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Insights into soil carbon dynamics across climatic and geologic gradients from time-series and fraction-specific radiocarbon analysis

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Understanding the interaction between soil organic matter (SOM) and climatic, geologic and ecological factors is essential for the understanding of potential susceptibility and vulnerability to climate and land use change. Radiocarbon constitutes a powerful tool for unraveling SOM dynamics and is increasingly used in studies of carbon turnover. The complex and inherently heterogeneous nature of SOM renders it challenging to assess the processes that govern SOM stability by solely looking at the bulk signature on a plot-scale level. This project combines bulk radiocarbon measurements on a regional-scale spanning wide climatic and geologic gradients with a more in-depth approach for a subset of locations. For this subset, time-series and carbon pool-specific radiocarbon data has been acquired for both topsoil and deeper soils. These well-studied sites are part of the Long-Term Forest Ecosystem Research (LWF) program of the Swiss Federal Institute for Forest, Snow and Landscape research (WSL). Statistical analysis was performed to examine relationships of radiocarbon signatures with variables such as temperature, precipitation and elevation. Bomb-curve modeling was applied determine carbon turnover using time-series data. Results indicate that (1) there is no significant correlation between Δ14C signature and environmental conditions except a weak positive correlation with mean annual temperature, (2) vertical gradients in Δ14C signatures in surface and deeper soils are highly similar despite covering disparate soil-types and climatic systems, and (3) radiocarbon signatures vary significantly between time-series samples and carbon pools. Overall, this study provides a uniquely comprehensive dataset that allows for a better understanding of links between carbon dynamics and environmental settings, as well as for pool-specific and long-term trends in carbon (de)stabilization.