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Plant growth controls short-term changes in soil organic carbon (SOC) stocks of croplands – new insights from the CarboZALF experiment

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The long-term influence of crop rotations, climate conditions or soil type on soil organic carbon stock (SOC) patterns and gaseous C emissions of agricultural landscapes is widely recognized. However, the question of short-term seasonal changes in SOC within these areas remains unclear. A main reason for this is the detection problem of temporal and spatial variability in gaseous C exchange and thus, changes in SOC stocks (ΔSOC) in a high resolution.

This study introduces dynamic C balances as a method to obtain seasonal changes in SOC stocks.
Dynamic C balances were calculated by a combination of automatic chamber CO_2 exchange measurements and empirical biomass models. Measurements were performed for three consecutive years at a colluvial depression (Colluvic Regosol) in the hummocky ground moraine landscape of NE Germany (CarboZALF experimental site). The investigated crop rotation was maize, winter fodder rye, maize, winter fodder rye, and sudangrass. The site is characterized by a gradient in ground water level (GWL) and related spatial heterogeneity in soil properties, such as SOC as well as soil nitrogen (Nt) stocks.

Modelled dynamic C balances reveal that up to 79% of the standard deviation of estimated annual ΔSOC between single chambers emerged during the main period of crop growth (three months in summer). No significant changes in ΔSOC were detected outside the growing season. Instead, differences between chambers remain constant despite ΔSOC dynamics. Environmental variables (Nt stocks of Ap horizon and GWL), affecting plant-mediated C sequestration, explained up to 95% of temporal and spatial variability in CO_2 exchange and ΔSOC. Thus, plant activities were the major catalyst for small scale differences in annual ΔSOC of croplands.