

Biochar soil carbon

Relevance to political climate targets

Magnus Bo Karlsson

Roskilde University, Department of People and Technology

RGO webinar - Negative emissions from biochar

Background and purpose



Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Science of the Total Environment

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Dynamic assessment of biochar soil carbon climate change impacts

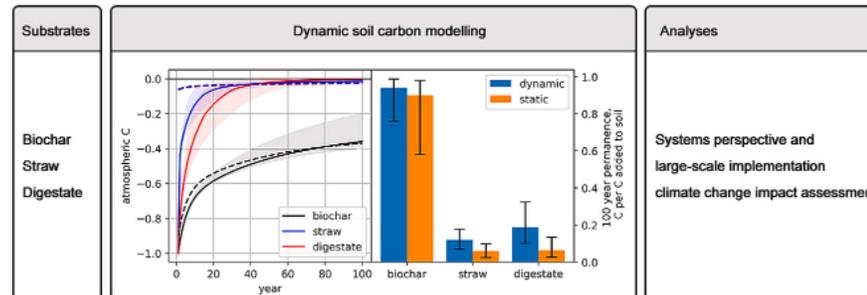
M.B. Karlsson^{a,*}, A. Kamp^a, T.P. Thomsen^a

^a Roskilde University, Department of People and Technology, Universitetsvej 1, 4000 Roskilde, Denmark

HIGHLIGHTS

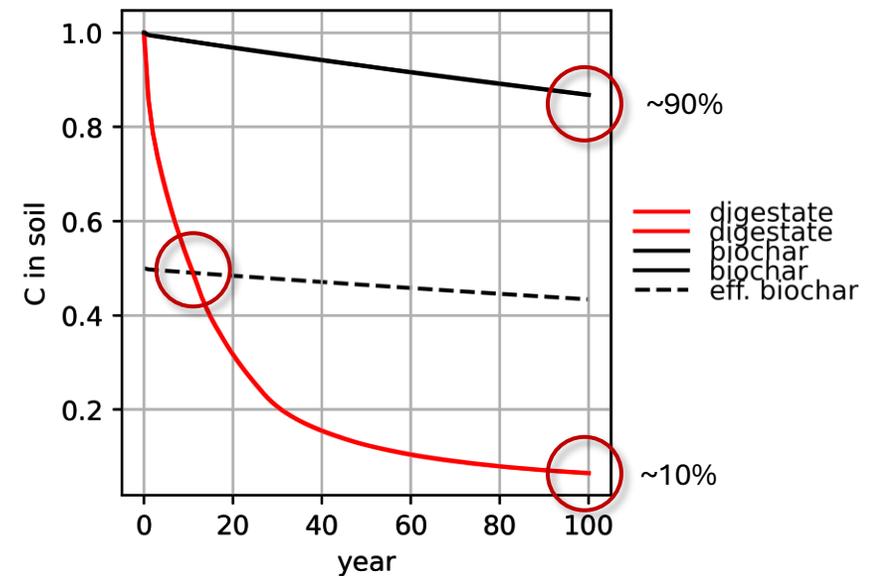
- Biochar provides soil C climate change benefits over biomass soil application.
- Static modelling underestimates biomass soil C climate impacts by a factor of 2–3.
- Scaling biochar production towards 2050 provides benefits towards temperature targets.
- Misaligned incentives in LULUCF methods can become a barrier to biochar deployment.

GRAPHICAL ABSTRACT



Background and purpose

- Biochar soil C is more stable than biomass
- ~50% of biomass C becomes bioenergy in pyrolysis
- What is the impact of the delay in soil carbon storage benefit?
- Static method disregards short term soil C storage



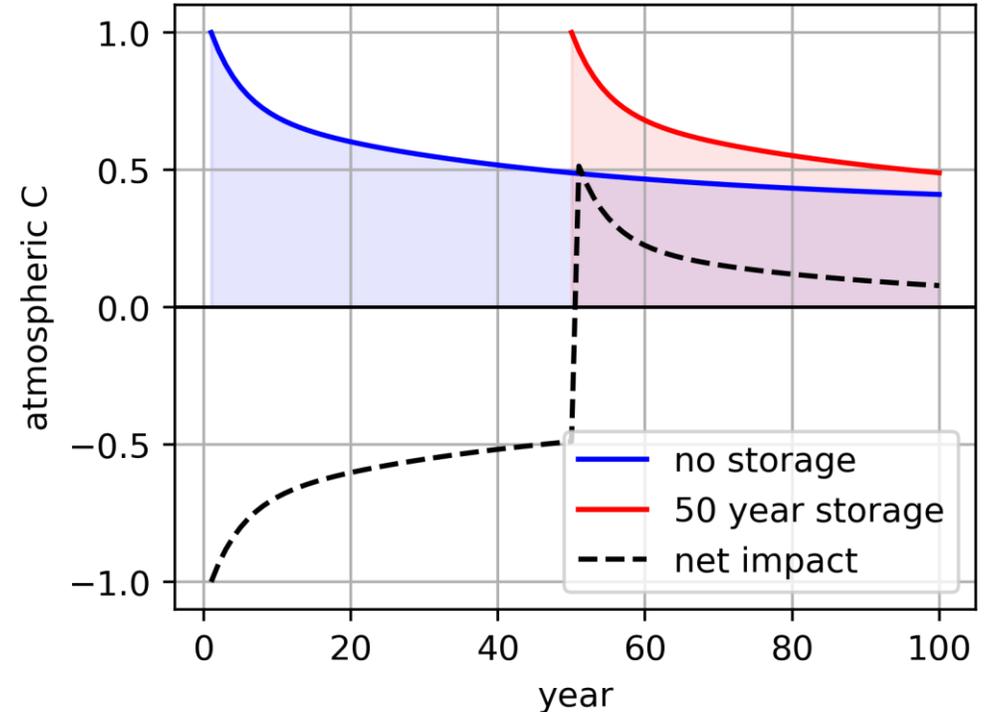
Methods

Dynamic climate change impacts

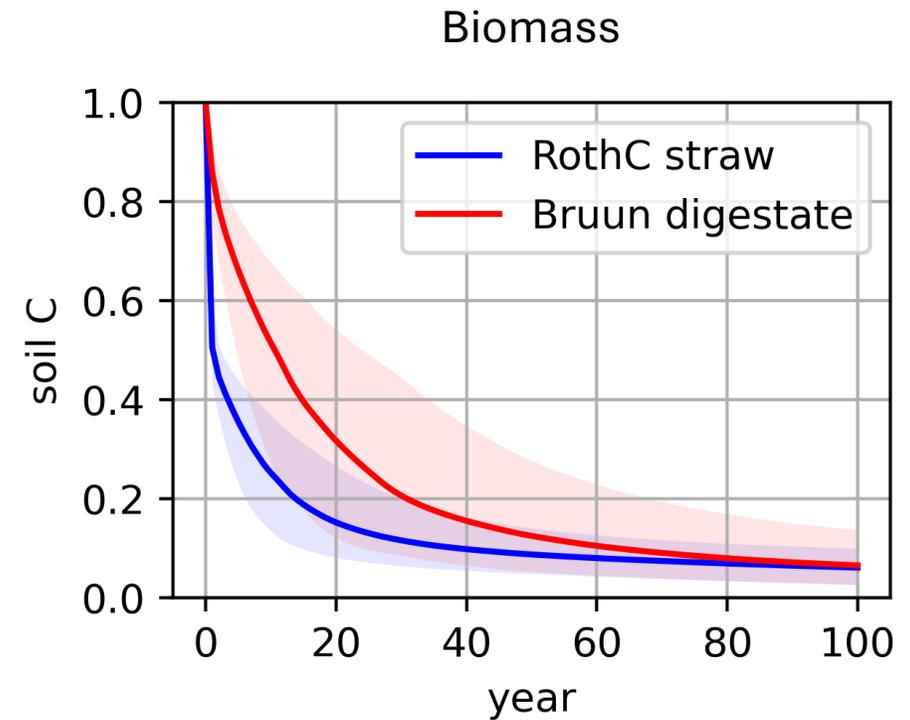
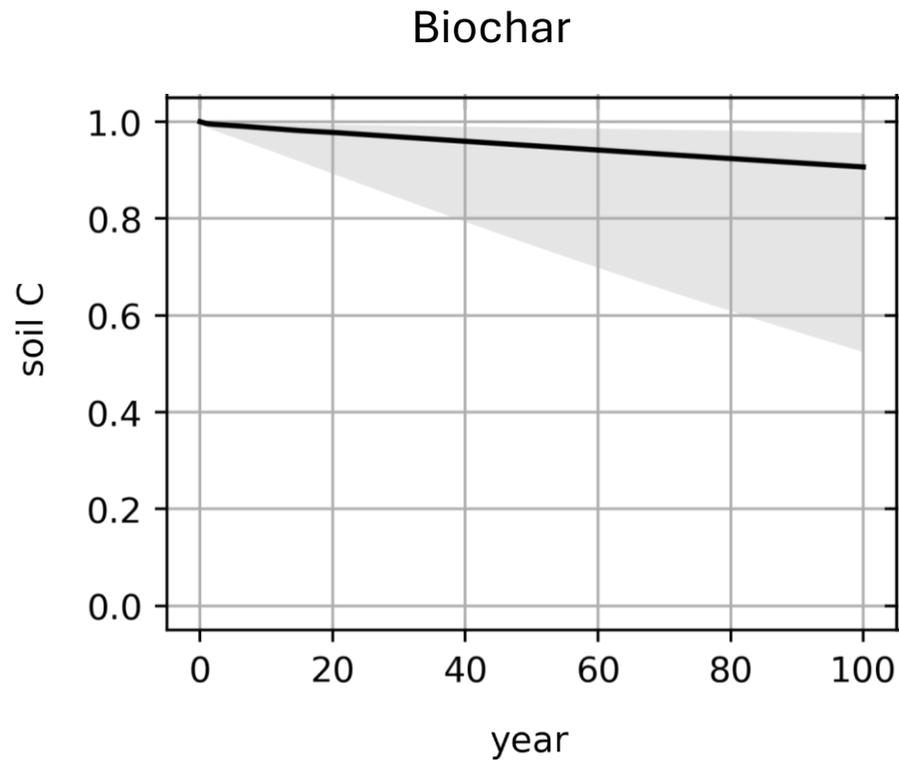
- The impact of temporarily removing carbon from the atmosphere (Levasseur et al. 2010)

Soil carbon storage

- Biochar (Azzi et al. 2024)
- Biomass (Modified RothC, Jenkinson et al. 1991)



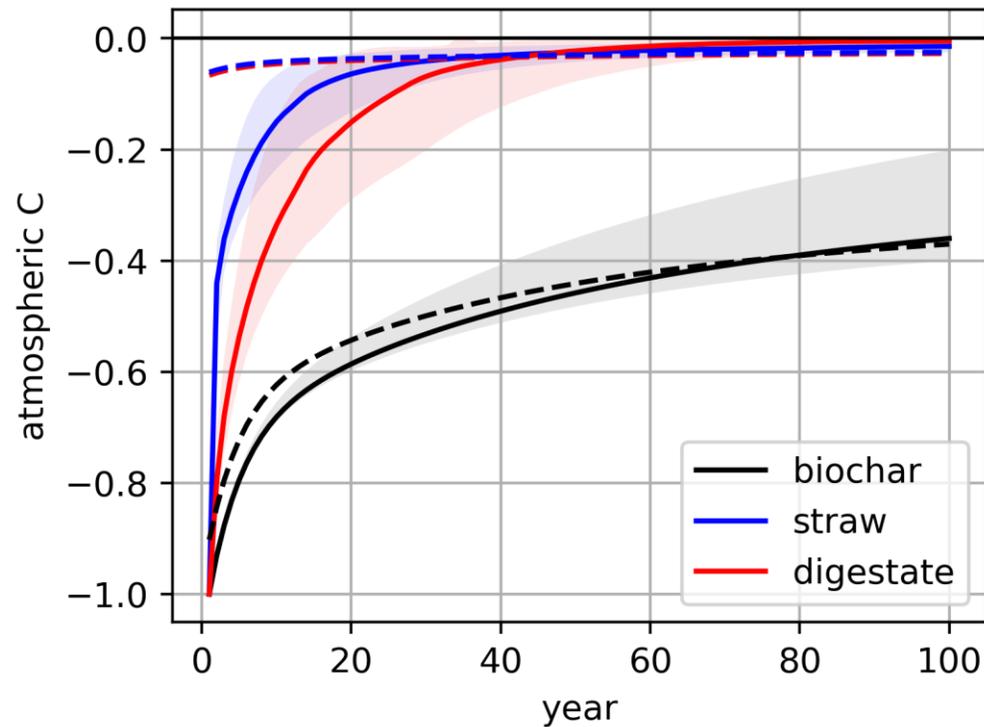
Results - soil carbon



Shaded areas are 95% confidence intervals

Results – impact per unit carbon to soil

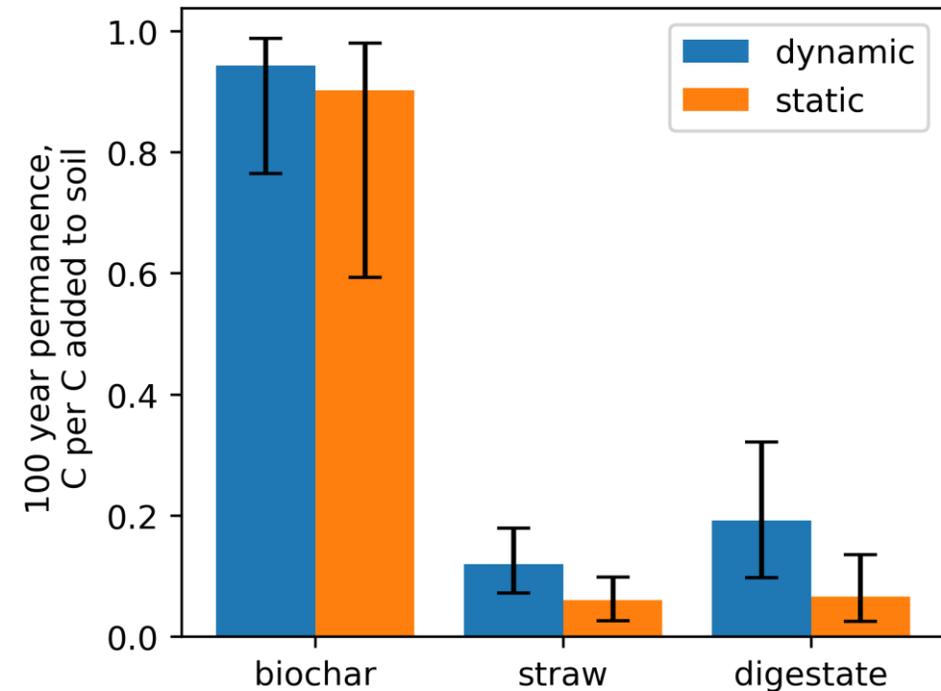
Impact of biomass and biochar soil C storage on atmospheric C content



Dashed lines show static result

Shaded areas are 95% confidence intervals

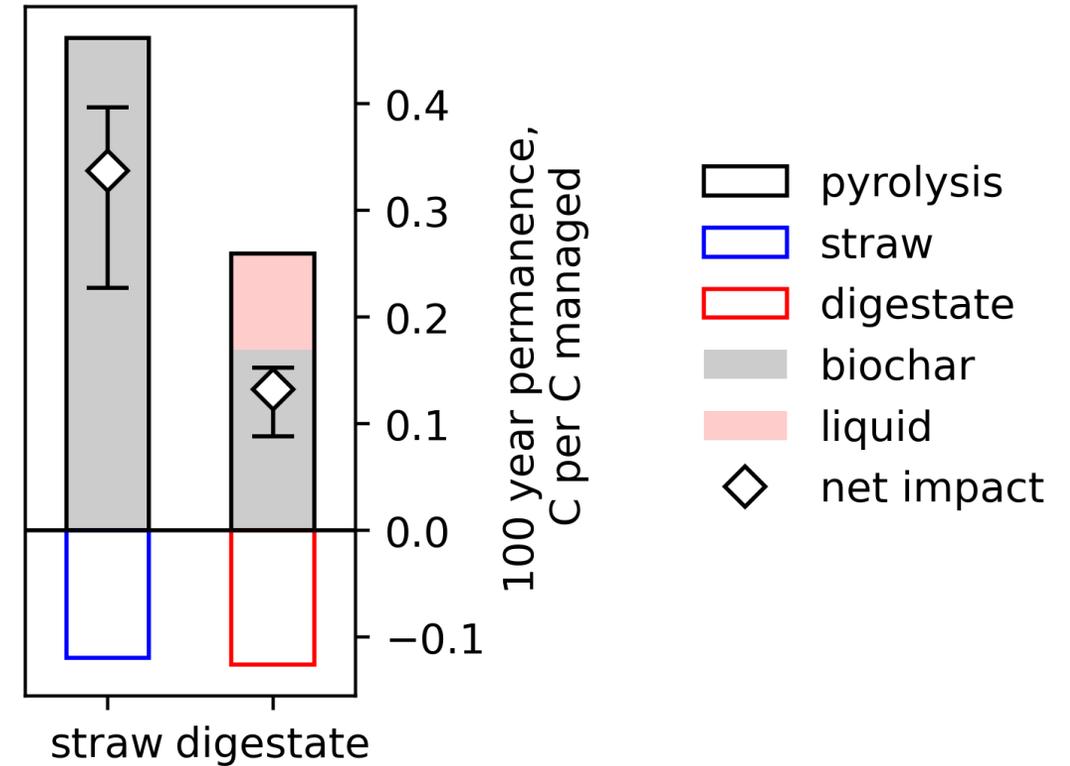
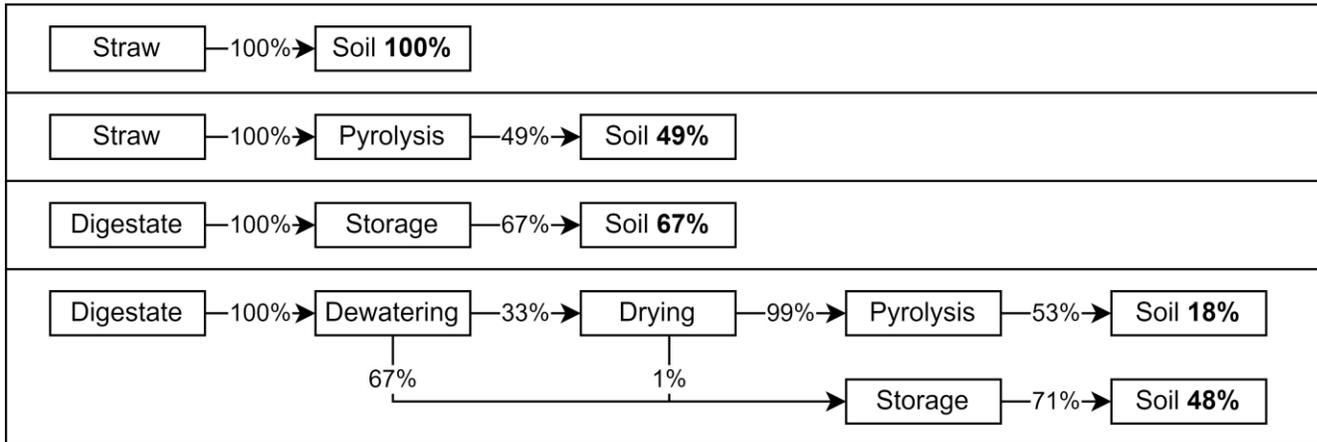
Impact expressed as single factor



Error bars show 95% confidence intervals

Results – systems perspective impact

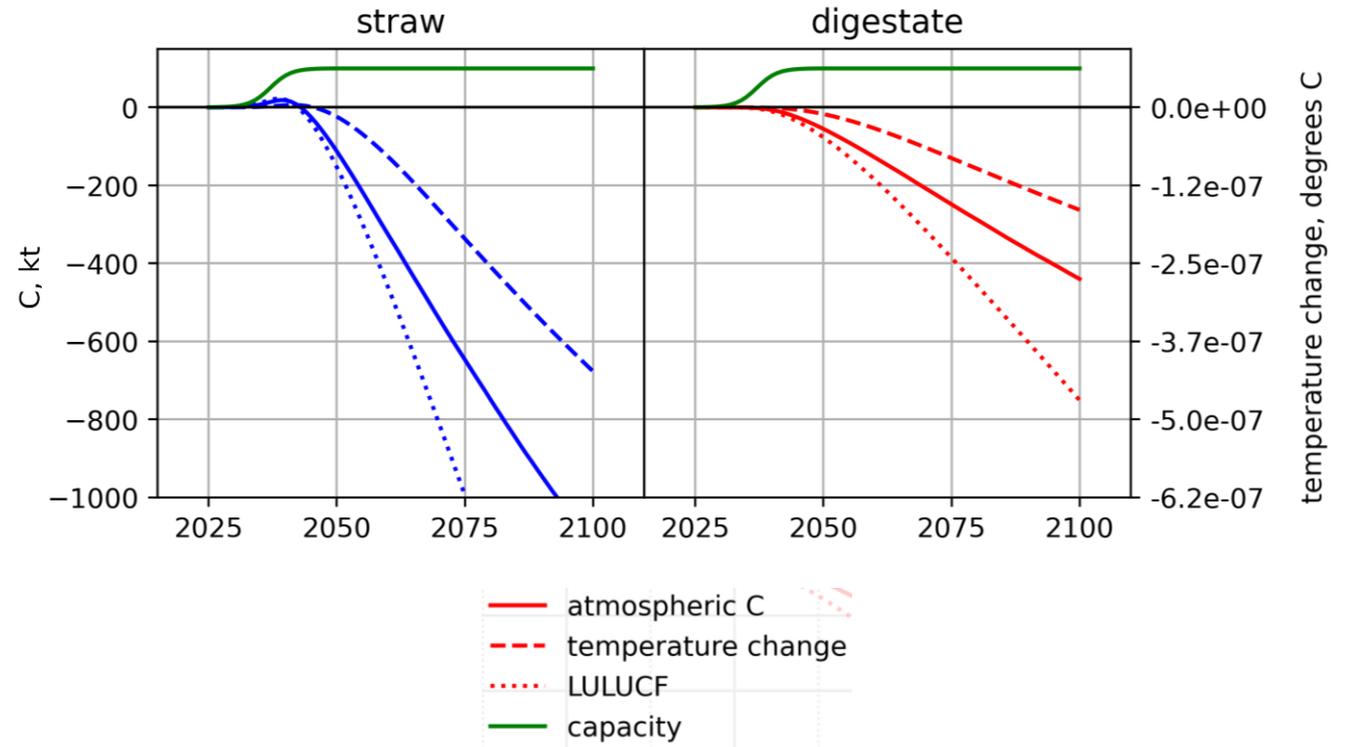
Carbon flow in modelled scenarios



Results – scale up scenario

What happens if we scale pyrolysis capacity over time?

- Faster scale-up gives earlier and greater impact
- Large benefit towards Paris agreement 2100 temperature target



Political climate targets

How does biochar fit into political targets?

- Biochar accounted in LULUCF as change in soil carbon stock
- Fast degrading C not accounted to limit variation (+/- 5 Mt CO₂e)

Increased global temperatures, a steady total carbon stock was modelled between 2000 and 2010, while the total SOC increase after 2010. Since 1990, C-TOOL has estimated a decline of 0.04 % of the total SOC in the mineral agricultural soils (average 1988-1992 to average 2016-2020). No precise uncertainty calculation has been made. However, it is assumed that the uncertainty of the annual loss/gain is around 25 %. Denmark has very good data on harvest yields and cultivated area data, which indicate a low uncertainty.

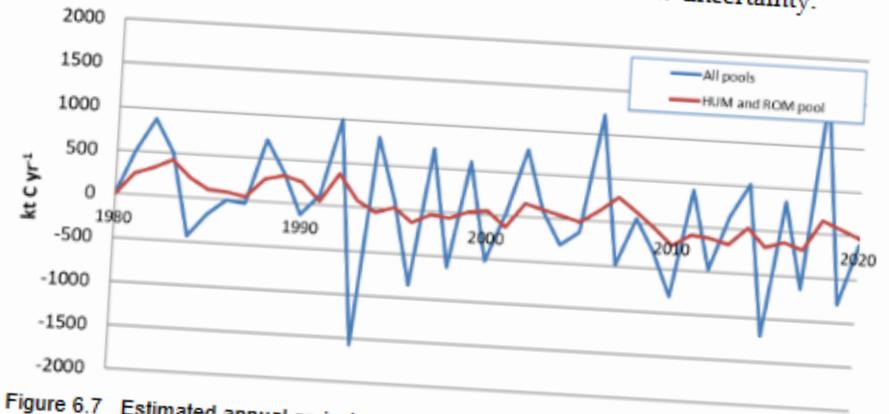


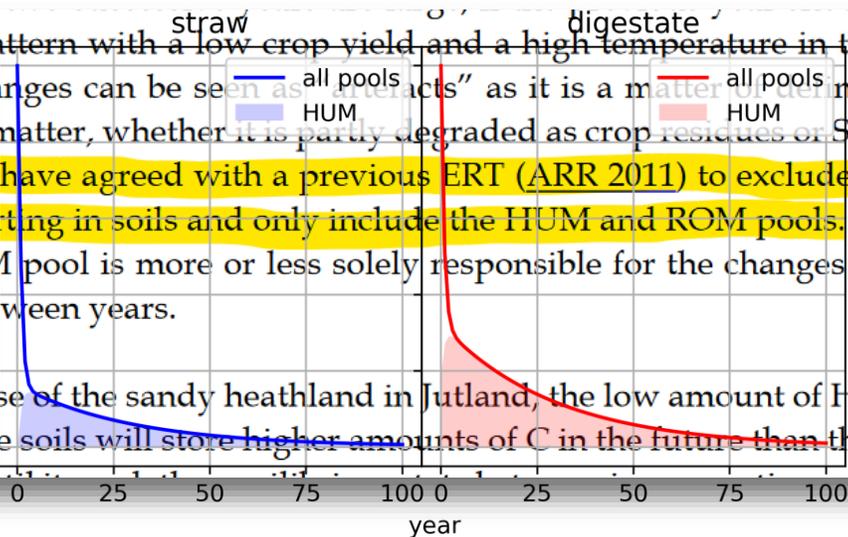
Figure 6.7 Estimated annual emissions from mineral soils 1981 to 2020 (kilo tonnes CO₂ yr⁻¹).

Verification of C-TOOL

C-TOOL is partly parameterised with data from the Danish Agricultural soil sampling grid. The grid was established in 1987 in a 7 x 7 km² grid. In 1987, > 600 agricultural plots were sampled and analysed for carbon. Half of the grid were resampled in 1998 and a full resampling of 464 plots was made in 2008/2009. Figure 6.8 shows the development of the carbon stock in 0-100 cm depth in the paired plots, which indicate an increase for the soil C stock at the sandy soils (Coarse Sand, Fine Sand and Loamy Sand). This is mainly due to increase of the crop yields, which increase the amount of organic matter returned to soil. Furthermore, the Danish Agricultural Research Institute (MIP) has conducted a series of experiments with straw and digestate treatments. In the case of the sandy heathland in Jutland, the low amount of HUM means that these soils will store higher amounts of C in the future than the other soil

positive pattern with a low crop yield and a high temperature in the autumn. Such changes can be seen as "interacts" as it is a matter of definition of the organic matter, whether it is partly degraded as crop residues or SOM. Therefore, we have agreed with a previous ERT (ARR 2011) to exclude FOM from the reporting in soils and only include the HUM and ROM pools. As a result, the HUM pool is more or less solely responsible for the changes in the SOC stock between years.

In the case of the sandy heathland in Jutland, the low amount of HUM means that these soils will store higher amounts of C in the future than the other soil

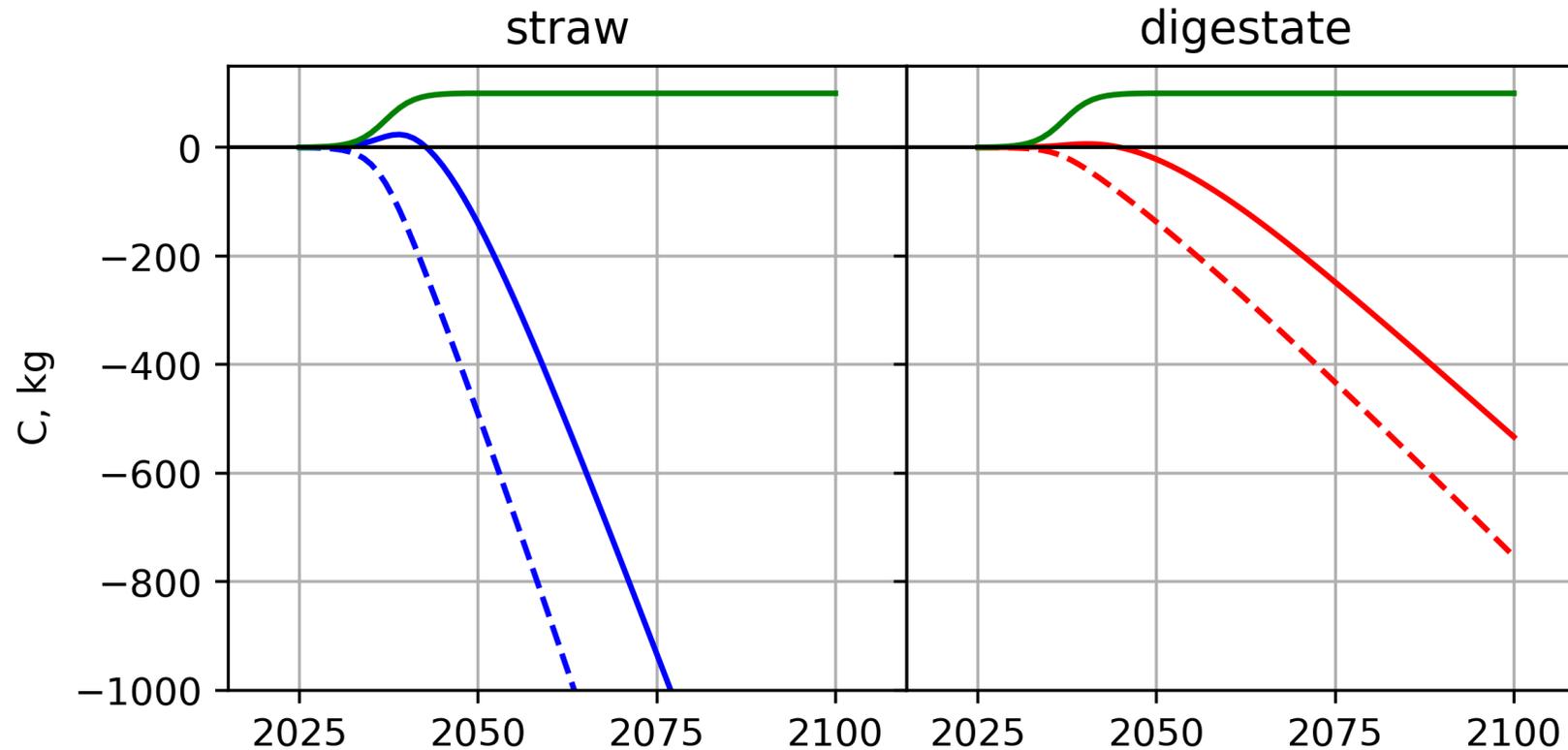


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Results – scale up scenario LULUCF

Biochar is always beneficial with DK LULUCF methods



Conclusions

- Dynamic modelling improves accuracy of climate change impact assessment
- Biochar is a potent tool for climate change mitigation through soil carbon storage
- Large scale implementation of biochar can contribute beneficially towards 2100 temperature target
- LULUCF accounting methods and short term political climate targets can become barrier to fulfilling biochar climate change potential

References

- Azzi et al. (2024) Modelling biochar long-term carbon storage in soil with harmonized analysis of decomposition data. [10.1016/j.geoderma.2023.116761](https://doi.org/10.1016/j.geoderma.2023.116761)
- Jenkinson et al. (1991) Model estimates of CO₂ emissions from soil in response to global warming. [10.1038/351304a0](https://doi.org/10.1038/351304a0)
- Levasseur et al. (2010) Considering time in LCA: Dynamic LCA and its application to global warming impact assessments. [10.1021/es9030003](https://doi.org/10.1021/es9030003)