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Topographic controls on soil organic matter in semi-arid environments

Wolfgang Schwanghart (1) and Thomas Jarmer (2)

(1) University of Basel, Department of Environmental Sciences, Basel, Switzerland (w.schwanghart@unibas.ch), (2) University of Osnabrueck, Institute for Geoinformatics and Remote Sensing, Osnabrueck, Germany

A key uncertainty in our understanding of the global carbon cycle is the lateral movement of carbon through the terrestrial system driven by erosion and deposition of soil derived particles. These processes create spatial patterns of soil organic carbon (SOC) depletion and accumulation in soils. Since soils are the major storage of carbon in the terrestrial biosphere, reliable estimates of spatial patterns of SOC are required for greenhouse gas inventories and carbon mitigation projects.

The aim of this study is to characterize spatial patterns of SOC in a Mediterranean, semi-arid area in south-eastern Spain and to assess the relationship between these patterns and topography. We adopt a remote sensing based approach for the estimation of SOC in the topsoil. This approach utilizes the statistical relation between visible and near-infrared spectra of soils and SOC retrieved by Partial Least Squares (PLS) regression. Spatially distributed estimates of SOC at the regional scale (resolution 6 m) are obtained from the transfer of the statistical model to airborne hyperspectral data (HyMAP). Geostatistical techniques and digital elevation model analysis are used to characterize spatial patterns of SOC.

The results indicate that the semi-arid hydrological and geomorphological process domain in the study area exerts strong control on the lateral distribution of SOC generating high, small scale variability but also spatially contiguous patterns at larger scales. Spatial variability of SOC is high on steep slopes where a strong relation between topographic wetness indices and SOC can be identified. Moreover it can be shown that Thalwegs, preferential runoff pathways and colluvial sediments show increased SOC. We conclude that hyperspectral remote sensing can be successfully applied to quantify the spatial distribution of SOC and suggest that remote sensing approaches in combination with sampling schemes that disentangle SOC variations with depths are promising to advance SOC inventories in semi-arid and arid regions.