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Spatial heterogeneity of soil organic carbon in a small alpine catchment (Grindelwald, Switzerland)

U. Poppe and N. Kuhn

Institute of Geography, Enviromental Sciences, Basel, Switzerland (ulrike.poppe@unibas.ch)

Soils represent a major pool in the global carbon cycle. Their behaviour as a carbon reservoir in global climate and environmental issues is far from fully understood. Surface soil organic carbon (SOC) pools and turnover times are particularly sensitive to a range of factors, such as climate, vegetation, topography, soil properties, soil and crop management and other anthropogenic conditions. These factors are important to formulate process-based C cycling models and to evaluate the influence of future land use and climate changes on SOC content. Mountain environments are strongly affected by and highly sensitive to climate change (geomorphology, vegetation), while also experiencing significant land use change. Little attention has so far been given to the spatial heterogeneity of alpine SOC stocks. In mountain environments, relief exerts a strong control on factors which control SOC, e.g. through meso-climatic differences, but surface processes such as mass wasting and water erosion. While the general relationships between environmental variables and SOC are known, there is uncertainty regarding the specific quantitative relationships between SOC and environmental variables. Particularly, the interaction between geomorphic processes, soil thickness and soil carbon storage is not well understood.

A priori reasoning suggests that spatial patterns of SOC in mountain areas are closely correlated to the spatial patterns of terrain attributes that influence soil-forming processes. In this study, we examined the relationships between SOC stocks and climate, topography (elevation, slope, curvature,) and land use along an elevation transect from Grindelwald Grund to the ridge of Kleine Scheidegg in the canton of Bern. Soil samples were collected across a range of elevations, slope, curvature, soil texture, vegetation types, and terrain positions. Topographic variables (e.g. elevation, slope, curvature) were extracted from a high resolution digital elevation model. SOC concentration of the soil samples was determined by Loss on Ignition. For each sample, carbon densities C_{dens} (in g/cm^2) were estimated for the topsoil layer.

Our results show large differences in SOC across the landscape. The high spatial variability is related most strongly to bed rock geology (lithology and soil type) and land use. Somewhat surprisingly, site location relative to visible evidence of surface processes is of minor importance. This lack of correlation at the scale of the study area appears to indicate that geomorphic processes control the thickness of soils and thus C content only on a smaller scale. This fact will be tested with a higher spatial sampling density. Our results also indicate that SOC in mountainous environments is controlled by a range of factors and that only some of them are affected by climate change.