Geophysical Research Abstracts
Vol. 18, EGU2016-11335, 2016
EGU General Assembly 2016

Drivers of soil organic matter vulnerability to climate change, Part II: RothC modelling of carbon dynamics including radiocarbon data

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It is still largely unknown what drives the vulnerability of soil organic carbon (SOC) stocks to climate change, i.e. the likelihood of a soil to loose its SOC along with the change in environmental conditions. Our objective is to assess the SOC vulnerability of Swiss forest soils and identify its potential drivers: climate (temperature, soil moisture), soil (clay content, pH) and landscape (slope, aspect) properties. Fifty-four sites were selected for balanced spatial and driver magnitudes distribution. We measured the SOC characteristics (content and radiocarbon) and studied the C decomposition by laboratory soil incubations (details in Part I, abstract by B. González Domínguez). In order to assess the current SOC pool distribution and its radiocarbon signatures, we extended the Rothamsted Carbon (RothC) model with radiocarbon (14C) isotope modelling (RothCiso).

The RothC model distinguishes four active SOC pools, decomposable and resistant plant material, microbial biomass and humified organic matter, and an inert SOC pool (Jenkinson 1990). The active pools are decomposed and mineralized to CO_2 by first order kinetics. The RothCiso assigns all pools a 14C signature, based on the atmospheric 14C concentrations of the past century (plant C inputs) and their turnover. Currently we constrain the model with 14C signatures measured on the 54 fresh and their corresponding archived bulk soil samples, taken 12-24 years before. We were able to reproduce the measured radiocarbon concentrations of the SOC with the RothCiso and first results indicate, that the assumption of an inert SOC pool, that is radiocarbon dead, is not appropriate. In a second step we will compare the SOC mean residence time assessed by the two methodological approaches – incubation (C efflux based) and modelling (C stock based) – and relate it to the environmental drivers mentioned above.

With the combination of the two methodological approaches and 14C analysis we hope to gain more insights into the source of the C lost along with climate change – is it "young" C from active pools with high turnover (e.g. plant material) or is it rather "old" C that was stabilized in pools with slow turnover (e.g. "humified" or stabilized organic matter)? This will enable us to judge if the C losses observed in the incubation experiments are relevant for longer time scales (decades) and could not be easily compensated for by increased C inputs. Thus, the SOC vulnerability to climate change will be rated based on the amount and source of C lost and compared with climate, soil and landscape properties to gain insights on the drivers of the SOC vulnerability on a regional scale.

References

Jenkinson, D. S. (1990). The turnover of organic carbon and nitrogen in soil. Phil. Trans. R. Soc. Lond. B, 329, 361–368.