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Moisture-temperature interactions in soil carbon fluxes as a result of substrate dynamics

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Soil carbon fluxes are complex and often non-linear with respect to their drivers. Mechanistic soil carbon models have the capacity to simulate such non-linear responses, but identifying optimal model structures and parameterizations remains a challenge. In this study we focus on the combined effects of temperature and moisture on two soils contrasting in carbon content. We applied a data driven modelling approach to study the interactive effects of temperature and moisture on soil microbial CO_2 production. Using a process-based model we found that substrate and enzyme dynamics create interactive effects that occurring in both directions. The observed interactions emerge in model simulations that combine diffusion with non-linear reaction kinetics. Diffusion limitations lead to a decoupling of respiration and decomposition fluxes and to differences in the response to temperature that occurs at all moisture levels but are more pronounced under drier, colder and generally low substrate conditions. Our model also demonstrates the time-dependent nature of temperature and moisture responses, a result that has implications for predictions at different time scales. The findings highlight the importance of moisture for understanding and predicting both short and long term soil carbon dynamics.