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Subsoil organic carbon turnover is dominantly controlled by soil properties in grasslands across China

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Soil carbon turnover time (τ, year) is an important indicator of soil carbon stability, and a major factor in determining soil carbon sequestration capacity. Many studies investigated τ in the topsoil or the first meter underground, however, little is known about subsoil τ (0.2 – 1.0 m) and its environmental drivers, while world subsoils below 0.2 m accounts for the majority of total soil organic carbon (SOC) stock and may be as sensitive as that of the topsoil to climate change. We used the observations from the published literatures to estimate subsoil τ (the ratio of SOC stock to net primary productivity) in grasslands across China and employed regression analysis to detect the environmental controls on subsoil τ. Finally, structural equation modelling (SEM) was applied to identify the dominant environmental driver (including climate, vegetation and soil). Results showed that subsoil τ varied greatly from 5.52 to 702.17 years, and the mean (± standard deviation) subsoil τ was 118.5 ± 97.8 years. Subsoil τ varied significantly among different grassland types that it was 164.0 ± 112.0 years for alpine meadow, 107.0 ± 47.9 years for alpine steppe, 177.0 ± 143.0 years for temperate desert steppe, 96.6 ± 88.7 years for temperate meadow steppe, 101.0 ± 75.9 years for temperate typical steppe. Subsoil τ significantly and negatively correlated ($p < 0.05$) with vegetation index, leaf area index and gross primary production, highlighting the importance of vegetation on τ. Mean annual temperature (MAT) and precipitation (MAP) had a negative impact on subsoil τ, indicating a faster turnover of soil carbon with the increasing of MAT or MAP under ongoing climate change. SEM showed that soil properties, such as soil bulk density, cation exchange capacity and soil silt, were the most important variables driving subsoil τ, challenging our current understanding of climatic drivers (MAT and MAP) controlling on topsoil τ, further providing new evidence that different mechanisms control topsoil and subsoil τ. These conclusions demonstrated that different environmental controls should be considered for reliable prediction of soil carbon dynamics in the top and subsoils in biogeochemical models or earth

system models at regional or global scales.