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Integrated modelling of soil carbon storage in croplands under climate and agro-economic change in a central European river basin

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Changes in climate and land use caused by socio-economic changes, greenhouse gas emissions, agricultural policies and other factors, are known to affect soil Carbon (C) storage.

This study provides an assessment of present day (1951 – 2000) soil C dynamics and of effects of plausible regionalized climate and agro-economic change impacts on soil C storage and net C fluxes to the atmosphere for croplands in the German part of the Elbe river basin for the period 2001 to 2055. Beside possible future climate change impacts, regionalized agroeconomic change impacts on soil C storage have been assessed. An increase of surplus-arable land (land which falls out of agro-economic use and becomes abandoned) of approx. 30 % cropland area is anticipated. Based on four scenario runs (surplus land converts to (1) setaside with black fallow use, (2) ley-arable use, (3) bioenergy crops, and (4) use of harvest byproducts for energy generation) trajectories of agro-economic change effects on soil C storage and land-atmosphere fluxes of C have been investigated.

Results indicate that currently (average of 1991 to 2000 period) croplands are a net source of carbon (net annual flux of 11 g C m-2 yr-1 to the atmosphere). Climatic trend present for the years 1951 to 2000 (+ 0.8 ˚ C in summer and + 1.4 ˚C in winter mean temperature) already causes a net flux of 7 g C m-2 yr-1 to the atmosphere. Future climate change only effects results in an increased net flux of additional 3 g C m-2 yr-1, but this effect is less than agro-economic changes (range between -14 to 12 g C m-2 yr-1). The different assumed agro-economic scenarios yield to an extra flux of 12 g C m-2 yr-1 for (1), and a soil C sequestration of 14 g C m-2 yr-1 for (2), 7 g C m-2 yr-1 for (3) and 0.5 g C m-2 yr-1 for (4) on a basin scale average. Uncertainty stemming from climate change scenario ranges was low with only small alterations in simulated soil C components.

Other uses of surplus arable land (bioenergy crops or ley-arable) lead to a considerable reduction of net flux to the atmosphere with ley-arable use converting the basin from a source to an overall C sink. Additionally substitution effect of fossil fuel resources by bioenergy crops and harvest by-products is substantial ($\sim$ 162 800 TJ yr-1, 1012Joule). The use of harvest by-products as bioenergy resource although has to be seen critically, as harvest byproducts are important for soil C reproduction and for maintaining soil fertility.

Based on this study a present day assessment of soil C balance was obtained together with future soil C development under possible environmental changes. Furthermore, regions suffering largest changes and regions offering potential for soil C sequestration in the Elbe basin could be identified. Hence, this assessment may deliver useful information for decision making in environmental change mitigation.