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Soil Science Society Belgium (SSSB)
BBV-SBSS

Thematic Day 2014
Soil-plant interactions in a changing world

BOOK OF ABSTRACTS

Friday December 5th, 2014
The Royal Academies for Science and the Arts of Belgium, Hertogsstraat 1 Rue Ducale, Brussels

Programme

Soil, plants and chemistry

09:00-09:20 'Capacity of microorganisms to decompose organic carbon affected by an increasing content of reactive mineral phases in a podzolic soil chronosequence.' Vermeire et al. (UCL)

09:20-09:40 'Calibration of δD n-alkane as paleo-climate proxy in the DeepCHALLA archive.' De Wispelaere et al. (UGent)

09:40-10:00 'Effects of different types of fertilizers on phosphorus availability in a soil with low P content.' Barbieux et al. (ULg)

Coffee break (30 min) + poster session

Soils and plant roots

10:30-10:45 'Can root distribution be related to soil water potential in an irrigated 'Conference' pear orchard?' Janssens et al. (Soil Service of Belgium)

10:45-11:00 'A review of the effects of plant roots on concentrated flow erosion.' Vannoppen et al. (KULeuven)

11:00-11:15 'Can electrical resistivity tomography offer us a dynamic view on what happens in the soil-plant continuum?' Garré et al. (ULg)

11:15-11:30 'Differential hydrological strategies: a stable isotope perspective on trees water sources.' Hervé-Fernández et al. (UGent)

11:30-11:45 'Improving macroscopic modelling of water and osmotic stresses on root water uptake.' Jorda Guerra et al. (KULeuven)

11:45-12:15 *Invited talk:* 'Water relations in the soil-plant system: what can we learn from functional-structural plant models.' Lobet et al. (ULg)

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Chemical weathering in response to tectonic uplift and denudation rate in a semi-arid environment, southeast Spain

Yolanda Ameijeiras-Mariño (yolanda.ameijeiras@uclouvain.be), Sophie Opfergelt, Jérôme Schoonejans, Veerle Vanacker, Philippe Sonnet, Pierre Delmelle

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Soil thickness reflects the balance between soil production and denudation by chemical weathering and physical erosion. At topographic steady state, the soil weathering intensity is expected to be higher at low denudation rate (transport-limited) than at high denudation rate (weathering-limited). We tested this hypothesis for the first time in a semi-arid environment where chemical weathering processes are generally slow.

The study site is the Internal Zone of the Betic Cordillera in Southeast Spain, Almeria province. The lithology is mainly mica-schist and quartzite with local presence of phyllite. Three catchments (EST, FIL, CAB) were selected along a gradient of increasing uplift rates (10-170 mm/kyr) and increasing denudation rates (20-250 mm/kyr), following the sequence EST<FIL<CAB. In each catchment, two soil profiles were sampled. The presence of secondary pedogenic carbonates (in the CAB catchment) was taken into account to estimate soil weathering intensity.

Three independent indices were used to compare soil weathering intensity across the EST, FIL and CAB catchments: the Total Reserve in Bases; the soil Fed/Fet ratio that reflects the formation of secondary Fe-oxides, and the Cation Exchange Capacity (CEC) that varies with the amount of secondary clay minerals and organic matter. The difference in TRB between the soil and the bedrock should be more negative as weathering increases, whereas the Fed/Fet ratio is expected to augment with the intensity of weathering. Since these soils have low organic carbon content, the CEC should increase with weathering degree.

Our results indicate that the TRB (cmolc.kg-1) is -8±14 (n=8), -79±2 (n=8) and -51±38 (n=9) for CAB, FIL and EST, respectively. The Fed/Fet ratio for CAB, FIL and EST is 0.20±0.05 (n=8), 0.20±0.03 (n=8) and 0.29±0.05 (n=9), respectively. The CEC (cmolc.kg-1) increases from 3.3±1.7 (n=8) to 8.2±1.3 (n=8) and 10.4±3.0 (n=9) from CAB to FIL and EST.

Based on the CEC, and to a lesser extent the TRB values, the soils from the CAB catchment appear less weathered than those from the two other catchments. However, using the Fed/Fet ratio, both CAB and FIL soils seem less weathered than EST. Overall, the intensity of soil weathering tends to increase from CAB to EST. Given that the uplift and denudation rates increase from EST to CAB, these results support the hypothesis that a stronger uplift and denudation rate result in a less intense chemical weathering in soils in this semi-arid environment.

Effects of different types of fertilizers on phosphorus availability in a soil with low P content

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Phosphorus (P) is a limiting factor to plant growth but its availability can be increased by application of amendments. The most common input used is mineral P fertilizer. Nevertheless the world reserves of mineral P are limited and non-renewable at human scale. The disappearance of phosphate rock of high quality is expected in the coming decades. In addition, three countries control the remaining reserves: China, the United States and Morocco. The European countries are dependent on them, resulting in geopolitical tensions. To overcome that, fertilizers from waste are developed and organic amendments as manure are valorized. In that context, this experiment aims to study the effects of different types of amendments on P availability.

The experimental protocol is based on a micro-culture in pots. The test-plant used is Italian ryegrass (Lolium multiforium L.). The fertilizers selected are struvite, manure and triple superphosphate. Struvite is a Mg-ammonium phosphate complex with high nutrient content precipitated from human urine. Triple superphosphate fertilizer is used as reference for comparison. Studied soil is a silty soil from the southern Belgium with a long agricultural past. Fertilizers were added to soil at following rates: 20, 40 & 80 kg P/ha. Plants were first grown in pure sand without addition of P. Ten days after the plant emergence, roots were brought into contact with the studied soil-fertilizer mixes during fifteen more days. At the end of the experimentation, analyses were performed on plant material (biomass, P content) and on soil (available and soluble elements, phosphatases activity, pH, COT).

Generally, a gradient of soluble and available P content is observed with increased rate of fertilizer. Results also showed an influence of the type of fertilizer on soluble P content in soil: mineral sources display a higher solubilization than organic. Nevertheless no effect of the amendment type was noticed on phosphatase activity neither of P content in plants. However results are weakly expressed. Protocol should be adapted: plants should stay longer in contact with the soil in order to observe more soil-plant exchanges.

Role of vegetation on soil restoration in gully systems (southern Ecuador)

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Revegetation projects in degraded lands have a potential to recover essential soil functions. If vegetation restoration is combined with bioengineering techniques, such as the construction of retention dams in active gully systems, soil restoration could be enhanced. One important aspect of this process is the role of vegetation on restoration of soil chemical and physical properties. There is currently a lack of knowledge on the potential of soil restoration in active badland systems, as most studies have concentrated on the direct and visible effect of revegetation on erosion control. First, the soil physical and/or chemical parameters that are most sensitive to track environmental change were evaluated. Second, the role of vegetation on soil restoration was quantified. Soil samples were taken in sites with different vegetation cover, land use and physiographic position. The following physical and chemical parameters were measured: volumetric water content (%), bulk density (g cm-3), resistance to penetration (kg cm-2), pH, organic matter (%), C and N content (%). Our first results do not show a clear relationship between volumetric water content at saturation (θsat), bulk density, or C content. The saturation water content does not vary significantly between different sites, or land use types. However, significant differences are found between sites at different stages of restoration; and this for most chemical and physical soil properties. Vegetation cover (%) appears to exert a strong control on the C content in the mineral soils. The highest C values are found in soils of forest plantations with Eucalyptus and Pinus species. These plantations are located in areas that were previously affected by active gullying. Our results show that the establishment of a protective vegetation cover is an important factor in soil restoration.

Do crop residue management influence the spatial and temporal pattern of soil water content?

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Hydraulic processes and soil storage capacity may be affected by the crop residue management. Thus, a better understanding of the spatial and temporal distribution of water as a consequence of different tillage methods is needed.

The distribution of soil water content is basically studied thanks to soil moisture sensors such as time domain reflectometry (TDR) probes. However, this method requires the disturbance of the soil and only provides local information. Comparatively, electrical resistivity tomography (ERT) slightly alters the soil structure. It has been considered as a proxy to assess the spatial and temporal variability of the soil water content.

This study aims at assessing whether and to which extent the crop residue management influences soil water dynamics and the water availability for maize. Water content will be monitored from March to October 2014, under three crop residue managements: conventional tillage realized in the end of autumn, conventional tillage realized just before sowing, and strip tillage. A bare soil under conventional tillage will also be monitored so as to better understand the influence of the plant over the growing season. So as to better understand the dynamics of water in the soil-water-continuum, the influence of the crop residue management on the soil structure and the plant development will also be investigated.

The soil water pattern will be daily monitored on a surface of two square meters through surface stainless steel electrodes, corresponding to three rows of seven maize plants. Five additional sticks with buried electrodes will be setup to get more detailed information near to the maize row. For each of the monitored zone, two TDR probes will help validating the data. In order to calibrate the relationship between electrical resistivity and soil water content, a dig will be dug, in which a set of four electrodes, one TDR probe and one temperature sensor will be placed at four different depths. Two suction cups placed on each of the monitoring zone will help getting the electrical conductivity of the soil solution.

Calibration of δD n-alkane as paleo-climate proxy in the DeepCHALLA archive

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Severe and recurrent drought is the principal weather-related hazard for vulnerable developing economies throughout sub-Saharan Africa, and the quality of long-term predictions is a bottleneck hampering adaptation to drought. This is aggravated by the highly uncertain impact of 21st-century anthropogenic climate change on the region's rainfall and freshwater resources, due to at best fragmentary understanding of the effects of a warming atmosphere on the tropical hydrological cycle at the regional scale. To reduce this uncertainty in long-term climate prediction, climate models must be validated using long time series of climate data extracted from e.g. high-quality natural climate archives.

Therefore, the DeepCHALLA consortium is preparing an ICDP (International Continental Drilling Program) deep-drilling project on Lake Challa, a crater lake near Mt. Kilimanjaro. The principal objective of the DeepCHALLA project is to acquire high-resolution and accurately dated proxy data of continental climate and ecosystem change near the Equator in Eastern Africa over 250,000 years. Such a climate record would encompass the entire known existence of modern humans (H. sapiens) in East Africa. Within the DeepCHALLA consortium, the Isotope Bioscience Laboratory (ISOFYS) of Ghent University will be responsible for 'molecular paleohydrology'. Herein the hydrogen-isotopic composition of fossil plant leaf wax n-alkanes, archived in the lake-sediment, will be used as proxy for past changes in equatorial African water regimes.

Hydrogen isotopic composition of n-alkane in sediment cores provides a stable record of δD in historic precipitation water, which in turn relates to precipitation amounts. This proxy needs, however, local calibration. Therefore, an altitudinal transect is being set from lake Challa to the southeastern slope of Mt. Kilimanjaro along different vegetation zones (savannah, lower montane forest, upper montane forest and subalpine zone). Sampling includes seasonal collection of present precipitation, leaf and xyleme water, leaf n-alkanes and modern sediment. In a preliminary campaign, samples were taken around Lake Challa at lake shore, mid slope, top slope and savannah.

Can electrical resistivity tomography offer us a dynamic view on what happens in the soil-plant continuum?

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Root water and nutrient uptake and its relation to environmental factors is one of the least understood components in the terrestrial water balance and is of high importance for water resources management, ecology and agriculture. As the processes in the soil-plant continuum are complex and inextricably intertwined, alternative, non-invasive measurement methods are necessary to unravel spatial and temporal dynamics of the system. Electrical resistivity tomography (ERT) has been proposed as a promising technique, since bulk resistivity maps and their temporal evolution may serve as a proxy for changes in soil moisture and pore water salinity, amongst others. However, the variables affecting the measured bulk electrical resistivity often change simultaneously in natural environments and not all influencing factors are yet well understood (e.g. influence of root biomass). Therefore, the method needs field-specific calibration. In addition to limitations due to signal-to-noise ratio and data inversion strategies, this implies that ERT still needs further development and research efforts for its use to characterize the soil-plant continuum.

Designing a glass house experiment for understanding carbon-nitrogen interactions in plant and soil at elevated CO2 concentration

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Climate change can imply a serious threat for crop production. Changes in temperature, precipitation and atmospheric CO2 concentration ([CO2]) affect crop production directly, and indirectly via altered nutrient relations. To study the interactions between elevated [CO2] and carbon-nitrogen dynamics in crops and soils, a glass house experiment is designed. Wheat plants are grown simultaneously in an ambient [CO2] and an elevated [CO2] glass house compartment under different levels of nitrogen. Carbon content, nitrogen content, root growth and crop water use efficiency are amongst the variables that are measured in the experiment to test hypotheses on increased nitrogen use efficiency, decreased nitrogen uptake and diminished plant nitrogen concentration. The study results can contribute to sustainable fertilizer guidelines for crop production under future climatic conditions.

Differential hydrological strategies: a stable isotope perspective on trees water sources.

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Land cover changes, from native to exotic fast growing species is a common practice worldwide. However, it has still unknown hydrological consequences. Recently, studies have described that trees were using a stationary water pool, bonded to soil particles; and not the "available" or mobile soil water pool (MSWP), which contributes to stream discharge during storm events.

In this study, we wanted to explore at which soil depth were trees withdrawing water from, using deuterium (δ^2H) as a tracer for soil depth; and if there was a difference in soil water pool uses seasonally; between native evergreen species and exotic fast growing species using water stable isotopes ($\delta^{18}O$ and δ^2H). We selected two headwater catchments: (i) ONE, covered by old growth evergreen forest (Laureliopsis phyllipianna, Aetoxycon punctatum and Eucryphia cordifolia); and (ii) EC, covered by 6 and 16 years old Eucalyptus nitens stands in the coastal mountain range, southern Chile (40°S). We collected data for MSWP, at: 0,3; 0,6 and 1 m depth using suction lysimeters; and from bulk soil water (a mix of mobile and stationary water) (BSWP) pool, sampled at: 5; 30; 60; 100; 150 and 180 cm soil depth.

Our data suggests that E. nitens withdraws water from the BSW pool and is able to withdraw water from the whole sampled profile (from 0.05 to 1.8 m depth). While native evergreen species withdraws water from a different water pool, that does not share the isotopic signature of MSW or BSW pools.

Our conclusion is that Eucalyptus nitens uses water from the whole soil profile, and is able to use bulk soil water (a mix of mobile and stationary water) throughout seasons. In contrast to native evergreen species which are using water from different soil water pool, which is not MSW or BSW pools, on all seasons.

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Can root distribution be related to soil water potential in an irrigated 'Conference' pear orchard?

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In Belgium 'Conference' pear tree (Pyrus Communis, cv. 'Conference') is irrigated to maintain a high fruit yield in dry years. Knowledge of soil water dynamics in the root zone of pear orchards permits better insight in irrigation management. Root water uptake patterns of trees can be calculated numerically using a sink term presented by Feddes et al. (1978). Input parameters needed for the numerical calculation are soil hydraulic properties, rainfall, irrigation rate, evaporation, transpiration of the tree and root distribution of the tree.

Root distribution of the tree is probably the parameter the most difficult to obtain. Previously root distributions for numerical calculations have been derived from observed root length densities, derived from literature, assumed to decrease linearly with depth or derived from soil moisture observations using inverse modelling techniques. This raises the question how crucial are root observations in the calculation of soil water potential (Ψsoil)? Can root distribution be related to the observed Ψsoil in a 'Conference' pear orchard? Two irrigated plots and one rainfed plot in the center of a 'Conference' pear orchard in Sint-Truiden, in 2009 and 2011, were selected for the experiment. Watermark granular matrix sensors where used to observe Ψsoil. Water stress and possible transpiration deficits were monitored using sap flow sensors and measurements of stem water potential (Ψstem). Root distribution in each plot was acquired by sampling the root zone with cylindrical cores and washing out the fine roots. Ψsoil was calculated using observed root length distribution (RLD), root weight distribution (RWD) and using root observations derived from literature. A reasonable accordance between calculated and measured Ψsoil was observed with R^2 = 0.56 and RMSE = 13.4 kPa over 1320 observations. Furthermore the sensitivity of the numerical calculation to the selected root distribution was shown.

The Ψsoil calculation with the root distribution parameterized by RLD gave satisfactory results for all plots, while a Ψsoil calculation based on other root observations (RWD, root observations found in literature) did not. The observed RLD was correlated (R^2=0.58) to Ψsoil decrease and the observed transpiration deficit in the rainfed plot could only be calculated when the root zone was parameterized using RLD. It evidences that root zone parameterization can have a significant influence on the Ψsoil calculation in pear orchards.

Improving macroscopic modeling of water and osmotic stresses on root water uptake

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Accurate modeling of water and salt stresses on root water uptake is critical for predicting impacts of global change and climate variability on crop production and soil water balances. Soil-hydrological models use reduction functions to represent the effect of osmotic stress in transpiration. However, these functions, which were developed empirically, present limitations in relation to the time and spatial scale at which they need to be used, fail to include compensation processes and do not agree on how water and salt stresses interact.

This research intends to develop a macroscopic reduction function for water and osmotic stresses based on biophysical knowledge. Simulation experiments will be conducted under a wide range of atmospheric conditions, soil and plant properties, irrigation water quality and scheduling; using a 3-D physically-based model that considers root architecture and resolves water flow and solute transport in the soil and the root system at the scale between single roots. The output of these simulations will be averaged in time and space, and will be used to derive macroscopic model parameters. Two approaches (regression analysis and artificial neural networks) will be used to link the high resolution with the macroscopic model parameters. The resulting macroscopic reduction function will be implemented in HYDRUS and parameterized by inverse modelling using additional simulation data. Finally, we will perform a series of lysimeter experiments with two crops with different salt tolerance and root system architecture, in two soil types, under two evaporative demands and different irrigation water quality and leaching fractions. The monitored and measured parameters from the lysimeter experiments will be used to validate the developed macroscopic reduction function.

We expect a macroscopic reduction function whose parameters are fully linked to biophysical concepts to be able to effectively simulate water and osmotic stresses on root water uptake under transient conditions for spatially variable water applications.

Water relations in the soil-plant system: what can we learn from functional-structural plant models

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Water movement in the plant is driven by water potential differences between the atmosphere, the shoot, the roots and the surrounding soil. At the shoot level, the plant tightly regulates the total water demand through the regulation of stomata. At the root system level, continuous interactions between heterogeneous (in time and space) soil and root hydraulic properties influence the amount of water entering the plant.

At the root scale, hydraulic properties are defined by anatomical (e.g. presence of endodermis, number of xylem poles) and functional features (e.g. expression of aquaporins). At the plant scale, these features are combined into a root hydraulic architecture, that ultimately defines the intrinsic capacity of a plant to uptake water.

This uptake capacity is subordinate to the amount of available water in the surrounding soil. In dry soil portions, low soil water potential and hydraulic conductivity, both directly linked to the soil water content, restrict local water flows and can have a strong effect on the overall uptake process.

Using two functional-structural plant models (PlaNet-Maize and R-SWMS) we will show that regulatory processes, both at the plant or the soil level, must be explicitly considered when exploring water uptake mechanisms. We will show how these processes interacts and influences with each other and why functional-structural plant models are essential tools to their study.

Increasing contrast of soil particulate organic matter in X-ray CT scans

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Soil organic matter (SOM) content is related to multiple factors that have an influence on plant growth. Concerning this, nutrient cycling and land productivity are important. Conservation of organic matter pools or protection of organic matter against degradation is thus an important research topic. Soil pore structure can have a significant impact on this protection of organic matter by regulating diffusion of substrates and metabolites, moisture distribution and aeration. Because of the small dimensions of many soil pores, X-ray Computed Tomography (CT) is commonly used to study the soil pore network. This non-destructive technique allows to visualize the 3D architecture of soils at the relevant scales.

Despite recent advances in software development, a main problem concerning the use of X-ray CT images in soil science is the limited soil phase differentiation. Low contrast between those phases is one of the aspects that contributes to this difficulty. Application of heavy element contrast agents that enhance X-ray attenuation of targeted structures could facilitate phase determination. Recently, the effectiveness and selectivity of different staining agents towards water, SOM and mineral matter (MM) has been investigated. Subsequent staining of water and SOM resulted in the selection of four staining agents that were able to increase the attenuation of SOM. The potential of these agents (lead nitrate, lead acetate, silver nitrate and phosphomolybdenic acid) to selectively stain OM was further tested in MM/OM mixtures. Among the tested staining agents different selectivity towards the mineral sand fraction was observed. This suggests that soil matrices of different mineral compositions will probably require a specific selection of compatible staining agents. Therefore it is important that the selectivity of staining agents towards other mineral soil fractions is tested as well.

Improved visualization of organic matter and other soil fractions will contribute to more accurate and efficient processing of the X-ray CT images. The combination of this technique with measurements of the microbial community and activity could result in new insights in small scale carbon cycling.

Combining in vivo and in silico experiments to decrypt root water uptake dynamics

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In our experiments, we monitored in 2D the evolution of soil water content around roots of transpiring maize plants using a light transmission imaging technique on a rhizotron. Subsequently, we digitized the entire root system in order to create an input file for the model RSWMS (HYDRUS-like model for soil-plant water transfers). A sensitivity analysis of the modeled experiment highlighted the plant parameters that can be measured thanks to such a procedure. Then fitting the simulated changes of distributed Sink term in Richards equation to experimental data enabled us to depict the local radial and axial conductivities. The use of the RSWMS model in association with experimental data gave us an insight on the water potential distribution in the plant and fluxes by and through individual segments during the entire duration of the experiment. Now this analysis can be optimized by changing the timing and/or types of measurements included in the protocol in order to maximize the information content. A validation of the results can also take place: the optimized conductivities of the root segments are indeed sensitive to a global conductance measurement and to other root water uptake experiments. Our new operation pipe clearly shows that the combined use of computer models and experimental data allows a better analysis of the water fluxes in the soil-plant system, can help researchers to decrypt the root water uptake dynamics and will improve the experimental protocol of previously used techniques. In the future, this experimental set-up will enable us to compare genotypes hydraulic architectures in order to answer questions such as: which genotype is the best adapted to avoid a drought stress occurring at a certain time in a given environment?

Coupling physical erosion and chemical weathering along a tectonic gradient in the Betic Cordillera (SE Spain)

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The production and denudation of soil material are controlled by chemical weathering and physical erosion which influence one another. Better understanding and quantification of this relationship is critical for better understanding biogeochemical cycles in the critical zone. The intense silicate weathering that is taking place in young mountain ranges is often cited to be a negative feedback that involves a long-term reduction of the atmospheric CO2 and the temperature cooling. However the possible (de)coupling between weathering and erosion is not fully understood for the moment and could reduce the effect of the feedback.

This study is conducted in the eastern Betic Cordillera located in southeast Spain. The Betic Cordillera is composed by several mountains ranges or so-called Sierras that are oriented E-W to SE-NW and rise to 2000m.a.s.l. The Sierras differ in topographic setting, tectonic activity, climate and vegetation. The mountain ranges located in the northwest, such as the Sierra Estancias, have the lowest uplift rates (~20-30 mm/kyr); while those in the southeast, such as the Sierra Cabrera, have the highest uplift rates (>150mm/kyr). Sampling was realised in four small catchments located in three different Sierras. In each of them, two to three soil profiles were excavated on exposed ridgetops, and samples were taken by depth slices. The long-term denudation rate at the sites is inferred from in-situ 10Be CRN measurements. The chemical weathering intensity is constrained using a mass balance approach that is based on the concentration of immobile elements throughout the soil profile (CDF).

Our results show that the soil depth decreases with an increase of the denudation rates. Chemical weathering accounts for 5 to 35% of the total mass lost due to denudation. Higher chemical weathering intensities (CDFs) are observed in sites with lower denudation rates (and vice versa). The data suggest that chemical weathering intensities are strongly associated with long-term 10Be derived denudation rates. Several causative factors may contribute to this observation, amongst which variation in climate, topography, and vegetation that are all associated with the measured variation in denudation rates. Finally, our data do not support a positive relation between the weathering rate and the physical erosion rate in the soil.

Si pools in soils: the effect of natural and human disturbances

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The Si cycle is a globally important biogeochemical cycle, with strong connections to other biogeochemical cycles, including C. Dissolved silica is taken up by plants to form protective structures called phytoliths, which become a part of the soil and contribute strongly to soil Si cycling upon litter burial. Different silica fractions are found in soils, with phytoliths among the most easily soluble, especially compared to silicate minerals. A whole set of secondary non-biogenic fractions exist, that also have a high reactivity (adsorbed Si, reactive secondary minerals…). A good characterization of the different fractions of reactive silica is crucial to move forward knowledge on ecosystem Si cycling.

We use a new method to analyze the different fractions of silica in soils. Using a continuous extraction of Si and Al in 0.5M NaOH, biogenic and non-biogenic reactive fractions are separated based on their Si/Al ratios and their reactivity.

Applying this new method we are investigating the effects of:

- Land use. The effects on the Si cycle due to agricultural and forestry management have already been shown earlier in temperate soils. Now we are assessing whether recently deforested soils in a subtropical context are impacted in a similar way in the south of Brazil.

- Fertilization. Society uses fertilizers to increase crops growth and to avoid plagues affecting soil biogeochemistry. We set up a greenhouse experiment where olivine fertilization is applied to two crops, at two rain application regimes and with different fertilizer grain sizes. The aim of this project is to investigate how olivine application affects Si fractionation and reactivity in the soil profile.

- The effect of fire. According to the IPCC report, extreme events such as fires (number and intensity) will increase due to climate change. We analyzed litter from spruce forest, beech forest and peat soils at two burning levels, after 350°C and 550°C burnings. The results showed differences in silica fractions between treatments and between soil types. We found mostly biogenic silica in the litter from forest and more mineral phases in the peat samples. The reactivity and the origin also changed along the burning treatments, suggesting a gradual crystallization of silica. A dissolution experiment carried out in rain water showed high dissolution rates mostly for ashes which may have strong implications for ecosystem Si mobility.

Capacity of microorganisms to decompose organic carbon affected by an increasing content of reactive mineral phases in a podzolic soil chronosequence

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Soil organic matter stabilization has received considerable interest in the last decades due to the importance of the soil organic carbon (SOC) pool in the global C budget. There is increasing evidence that the formation of organo-mineral associations play a major role in the mechanisms of organic carbon stabilization, indicating that the persistence of organic matter in soils relates primarily to soil physico-chemical and biological conditions than to intrinsic recalcitrance. Al and Fe oxy-hydroxides and short-range ordered aluminosilicates are known for their high capacity to sorb organic carbon. However, the impact of the evolution of these reactive mineral phases over short time scale on the distribution of microorganisms and their ability to decompose SOC is still poorly understood.

To further study the short-term evolution of organo-mineral associations, we investigated a 500-year podzolic soil chronosequence which is characterized by an increasing amount of secondary reactive mineral phases with pedogenesis and soil age, and thus by increased organo-mineral associations. In order to determine the impact of these secondary mineral phases on the degradation of SOC by microorganisms, an incubation experiment was carried out using soil horizons up to 1m deep from 6 profiles of different ages along the chronosequence. Furthermore, we used amino sugars and phospholipid fatty acids as tracers of dead and living microbial biomass, respectively, in the incubated samples.

Our results show that SOC mineralization was significantly lower in the illuvial Bh/Bhs horizons (which contain more reactive mineral phases) compared to the surface E horizons (depleted in reactive mineral phases), although the content in amino sugars is similar in these horizons. In the deeper Bw and BC horizons, as well as in the young profiles (<300 yrs) that have not yet undergone podzolization and related formation of organo-mineral associations, SOC mineralization rates were the highest. These findings suggest that stabilization of OC through organo-mineral interactions with reactive mineral phases in our study site strongly controls the ability of microorganisms to decompose soil organic matter.

A review of the effects of plant roots on concentrated flow erosion

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Natural vegetation is frequently used in ecological restoration programs to prevent or reduce the severe impact of soil erosion processes. Over the last two decades the focus of research on controlling soil erosion by vegetation gradually shifted from aboveground biomass towards the role of belowground biomass. Several case studies reported on the effects of plant roots in controlling concentrated flow erosion, however a global analysis of these root effects is still lacking. The objectives of this study are therefore: 1) to provide an overview of the empirical studies reporting the effects of root variables on soil erosion rates, 2) to establish a global dataset and to analyse the erosion-reducing effects of plant roots and 3) to investigate the influence of soil texture and root system architecture on soil erosion-reducing effects of roots. An extensive literature review resulted in 34 publications on the effects of plant roots in controlling soil erosion by water. Data from respectively 13 and 6 studies for root density (RD, kg/m^3) and root length density (RLD, km/m^3) were pooled resulting into two global datasets containing 822 and 274 observations of the relative soil detachment rate (RSD, -). Non-linear regression analysis resulted in the Hill curve model (RSD=(R(L)D)^(-b)/(c+(R(L)D)^(-b)); with b and c model parameters) as best fit model in order to estimate the erosion-reducing potential of plant roots. Both datasets showed a large variability due to differences in root characteristics of tested plant species, soil characteristics and experimental set ups which resulted into a low predictive accuracy. By means of a Monte Carlo simulation this uncertainty was quantified allowing us to use the models as a first assessment of the erosion-reducing effects of plant roots. Minimal values for RD and RLD at which plant roots have a positive erosion-reducing effect at 95% confidence interval amount to 1.3 kg/m^3 and 16 km/m^3 respectively. Efforts to improve the model by using additional variables (soil texture and root architecture) were not effective. However it is likely that a high percentage of sand as well as a tap root system negatively influence the erosion-reducing effect of roots. Preference is given to the global model based on RLD to estimate RSD as RLD takes into account the effect of root system architecture which is not the case for RD.