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Biogeosciences Discussions

Interactive comment on "Soil carbon stocks in ecoregions of Africa" *by* M. Henry et al.

M. Henry et al.

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Referee #1 (below named as R1:) Author answer (below named as A:)

R1: A main justification for the work relates to developing C-sink activities. However the approach and types of data used are unsuitable for this type of application, presenting a mismatch between the discussion of the significance of the work and the actual research presented.

A: The main justification of this study is to present the status of knowledge on SOC at continental and regional scale in order to provide information to better understand the relation between terrestrial pools and the climate. The aim is not to produce data to develop C sink activities through SOC sequestration. The data were additionally used to discuss this issue.

R1: The error or uncertainty in measurements discussed (up to 60% from the authors’ calculations) suggest that quantification of the existing African SOC

stocks will be a huge task, and calculating change in storage even more difficult, requiring very large numbers of samples and careful sample pairing. While compensation for SOC sequestration is a hot topic, it seems inappropriately discussed here. See comments 3, 19.

A: the answers are presented to the point 3 and 19

R1: There is insufficient discussion of the methods or variability in the soil profile data for the reader to judge how well the datasets capture the spatial variability in SOC stocks, and how well the different datasets perform. This must be addressed before this manuscript is accepted for publication. This includes presenting the distribution of profile data relative to mapped soil variability,

A: the database Batjes 1996 is the only one with access to the soil properties. It is furthermore not possible to analyse the variability in the other databases. Furthemore, a table was added to show the variation of soil properties (BD and C content) and n between soil classes using the database batjes 1996.

p809 L.7 one paragraphs was added to present and discuss the results of the table 5.

The soil properties variability in soil profiles was reported in Batjes (1996). The bulk density varied within soil types. The histosols soil type had the lowest bulk density (0.31ś25 (SD) Mg m-3) while the vertisols had the highest bulk density (1.67ś27 Mg m-3) (Table 6). The Yermosols had the lowest soil organic carbon (1.3ś157 kg m-2) and histosols had the highest (28.3ś1330 kg m-2). It appeared that the number of soil profiles varied a lot between the soil classes. While 0.0014 bulk density measurements were achieved for 1000 km2 of fluvisols, 72.61 were achieved for phaeozems. In addition, the number of carbon content measurements for 0-30 cm soil layer was the highest for phaeozems soil type and the lowest for lithosols. The number of carbon content measurements that was much higher for 0-30 cm soil layer (n=3876) than the 0-200cm soil layer (n=200). The number of soil measurements is not proportionally distributed according to the land area per soil type and to soil depth. The data provided

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by Batjes (1996) are not enough numerous and the standard deviation is too much important to really capture the spatial variability when linking the data with the spatial units. However, this analysis is limited to the database of Batjes (1996) because the soil properties of the soil profiles for the other database were not available.

R1: number of samples and standard deviation of SOC stocks in tables and discussion of results. See comments 4, 6,10 +

A: the answers are presented to the point 4, 6 and 10

R1: The dataset performance comparison is unclear. In all, 5 profile datasets and 4 digital soil maps were assessed (Table 1)- but there was no cross comparison (e.g. test stocks calculated using profile database A with maps 1-4) which would produce 20 results. How were the pairings defined, and why? What can this tell us about optimal selection of spatial datasets for SOC estimation?

A: The cross comparison was not possible because the soil classification system was not the same between the maps and the soil properties databases e.g. the HSWD map use a mixture of map units with two different classification -SOTER legend and the FAO soil classification 1990

R1: The authors state that more intensive sampling and more detailed maps will increase the magnitude of estimated stocks.

A: the ambiguous sentence was changed

R1: However, through some process not clearly explained have determined that estimates using the HWSD (a much more detailed spatial dataset: 31000+ map units) overestimates SOC, I assume in relation to published studies. However, is this overestimate simply due to the more detailed nature of the spatial dataset? These findings are not at all clear as currently presented.

A: one sentence was added: However, it was not possible to identify the detailed nature of this overestimation.

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R1: If the authors did a more in depth analysis of their current datasets (looking at within map unit variability, stratification prior to map unit averaging, etc)

A: This type of data was not available into the presented databases

R1: I think they could directly address some of the issues relating to uncertainty in SOC stock estimates raised in the discussion. This would form a significant contribution that could help shape future sampling and monitoring activitity.

This is likely beyond the scope of the current paper, but would dramatically increase the importance of the work and increase its appeal to a wider audience.

R1: Detailed comments:

R1: 1. The title of the paper focuses on ecoregions, but SOC stock calculations in ecoregions are treated equally with country estimates, and most effort in the manuscript is focused on a comparison among datasets. Either the title needs to be adjusted to accommodate the work discussed, or the emphasis of the paper should be shifted to focus more on the importance of ecoregion estimates and the country level analyses removed.

A: the authors considered that it was not necessary to change the title

R1: 2. Page 798 Line 8: i) ... to assess the original soil C stocks of Africa... What are the "original" stocks? Do you mean a main aim of this work is to provide a SOC inventory for Africa?

A: The ambiguous sentence was modified

R1: 3. Page 800 Line 20: ... decisions cannot be made without maps... potentially for carbon trading.. . verifying and monitoring the changes in SOC over time and space.... While this is absolutely true, the current study does not represent a quantitative inventory appropriate for these purposes, although this is implied in the discussion of the study in the introduction and conclusions. See literature concerning calculation of SOC

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changes and design of SOC monitoring programs (such as Bellamy et al, 2005, Carbon losses from all soils across England and Wales 1978-2003, Nature 437:245-248 ; Saby et al., 2008 Will European soil-monitoring networks be able to detect changes in topsoil organic carbon content? Global Change Biology 14:2432-2442).

A: This study present difference of national and regional SOC estimates.

R1: 4. Page 802 Line 25: How many profiles were identical between the different datasets? If later databases included additional samples, how did the distributions shift? For instance, were all samples added to database B located in the Western Sahara? Or all additional samples were in tropical forest? How well distributed are the samples, and how does sample density relate to the mapped soil variability? You could even just add a figure showing sample locations and country boundaries for a start, and discuss the difficulties inherent in achieving an optimal dataset.

A: The soil database does not allow to georeference the soil profile. It is furthermore not possible to analyse the distribution of the soil profiles.

R1: 5. Page 801 line 8: The authors state ...the large variation between estimates is explained by the difference in base maps selected and the various assumptions made about soil attributes...

Therefore, transportability of this work is dependent on the assumptions and developed rules for linking SOC measurements with the soil units in existing maps. These relationships need to be included in the paper, yet the only discussion of the authors methods for this are on Page 803 Line 8: ...link derived interpretations of soil properties with the soil units.... At the very least, a flavor of the authors approach needs to be conveyed (e.g. explain how this was done for selected soil types), an an example from the FAO-UNESCO legend included.

A: it is possible to use the same methodology to other continents but only when considering national or continental scale. When considering the higher spatial resolution, the

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soil maps are generally few and it is not possible to make comparison as in this study.

R1: 6. Page 803 line 24: ...mean bulk density for corresponding soil unit used... How often did this occur? How many samples per soil unit on average had BD?

A: it is not possible to know from the database if the profiles were virtual or real, there is no indication on the difference between the BD data from pedotransfer rules and those from BD measurements.

R1: 7. Page 804 Line6: ...soil composition of map units is homogenized per soil profile type... What does this mean? Per classified soil types as described at profile locations?

A: the ambiguous sentence was deleted

R1: 8. Page 804 Line 17: Where is n in Equation 3? Maybe move reference to n closer to Equation 4, if that is the first time it is used.

A: the ambiguous sentence was modified

R1: 9. Page 804 Line 19: ... each soil profile is homogenous in each map unit... Please explain. Is a new modal profile created for each unit? How can the multiple soil profiles used for stock calculation be homogeneous?

A: the ambiguous sentence was modified It is assumed that each soil profile is representative of it respective map unit.

R1: 10. Page 806 Line 8 and Table 2 : The means are reported but no standard deviation. This is critical for assessing variability and distinctions among soil types or map units. Please add within reporting unit standard deviation of SOC stocks to Table 2 and discussion. In fact, could you use standard deviation to come up with measures of uncertainty across calculations made on all permutations of datasets? You could even build a series of map realisations that would give a better idea of the effect of within map unit uncertainty, and perhaps lead to a clearer comparison of dataset performance.

A: the SD was added to the table 2

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R1: 11. Page 806 Line 13: ...most of the map units contained soil in both regions... So should the continent be stratified prior to this analysis, and soil map units treated separately within these strata (Western Sahara, middle Africa, southern Africa)? This would be an important finding to improve estimates, but wasn’t addressed at all.

A: the stratification was not possible because the soil profiles were not georeferenced

R1: 12. Page 806 Line 15: Omit sentence: When considering soil .... Redundant.

A: the ambiguous sentence was deleted

R1: 13. Page 806 Line 23: How do your estimates of %SOC in depth increments compare to the literature?

A: the sentence was modified and one reference was added #while Batjes (1996) reported 47%.#

R1: 14. Page 806 Line 23: Move sentence While the horizon... to Page 807 Line 25 (discussion of landcover change).

A: the ambiguous sentence was deleted

R1: 15. Page 806 and Page 807: which datasets were used for the numbers reported in Table 2 and Table 3? This needs to be made clear - in the text and the table captions.

A: the text and the table captions were modified

R1: 16. Page 808 Line 25: Could you link this discussion with the carbon sink issue? What areas have the highest potential for sequestration based on a process understanding of soil formation? Could this help focus efforts for collecting field validation datasets for global modeling efforts, or could you discuss the relative importance of SOC stocks and change potential into perspective in relation to land cover change and management?

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A: this map does not allow localizing the C sequestration potential but can be used as an indicator of the potential SOC stocks.

R1: 17. Page 808 Line 17 ... spatial resolution of the maps should increase the SOC estimates... The assumptions behind the statement need to be clarified. I assume this is related to higher density sampling capturing high SOC soil map inclusions...?

A: the sentence was modified, ... spatial resolution of the maps should increase the precision of the SOC estimates

R1: 18. Page 810 Line 28 ...The HWSD overestimated SOC ... Against what baseline is this overestimate defined? Or should this read something like ...the HWSD produced much higher estimates...

A: the sentence was modified: the HWSD produced much higher estimates of at least 2.8 and 15.4% for 0–30 and 0–100cm layer in central Africa, 28.5% etc.

R1: 19. Page 812 Line 4: Trading C credits: Given the uncertainty calculated in this exercise, the authors need to comment on the reality of C trading. It sounds like its unfeasible at the country scale, never mind the additional complexity (plus lack of sound inventory or sufficient samples or monitoring programs for statistical detection of change in SOC stocks) at the farm scale.

A: One sentence was added in the conclusion

R1: 20. Tables 1 and 4: the rows in these tables need to match - it is very confusing to read with the different data combinations listed in different orders. Also please check years for Batjes databases. Sometimes 1995 is used, and sometimes 1996 throughout the tables.

A: the table 4 was modified

R1: 21. Table 2, Table 3: Define datasets used for calculations in captions. Add in standard deviations and number of samples per reported unit. Can this study help

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pinpoint where (geographically or in environmental space) more samples would be most beneficial??

A: the SD and the n were added this study cannot identify the geographical location for more SOC samples.

R1: 22. Table 4 and 5 don’t seem to be compatible, or lack explanation. The 0-100cm estimates for the last 3 databases (Batjes 205, 2006, FAO/IIASA 2008) do not match. Maybe the spatial dataset used for the calculations in Table 5 just needs to be added to the caption, but this is confusing.

A: the title of table 5 was modified in order to better understand the difference between the two tables. Table 5 shows the results when using the same map and different soil properties databases

R1: 23. Figure 1: Add units to the map legend (kgmˆ-2), and reference the soil map used for the calculation shown

A: The units were added to the graph

R1: 24. Figure 2: Change graphs

A: The graphs were modified

R1: 25. The manuscript would benefit from copy editing to clarify verb tenses, articles (of, on), and some word choices that are a distraction from the story presented.

A: We tried to do our best

Interactive comment on Biogeosciences Discuss., 6, 797, 2009.