Projected SOC stocks in German croplands under different climate change scenarios

Additional information

Catharina Riggers, Christopher Poeplau, Axel Don, Cathleen Frühauf, René Dechow

Thünen Institute of Climate-Smart Agriculture

THÜNEN

Snapshot of methods

Multi-model ensemble

- Combinations of SOC model and OC input estimation method
- Evaluated in Riggers et al., 2019

SOC model	OC input estimation method
CENTURY[1]	ccb[6]
	ipcc-nir[7]
	bze[8]
C-TOOL[2]	bolinder[9]
	ipcc-nir[7]
ICBM[3]	ccb[6]
	ipcc-nir[7]
ROTH-C[4]	ccb[6]
YASSO07[5]	ipcc-nir[7]

+

Climate scenarios

NO FUTURE CLIMATE CHANGE
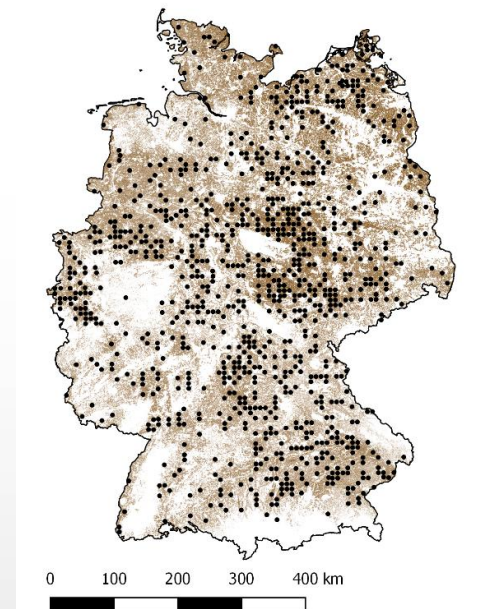Repetition of temperature and precipitation of last decade

CLIMATE CHANGE
Representative concentration pathways (RCPs)
- RCP2.6
- RCP4.5
- RCP8.5

+

German croplands

- Soil characteristics
- Land management of last decade

Riggers et al.
EGU 2020

[1]Parton et al. (1994), [2]Taghizadeh-Toosi et al. (2014), [3]Andrén and Kätterer (1997), [4]Coleman and Jenkinson (2005), [5] Tuomi et al. (2011), [6]Franko et al. (2011), [7]Rösemann et al. (2017), [8]Jacobs et al. (2018), [9] Bolinder et al. (2007)
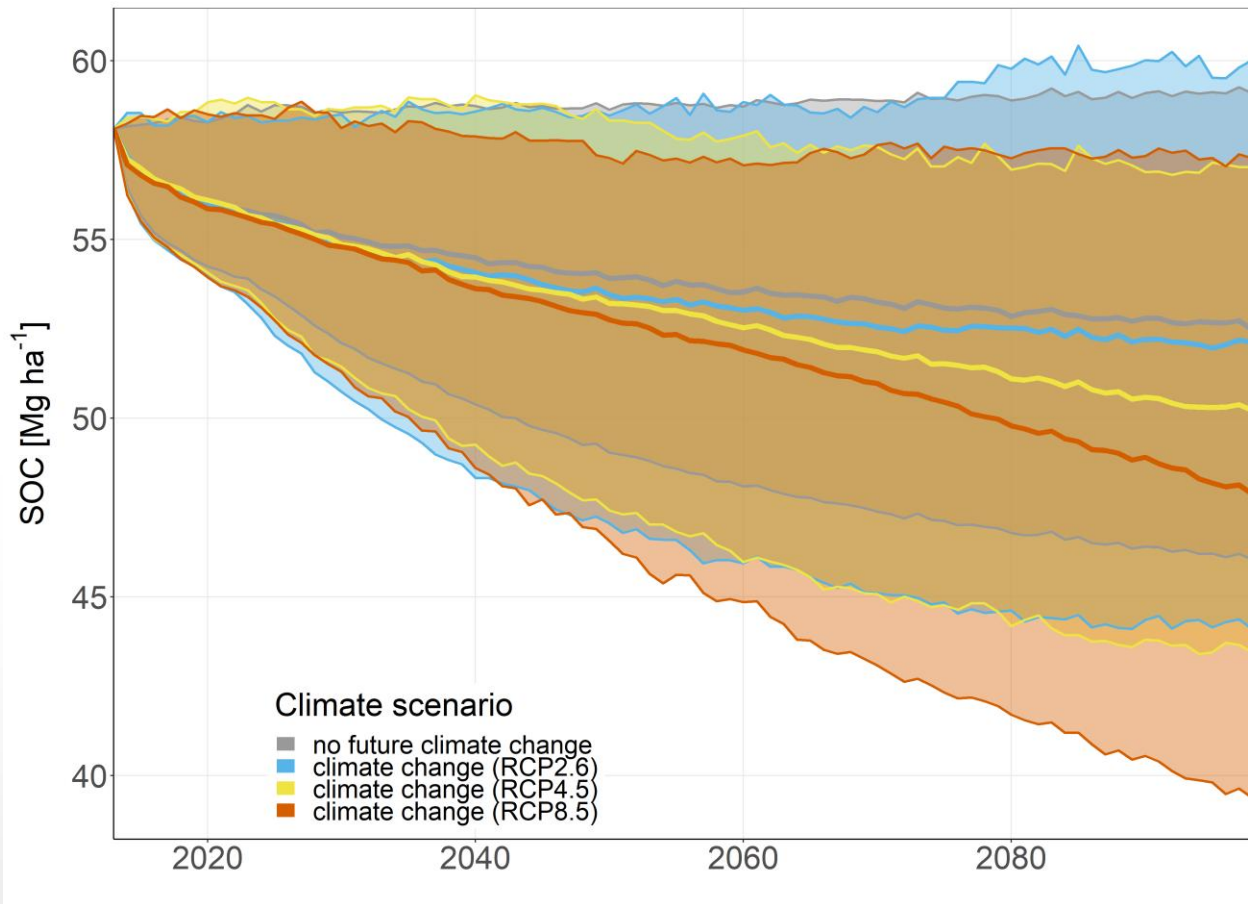
Declining SOC stocks in German croplands

Fig. 1: Mean projected SOC stocks under current yield levels and the 95 % confidence interval summarizing the ensemble uncertainty of climate projections and SOC models.

THÜNEN

Snapshot of methods II

Multi-model ensemble	+	Climate scenarios	+	German croplands

+

One-dimensional optimization

$$\Delta SOC = SOC_{target} - \left(\frac{1}{10} \sum_{i=2090}^{2099} SOC_{cinput,i} \right)$$

SOC_{target}: chosen target SOC stock [Mg ha^{-1}]
SOC_{cinput}: SOC stock time series of the scenario with increased OC input [Mg ha^{-1}]

SOC targets

1) SOC stock in 2099 is the same as in 2014 (= 58 Mg ha^{-1})

2) SOC stock in 2099 is increased by 4 ‰ a^{-1} (= 78 Mg ha^{-1})
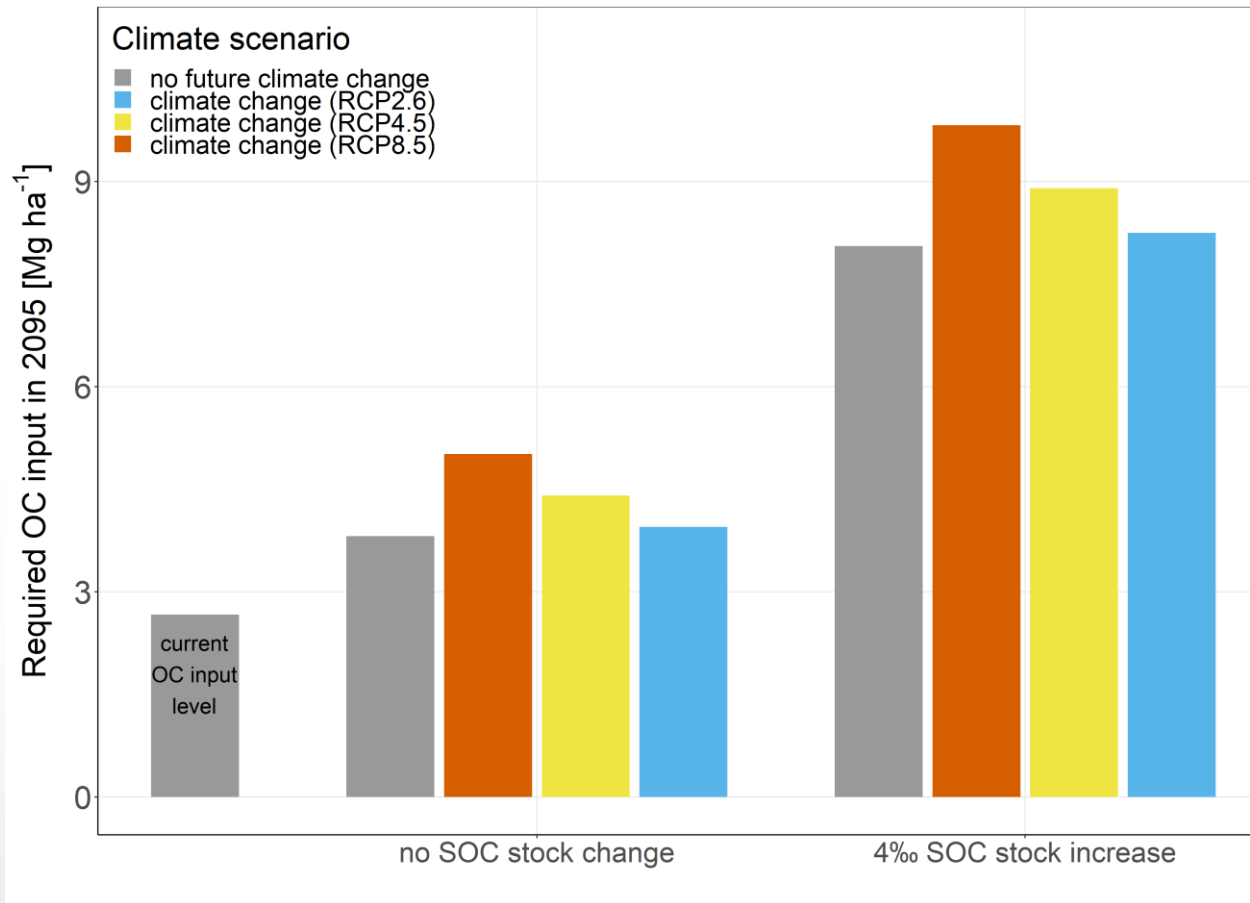
Estimated required OC input in 2095

Fig. 2: Estimated required above- and belowground OC input from plant residues, roots and root exudates for the year 2095.

THÜNEN

Literature

Andrén, O., Kätterer, T., 1997. ICBM: The introductory carbon balance model for exploration of soil carbon balances. Ecol Appl 7(4), 1226-1236.

Bolinder, M.A., Janzen, H.H., Gregorich, E.G., Angers, D.A., VandenBygaart, A.J., 2007. An approach for estimating net primary productivity and annual carbon inputs to soil for common agricultural crops in Canada. Agr Ecosyst Environ 118(1-4), 29-42.

Coleman, K., Jenkinson, D.S., 2005. ROTHC-26.3: A model for the turnover of carbon in soil: Model description and windows users guide. IACR Rothamsted, Harpenden.

Franko, U., Kolbe, H., Thiel, E., Liess, E., 2011. Multi-site validation of a soil organic matter model for arable fields based on generally available input data. Geoderma 166(1), 119-134.

Jacobs, A., Flessa, H., Don, A., Heidkamp, A., Prietz, R., Dechow, R., Gensior, A., Poeplau, C., Riggers, C., Schneider, F., Tiemeyer, B., Vos, C., Wittnebel, M., Müller, T., Säurich, A., Fahrion-Nitschke, A., Gebbert, S., Hopfstock, R., Jaconi, A., Kolata, H., Lorbeer, M., Schröder, J., Laggner, A., Weiser, C., Freibauer, A., 2018. Landwirtschaftlich genutzte Böden in Deutschland - Ergebnisse der Bodenzustandserhebung. Johann Heinrich von Thünen-Institut Thünen Report(64), 316 p.

Parton, W.J., Ojima, D.S., Cole, C.V., Schimel, D.S., 1994. A general model for soil organic matter dynamics: sensitivity to litter chemistry, texture and management. Quantitative modeling of soil forming processes (quantitativemod), 147-167.

Riggers, C., Poeplau, C., Don, A., Bamminger, C., Höper, H., Dechow, R., 2019. Multi-model ensemble improved the prediction of trends in soil organic carbon stocks in German croplands. Geoderma 345, 17-30.

Rösemann, C., Haenel, H.-D., Dämmgen, U., Freibauer, A., Döring, U., Wulf, S., Eurich-Menden, B., Döhler, H., Schreiner, C., Osterburg, B., 2017. Calculations of gaseous and particulate emissions from German agriculture 1990-2015: Report on methods and data (RMD) submission 2017. Thünen Report 46, 424pp.

Taghizadeh-Toosi, A., Christensen, B.T., Hutchings, N.J., Vejlin, J., Kätterer, T., Glendining, M., Olesen, J.E., 2014. C-TOOL: A simple model for simulating whole-profile carbon storage in temperate agricultural soils. Ecol Model 292, 11-25.

Tuomi, M., Rasinmäki, J., Repo, A., Vanhala, P., Liski, J., 2011. Soil carbon model Yasso07 graphical user interface. Environ Modell Softw 26(11), 1358-1362