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Impact of land-use change on soil organic carbon dynamics – Development of carbon response functions

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Soils contain about twice as much carbon as the atmosphere and therefore the balance of inputs and outputs of soil organic carbon (SOC) has a critical influence on atmospheric CO2 concentration. Land-use changes are major impacts on this balance and may therefore turn soils into sinks or sources of CO2 for a certain period of time. This transition time for soils to reach a new steady state after a certain land-use change (LUC) is expected to be longer in the temperate zone than in the tropics. For greenhouse gas reporting it is crucial to quantify climate zone specific SOC dynamics as a function of time. However, in most existing reviews SOC changes after LUC are given as overall means, while the temporal dynamic is ignored. Furthermore, they are often not restricted to specific climate zones. In the presented work we compiled 95 studies covering 322 test sites with paired plot, chronosequence or mono site design in the temperate zone. On the basis of this data we derived Carbon Response Functions (CRFs) to model the temporal dynamics of SOC after LUC. In total, 5 different LUC could be investigated: Cropland to grassland and vice versa, cropland to forest and vice versa, grassland to forest. SOC dynamic followed the hypothesis "slow in, fast out" with no new steady state being reached within 120 years in the case of SOC accumulating LUC types. In afforestations 200 years of linear accumulation of C in the litter layer were found, comprising 30 % of the total soil C accumulation. Conversion of grassland or forest to cropland caused a rapid C loss of 31-36 % within 17-23 years. To investigate the influence of environmental parameters on the SOC change rate and to improve the modelling efficiency, mean annual temperature (MAT), mean annual precipitation (MAP), clay content and sampling depth were used as explanatory variables in a more complex model. The SOC change rate increased with temperature and precipitation but decreased with clay content and sampling depth. As a simple and robust model approach the developed CRFs provide an easily applicable tool to estimate SOC stock changes after LUC to improve greenhouse gas reporting in the framework of UNFCCC.