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.

1 Introduction

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2 Method (50)

2.1 Carbon Budget (50)

Based on the IPCC guidelines vol. 4 and their refinement ((IPCC, 2006),(IPCC, 2019)) for soil organic carbon stocks, we combining approaches to estimate SOC stocks by weighting inflows via dead plant material (see 2.1.1) against outflows through SOC decay (see 2.1.2). Carbon displacement via leaching and erosion is neglected in this study. We calculate annual land use type specific budgets for cropland, pastures and natural vegetation, also representin land conversion as transfer between landuse type budgets. A simple approach based o the tier 1 method of the older IPCC guidelines vol 4. (IPCC (2006)) using stock change factors, is applied to cross validated results 2.1.3

2.1.1 Carbon Inputs to the Soil

Carbon input estimations are based on the land use type. Whereas cropland inputs are mainly formed by disaggregated country statistics on residue, dead below ground and cover crop biomass, pasture and natural vegetation inputs are estimate via modelled annual litterfall rates. Using the steady-state method of the IPCC guidelines ((IPCC, 2019)) carbon inputs have to be accompined by data on lignin and nitrogen content to allocate dead plant biomass to the corrosponding soil pools based on the chemical texture. Sources for all use data can be found in table 1

Table 1. Sources for carbon input data

Land use types	carbon inputs	nitrogen and lignin content
Cropland	FAO statistics, AQUASTAT, LPJmL4 [1]	default values [IPCC (2006)]
Pasture	annual litterfall in $\frac{gC}{m^2}$ from LPJmL4 - manage grassland [3]	default values [2]
Natural vegetation	annual litterfall in $\frac{gC}{m^2}$ from LPJmL4	Nitrogen and lignin content of tree compartments used in CENTURY

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

We are following the steady-state method of the refinement of the IPCC guidelines vol. 4 (IPCC (2019)) by calculating yearly turnover and transfer rates between three different SOC pools for the topsoil (0-30 cm). The approach is based on global parameters ([@ref(ipcc_2019_2019)]) as well as half-degree data on sand fraction (SoilGrids), temperature, preciptation and potential evapotranspiration (CRU). Next to the given climatic and natural biophysical properties irrigation regime (rainfed vs. irrigated) as well as tillage (as soil disturbance indicator) modificate processes. For cropland an assessment of tillage types and irrigation conditions has been made, whereas on pastures and natural vegetation, we assume rainfed and non-tilled conditions.

2.1.3 Soil Carbon turnover following Tier 1 (150)

Following the tier 1 approach of the IPCC guidelines vol. 4 (IPCC (2006)), stocks are estimated via stock change factors given by the IPCC for the topsoil (0-30 cm) and based on measurements. The factors are differentiate between different crop and management systems reflecting different dynamics under changed in- and outflows without explicitly tracking these. They can be seen as conservative guesses and will be used to evaluate our modelling based results.

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)

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)

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)

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

3 Results

4 Discussion

5 Conclusions

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

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

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.

A2 Option 2

If you put all figures after the reference list, please insert appendix tables and figures after the normal tables and figures.

`\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. 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: To rename them correctly to A1, A2, etc., please add the following commands in front of them:

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.

Disclaimer. We like Copernicus.

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References

IPCC: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Tech. rep., 2006.

IPCC: 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories — IPCC, Tech. rep., https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/, 2019.