**Thesis title: Modelling soil organic carbon dynamics under land use and climate change**

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Summary

Soil organic matter (SOM) models simplify the complex – and not yet fully understood – turnover dynamics of organic matter in soils. While process understanding advances rapidly, the implementation of critical issues in SOC models lags behind. Two of these processes are the stabilization mechanisms of SOM (of which carbon (C) is a substantial constituent) and the integration of SOC dynamics of organic soils into regional scale SOC assessments. Stabilization mechanisms are currently thought to play a dominant role in SOM turnover but are not explicitly accounted for in most SOM models. One paper of this thesis addresses the implementation of a simple approach to account for the stabilization mechanism of physical protection in the SOC model RothC using $^{13}$C abundance measurements in conjunction with soil size fractionation data. This approach improves the applicability of RothC under land use change where soil C is rapidly lost, which makes the conceptual model pools potentially measurable and is in line with currently proposed new conceptual models on SOM turnover.

SOM models are not only applied for the sake of scientific research but are increasingly used to support policy decisions on C mitigation. As such, the variability and credibility of model results have moved into the focus of interest. Credibility describes the probability of the model's predictions being correct, or the uncertainty of model results. While the techniques of uncertainty assessments are well established, the applications of such analyses with SOM models are still in early stages. In this thesis, a site scale Monte Carlo based uncertainty analysis of a SOM-pasture model was carried out. The variability of net-ecosystem-exchange predictions, as an integrator for ecosystem carbon processes due to model input data uncertainty, was estimated. Additionally, the contribution of each individual input factor was quantified. One of the major results was that uncertainty and factor importance depends on the combination of external drivers. This implies that site scale uncertainty derived with such an approach cannot easily be spatially up-scaled.

A simpler approach was used to estimate uncertainties in SOC stock changes of mineral and organic soils in Scotland. This assessment evaluated the precision of the SOM model ECOSSE at a range of soil monitoring sites. The average statistical model error at site scale was transferred to regional scale uncertainty. ECOSSE integrates SOM dynamics of mineral and organic soils and can be applied using only a limited amount of data which reflects the data availability at national scale. While the statistical analysis of model error was limited to a small number of sites, the mean deviation between simulated and observed SOC stock changes gave an indication of the uncertainty in national scale predictions. National scale simulations were carried out subsequently to quantify SOC stock changes differentiating between organic and mineral soils and land use change types. Organic soils turned out to be most vulnerable to SOC losses in the last decades. This finding was not compromised by the previously estimated uncertainty, and the results were used to delineate land use change specific policy relevant soil C mitigation options. The last study used the RothC model to simulate possible futures of global SOC stock changes under land use change and ten different climate scenarios. Land use change turned out to be of minor importance and the regional balance between soil C inputs and decomposition leads to a diverse map of regional C gains and losses with different degrees of certainty.