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Climatic versus geochemical controls on soil organic matter stabilization and greenhouse gas emissions along altitudinal transects in different mountain regions

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Terrestrial ecosystems are strongly influenced by climate change and soils are key compartments of the global carbon (C) cycle in terms of their potential to store or release significant amounts of C. This study is part of the interregional IAEA Technical Cooperation Project INT5153 "Assessing the Impact of Climate Change and its Effects on Soil and Water Resources in Polar and Mountainous Regions" and aims to elucidate driving factors (climatic versus geochemical) of soil organic carbon (SOC) stabilization and greenhouse gas emissions along altitudinal transects in different mountain regions.

We present novel data from altitudinal transects of four different mountain regions (Zongo, Cordillera Real, Bolivia; Mount Kilimanjaro, Tanzania; Gongga, Hengduan Mountains, China; Rauris, Hohe Tauern, Austria). All altitudinal transects cover a wide range of natural ecosystems under different climatic (MAT, MAP) and soil geochemical parameters. Bulk soil samples (four field replicates per ecosystems) were subjected to a combination of aggregate and particle-size fractionation followed by organic C, total nitrogen (N), stable isotope (^{13}C, ^{15}N) and radiocarbon (^{14}C) analyses of all fractions. Bulk soils were further characterized for their texture, geochemistry (Na, K, Ca, Mg, CEC_{pot}, Al, Fe, Mn, Si, pH), nutrient status (NH_4^+, NO_3^-, P_{tot}) and incubated for 63 days to assess greenhouse gas emissions (CO_2, CH_4, NO, N_2O). Moreover, stable C isotope signatures of CO_2 were determined to estimate potential sources of soil respiration (using Keeling plots).

Cumulative soil CO_2 emissions (in g_{CO2}-Ckg_{SOC}^{-1}) were highest for the high altitude grassland and forest sites of Rauris (25.5-25.8) and lowest for the Kilimanjaro forests (4.8-6.9) as well as Bolivian high altitude grasslands (2.5-4.3). Soil CO_2 emissions were negatively correlated with SOC content (Pearson correlation coefficient r_p=-0.35, p=0.002), showing that soils with low SOC contents release the highest amount of CO_2 per soil C, possibly due to large fractions of unprotected SOC and thus low SOC stabilization.

Particulate organic matter (POM) and sand content were positively correlated with CO_2 emissions (r_p=0.43, $p<0.001$ and r_p=0.57, $p<0.001$, respectively) and negatively correlated with SOC content (r_p=-0.61, $p<0.001$ for sand content), showing that high amounts of POM and/or a sandy soil texture impede SOC storage and support CO_2 emissions. In contrast, microaggregates and clay minerals were negatively correlated with CO_2 emissions (r_p=-0.45, $p<0.001$ and r_p=-0.51, $p<0.001$, respectively) and positively correlated with SOC content (r_p=0.84, $p<0.001$ for clay content), showing their importance for SOC stabilization.

Cation exchange capacity (CEC) was positively correlated with SOC content (r_p=0.93, $p<0.001$) and negatively correlated with CO_2 emissions (r_p=-0.41, $p<0.001$). Oppositely, both Si content and the Si/Al ratio were negatively

correlated with SOC content (r_p=-0.86, $p<0.001$ and r_p=-0.56, $p<0.001$, respectively) and positively correlated with CO_2 emissions (r_p=0.36, p=0.002 and r_p=0.34, p=0.003). These relationships point towards an important role of soil weathering and geochemistry for the potential of soils to store SOC or release CO_2.

Further results of soil fractionation, greenhouse gas emissions and geochemistry will be presented in conjunction with climatic data of the altitudinal transects to elucidate driving factors of SOC (de)stabilization in high altitude mountain regions.