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Temperature sensitivity of decomposition of soil organic carbon fractions

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Knowing the temperature sensitivity of soil organic matter (SOM) decomposition is important for estimating the release of carbon from soil to the atmosphere in response to global warming. This temperature sensitivity is known relatively well for the most labile SOM fractions but still quite poorly for more recalcitrant fractions that represent the great majority of SOM.

We report results for the temperature sensitivity of various SOM fractions in two different experiments in which we utilized natural abundances of carbon isotopes 13C and 14C combined with Bayesian mathematical modelling. In one experiment, the different age fractions were distinguished based on depth in a peat profile. In the other experiment, the age fractions were separated based on a time series of conversion from C3 vegetation to C4 vegetation. In both experiments, the temperature sensitivity of the SOM fractions was estimated by measuring the carbon isotope composition of heterotrophic soil respiration at different temperatures in laboratory.

The results from these experiments suggest that the temperature sensitivity of unprotected SOM fractions increases with age, but if an environmental factor, such as bonding to soil minerals, limits decomposition of a SOM fraction, the temperature sensitivity is reduced. Our results are in agreement with the theory that suggests that in soil without environmental, physical or chemical protection, temperature sensitivity of carbon compounds is mainly determined by its chemical structure. The more complex the structure is the higher activation energy is needed and the higher its temperature sensitivity. Since SOM enriches with more complicated carbon compounds with time, this leads to increase in temperature sensitivity as SOM ages. However, our results also indicate that if the soil carbon is associated with minerals it might exhibit lower temperature sensitivities than when the carbon is “free” in the soil. Since the mineral associated carbon can have high residence times this finding contradicts with the expected correlation between age and temperature sensitivity of SOM. Temperature sensitivity of soil respiration thus depends on the decomposing soil carbon fraction and is not necessarily higher for older carbon compounds. We are using the results of these experiments to improve the Yasso soil carbon model.