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Predicting decadal trends and transient responses of radiocarbon storage and fluxes in a temperate forest soil

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Representing the response of soil carbon dynamics to global environmental change requires the incorporation of multiple tools in the development of predictive models. An important tool to construct and test models is the incorporation of bomb radiocarbon in soil organic matter during the past decades. In this manuscript, we combined radiocarbon data and a previously developed empirical model to explore decade-scale soil carbon dynamics in a temperate forest ecosystem at the Harvard Forest, Massachusetts, USA. We evaluated the contribution of different soil C fractions to both total soil CO_2 efflux and microbially-respired C. We tested the performance of the model based on measurable soil organic matter fractions against a decade of radiocarbon measurements. The model was then challenged with radiocarbon measurements from a warming and N addition experiment to test multiple hypotheses about the different response of soil C fractions to the experimental manipulations. Our results showed that the empirical model satisfactorily predicts the trends of radiocarbon in litter, density fractions, and respired CO_2 observed over a decade in the soils not subjected to manipulation. However, the model, modified with prescribed relationships for temperature and decomposition rates, predicted most but not all the observations from the field experiment where soil temperatures and nitrogen levels were increased, suggesting that a larger degree of complexity and mechanistic relations need to be added to the model to predict short-term responses and transient dynamics.