SYMPOSIUM INVITED SPEAKERS ABSTRACTS

Sorted alphabetically
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Monitoring and mapping Scotland's peat soils: legacy and development

Dr Matt Aitkenhead

Scotland's soils are approximately one-quarter peat in area and contain a significant proportion of the UK's environmental carbon stocks. Previous mapping and survey work provided information at the level of mapping units but did not provide information about the presence or absence of peat at specific locations. In recent years, a group of researchers at the James Hutton Institute have been working to improve our understanding of the distribution and characteristics of peat soils in Scotland. This work has been informed from a variety of sources and carried out in collaboration with other research organisations and government agencies. Here I will present several strands of work in this area and show how they have come together to provide a more detailed and policy-relevant source of information. I will also describe how these efforts have been used to inform environmental and climatjenne change related policy in Scotland.

Organomineral interactions: Zoom at nanoscale using EXAFS and MET-EELS

Dr Isabelle Basile-Doelsch[1,2], Nithavong Cam[1], Clément Levard[1], Emmanuel Doelsch[2], Jérôme Rose[1]
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Organo-mineral interactions are recognized as a key factor in stabilizing organic matter (OM) in soils and short-range order mineral phases are increasingly considered as key mineral phases in the control of OM dynamics (Rasmussen et al., 2018). Coprecipitation has been recently proposed as one of the main mechanisms involved. A recent conceptual model proposes that coprecipitates form continuously upon soil mineral weathering in contact with organic compounds of the soil solution (Basile-Doelsch et al., 2015). For silicate minerals, this process imply that Si may also take part in the structure of coprecipitates. However, only Fe and Al coprecipitates have been considered as coprecipitating cations in the literature. Experimental work precipitated nanophases from a solution containing ionic Fe, Al, Si, Mg and K, obtained from a biotite weathered leachate. TEM and Fe K-edge EXAFS showed that they were structured mainly by small oligomers of Fe, together with Si and Al (Tamrat et al., 2018). By adding an organic ligand (DOPA, initial M:C≈1), coprecipitates were structured by a loose and irregular 3D network of small oligmers of Fe, Si and Al forming a highly reactive open-structured mineral skeleton on which OM was bond. A conceptual model of the nanometer-scale structure, animated in 3D, has been proposed (Tamrat et al., 2019) and named "nanoCLICs" for "Nanosized Coprecipitates of inorganic oLIgomers with organiCs". It differs significantly from the previous models presented for ferrihydrite and amorphous Al(OH)3 coprecipitates (Kleber et al., 2015). We will present the main results that lead to the proposition of the nanoCLICs fine structure model, as well as ongoing imaging of nanoCLICS at nanometer scale by TEM, TEM-EELS and STXM.

Lateral transport of SOM through landscapes

Prof. Asmeret Asefaw Berhe[1]
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Most of the earth's terrestrial ecosystem is composed of sloping landscapes, where soil organic matter dynamics is partly controlled by the mass movement events that laterally distribute topsoil. Accurate estimation of the global soil carbon stock or the potential of soils to sequester atmospheric carbon dioxide are complicated by the effects of soil redistribution on both net primary productivity and decomposition. In this presentation, I will discuss: (1) why and how soil erosion can constitute a C sink; and how soil erosion is being considered within the context of global climate models; (2) the role of soil erosion on determining spatial distribution and stocks of SOM, stability, and stabilization mechanisms; (3) emerging understanding of the role of soil erosion in soil nitrogen dynamics; and I will conclude the presentation by highlighting remaining knowledge gaps in our understanding of the role of soil erosion in soil phosphorus dynamics, and SOM dynamics in temperate and arctic ecosystems.

Soil capital- our last rampart to address climate change, food security & reaping societal challenges

Dr Abad Chabbi

The 21st century has come with drastic environmental, social and economic changes that need real world solutions. By the middle of this century anthropogenic pressures will have caused additional change to the globe and all its inhabitants. While technological changes are occurring at a rapid pace, globalization has brought about both possibilities, but also environmental problems which are reaching or have reached a tipping point. For instance, soil capital resources and sustainability are drastically affected. More than 40% of soil used for agriculture around the world is classed as either degraded or seriously degraded. Because of poor management and intensive conventional farming methods that strip the soil of carbon, soil resources is being lost at between 10 and 40 times the rate at which it can be naturally replenished. There are two key issues. One is the loss of soil productivity (e.g. 30% less food over the next 20-50 years). Second, water will reach a crisis point that will further accentuate tensions among farmers and fuel local conflict, with potential geopolitical subregional implications. Taken together, this is a potent new cocktail, we need to redefine our relationship to the soil system and especially review radically our economic model and wealth indicators. In other words, the concept of exponential growth in a world of finite resources is no longer sustainable. We need to recognize that this is a global problem that would benefit from a global approach. We don't need to reinvent the wheel in each country, and we don't have time to do so. We just need to considerer reliable systems as quickly as possible that substantially rewards any effort to preserve the soil capital. Changing the way, the soil is managed, can have a clear influence on the amount of carbon that the soil can hold with big impact on global warming and food security.

Improving understanding and forecasting of Soil Organic Matter dynamics to transform challenges into opportunities

Professor Francesca Cotrufo

Soil organic matter (SOM) is at the nexus of the most wicked challenges facing humanity, from mitigating climate change to assuring sustainable food, fiber and bioenergy production to a growing population. It is our role to quantify and characterize it, understand mechanisms and drivers of its formation, transformation and mineralization, and use this understanding to forecast its vulnerability to changes and disturbances as well as its capacity to regenerate. This is our ambition at Colorado State University and to achieve it we recently developed a fully integrated measurement-modeling approach to use for research as well as in decision support tools. We will report on how our most recent work using this approach across the European continent and on future developments.

Soil C cycling in a changing world: the role of root-microbe interactions

Professor Franciska de Vries[1]
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Soil microbial communities play an important role in ecosystem functioning: they perform important steps in soil nutrient and carbon cycles and feed back to plant performance and community composition. Plants strongly alter the soil environment through root processes and are therefore likely to modify how soil microbial communities, and their functioning, respond to changing environmental conditions. Here, I will present the results from three experiments, ranging from field-based mesocosm, to glasshouse, to growth chamber experiments. Using these case studies, I will highlight different mechanisms through which roots can alter belowground microbial response to changes in plant community composition and drought, and the consequences for ecosystem functioning, including plant growth and community composition.

Biofunctionality of soil organic matter

Professor Ellis Hoffland[1], Thom Kuyper[1], Rob Comans[2], Rachel Creamer[1]
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Soil organic matter serves various functions. Interest in SOM as the source of plant nutrients is ancient. And while mineral fertilizers have, in many agro-ecosystems, replaced the role of SOM as supplier of nutrients, that interest has remained, also because of additional roles of SOM in maintaining or enhancing soil health. Since awareness about global warming grew in the 1980's, however, the focus within research has somewhat shifted from a soil fertility perspective to C sequestration as an opportunity for climate regulation. Despite a huge body of research, there is lack of knowledge regarding the chemical, biochemical, and biological factors responsible for the various functions of SOM. We propose the term "biofunctionality" to describe the quality of SOM suitable to serve any soil ecosystem function as a result of SOM effects on the decomposer community. In our presentation I will try to link properties of SOM to the functions and ecosystem services that they provide. Apart from scientists, the concept of "biofunctionality" should also guide managers who need instruments to manage SOM for the various purposes that it has.

Mineral surface area and organic matter accrual

Prof. Ingrid Kögel-Knabner

Soil is build of a dynamic and hierarchically organized system of various organic and inorganic constituents and organisms, the spatial structure of which defines a large, complex and heterogeneous biogeochemical interface. Recent evidence shows a zonation of fine soil particle surfaces into key sites with high OM sequestration in multi-layered stacked OM patches decoupled from the mineral surface area. We explain why soils, even if they contain less fine minerals and particulate OM than others, can store substantial amounts of stacked OM piled-up through their three-dimensional arrangement. This sustains a coexistence of soil functions provided by mineral surfaces beyond OM sequestration. We provide a new concept for patchy, piled-up OM sequestration in soil microstructures independent from the specific mineral surface area. This opens new perspectives for the potential of soils to sequester organic carbon. A significantly advanced understanding of the structure, dynamics and functioning of the soil architecture holds the promise to explain organic matter stabilizations within a general mechanistic framework and thus will launch the integration of this information into field-scale concepts and models of CO_2 sequestration in soils.

Recycled Organic Amendments: targeting use towards underlying soil constraints

Lynne Macdonald
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Recycled organic resources have a role to play in supporting soil health and function, food production, and regulating greenhouse gas emissions. Widespread use, however, can be hampered by variable composition, unpredictable results, biophysical barriers, and economic feasibility. There are opportunities to improve uptake through targeting amendment choice according to an understanding of the mode of action and the underlying soil constraints limiting plant growth. Here we discuss the chemical variability in a range of organic amendments, the role of carbon chemistry and nutrient stoichiometry in decomposition dynamics, and expected longevity of effect. Stepping from fundamental research to field based applications, we discuss opportunities and challenges for the use of organic amendments in supporting soil function and agricultural productivity. Highlighting limitations in surface application, we lean on examples from recent field based research aiming to overcome soil constraints through deep soil amelioration.

Indigenous Perspectives on SOM – New Zealand

Mr Robert McGowan[1]
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On March 20th 2017 the New Zealand parliament passed the Te Awa Tupua (Whanganui River Claims Settlement) Bill which established the Whanganui River as a legal "person" with all of the rights, powers, duties, and liabilities of the same. The Act endorses and illustrates how Māori perceive their relationship to the natural world. The passing of the Act challenged the River people to restore their ancestral river to good health. Changes in land use beginning in the later part of the 19th century had seen soil fertility decline, water quality deteriorate and the soils that sustained life in its catchment increasingly washed out to sea. These impacts profoundly changed the lifestyles of the people that belonged to it. Describing the issues facing the River Iwi (tribes) and their response to them will help illustrate traditional understandings relating to the River, the Whenua (the land) and the life sustain capacity of the soil. It also serves to demonstrate the relevance of traditional knowledge to addressing the current ecological crisis.

This presentation will focus on key concepts from Māori understandings of the natural world that relate to the primary themes of this conference and suggest how they can contribute toward deepening and broadening our knowledge of soils and what needs to be done to sustain them. In particular the concept of "Mauri" will be explored and how that relates to the capacity of soils to support the life that belongs there. Māori and many traditional peoples regard the whole landscape as essentially interdependent and that the wellness of any part of it, be it soils, vegetation, water quality, etc., can only be understood within the context of the whole network of connections that sustain life. The challenge for researchers, from an indigenous perspective, is to be mindful of the "whole" while focusing on the areas of their particular expertise.

Wetland blue carbon storage controlled by millennial scale variation in sea-level rise and soil organic matter is influenced by sea level variations

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The urgent need to mitigate climate change has focussed attention on the extraordinary capacity of coastal and marine ecosystems to sequester and store carbon within living biomass and substrates. Known as blue carbon ecosystems due to their connection with oceans, mangrove and saltmarsh are reported to have amongst the highest carbon stock density and rates of carbon sequestration of all ecosystems. Soil carbon storage is related to vegetative capacity to add organic matter to substrates, and physical processes that enhance to organic matter preservation and/or limit organic matter decomposition; periodic inundation by saline tidal water is crucial for both vegetative additions, and processes favouring preservation over decomposition. Global scale analyses have variably highlighted the role of temperature and precipitation on blue carbon storage, but surprisingly have ignored the critical role of sea level in influencing tidal inundation. The influence of global variation in relative sea level over the past few millennia on soil organic matter and carbon storage within substrates of blue carbon ecosystems is demonstrated. Using a unique study site exposed to rapid relative sea-level rise, the relationship between carbon sequestration and sea-level rise is validated over shorter time scales, confirming the capacity for coastal wetlands to adjust to sea-level rise by storing soil organic matter. Unlike terrestrial ecosystems blue carbon ecosystems do not become carbon saturated and can continue to store organic matter providing vertical and lateral space is provided by sea-level rise. The space available for carbon storage within mangrove and saltmarsh has become increasingly limited for many coastal wetlands where sea level has been stable for the past few millennia, particularly in the southern hemisphere. This paper confirms that sea-level rise will enhance carbon sequestration providing sediment supply to coastal wetlands is sufficient and space for lateral expansion does not become limited by coastal squeeze.

Linking microscale processes with the macro world: Microbes, molecules, and moisture through the soil profile

Dr Joshua Schimel

Microbes control planet Earth. Yet, integrating microbial information into large scale-perspectives and models remains difficult. Classical biogeochemical models assume that microbes are in equilibrium with their environment, an assumption that is increasingly false as climate change increases extremes. Currently, at least 1/3 Earth's land experiences regular drought, and climate models suggest this will increase. Important dry-soil phenomena remain unexplained, such as the "Birch Effect"—the pulse of respiration on rewetting a dry soil. Important and surprising processes occur during the dry season. For example, during the summer in California grasslands, soils are dry and plants are dead, but microbial biomass increases, even though activity is limited. Additionally, pools of bioavailable C increase, which primes the system to produce a pulse of activity following rewetting. These changes appear to result from a combination of microbial drought survival physiology and disconnections in soil water films that limit substrate diffusion. A focus of the talk will be about how we bridge the scales from the micro- to the ecosystem. Current dominant carbon cycling models do a poor job of capturing drought and rewetting dynamics—how can we incorporate the dry-soil and pulse processes into large-scale models of soil carbon processes?

Generalizing soil organic matter models for understanding overall system properties

Mr Carlos Sierra[1]

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Models of soil organic matter (SOM) dynamics have become essential for integrating concepts and observations on different aspects of the cycling of carbon and elements in soils. Every year, a large number of models are proposed in the literature addressing new ideas on the biology, chemistry, and physics of SOM dynamics such as the role of microorganisms, mineralogy, and vertical transport. From this large variety of models, it is difficult to assess main model differences that would lead to very different qualitative dynamics; or, on the contrary, to equifinal predictions among models. Here, we will present an effort to generalize models of SOM dynamics with the aim to extract common concepts and principles among models. In addition, we will introduce a set of metrics to assess system-level properties among models. These metrics include: SOM age, transit time, and entropy. We propose SOM age as a meaningful metric to assess persistence of carbon and nutrients in soils, and SOM transit time as a metric to assess time-scales of carbon sequestration in soils. SOM entropy is introduced as a metric to assess complexity of models, and as a tool for parsimonious model selection. Overall, these metrics contribute to system-level understanding of the SOM system.

Quantifying changes in soil carbon stocks of grazed pastures: identifying gains and avoiding losses

Professor Louis Schipper

There is an increasing emphasis on removing carbon dioxide from the atmosphere and storing this carbon in soil to mitigate against predicted trajectories of climate change. While simple in concept facilitating this transformation requires deep understanding of carbon cycling scaling up from fundamental processes of surface chemistry, photosynthesis and respiration and aggregating these up to (agro)ecosystems and their management. I will take the top down approach examining evidence for changes in carbon stocks associated with management of intensively grazed pastures. The timeframe to identify management practices that encourage gains and avoid soil carbon losses mean that traditional soil sampling approaches may take too long to answer these questions. Techniques such as eddy covariance allow us to identify subtleties of carbon cycling at hectare scales to rapidly identify possible management solutions and collaborate across scales from the hectare to the soil surface of soil particles. These management practices need to be practical, maintain food production, decrease greenhouse gas production or at a minimum increase efficiency at producing food per unit of greenhouse gas production

SOM dynamics in fire prone landscapes

Dr Jennifer Soong

The occurrence of wildfires is increasing globally, yet their impact on SOM dynamics is not very well understood. The impact of fires on SOM can vary greatly with ecosystem type, fuel load condition and fire severity. Although fires combust and remove biomass from ecosystems, they also transform the litter layer, top soil and plant material leaving behind pyrogenic organic matter residues. Pyrogenic organic matter has chemical and structural properties that impedes decomposition by biota but also retains nutrients and impacts hydrology in the soil. Surface litter and pyrogenic organic matter also have very different decomposition pathways to SOM formation, which can help to explain the impact of frequent burning on soil carbon and nitrogen dynamics. I will present an overview of how the study of SOM characteristics and dynamics in fire-prone landscapes has evolved rapidly in recent years and discuss the upcoming needs and opportunities for SOM researchers to inform better management and planning for the future in fire-prone landscapes.