Geophysical Research Abstracts
Vol. 13, EGU2011-7133, 2011
EGU General Assembly 2011

Soil erosion and its impact on organic carbon storage in changing agricultural landscapes: A multi-scale analysis

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Erosion-induced changes in soil organic carbon distribution (SOC) as a result of human activities have recently received considerable attention. Recent work done has described agricultural soils as dynamic systems that can change rapidly. Current methods to characterize the horizontal (across the earth surface) and vertical (with depth) variability at a regional scale are limited and lack the ability to link locally detailed assessments to larger scales. Key mechanisms to explain SOC distribution patterns need to be identified to come from point-scale process understanding to larger-scale dynamics. Here, we present and apply a new method postulating that soil redistribution is the main forcing for regional SOC distribution on cropland, and use topography to delimit zones of differing SOC distribution.

We characterize the variation of SOC within the first meter of soils in three dimensions (spatial variation and vertical gradients). Spatial modeling is used to integrate soil surface data from airborne image spectroscopy (2m resolution) and vertical SOC gradients from high resolution (0.10m) soil sampling. Analysis of the data provides clear evidence that geomorphic gradients play a key role in soil carbon profile development in agricultural landscapes, even at very short time periods, and must be considered for realistic SOC modeling. Eroding positions have a sharp decline of carbon content with depth and lower topsoil carbon than stable, and especially depositional sites, which in contrast store high amounts of carbon in greater depths. Our data shows that in eroding agricultural landscapes soil redistribution processes also supersede or control other important SOC modeling parameters such as drainage and soil texture in regions of similar soil types, and that the link between topography and carbon content is consistent throughout a large variety of soil types.

We integrated a temporal aspect into this analysis by using the fallout radionuclide 137Cs to assess recent [since $\approx$1955] lateral fluxes of carbon as a result of soil erosion in our study area. As a next step, this allows the development of a 4D model of SOC dynamics to be applied on agricultural areas of central Europe.