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Modelling *in situ* enzyme potential of soils: a tool to predict soil respiration from agricultural fields

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The fate of soil organic carbon (SOC) is one of the largest uncertainties in predicting future climate and terrestrial ecosystem functions. Extra-cellular enzymes, produced by microorganisms, perform the very first step in SOC degradation and serve as key components in global carbon cycling. Very little information is available about the seasonal variation in the temperature sensitivity of soil enzymes. Here we aim to model *in situ* enzyme potentials involved in the degradation of either labile or recalcitrant organic compounds to understand the temporal variability of degradation processes. To identify the similarities in seasonal patterns of soil respiration and *in situ* enzyme potentials, we compared the modelled *in situ* enzyme activities with weekly measured soil CO_2 emissions. Arable soil samples from two different treatments (4 years fallow and currently vegetated plots; treatments represent range of carbon input into soil) were collected every month from April, 2012 to April, 2013, from two different study regions (Kraichgau and Swabian Alb) in Southwest Germany. The vegetation plots were under crop rotation in both study areas. We measured activities of three enzymes including β-glucosidase, xylanase and phenoloxidase at five different temperatures. We also measured soil microbial biomass in form of microbial carbon (C_{mic}). Land-use and area had significant effects ($P < 0.001$) on the microbial biomass; fallow plots having less C_{mic} than vegetation plots. Potential activities of β-glucosidase ($P < 0.001$) and xylanase ($P < 0.01$) were significantly higher in the vegetation plots of the Swabian Alb region than in the Kraichgau region. In both study areas, enzyme activities were higher during vegetation period and lower during winter which points to the importance of carbon input and/or temperature and soil moisture. We calculated the temperature sensitivity (Q_{10}) of enzyme activities based on laboratory measurements of enzyme activities at a range of incubation temperatures. Q_{10} of β-glucosidase activity changed significantly across the year (Q_{10} values ranges from 1.5 to 2.0 in Kraichgau and 1.6 to 2.1 in Swabian Alb), while for xylanase activity, no significant effects were found (Q_{10} values ranges from 1.2 to 3.0 in Kraichgau and 1.3 to 3.3 in Swabian Alb) in both study regions. By using laboratory based enzyme activities, calculated Q_{10} values, and daily soil temperature data, we modelled *in situ* enzyme potentials in soils for labile and recalcitrant carbon pools for both study regions. We observed an increase in modelled *in situ* enzyme activities during the summer period and a substantial decrease during winter indicating temperature as a strong controlling factor. A significant higher positive correlation of soil surface CO_2 flux with modelled *in situ* β-glucosidase activity was found in both study regions compared to modelled *in situ* xylanase activity.

These results demonstrate that (1) Q_{10} values are site and season specific and should be added into carbon models and (2) the indication of the relevance of greater contribution of labile carbon pool to soil CO_2 emissions.