawbacks which need to be considered further in the review. The authors provide only little information about parent material, except that there is some loess underlain. It would be good to have a map of the sites or some information about the depth of the loess sediments and the material below. Texture and mineralogical composition are crucial parameters for the storing capacity of OC in mineral soil layers. OC contents strongly correlate positively with mineral parameters such as clay, silt, Fe-Al- hydroxides in soil. Already small changes in these parameters have strong impact on the overall OC storage capacity. The space for time approach assumes that these parameters are similar between the sites. Unfortunately, no information on texture are presented. An increase of clay content by only 5% can result, for example, in up to 2% higher OC concentrations in temperate arable soils. If for example, the Inceptisols would have the highest clay content, than the gain in the mineral-associated fraction could be explained by that. Similar, the loss toward Mollisols could be explained by a slightly lower clay or Fe content. I'm afraid that the massage could be biases without considering these very important parameters. Incorporating these parameters in mixed effects models, or at least showing that clay is not a principle driver for OC stock change between the sites should solve the problem. Further, the gradient of sampling sited not only reflects a temperature gradient but also a precipitation gradient, from 270 mm in Gelisols to 850mm in Iova. How does the climate scenarios reflect changes in precipitation in the arctic? Precipitation and thus, soil moisture are next to temperature, the main drivers for OC mineralization. Therefore, it would be good to read how this moisture gradient reflects the model results.

General comments: I found no information's about how many profiles or soil samples have been analyses. Also the data in supplement were not very helpful. How many samples have been fractionated?

Specific comments: P2L3: “Fitting an exponential equation to depth trends in soil C. . .” please explain if specific pools are fitted or the bulk soil. The same for the depths of rooting and changes in bulk density. Pools or bulk? P3L3-12: the paragraph described that SOC stocks and MRT depend from environmental and substrate-specific factors. In terms of substrates, the authors refer mainly to the quality and quantity of plant residue inputs. One crucial factor for the SOC storing quantity is the parent material or the substrate for soil formation. Clay, silt and Fe-Al-(oxy)hydroxide content effecting the overall storage capacity of SOC (Kleber et al., 2015; von Lützow et al., 2006). This should be mentioned here, because mineral-organic interactions are part of the manuscript. There are also some latest works on organo-mineral stabilization in permafrost soils (Gentsch et al., 2015, 2018; Mueller et al., 2017). P4L16 following: Please describe how the samples were taken. How was bulk density measured, which is used in calculating the C density? P5L12: “dramatic differences” sounds a bit fishy. Please chance the phrase. P8L15: I found it pretty hard to understand what Zmin means. Would be nice to have a quick excess explanation P9L14: please delete relatively before modern. Everything F>1 is per definition modern. So the whole profile LF is modern. P12-13 Fig 4: there is probably a mistake in units by description of the model results from Fig 4. In the text the changes are given in g C m-2 which is reasonable for me. Figure 4 reported values in kg C m-2 y-1 which resulted in incredible amounts of C when scaling them up to a larger area or over 200years. P13L17: correct Zmin lower case. Also in later sentences. Figure 3: please specify how many profiles were involved in the model

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