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Topographic variability influences the carbon sequestration potential of arable soils

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There is presently limited knowledge on the influence of field spatial variability on the carbon (C) sink-source relationships in arable landscapes. This is accompanied by the fact that our understanding of soil profile C dynamics is also limited. This study aimed at investigating how spatial variability along a short catena influences C sink-source relationships and temporal dynamics of CO_2 concentrations in soils. In spring 2011, soil samples were collected from topsoil (2-5.5 cm) and subsoil (38-41.5 cm) horizons at upslope and footslope positions in a Danish winter wheat field on a sandy loam soil developed on glacial till. Bulk densities and C concentrations of the soils were characterized. From June 2011, gas samples were collected at least bimonthly from the same slope positions in four spatial replicates using stainless steel needles that were permanently installed at 5, 10, 20 and 30 cm soil depths. Concurrently, gas was sampled from 40, 50, and 80 cm depths using steel rods connected to a sampling port. Concentrations of CO_2 in the gas samples were analyzed by gas chromatography. The results show that at the upslope position, soils from the topsoil horizon clearly had higher C pools (5.2 Mg C ha-1) compared to those from the subsoil horizon (1.0 Mg C ha-1). At the footslope position, however, C pools in topsoil (6.9 Mg C ha-1) and subsoil (7.0 C Mg ha-1) horizons were similar but higher than those at the upslope position. The gas monitoring study is still ongoing, but preliminary results show that CO_2 concentrations generally increased with depth. At the upslope position, CO_2 concentrations ranged between 800 and 24000 ppm and were generally lower than the concentrations observed at the footslope position (3000−42000 ppm) for similar soil depths. The upslope position has been subject to soil erosion while the footslope position has been a depositional site; thus the subsoil at the footslope position was to a large extent a buried topsoil horizon. The topographic relationship between the upslope and footslope position made the latter a sink for soil C transported through processes such as tillage erosion. This led to the presence of higher C pools and CO_2 concentrations at the footslope compared to the upslope position. Despite the fact that higher CO_2 concentrations with depth may be influenced by the relationship between CO_2 production and transport, our results indicated that variability across arable landscapes makes footslope soils both a larger sink of buried soil C and a bigger potential CO_2 source than upslope soils.