Cation exchange capacity (CEC) was positively correlated with SOC content ($r = 0.93$, $p < 0.001$), showing that high amounts of POM and/or a sandy soil texture impede SOC storage and support ($2.5-4.3$). Soil CO$_2$ emissions were negatively correlated with SOC content (Pearson correlation coefficient $r = -0.51$, $p < 0.001$, respectively) and positively correlated with SOC content ($r = 0.61$, $p < 0.001$ 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 ($r = -0.61$, $p < 0.001$ and $r = -0.51$, $p < 0.001$, respectively) and positively correlated with SOC content ($r = 0.84$, $p < 0.001$ for clay content), showing their importance for SOC stabilization.

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

Marco Griepentrog (1, 2), Samuel Bodé (1), Mathieu Boudin (3), Gerd Dercon (4), Sebastian Doetterl (5), Timothy Eglington (2), Negar Haghipour (2, 6), Sebastian Joya (1), Victoria Martin (7), Machibya Matulanya (8), Anna Msigwa (9), Xiangyang Sun (10), Pieter Vermeir (11), Xiaoguo Wang (10), Andreas Richter (7), and Pascal Boeckx (1)

(1) Isotope Bioscience Laboratory (ISOFYS), Department of Green Chemistry and Technology, Ghent University, Coupure Links 653, 9000 Gent, Belgium (marco.griepentrog@erdw.ethz.ch), (2) Biogeoscience, Department of Earth Sciences, ETH Zurich, Sonneggstrasse 5, 8092 Zurich, Switzerland, (3) Royal Institute for Cultural Heritage (KIK-IRPA), Jubelpark 1, 1000 Brussels, Belgium, (4) Soil and Water Management & Crop Nutrition Laboratory, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Department of Nuclear Sciences and Applications, International Atomic Energy Agency (IAEA), PO Box 100, 1400 Vienna, Austria, (5) Water and Soil Resources, Department of Geography, University of Augsburg, Alter Postweg 118, 86159 Augsburg, Germany, (6) Laboratory of Ion Beam Physics, Department of Physics, ETH Zurich, Otto-Stern-Weg 5, 8093 Zurich, Switzerland, (7) Terrestrial Ecosystem Research, Department of Microbiology and Ecosystem Science, University of Vienna, Althanstrasse 14, 1090 Vienna, Austria, (8) Tanzania Atomic Energy Commission (TAEC), P.O. Box 743, Arusha, Tanzania, (9) Nelson Mandela African Institution of Science and Technology (NM-AIST), P.O. Box 447, Arusha, Tanzania, (10) Key Laboratory of Mountain Environment Change and Regulation, Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, Renminnian Road 9, 610041 Chengdu, China, (11) Department of Applied Biosciences, Ghent University, Valentyn Vaerwyckweg 1, 9000 Gent, Belgium

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$_2$O). 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 CO$_2$-C kg$^{-1}$SOC) 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 $r = -0.35$, $p = 0.002$), 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.