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Model-based analysis of layer-specific soil organic carbon patterns affected by soil redistribution processes

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The influence of lateral soil redistribution on the spatial patterns of soil organic carbon (SOC) in sloped agricultural landscapes has been widely recognized. However, regarding measured SOC patterns which result from long-term processes, it can hardly be determined if these patterns explicitly emerge from carbon redistribution processes or if other processes are also involved. A detailed understanding of the interaction between processes and patterns is of major importance to model the layer-specific spatial distribution of SOC.
The major goal of this study was to analyze an actual SOC pattern measured in a 4.2 ha agriculturally used catchment in Western Germany using the combined soil redistribution (including water and tillage erosion as well as soil loss due to crop harvesting) and soil carbon dynamics model SPEROS-C. The model is spatially explicit and simulates SOC content in multiple soil layers up to 1 m depth. SOC dynamics at reference sites (without erosion or deposition) were determined using SPEROS-C in an inverse modeling approach using yearly management data (1950-2008) after agricultural intensification. Based on this calibration SOC dynamics within the catchment were modeled taking soil and corresponding carbon redistribution into account. The model results were compared with layer-specific (< 0.25, 0.25-0.50, and 0.5-0.90 m) data of SOC sampled in a 17.7 x 17.7 m raster and geostatistically interpolated to 6.25 x 6.25 m as well as with spatially distributed measurements of soil respiration.
First model results show that soil redistribution leads to a distinct spatial distribution of soil organic carbon with lower SOC values at eroding sites and higher values at depositional sites of the test site. This spatial pattern becomes more pronounced with increasing soil depth. In general, these modeled SOC patterns fit well to the measured SOC distributions in the different soil layers supporting the underlying assumption, that SOC patterns and soil redistribution are closely linked. However, there are areas where modeled SOC profiles are dissimilar from the measured ones indicating that also other processes, such as spatial differences in C-input or differences in C respiration should be included.