

Authors response

Dear Editor

Following the review provided by the two anonymous referees we have submitted an updated manuscript for your consideration. We found both reviews to be insightful and useful and we believe it has helped us produce a much improved manuscript. The main changes to the manuscript are summarized below:

- We now only report 95% confidence interval ranges which makes the manuscript more clear and the message more straightforward.
- We have removed the upscaling by continent entirely. We felt that this confounded the main take-home message and made the study unnecessarily complicated.
- Following the suggestions by Ref. 1 we have recalculated the confidence intervals using a covariance matrix and by including representation error. We have provided a new overview figure that explains the procedure in detail (supplement figure S1).
- We have updated figure 2 to be more legible and redirected the presentation of the SOC storage data that were used in upscaling in a new table 2.
- We have added a table to compare our estimates to previous studies (table 6)
- We extended the discussion around limited data availability, additional sources of uncertainty not accounted for by our calculations and comparisons to previous studies

There is only one major suggestion that we have failed to address; Referee 1 suggested that we should include spatially distributed uncertainty maps. We feel that this is a very significant addition that would warrant an entirely new manuscript (see response below).

We think that the revised manuscript is more streamlined and understandable to the reader when some components were scaled away. Below we provide point by point answers to separate comments by the referees.

Sincerely, the Authors

Authors reply to Referee 1

We are grateful to Anonymous Referee 1 for a careful and in depth review. The comprehensive feedback on the methodology for statistical evaluation of upscaling uncertainties was especially useful and appreciated. We feel confident that we have submitted an improved revised manuscript with the support of these comments.

Major/method comments

Below we provide our view on some of the major comments of Anonymous Referee 1 which largely relate to the statistical approach we have taken when estimating upscaling uncertainty.

Inconsistency in use of confidence intervals (CI): We agree that the use of several different metrics of uncertainty made the paper cumbersome to read and interpret. We have revised the manuscript to only report 95% CI ranges.

Incorrect use of the formulas for error propagation: We found the ideas and concepts presented by the referee very thoughtful and indeed useful. In general the idea that SOC stocks are correlated within soil orders but uncorrelated across soil orders is sound and we applied this reasoning in the revised manuscript. We believe that our previous method section made a poor job of explaining the exact calculations so we have added a figure (S1) that shows how calculations were made.

Representation error: This is a very good point raised by the referee. Indeed, we are not confident that our current samples for some soil orders in the thin sediment regions (or the High Arctic) are truly representative. In the updated manuscript we have included representation errors for the upscaling in thin sediment regions and deltaic sediments. We calculated the representation error CI ($_{rep_err}CI$) by simulating subsampling of the larger dataset (for e.g. thick sediment areas) as the referee suggested. We did this subsampling based on 499 random iterations. The $_{rep_err}CI$ was then combined with the $_{landscape}CI$ (using the quadrature formula of uncorrelated errors).

Minor/editorial comments

Referee 1 provided extensive editorial feedback and many minor comments. We found these comments useful and constructive and incorporated them in the updated manuscript.

Below we provide explicit response to some of the minor comments by referee 1.

We agree that the terms uncertainty and variance are sometimes used interchanged, we will correct this throughout the manuscript.

We have remove algebraic symbols (such as < and >) from the running text.

The referee suggests adapting figures 2 and 3 to contain only the data used to calculate stocks and move the comparisons between the two datasets to supplementary materials. We have now created a table that summarizes all data used in upscaling while the new figure 2 shows the data from the new pedon dataset 2. We want to keep the consistency of the depth profiles in the figure and we therefore argue that such a figure must be based on one consistent dataset.

We have added SOC storage numbers for 0-30 cm depth in the figures and tables.

The referee suggests that much of the results from the running text be transferred to a table. We have now added one table summarizing SOC storage (table 2) and one table comparing our results to previous studies (table 6).

The referee suggests that we add maps of spatially distributed uncertainties. This would entail significant additional work beyond what has already been undertaken. Such analyses would also mean significant additions to methods, results and discussion of this manuscript and we feel that this manuscript is already very long and intricate. We are currently pursuing such GIS-analyses but will present this in a separate manuscript.

Authors reply to Referee 2

We are grateful to Anonymous Referee 2 for a careful and useful review. We are particularly grateful for comments on how we can improve the assessment and description of uncertainty ranges and for issues that we should provide further discussion on. We feel confident that we have submitted an improved revised manuscript with the support of these comments.

Inconsistency in use of confidence intervals (CI): We agree that the use of several different metrics of uncertainty makes the paper cumbersome to read and interpret. We have revised the manuscript to only report 95% CI.

Added discussion on uncertainty sources: The referee correctly points out that we have not addressed several sources of uncertainty (such as map-errors or laboratory errors). We have addressed these issues more clearly in an updated discussion and clarified what additional analyses could be made (section 4.3.6 of the updated manuscript).

The referee brings up the interesting point of intra-site variability. From some few areas this is available, but we do not have sufficient data for comprehensive analyses or discussion of this. To some extent this issue will be addressed by the introduction of representation error as suggested by referee 1.

Revise figures: We have revised the layout and scope of figures 2 so that it has become more legible and hopefully conveys the information in a better way. We have added the location of the included deltas to figure 1.

Limited field data for deltaic deposits: The referee suggest that we expand the explanation/discussion of data availability for deltaic deposits. We agree that this is an important topic and we have expanded the discussion on this issue (section 4.3.4 of the updated manuscript). We have strived to be very clear in our presentation of the available data for deltaic deposits and the limitations are mentioned in many places including the Results, Discussion and Conclusions. The data is very limited, but it still represents a very substantial improvement over the previous estimate which was based on observation from only one delta.

Distribution of field data: The referee points out that some regions are greatly under-sampled and asks that we provide more discussion on this topic. We have added additional discussion on this in sections 4.3.1 and 4.3.2 of the updated manuscript.

Sources of differences between estimates: The referee suggests that we provide more in depth discussion explaining similarities and differences between this and previous estimates. This is a good idea and that adds value for potential data users. We have expanded this topic in the discussion (section 4.1 of the updated manuscript) and included table 6 which provides direct comparisons with previous studies.

Differences between thick/thin sediment areas: The referee correctly points out that this simplified classification oversimplifies the real conditions and that it is desirable that future estimates moves away from such categorical treatment of data. We have added some perspectives on this issue in the discussion, section 4.2.1 of the updated manuscript.