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Interactive comment on "Soil properties override climate controls on global soil organic carbon stocks" *by* Zhongkui Luo and Raphael Viscarra-Rossel

Anonymous Referee #1

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Review BG_2020_298 I have reviewed the Biogeosciences manuscript with the title " Soil properties override climate controls on global soil organic carbon stocks" by Luo & Viscarra-Rossel. The manuscript provides a data driven analyses on the controls of soil organic carbon stocks at the global scale using a data driven approach and a machine learning technique. The manuscript touches a timely issue, is well written and well structured. I also like how the authors have discussed their findings and constrained themselves from speculation, something that I find very important for correlation studies. Good job! My comments are mostly on clarification and some added context. Something that I would say requires a medium sized revision. Nothing dramatic, but probably requiring some additional analyses.

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My main comments:

1. Subsidiary analyses: The author make a strong case for soil data to become more prominent at global scales for modeling soil C stocks in earth system models. However, I wonder how good the models actually work if you would leave out the soil data and let the other variables do the job. Probably also a quite strong model at the end. Have you checked for that?

Second question in that direction: You did PCA for the variables from worldclim but not for any edaphic variables. Why? They are also cross-correlated I would assume. Connected to this: I found the two very similar figures S4 and 2 almost bit confusing. Also because of the way you indicated you would use the findings between primary variables and PCA in l.179-181. I wonder if you might be better advised to bring in S4 into the main part and abandon Figure2. Similar comment for figures S6 and figure 3.

2. Uncertainty and global data distribution With a global dataset of that size you should be able to make some statements on the uncertainty of your assessment. For example, we all know that tropical soils or wetlands are still very underrepresented at the global scale. The map in the supplement cannot really tell us much about that issue in your study, but shows quite some empty space for boreal zones, for example. Can you give the reader some insight into how the dataset that you include is structured? What's the data distribution across climate zones and land use to name just two important factors? Is the depth distribution of observations for the most important target variables fairly reasonable for all those profiles?

Connected to this point, I think you need to revise figure 3 a bit. At least present the overall uncertainty behind these assessments of controls or (even better) give some idea on how and if this differs across certain areas of the globe.

3. Framing of the importance of identified controls Some framing on the identified controls and where across the globe they might be particularly important might be good. Some of them are universal, but for sure differ in strength across climate zones. Sim-

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ilarily, when discussing this dataset and going into some detail about what the output means I think you need to address that some controls are simply not included. For example, I was very surprised that you stress the importance of aggregation (which is very important of course) but you don't say much about pedogenic short range oxides, different clay minerals etc. These controls are very important and they also structure soils (and can build up aggregates). They differ greatly across the globe, too. So bringing soil into the global picture with the variables that you do is important, but you should stress that there is a long way to go. I highly recommend checking out the Ito & Wagai study from 2017 (Global distribution of clay-size minerals on land surface for biogeochemical and climatological studies. The maps he provides might be a very valuable addition to your assessment of potential controls and you could include them to make your case stronger.

Minor comments: - Some of the references cited in the text are not in the reference list. Please double check (Jenny 1994 for example). - L. 294 the second "directly" should be "indirectly" - Title states that the title that soil "overrides" climate. Maybe a bit too strong. I would say it has a more direct control on SOC than climate, but not necessarily overrides its. As the authors state themselves, that climatic influence can be direct and indirect, a statement that has also been propagated before by some of the cited references. - There are some minor grammar problems here and there. Should be fixed before sending the revision

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