

Historical Soil Organic Carbon Budget

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Abstract. SOC one of larges c sinks on earth (3 times larger biospehre pool). Agricultural management leads to a depletion of soil organic crabon. However this depletion of soil organic carbon (SOC) pools are so far not well represented in global assessments of historic carbon emissions. While SOC models often represent well the biochemical processes that lead to the accumulation and decay of SOC, the management decisions driving these biophysical processes are still little investigated. Here we create a spatial explicit data set for crop residue and manure management on cropland based on global historic production (FAOSTAT) and land-use (LUH2) data and combine it with the IPCC Tier 2 approach to create a half-degree resolution soil organic carbon budget on mineral soils. We estimate that due to arable farming soils have lost over (?) GtOC of which (??) GtOC have been released within the period 1990-2010. Tier 2 IPCC methodolgy estimates higher soil organic carbon losses than Tier 1 methods, which may origin from We also find that SOC is very sensity to management decision such as residue recycling indicating the nessessity to incorporated better management data in soil models.

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1 Introduction

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2 Method (50)

2.1 Carbon Budget (50)

Based on the IPCC guidelines (Dirac, 1953, Feynman and Vernon Jr. (1963)) for soil organic carbon stocks, we combining approaches to estimate SOC stocks by weighting inflows via dead plant material (see @ref(sec:carboninputs)) against outflows
5 through SOC decay (see @ref(sec:tier1), @ref(sec:tier2)). Carbon displacement via leaching and erosion is neglected for this budget.

Connecting carbon inputs with soil carbon dynamics will create a budget of in- and outflows.

2.1.1 Soil Carbon turnover following (new) Tier 2 method (300)

Yearly turnover between three different SOC pools for the topsoil is model using global parameters.

10 2.1.2 Soil Carbon turnover following Tier 1 (150)

Stock changes are calculated using simple change factors on the SOC pools for the topsoil.

2.1.3 Carbon Inputs to the Soil

Carbon inputs are estimated based on the land use. Whereas cropland inputs are mainly formed by residue, dead below ground and cover crop biomass alterate by the corresponding management practice, pasture and natural vegetation inputs are estimate
15 via modelled annual litterfall rates. For the former we use various data sets and rule based approaches, which are specified in @ref(sec:agrimanagement)

2.2 Agricultural management (50)

We combine data sets to estimate agricultural flows and management decisions on cropland.

2.2.1 Landuse and Landuse Change (150)

20 We use LUH2v2 data for major Landuse types and their transition and fit cropspecific areas to country scale FAO data.

2.2.2 Crop Production and Residues (300)

FAO Production values are combined with Feed estimations from [Isabelles Paper] and rule based demand shares. LPJmL yield and LUH landuse patterns are used to scale down to half-degree.

2.2.3 Livestock Distribution and Manure Excretion (300)

25 Based on [Gridded Livestock of the world] we use rule based asumption to estimate livestock and manure distribution on the globe. Animal waste system shares are used as is [Bodirsky].

2.2.4 Irrigation (100)

Simple growing period calculations together with irrigation shares of LUH2v2 are use to estimate water effects on decay rates.

2.2.5 Tillage (100)

- 5 Tillage data sets of [Vera, others] together with rules are used to drive tillage effect on decay rates.

3 Content section with citations

See the R Markdown docs for bibliographies and citations.

Copernicus supports biblatex and a sample bibliography is in file `sample.bib`. Read [], and [see].

4 Content section with R code chunks

- 10 You should always use `echo = FALSE` on R Markdown code blocks as they add formatting and styling not desired by Copernicus. The hidden workflow results in 42.

You can add verbatim code snippets without extra styles by using ````` without additional instructions.

```
sum <- 1 + 41
```

5 Content section with list

- 15 If you want to insert a list, you must

- leave
- empty lines
- between each list item

6 Examples from the official template

20 6.1 FIGURES

When figures and tables are placed at the end of the MS (article in one-column style), please add

between bibliography and first table and/or figure as well as between each table and/or figure.

6.2 FIGURES

When figures and tables are placed at the end of the MS (article in one-column style), please add

Table 1. TEXT

a	b	c
1	2	3

Table Footnotes

Table 2. TEXT

a	b	c
1	2	3

Table footnotes

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6.2.1 ONE-COLUMN FIGURES

Include a 12cm width figure of Nikolaus Copernicus from Wikipedia with caption using R Markdown.

5 6.2.2 TWO-COLUMN FIGURES

You can also include a larger figure.

6.3 TABLES

You can ad \LaTeX table in an R Markdown document to meet the template requirements.

6.3.1 ONE-COLUMN TABLE

10 6.3.2 TWO-COLUMN TABLE

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- 15
- Physical quantities/variables are typeset in italic font (t for time, T for Temperature)

Indices which are not defined are typeset in italic font (x, y, z, a, b, c)

Items/objects which are defined are typeset in roman font (Car A, Car B)

Descriptions/specifications which are defined by itself are typeset in roman font (abs, rel, ref, tot, net, ice)

Abbreviations from 2 letters are typeset in roman font (RH, LAI)

Vectors are identified in bold italic font using \boldsymbol{x}

Matrices are identified in bold roman font

Multiplication signs are typeset using the LaTeX commands `\times` (for vector products, grids, and exponential notations)

5 or `\cdot`

The character `*` should not be applied as multiplication sign

6.5 ALGORITHM

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10

Algorithm 1 Algorithm Caption

```
 $i \leftarrow 10$ 
if  $i \geq 5$  then
   $i \leftarrow i - 1$ 
else
  if  $i \leq 3$  then
     $i \leftarrow i + 2$ 
  end if
end if
```

7 Conclusions

The conclusion goes here. You can modify the section name with `\conclusions[modified heading if necessary]`.

15 *Code and data availability.* use this to add a statement when having data sets and software code available

Appendix A: Figures and tables in appendices

Regarding figures and tables in appendices, the following two options are possible depending on your general handling of figures and tables in the manuscript environment:

A1 Option 1

If you sorted all figures and tables into the sections of the text, please also sort the appendix figures and appendix tables into the respective appendix sections. They will be correctly named automatically.

5 A2 Option 2

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To rename them correctly to A1, A2, etc., please add the following commands in front of them: `\appendixfigures` needs to be added in front of appendix figures `\appendixtables` needs to be added in front of appendix tables

Please add `\clearpage` between each table and/or figure. Further guidelines on figures and tables can be found below.

10 *Author contributions.* Karstens wrote code and paper build on work of Bodirsky. Bodirsky and Popp revised paper.

Competing interests. The authors declare no competing interests.

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References

- Dirac, P.: The lorentz transformation and absolute time, *Physica*, 19, 888–896, [https://doi.org/10.1016/S0031-8914\(53\)80099-6](https://doi.org/10.1016/S0031-8914(53)80099-6), 1953.
- Feynman, R. and Vernon Jr., F.: The theory of a general quantum system interacting with a linear dissipative system, *Annals of Physics*, 24, 118–173, [https://doi.org/10.1016/0003-4916\(63\)90068-X](https://doi.org/10.1016/0003-4916(63)90068-X), 1963.