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Interactive comment on "Global soil organic carbon removal by water erosion under climate change and land use change during 1850–2005 AD" *by* Victoria Naipal et al.

Victoria Naipal et al.

victoria.naipal@lsce.ipsl.fr

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We would like to thank the anonymous reviewer for his or her constructive comments. In this response we provide an answer to all the comments and the indicated changes will be applied in the revised manuscript.

Comment 1: "I was not fully convinced by the vertical discretization approach that the emulator used. First of all, different soil layers have totally different biogeophysical and biogeochemical features. Different layers are experiencing different amount of fresh carbon input (e.g., from fine roots exudates, fine root litter), different microbial community (e.g.,fungi/bacteria with different carbon use efficiency), and have different soil

structure (e.g., microagregate, macroagregate). Secondly, even the idea of summarizing the above-mentioned vertical difference into one single factor (re) is believable, the value of re should be carefully inferred for this model, rather than taking from other studies. Thirdly, and most importantly, the vertical discretization, artificially, increase total global SOC stock by 44%. This type of artifact should be removed. My suggestion is that, since ORCHIDEE has one single soil layer, k0 of ORCHIDEE is supposed to represent the mean turnover rate of the whole soil column. Therefore, the k0 (equation 5) in the emulator (here aims to represent top soil turnover) should not be k0 from ORCHIDEE. One approach is to change k0 in emulator to offset the total SOC stock artifact until it's removed."

Answer: We understand the reviewer's concern regarding the vertical discretization scheme of the emulator and agree that discretizing the SOC over depth is a complex process that has a large impact on the overall SOC stocks. Vertical discretization of SOC has just recently started to be implemented in land surface models. ORCHIDEE is one of the first global land surface models where recently a vertical SOC scheme has been implemented that includes biological production and consumption of SOC, adsorption and desorption processes and diffusion or vertical mixing (Camino-Serrano et al., 2018; Guimberteau et al. 2018). However, for our study we used a simpler version of the ORCHIDEE model without an explicit vertical SOC discretization scheme. One of the main reasons is the need to balance the complexity of the emulator with the computational speed, meaning that including processes such as diffusion would make the emulator with the carbon balance of each layer more complex and slower, complicating the performance of our erosion simulations. One of the primary reasons for using the C emulator was for its speed and simplicity, so that we could clearly separate and quantify the various effects of soil erosion on the SOC stocks.

However, a vertical SOC profile is necessary to account for smaller SOC erosion rates over time due to the generally decreasing SOC concentration with depth on eroding hillslopes (Hoffmann et al., 2013). Without a vertical SOC profile the removal of SOC by erosion would be most likely overestimated. To simulate the generally declining SOC with depth (on hillslopes) using the emulator, we let the C input to the soil by belowground litter (roots, shoots) decrease exponentially with depth according to the root-profile exponent 'r' (equations 6 and 8b of the original manuscript), and we let the soil respiration rate also decrease exponentially with depth using the exponent 're'. To stay consistent, we use the same values for the exponent 'r' as in the ORCHIDEE model and make sure that the sum of the belowground litter input to each soil layer is equal to the overall belowground litter input to the soil as simulated by ORCHIDEE. Note that vertical injection of litter from roots in the more sophisticated versions of ORCHIDEE cited above also uses the same root-profile factor 'r'. However, as the ORCHIDEE model version we used has no vertical soil profile, the values for the exponent 're' have to be determined either from literature or calibrated in such a way that the vertical discretization does not influence the total SOC respiration and thus the total SOC stock as simulated by ORCHIDEE.

In the original manuscript we used a constant global value for the exponent 're' derived from a few local studies in a Belgian landscape. At the same time we assumed that the C pool-dependent soil respiration rate of the original ORCHIDEE model is equal to the surface soil respiration rate 'k0i' of the vertical C profile in the emulator (equation 5 of original manuscript). This setup resulted in a much higher SOC stock simulated by the emulator with vertical soil profile than simulated by the original ORCHIDEE model. We agree with the reviewer that this artifact should be removed, as it may intervene with the separation and quantification of the effects by soil erosion on the global SOC stock. By deriving 'k0i' based on the assumption that the average soil respiration rate over the 2m soil profile is equal to the soil respiration rate of ORCHIDEE per grid cell did not result in similar SOC stocks between the emulator and ORCHIDEE in the case of no soil erosion and no land use change (LUC). Actually, it was rarely possible to find a realistic value for 'k0i' per grid cell under a constant global 're' such that the SOC stocks of the emulator would be similar to those of ORCHIDEE (no soil erosion and no LUC).

Therefore, we decided to calibrate both the exponent 're' and variable 'k0i' for each grid cell and PFT under equilibrium conditions. For this calibration we needed information on the ratios between the SOC stocks of the active, slow and passive pools throughout the soil profile. The old vertical discretization scheme resulted in different ratios between the SOC stocks of the three pools with depth. However, there is very little information or data to constrain the pool ratios globally, mainly because the three SOC pools cannot be directly related to measurements (Elliott et al., 1996). Furthermore, neither the emulator nor the ORCHIDEE model we used include soil processes that may affect these pool ratios with depth, such as vertical mixing by soil organisms, diffusion, changes in soil texture (SOC protection and stabilization by clay particles), limitations by oxygen and by access to deep organic matter by microbes. There is also a lot of discussion on how sensitive SOC is to these other processes. For example, the study of Huang et al. (in revision for the journal Advances in Modeling Earth Systems) who implemented a matric-based approach to assess the sensitivity of SOC showed that equilibrium SOC stocks are more sensitive to input than to mixing for soils in the temperate and high-latitude regions. For all the above-mentioned reasons and to decrease the uncertainty we made the assumption that the ratios between the SOC stocks of the active, slow and passive pools are equal throughout the soil profile in the new vertical soil discretization scheme and similar to the pool ratios derived from ORCHIDEE.

For the transient period (1850-2005), we made 're' remain equal to the equilibrium state values, while 'ki0' was derived at a daily time-step to keep to SOC stocks of the emulator similar to those of ORCHIDEE and preserve the yearly variability in the soil respiration rates due to changes in soil climate (no soil erosion and no LUC). Details of how we calibrated the exponent 're' and variable 'k0i' we describe in the supplement.

Method for calibration of 're' and 'k0i' : We start off by selecting a default value for 're' of 2.5 (average between 0 and 5) and then proceed with deriving the values of 'k0i' according to equations 1-4 described in the supplement. After the derivation of 'k0i' we test if the total SOC stock per grid cell and PFT is similar to that of ORCHIDEE (difference should be smaller than 1 g m-2). If this is not the case we increase or decrease the value of 're', but make sure that it stays within the range of 0 and 5. If these is no optimized solution for both 're' and 'k0i', we use the values that produce the smallest difference in SOC stocks between emulator and ORCHIDEE.

In the transient period (no land use change or erosion) we assume a time-constant 're' fixed to the equilibrium state. Using the mass-balance approach we can find the daily values for k0a, k0s, k0p per grid cell and PFT with equations 8a,b,c (see supplement). In case there was no solution for the 'k0i' at a certain time-step we took the values from the previous time-step.

Implications of the new vertical discretization scheme: After implementing the above-mentioned empirical adjustments to the vertical SOC discretization scheme of the emulator, we found that the resulting SOC stocks for the equilibrium state are close to those of ORCHIDEE with some small deviations (Fig. S1). It was not always possible to precisely match the SOC stocks of the emulator and ORCHIDEE and at the same time have realistic vertical SOC profiles, where the 're' variable varies between 0 and 5.

Figure S2 shows that also for the transient period of simulation S4 (no erosion or LUC) the total SOC stocks are similar between emulator and the ORCHIDEE model. The difference between the SOC stock of the emulator and ORCHIDEE are between -1 and 0% of ORCHIDEE SOC stocks for most grid cells, however, the maximum difference can reach -10% for some grid cells. The total global SOC stock of the emulator in the year 2005 deviates by -0.5% from the SOC stock of ORCHIDEE. This differences between the emulator and ORCHIDEE are due to the fact that there was not always an optimal and realistic solution for 'k0i' and 're'.

Although the new vertical discretization scheme did change the values of the SOC stocks and the related changes to the SOC stocks during the transient period, the

main trends and findings of this study remain the same. In the following paragraph we describe the changes to our results, figures and tables as will be presented in the revised manuscript.

Changes in the manuscript: We will include the above-mentioned derivation of the variables of the new vertical discretization scheme of the emulator and the argumentation behind it, as explained above, in the revised manuscript in chapter 2.3 after line 200 instead of the paragraph between lines 200 and 208. We will include table S1 with the global mean values for the 're' exponent per PFT in the supporting material, together with the figures S1 and S2 showing the deviations in the SOC stocks due to the vertical discretization scheme of the emulator.

We also change the tables 2 to 7 of the original manuscript, where we include the new values for changes in SOC stocks and SOC erosion rates. In table 2 of the original manuscript we found that the values of SOC erosion rates and their standard deviations were presented in the wrong units, so we corrected them. Also table in 3 we corrected the standard deviations of the continental SOC erosion rates, which had the wrong units. Furthermore, we adapted figures 4B,4D,4F,4H, 5C,5D,5E,6A,7,8A,8B,8C according to the new results of the simulations with the new vertical discretization scheme. All the changes in the manuscript are provided at the end of this document.

We make the following changes to the abstract: L26: "We found that over the period 1850-2005 AD acceleration of soil erosion leads to a total potential SOC removal flux of 73 Pg C of which 60% occurs on agricultural, pasture and natural grass lands" L28: "Including soil erosion in the SOC-dynamics scheme results in an increase of 60% of the cumulative loss of SOC…" L30:" This additional erosional loss decreases the cumulative global carbon sink on land by 2 Pg for this specific period,…"

We make the following changes in the results chapter: L343: "This global soil loss flux (here 'loss' meaning horizontal removal by erosion) leads to a total SOC loss flux of 0.52 Pg C y-1…" L347: "The total soil and SOC losses in the year 2005 are an increase of 14% and 30%, respectively, compared to 1850" L356: " We found that the total soil erosion flux on agricultural land almost doubled by the year 2005 compared to 1850, while the SOC erosion flux increased by 45% (Fig. 4) and led to a cumulative SOC removal of 22 Pg on agricultural land since 1850 (CTR)." L358" On pasture land and grassland, the soil erosion flux increased by only 8.5%, while the SOC erosion flux increased by 50% (Fig. 4) and led to a cumulative SOC mobilization of 38 Pg since 1850." L364: " In total 7183 Pg of soil and 73 Pg of SOC is mobilized across all PFTs by erosion during the period 1850 - 2005, which is equal to approximately 60% of the total net flux of carbon lost as CO2 to the atmosphere due to LUC. . ." L372: ". . .we find that the overall global SOC stock decrease during the period 1850 – 2005 would be larger by 60% compared to a world without soil erosion (Fig. 6A)" L374:". . . where the total SOC stock shows a net decrease when the effects of soil erosion are taken into account compared to the net increase under no soil erosion" L383:" We calculated a total global SOC stock for 2005 in the absence of soil erosion (S3) of 1284 Pg, which is a factor of 0.85 lower than the total SOC stock from GSCE (Shangguan et al., 2014) for a soil depth of 2m (Table 5)." L386:" Including soil erosion (S1) leads to a total SOC stock of 1001 Pg for the year 2005 (Table 5). We also find that including soil erosion in the SOC-dynamics scheme slightly improves the root mean square error (RMSE) between the simulated SOC stocks and those from GSDE, for the top 30cm of the soil profile. This improvement in the RMSE occurs especially in highly erosive areas." L396:" This flux is paralleled by a SOC loss flux of 0.16 Pg C y-1 after including soil erosion in the CTR simulation (Fig. 4)." L405:" Furthermore, we find a cumulative soil loss of 1888 Pg and cumulative SOC removal flux of 22 Pg from agricultural land over the entire time period (CTR simulation). "

We make the following changes in the discussion chapter: L468:" We find that globally the SOC stocks decrease by 17 Pg due to LUC only during 1850 – 2005 (Fig. 6A, S3-S4). The overall change in carbon over this period summed up over all biomass, litter, SOC, and wood-product pools due to LUC without erosion is a loss of 101 Pg C which lies in the range of cumulative carbon emissions by LUC from estimates of

previous studies (Houghton and Nassikas, 2017; Li et al., 2017; Piao et al., 2009)" L471: "The increase in soil erosion by expanding agricultural- and grasslands (S1-S2) amplifies the decrease of SOC stocks implied by LUC in absence of erosion (S3-S4) by 4 Pg or a factor of 1.2 (Fig. 6A)" L473: "This leads to a total change in the overall carbon stock on land of -105 Pg." L492: " . . .and leads even to a net cumulative sink of carbon on land over this period of about 30 Pg C (S3)" L596:" In the presence of soil erosion, climate variability and the atmospheric CO2 increase lead to a slightly smaller net cumulative sink of carbon over land of 28 Pg C (S1). . ."

We make the following changes to the conclusion chapter: L551: "This potential soil loss flux mobilized 73 Pg of SOC across all PFTs, which compares to 60% of the total net flux of carbon lost as CO2" L553:" When assuming that all this SOC mobilized is respired we find that the overall SOC change over the period 1850-2005 would increase by 60%."

Comment 2: "Land use change map. The LUC is prescribed by PFT fractional change derived from Peng 2017. Wondered how this LUC dataset differs from Land-Use Harmonization (LUH2), the new CMIP6 land use change dataset. Given that LUC is a dominant factor of SOC erosion, I am curious about the uncertainty of SOC erosion, induced by using different LUC estimate (e.g., Peng 2017 vs LUH2)."

Answer: The PFT fractional map is based on LUHv2 land use dataset, historical forest area data from Houghton (for large regions) and present day forest area from ESA CCI satellite land cover data (Peng et al., 2017). The historical forest data from Houghton and the latest satellite land cover data from ESA are the best estimates that currently exist on forest area. Figure S3 shows that if the forest is not constrained with methods described by Peng et al. (2017), there is a stronger decrease in forest area over the period 1850-2005. Also the grassland shows an increasing trend, while in the PFT map with constrained forest the grassland shows globally a slight decreasing trend. In the rest of the text we will refer to the PFT map constrained with data on forest area as the 'constrained PFT map' and to the other PFT map as the 'unconstrained PFT map'.

We agree with the reviewer that different land use data can result in large uncertainties in both SOC stocks and soil erosion rates. To show the potential uncertainty in our results due to uncertainties in underlying land use data we performed 4 additional simulations (S1 to S4) using the unconstrained PFT map and the new vertical discretization scheme.

Differences in global average soil erosion rates between the different PFT maps are small (Fig. S4), mainly because the C-factor of our Adjusted RUSLE model is similar for forest and dense natural grass. As the change in cropland area globally was not very different between the 2 PFT maps, the overall soil erosion rates were similar. We expect, however, that the changes in soil erosion rates between the 2 PFT maps can be significant in areas where the change in forest area was significant over the historical period.

In contrast to the soil erosion rates, the 2 PFT maps resulted in significant differences in the SOC erosion rates and cumulative changes in SOC stocks during the transient period (Fig. S4). The global SOC stock in the equilibrium state without soil erosion (S3) is 8 % higher when the unconstrained PFT map is used, due to a larger global forest area in this map at 1850. The higher global SOC stock of the PFT map without constrained forest area lead to higher SOC erosion rates (Fig. S4b). According to the unconstrained PFT map, soil erosion leads to a total SOC removal of 79 Pg (S1) over the period 1850-2005, which is 6Pg larger than the total SOC removal by soil erosion under the constrained PFT map.

Interestingly, according to the unconstrained PFT map, the global cumulative SOC stock change over 1850-2005 under soil erosion and LUC (S1) is 60% smaller than the stock derived using the constrained PFT map. This is most likely due to the higher forest area at the start of the period A850-2005, leading to a larger increase in SOC stocks by increasing atmospheric CO2 concentrations. The global LUC effect on the SOC stocks of both PFT maps is found to be similar (Fig 5C, D).

Changes in the manuscript: The uncertainty due to different land use maps, as discussed above, will included in chapter 4.4 of the manuscript after line 535, and we will add the above-mentioned changes to the erosion rates and SOC stocks. The new figures S3 and S4 will be included in the supporting material. Specific comment 1: “L16: The first sentence gives me an incorrect hint that the paper is going to talk about agriculture activity accelerates soil erosion”

Answer: We agree that this may be misleading and changed this sentence to: “Anthropogenic land cover change has not only led to large carbon losses but also accelerated soil erosion rates by rainfall and runoff substantially, mobilizing vast quantities of soil organic carbon (SOC) globally.

Specific comment 2: “L38: 1.0 Pg, does it include fire emission?”

Answer: yes it does

Specific comment 3: “L56 what is bookkeeping models?”

Answer: Bookkeeping models are methods/tools to calculate land use change emissions by keeping track of the carbon stored in different pools before and after land use changes take place. These methods also keep track of the CO2 emitted after land use change has taken place. Specific comment 5: “L23 What’s the meaning of randomly projected? A more reasonable way is to repeat 1990-1910 climates during 1850-1900.”

Answer: “Randomly projected”, means that the climate of the years after 1900 was randomly assigned to the years between 1850 and 1900 because the climate data of CRU-NCEP was only available starting from year 1900. If we would choose to repeat the climates of 1900-1910, we would risk including the effects of extreme climate conditions multiple times.

Changes in the manuscript: After line 270 we will add: “This is done because the climate data of CRU-NCEP was only available starting from year 1900, and to avoid the risk of including the effects of extreme climate conditions multiple times if only a certain decade would be used repeatedly."

Specific comment 6: "L421 "Also, intense soil erosion is typically found in mountainous areas where climate variability has significant impacts, while at the same time these regions are usually poor in SOC." It's not clear in the manuscript whether or not ORCHIDEE has topography information? In another word, if ORCHIDEE simulates a low SOC stock over the grid cells that have mountains, is that because of the topographical feature of this gridcell can not hold a lot of SOC in ORCHIDEE? Or because of other reasons such as climate constraints (e.g., colder in mountain area)?"

Answer: ORCHIDEE has no soil depth information and thus cannot simulate low SOC stocks due to the fact that the gridcell cannot hold a lot of SOC. Low SOC might however be a result of the plant productivity, the climate (temperature and precipitation), soil moisture and clay content (which is a constant variable). ORCHIDEE has, however, topographical information such as slope that determines the flow directions for water/runoff and affects hydrological parameters such as soil moisture content.

Changes in the manuscript: "Also, intense soil erosion is typically found in mountainous areas where climate variability has significant impacts, while at the same time these regions are usually poor in SOC due to unfavorable environmental conditions for plant productivity."

Specific comment 7: "L465 CO2 fertilization effects on NPP is not fully convincing here, because ORCHIDEE does not have nutrient constraints. OCN might be a better surrogate model to be able to say something about CO2 fertilization effect on NPP."

Answer: In the ORCHIDEE model version we used the nutrients are indeed absent. Our intention, however, was to show the complete picture of possible direct and indirect interactions of soil erosion with the C cycle with the current model setup. The representation of nutrients in global land surface models is new and the related uncertainties are not well quantified. We work with a more or less simple version of ORCHIDEE and the C emulator to be able to understand and quantify the effects of soil erosion on the C

cycle. We will mention in chapter 4 of the revised manuscript some of the uncertainties due to the absence of nutrients.

Changes in the manuscript: L537: "The absence of nutrients in the current version of the ORCHIDEE model may result in an overestimation of the CO2 fertilization effect on NPP and may introduce biases in the effect of erosion on SOC stocks under increasing atmospheric CO2 concentrations. Soil erosion may also lead to significant losses of nutrients, especially in agricultural areas. For a more complete quantification of the effects of soil erosion on the carbon cycle, nutrients have to be included in future studies."
Specific comment 8: " Figure 4. I do not fully understand why climate change either decrease or not change erosion?

Answer: With climate change we mean temperature and precipitation changes. For soil erosion only precipitation changes are of interest. Globally we find that average yearly precipitation shows a slightly decreasing trend over the period 1950 – 2005 according to the ISIMIP2b dataset used to calculate soil erosion rates. A global smaller total precipitation with respect to 1850 AD will lead to smaller soil erosion rates when LUC is not included. The decrease in total precipitation over land is mostly coming from the tropics, where due to large precipitation amounts a change in precipitation can alter soil erosion significantly. At the same time precipitation is very variable and might not lead to a significant global net change in soil erosion rates over the total period 1850-2005. This result might be contradictory to the fact that major soil erosion events are caused by storms. But in our case we model only rill and interril erosion, which is usually a slow process and previous studies have shown that land use change is usually the main driver of behind accelerated rates of this type of soil erosion. Furthermore, there are very few studies that have quantified the individual effects of precipitation change versus land use change on soil erosion rates over a sufficiently long time period. Therefore, it is difficult to verify this result. However, our soil erosion model performs well for present-day and therefore any possible biases here could be mainly related to biases in precipitation rates, and soil parameters. We agree that this is an interesting point raised by the reviewer and will add some additional sentences explaining the trend.

Changes in the manuscript: L438: "The global decrease in precipitation in many regions worldwide, especially in the Amazon, as simulated by ISIMIP2b, lead to a slight decrease in soil and SOC erosion rates (Fig. 4). At the same time precipitation is very variable and might not lead to a significant global net change in soil erosion rates over the total period 1850-2005. This result might be contradictory to the fact that major soil erosion events are caused by storms. But in this study we only simulate rill and interril erosion, which are usually slow processes. In addition, previous studies have shown that land use change is usually the main driver behind accelerated rates of these types of soil erosion. Our study confirms this observation."

Please also note the supplement to this comment:
https://www.biogeosciences-discuss.net/bg-2017-527/bg-2017-527-AC1-supplement.pdf

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Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2017-527, 2018.

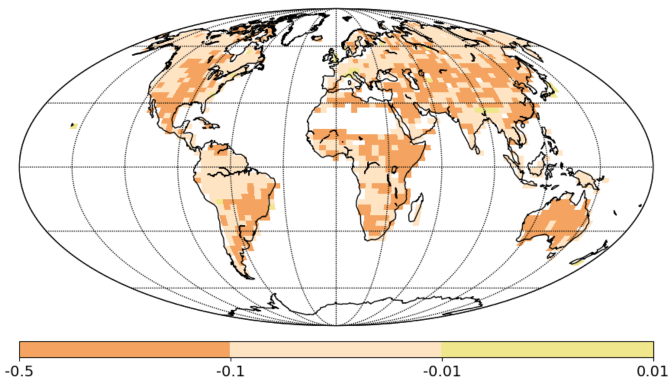

Figure S1: The difference in SOC stocks between the emulator and ORCHIDEE as a ratio (%) of the ORCHIDEE SOC stocks for the equilibrium state of the year 1850 without soil erosion. Positive values indicate larger SOC stocks of the emulator compared to the ORCHIDEE model, and negative values indicate smaller SOC stocks of the emulator compared to the ORCHIDEE model.

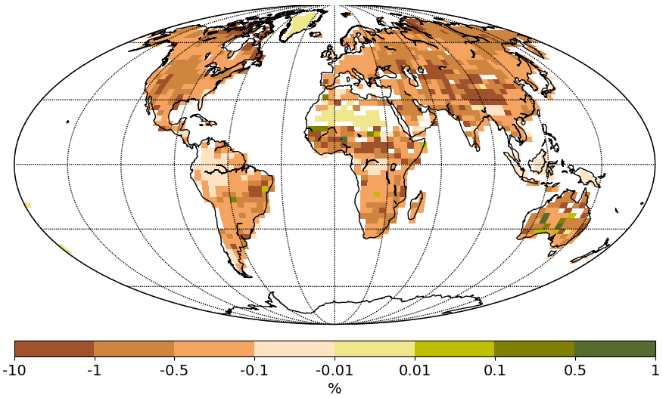

Figure S2: The difference in SOC stocks between the emulator and ORCHIDEE as a ratio (%) of the ORCHIDEE SOC stocks averaged over the period 1996-2005 for simulation S4 (no erosion, no LUC). The total Positive values indicate larger SOC stocks of the emulator compared to the ORCHIDEE model, and negative values indicate smaller SOC stocks of the emulator compared to the ORCHIDEE model.

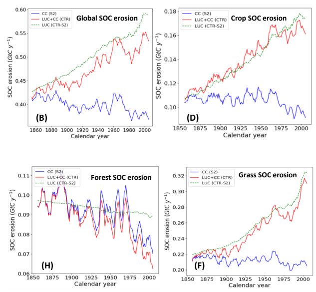

Figure 4: There are no significant changes in the historical trends due to the new vertical discretization scheme, except for the overall values.

Fig. 3. Figure4

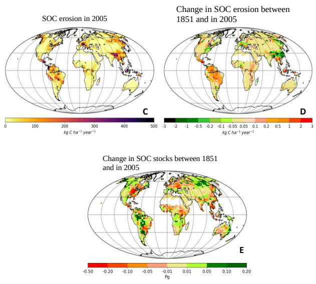

Figure 5: Only slight changes in the spatial variability of the SOC stocks and SOC erosion rates are observed, which are due to the new vertical discretization scheme.

Fig. 4. Figure5

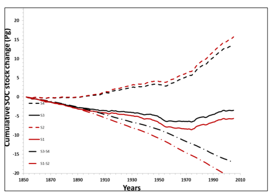

Figure 6A: No significant changes in the temporal trends of the cumulative SOC stock are observed when the new vertical discretization scheme is used. However, the overall changes in the cumulative stocks are smaller.

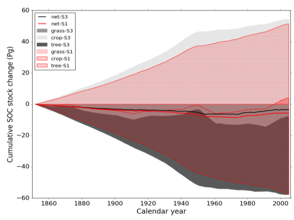

Figure 7: The cumulative SOC stock change in the original manuscript was wrongly projected and is corrected here. The grassland SOC stocks should decrease instead of increase. Overall, the historical trends in the cumulative SOC stocks follow closely the changes in the respective vegetation fractions. The overall changes in SOC stocks are smaller here compared to the figure in the original manuscript due to the new vertical scheme.

Fig. 5. Figure 6A and 7

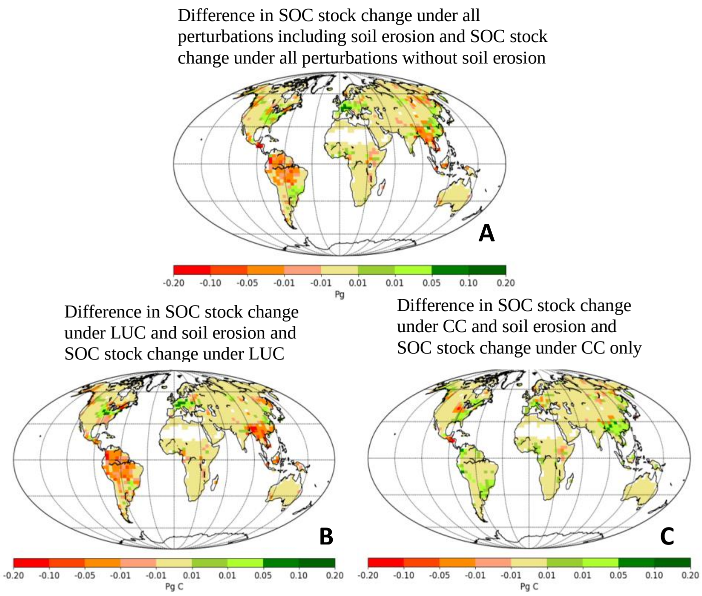

Figure 8: no significant changes are observed in the plots due to the new vertical scheme.

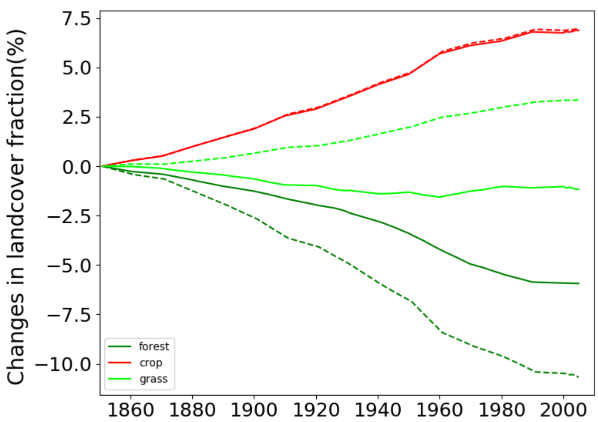

Figure S3: Changes (%) in forest (green), grass (light-green) and crop (red) fractions over the period 1850-2005 with respect to the year 1850AD. The dashed lines represent data from the PFT map without constrained forest, while the straight lines represent data from the PFT map from Peng et al. (2017).

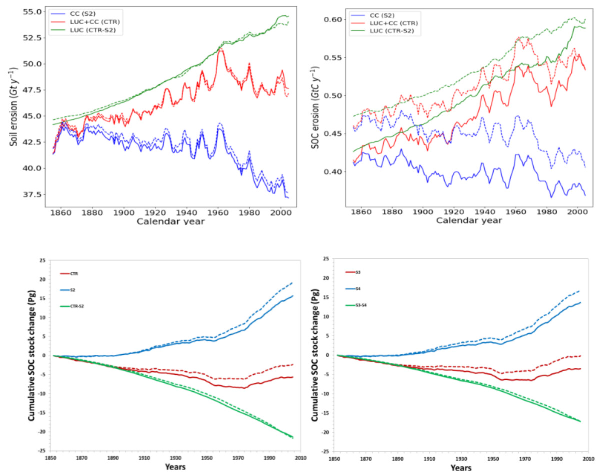

Figure S4: Differences in (A) soil and (B) SOC erosion rates and (C and D) cumulative SOC stock changes between the PFT map that is constrained by forest area data (straight lines) and the PFT map that is not constrained by forest area data (dashed lines).

Table S1: Global area-weighted average '*re*' values per PFT

	PFT description	**Area-weighted mean re**
0	Bare soil	2.5
1	Tropical broad-leaved evergreen	0.72
2	tropical broad-leaved raingreen	1.33
3	temperate needleleaf evergreen	1.29
4	temperate broad-leaved evergreen	1.25
5	Temperate broad-leaved summergreen	1.09
6	boreal needleleaf evergreen	1.33
7	boreal broad-leaved summergreen	1.13
8	boreal needleleaf summergreen	0.93
9	C3 grass	2.03
10	C4 grass	2.3
11	C3 agriculture	0.73
12	C4 agriculture	0.78

The tables of the original manuscript are changed as following:

Table2: only SOC erosion rates and their standard deviations are corrected

PFT	Mean soil erosion ($t\ ha^{-1}\ y^{-1}$)	Standard deviation soil erosion ($t\ ha^{-1}\ y^{-1}$)	Mean SOC erosion ($kg\ C\ ha^{-1}\ y^{-1}$)	Standard deviation SOC erosion ($kg\ C\ ha^{-1}\ y^{-1}$)
Crop	1.71	24.95	288.17	43563
Grass	1.88	32.67	83.52	4613
Forest	0.26	2.31	12.36	326

Table 3: only SOC erosion rates, their standard deviations and changes are corrected

Region	Mean soil erosion rate	Standard deviation soil erosion rate	Change in mean soil erosion rate	Mean SOC erosion rate	Standard deviation SOC erosion rate	Change in mean SOC erosion rate
	2005	2005	2005 -1851	2005	2005	2005-1851
	($t\ ha^{-1}\ y^{-1}$)	($t\ ha^{-1}\ y^{-1}$)	($t\ ha^{-1}\ y^{-1}$)	($kg\ C\ ha^{-1}\ y^{-1}$)	($kg\ C\ ha^{-1}\ y^{-1}$)	($kg\ C\ ha^{-1}\ y^{-1}$)
Africa	2.69	68.47	0.69	13.17	101	4.31
Asia	6.03	167.83	0.23	57.85	832	3.22
Europe	2.45	73.70	0.48	16.67	348	1.39
Australia	1.46	16.98	-0.50	5.14	23	1.81
South-America	4.69	117.58	1.35	74.27	1552	38.89
North-America	2.83	63.68	0.15	32.85	571	3.14
Global	3.92	104.48	0.50	38.49	691	8.92

Fig. 10. Table 2 and 3

Table 4

Region	Change SOC stocks S1	Change SOC stocks S2	Change SOC stocks S1-S2	Change SOC stocks S3	Change SOC stocks S4	Change SOC stocks S3-S4
	Pg C	Pg C	Pg C	Pg C	Pg C	Pg C
Africa	-1.55	-0.24	-1.31	-1.54	-0.55	-0.98
Asia	-0.36	7.94	-8.31	0.65	7.11	-6.47
Europe	-3.33	1.78	-5.12	-4.35	1.52	-5.87
Australia	0.21	0.05	0.16	0.29	0.01	0.28
South-America	2.24	2.82	-0.59	3.75	2.06	1.69
North-America	-2.62	3.19	-5.81	-2.5	3.03	-5.53
Global	-5.35	15.93	-21.29	-3.3	13.86	-17.16

Table 5: total SOC stocks are corrected for simulations S1 and S3, and the respective statistics

Soil depth (m)	GSDE SOC total (Pg)	S1 SOC total (Pg)	S3 SOC total (Pg)	RMSE S1	RMSE S3	r –value S1	r – value S3
0.3	670	428	556	5218	5861	0.43	0.44
1	1356	672	846	14077	10213	0.52	0.51
2	1748	1001	1284	12968	13195	0.56	0.55

Table 6: SOC loss of our study is 0.16

Table 7: only SOC fluxes from our study are corrected

	Our Study		*Doetterl et al. (2012)*	
Region	Sediment flux 2005 $Pg\ y^{-1}$	SOC flux 2005 $Tg\ C\ y^{-1}$	Sediment flux 2000 $Pg\ y^{-1}$	SOC flux 2000 $Tg\ C\ y^{-1}$
Africa	2.6	20.29	2.4	39.5
Asia	5.4	54.34	4.9	90.0
Europe	2.1	30.8	1.9	39.5
Australia	0.2	2.45	0.3	4.3
South-America	1.6	39.03	1.4	26.7
North-America	0.7	12.37	1.6	31.5
Total	12.6	161.53	12.5	231.5

Fig. 11. Tables 4 to 7