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Drivers of soil organic matter vulnerability to climate change. Part I: Laboratory incubations of Swiss forest soils and radiocarbon analysis

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Given the key role of soil organic carbon (SOC) on climate and greenhouse gas regulation, there is an increasing need to incorporate the carbon (C) feedback between SOC and the atmosphere into earth system models. The evaluation of these models points towards uncertainties on the response of CO_2-C fluxes, derived from the decomposition of SOC, to the influence of controls/drivers. SOC vulnerability refers to the likelihood of losing previously stabilized soil organic matter, by the effect of environmental factors. The objective of this study is to produce a SOC vulnerability ranking of soils and to provide new insights into the influence of environmental and soil properties controls.

Research on SOC vulnerability tends to focus on climatic controls and neglect the effect of other factors, such as soil geochemistry and mineralogy, on C stabilization/de-stabilization processes. In this work, we hypothesized that climate (mean annual temperature and soil moisture status proxy at the research sites in the period 1981-2010), soil (pH and % clay) and terrain (slope gradient and orientation) characteristics are the main controls of the CO_2-C fluxes from SOC. Following a statistics-based approach, we selected 54 forest sites across Switzerland, which cover a broad spectrum of values for the hypothesized controls. Then, we selected the study sites so that the controls are orthogonal to each other; thus, their effect was not confounded. At each site, we collected three non-overlapping topsoil (i.e. 20 cm) composites within 40 x 40 m2 plots. In the laboratory, we sieved fresh soils at 2 mm and run a 2-weeks pre-incubation, before beginning a 6-months aerobic soil incubation under controlled conditions of moisture and temperature. Periodically, we collected NaOH (1M) traps containing the CO_2-C derived from microbial heterotrophic respiration.

We calculated the cumulative CO_2-C respired and the one-pool SOC decomposition rates from the 54 forest sites, and linked these data to the controls. The main result is that soil moisture and pH drive the CO_2-C losses, and that temperature, % clay and terrain characteristics do not play a role. We will also present results on the relationship between the bulk soil radiocarbon signature of the 54 forest soils and their CO_2-C losses, as a preliminary insight into SOC vulnerability and SOC stabilization processes.