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Pedogenesis and soil moisture, but not soil temperature best explain large-scale patterns of soil carbon and soil nitrogen contents in the permafrost ecosystems of Tibetan alpine grasslands

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The Tibetan Plateau is an essential area to study potential feedback effects of soils to climate change due to the rapid rise of air temperature in the past several decades as well as the large amounts of organic carbon (C_{org}) stored in soils, particularly in permafrost-affected areas. In order to predict the impact of environmental change on ecosystem functioning, it is of great importance to understand how C_{org} and soil nitrogen (N) stocks are controlled under changing climate conditions in extreme environments. We therefore investigated the main parameters influencing C_{org} and N at 47 sites along a 1,200 km transect across the high-altitude and low-latitude permafrost region of the central-eastern Tibetan Plateau. Sites with continuous or discontinuous permafrost as well as areas without or heavily degraded permafrost were studied for comparison of soil dynamics under various environmental settings. Due to the high number of samples and the large-scale transect concept, sophisticated statistical analyses showing significant relationships between pedological parameters as well as C_{org} and N contents were carried out.

The aim of the presented research was to evaluate consequences of permafrost degradation for C and N stocks and hence nutrient supply for plants. The landscape along the investigated transect is a patchwork of geochemically very diverse micro-ecosystems showing variations in organic matter, nutrient stocks, plant communities and productivity. These differences are closely related to topographic position, hydrological regimes and consequently permafrost distribution. The main controlling mechanisms of this heterogeneity on the Tibetan Plateau are related to different soil drainage classes.

Ecosystem ecology has traditionally focused on temperature and modeled soils mostly as an ecosystem feature whose attributes vary strongly by thermodynamic principles. However, the general linear regression model (GLM) suggests soil moisture as the most important parameter explaining 64% of C_{org} and 60% of N variation. The explanatory power of the GLM for C and N concentrations is significantly improved by adding two parameters for pedogenesis to the model, i.e. $CaCO_3$ and soil texture. The extent of the effect of soil moisture is determined by permafrost, current aeolian sedimentation occurring mostly on sites with permafrost degradation, and pedogenesis.

We conclude that degradation of permafrost and corresponding changes in soil hydrology combined with a shift from mature stages of pedogenesis to initial stages, have severe impact on soil carbon and importantly on plant available N. Our study shows that other factors than temperature are more important between years and sites at regional and continental scales. Temperature dependence may rather be relevant for ecosystems when soil moisture or other factors are not limiting or altering the relationship between temperature and soil processes. Soil respiration data demonstrate that biomass and particularly belowground biomass as well as soil water content are determinant of spatial variation of soil respiration across the plateau.

In summary, both stocks (C_{org} and N) are coupled with complex feedback mechanisms between permafrost, aeolian processes and the stage of pedogenesis. The latter can be described by acidity, carbonate content and grain size distribution.