Evaluating the ecosystem services linked to water in agricultural ecosystems: a contribution to the French national assessment of ecosystem services

Isabelle Cousin, Anaïs Tibi, Julie Constantin, Anne Meillet, Thomas Poméon, Olivier Therond

HAL Id: hal-02734959
https://hal.inrae.fr/hal-02734959

Submitted on 2 Jun 2020

ISMC
International Soil Modeling Consortium

2ⁿᵈ ISMC Conference:
New Perspectives on Soil Models

Book of Abstracts

Wageningen University
Wageningen, the Netherlands
November 5 – 7, 2018

https://soil-modeling.org

Committees

Scientific Committee

Bradford, Scott (United States Department of Agriculture)
Euskirchen, Eugenie (University of Alaska Fairbanks)
Finke, Peter (Ghent University)
Flores, Alejandro (Boise State University)
Ghezzehei, Teamrat (University of California Merced)
Guenet, Bertrand (Laboratoire des Sciences du Climat et l'Environnement)
Michel, Eric (Institute for Agricultural Research)
Mishra, Umakant (Argonne National Laboratory)
Or, Dani (ETH Zürich)
Painter, Scott L. (Oak Ridge National Laboratory)
Robinson, David Centre for Ecology and Hydrology)
Simunek, Jirka (University of California, Riverside)
Tarquis, Ana M. (Universidad Politécnica de Madrid)
Todd-Brown, Katherine (Pacific Northwest National Labs)
van der Ploeg, Martine (Wageningen University and Research)
Van Looy, Kris (OVAM, BE)
Vereecken, Harry (Forschungszentrum Jülich)
Verhoef, Anne (University of Reading)
Wollschläger, Ute (Centre for Environmental Research - UFZ, Halle (Saale))
Young, Michael (University of Texas - Austin)

Organizing Committee

Baartman, Jantiene (Wageningen University)
Baatz, Roland (Forschungszentrum Jülich GmbH)
de Jong, Corien (Wageningen University)
Coleen, Carranza (Wageningen University)
Tol, Marnella van der (Wageningen University)
van der Ploeg, Martine (Wageningen University

Sponsors

Schedule

Time	Nov 5th	Nov 6th	Nov 7th
830 - 900	Opening	Soil modelling for the next generation of Earth System Models	New Perspectives on the Modeling of Colloidal Particle Fate in Soils
900 - 930	Modeling of soil ecosystem functions and services in landscapes		
930 - 1000			
1000 - 1030			Coffee Break
1030 - 1100		Coffee Break	Soil organic carbon dynamics modeling
1100 - 1130	Coffee Break	Permafrost, peat and frozen soils	
1130 - 1200	Linking Big Data to Smart Soil and Smart Environment		
1200 - 1230			
1230 - 1300		Lunch	Lunch
1300 - 1330	Lunch		
1330 - 1400		Group Picture	
1400 - 1430	Coffee / Poster Session	Strategic and future perspectives for ISMC (public)	Poster Session
1430 - 1500			
1500 - 1530		Excursion (visit Earth ecosystems)	Wrap-up, Closing
1530 - 1600	Advances in soil-plant-atmosphere modelling and measurements across scales		
1600 - 1630			
1630 - 1700			
1700 - 1730			
1730 - 1800	Executive Board Meeting / Tour World Soil's Museum / Reception		
1800 - 1830			
1830 - 1900		Conference Dinner / Awards	
1900 - 1930			
1930 - 2000			

Venue:

Gaia Rm. 1+2 - Gound floor

Gaia Main Hall - Ground floor

Gaia Plateau - First floor

Burger's Zoo

Lumen 4 VC Zaal (C.215)

Museum in Gaia Bldg.

Program

8:00   Registration (Gaia Main Hall – Ground Floor)

8:30   Welcome (Gaia Rm. 1 & 2)   - B. de Vos (ESG, WUR);

                             H. Vereecken (AI, Jülich);

                             M. van der Ploeg (SLM, WUR)

9:00-11:00 Modeling of soil ecosystem functions and services in landscapes (Gaia Rm. 1 & 2)
Convenors: Martine van der Ploeg, Kris van Looy, David Robinson

9:00   Why do we need models? – **B. Emmett**

9:20   Large-scale integration of soil erosion and organic carbon modelling: is it feasible? – **E. Lugato**

9:40   Soil modeling as an indispensable tool to realize inter- and transdisciplinarity – **J. Bouma**

9:52   Evaluating the ecosystem services linked to water in agricultural ecosystems: a contribution to the French national assessment of ecosystem services – **I. Cousin**

10:04 Soil ecosystem services appraisal and prioritization of soil remediation with a dynamic spatial modelling – **K. Van Looy**

10:16 Soil ecosystem services appraisal and prioritization of soil remediation with a dynamic spatial modelling – **B. Tupek**

10:28 Panel Discussion

11:00 Coffee break (Gaia Main Hall - Ground floor)

11:30-13:00 Linking Big Data to Smart Soil and Smart Environment (Gaia Rm. 1 & 2)
Convenors: Ana M. Tarquis, Ute Wollschläger, Teamrat Ghezzehei

11:30 SoilGrids: using big data solutions and machine learning algorithms for global soil mapping - **L.M. de Sousa**

11:50 Cross-database evaluation of machine-learning regression models for predicting soil water content at field capacity. - **S.E. Acevedo**

12:02 Spatiotemporal modelling of global SOC changes 1992-2015 at 300 m resolution - **T. Hengl**

12:14 Accounting for soil hardness to resculpt root system architecture - **C.K. Black**

12:26 Panel Discussion

13:00 Lunch (Gaia Plateau – 1st Floor)

14:00 Posters & Coffee & Booths (Gaia Main Hall - Ground floor)

15:30-17:30 Advances in soil-plant-atmosphere modelling and measurements across scales (Gaia Rm. 1 & 2)
Convenors: Anne Verhoef, Dani Or

15:30 Accounting for plant hydraulic properties in Earth system models (ESMs) – **J. Ogee**

15:50   Measuring water dynamics in the soil-plant-atmosphere continuum using radar - **S. Steele-Dunne**

16:10   Modelling soil hydric dynamic and soil nitrous oxide emissions under simulated rainfall in laboratory conditions at an intermediate scale of 10 m² x 0.3 m – **F. Poincot**

16:22   Spatial and temporal variability in water infiltration patterns – **L. van Schaik**

16:34   Connecting crop models with proximal soil sensing to improve agricultural management on field scale – **E. Wallor**

16:46   Listening to earthworms burrowing and roots growing - acoustic signatures of soil biological activity – **M. Lacoste**

16:58   Panel Discussion

> ### 17:30 Executive Board Meeting (Lumen 4 VC Zaal (C.215))
> ### 17:30 Reception (Gaia Main Hall - Ground floor)
> ### 17:30 Tour World Soil's Museum (Gaia Bldg.)

Tuesday - November 6, 2018

8:30 - 10:30 Soil modelling for the next generation of Earth System Models (Gaia Rm. 1 & 2)
Convenors: Harry Vereecken, Peter Finke

8:30   Introducing soil structure in land-surface models: implications for water and energy fluxes – **S. Fatichi**

8:50   Coupled soilscape-landform evolution: Recent insights – **G. Willgoose**

9:10   Scale-dependent parameterization of aquifer conductance to simulate groundwater - surface water interactions in regional hydrogeological models – **A. Di Ciacca**

9:22   On the static representation of soil in regional and global climate models – **A. Nemes**

9:34   Functional Sensitivity Study of Pedotransfer Functions for use in Land Surface Models - **L. Weihermüller**

9:46   Concepts and complications for implementing hydrologic processes in soil and landscape evolution models – **M. van der Meij**

9:58   Panel Discussion

> ### 10:30 Coffee break (Gaia Main Hall - Ground floor)

11:00–12:30 Permafrost, peat and frozen soils (Gaia Rm. 1 & 2)
Convenors: Umakant Mishra, Eugenie Euskirchen, Bertrand Guenet

11:00   Evolution of Permafrost in Alaska in 20th and 21st Centuries – **V. Romanovsky**

11:20   The influence of river migration on the storage and cycling of soil organic carbon in permafrost affected floodplains – **J. Rowland**

11:40   Modelling northern peatlands methane emissions for studying interactions between permafrost, peat soil carbon and atmosphere and feedbacks on climate – **E. Salmon**

11:52   The Canadian Model for Peatlands (CaMP): a national-scale peatland carbon accounting model – **C. Shaw**

12:04   Panel Discussion

> ### 12:30 Lunch (Gaia Plateau – 1st Floor)

13:30   Group Picture   (Gaia Main Hall- Ground floor)

14:00   Strategic and future perspectives for ISMC (public; Gaia Rm. 1 & 2)

15:00   Excursion (visit Earth ecosystems – Burger's Zoo)

18:00   Conference Dinner + Awards (Burger's Zoo)

20:00   Travel back to to Wageningen

Wednesday - November 7, 2018

8:30-10:00 New Perspectives on the Modeling of Colloidal Particle Fate in Soils (Gaia Rm. 1 & 2)
Convenors: Eric Michel, Scott Bradford

8:30   Upscaling remobilization using exposure-time – **T. Ginn**

8:50   Soil in catchment-scale models of water quality as affected by micropollutants and emerging contaminants - **Y. Pachepsky**

9:10   Modelling colloid-facilitated transport and geochemical effects on colloid transport – **J. Diederik**

9:22   Flow Interruption Facilitates Iron Oxide Colloid Retention Under Unfavorable DLVO Attachment Conditions - **J.F. Carstens**

9:34   Co-transport of nanoparticles and contaminants in groundwater: a coupled reactive transport model – **T. Tosco**

9:46   Panel Discussion

10:00 Coffee break (Gaia Main Hall- Ground floor)

10:30-12:30 Soil organic carbon dynamics modeling (Gaia Rm. 1 & 2)
Convenors: Michael Young, Alejandro Flores, Katherine Todd-Brown

10:30   The efficacy of soil carbon modeling: what types of information and data are needed to capture the dynamics, status, and fate of soil organic carbon? - **M. Williams**

10:50   Soil process modelling - from empirical description to emergent behavior - **M. Reichstein**

11:10   A conceptual framework for long-term, landscape-scale SOM models incorporating vegetative and mineral-matrix zones of influence - **C. Cagnarini**

11:22   SOM-aggregate dynamics in the plant-microbe-soil interaction model – **N. Vasilyeva**

11:34   Advances in National Scale Upland Forest Soil Carbon Modelling with the CBM-CFS3 – **C. Shaw**

11:46   A modelling approach for quantifying stable organic matter related to the soil biota activity – **O. Chertov**

11:58   Unifying soil organic matter formation and persistence frameworks into a mathematical model: MEMS v1.0 -   **F.M. Cotrufo**

12:10   Panel Discussion

12:30 Lunch (Gaia Plateau – 1st Floor)

13:30   Posters (Gaia Main Hall- Ground floor)

15:00 Wrap-up, Closing (Gaia Rm. 1 & 2)

Table of Contents

s

Modelling of soil ecosystem functions and services in landscapes

Why do we need models?

Bridget Emmett and CEH Soils and Land Use team

Email: *bae@ceh.ac.uk*
Affiliation: Centre for Ecology and Hydology, UK

Abstract

Soil models already play important roles in decision making sfor sustainable land use, identifying and protecting areas at risk from degradation, managing expectations of policy outcomes, and understanding drivers of change in soil monitoring programmes. What have we learnt from these applications, what is needed to improve soil models for the future, is there still a role for traditional soil monitoring approaches, and if so how should these be adapted to exploit new instruments in the field or laboratory? A growing consensus points to greater integration and co-development of soil models with emerging new techniques and approaches for soil monitoring. Bringing together field measurements, big-data tools, statistical approaches for data integration, and high resolution remote sensing data will help increased spatial and temporal resolution and our confidence in model projections. Process representation in models also needs to reflect new understanding and better link to soil functions and services at scales useful for decision making. Providing sufficient but not excessive levels of complexity and process representation is crucial for ensuring soil models are robust and efficient parts of any decision making process. Regardless of application, formulating and understanding the questions are key first steps for selecting which models to use or for designing new fit-for-purpose models. Overall, a more integrated approach between research communities and understanding 'how good is good enough' will help us meet the new urgent challenges ahead.

Large-scale integration of soil erosion and organic carbon modelling: is it feasible?

Emanuele Lugato and Panos Panagos

Email: *emanuele.lugato@ec.europa.eu*
Affiliation: European Commission, JRC

Abstract

Control of soil erosion and preservation of soil organic carbon are two of the main agro-environmental targets of the current and incoming Common Agricultural Policy (CAP). Some recommended practices, such as cover crops introduction, have the potential to act both under the geomorphological and biogeochemical cycles (i.e. reducing soil erosion and increasing soil organic carbon). However, the soil organic carbon turnover is still one of the main source on uncertainty on land-atmospheric carbon feedback and the possibility to improve its process-descriptions is further limited by the exclusion of soil erosion, which seems to induce controversial effects. We present a consistent biogeochemistry-erosion model framework, which could assess the impact of anthropogenic (management) and natural (climate change) drivers at continental scale, taking into account erosion-induced C feedbacks. We demonstrate how this modelling framework could dynamically integrate more dimensions (vertical and later fluxes) and landscape soil functions, being still parsimonious at large-scale.

Soil modeling as an indispensable tool to realize inter- and transdisciplinarity

Johan Bouma

Email: *johan.bouma@planet.nl*
Affiliation: formerly Wageningen University

Abstract

The seventeen Sustainable Development Goals (SDG's) of the United Nations, accepted by 193 governments in 2015, don't mention soils explicitly but food security, water quality, climate mitigation and biodiversity preservation cannot be achieved without of soil expertise. Soil contributions to the SDG's require therefore cooperation with other disciplines: interdisciplinarity, which is the more relevant as research funding is shifting to issues with societal relevance. Dynamic models of the soil-water-plant-atmosphere system require input from different disciplines and are therefore an ideal,practical and pragmatic vehicle to achieve interdisciplinarity. The challenge for soil science is to move beyond just providing basic soil data from available databases, focusing on representing living soils in living landscapes. Also, validated models are the only means to explore future soil and environmental conditions as a function of climate change and water scarcity scenarios, the focus on many questions by stakeholders and policy makers. Current "post-truth"and "fact-free" developments in society, enhanced by social media, require a different attitude of the scientific community facing stakeholders, citizens and politicians. Rather than produce straightforward solutions ("the truth") for each of the SDG's, alternative options can be generated, each of which representing different points of view and interest, from which stakeholders make a choice. This way, ideally, "ownership" is created for stakeholders in a process of " joint learning" where scientists are seen as concerned, well informed partners rather than as aloof, "elite" experts. Again, models, often as part of Decision Support Systems, are crucial to facilitate such processes.

Evaluating the ecosystem services linked to water in agricultural ecosystems: a contribution to the French national assessment of ecosystem services

Isabelle Cousin, Anaïs Tibi, Julie Constantin, Anne Meillet, Thomas Poméon, Olivier Therond

Email: *Isabelle.Cousin@inra.fr*
Affiliation: INRA, UR0272 SOLS

Abstract

As essential contributors to ecosystem services, soils store water and control its flows, whether these are transpired by plants for their biomass production, infiltrated or runoffed to groundwater or surface water, or evaporated toward the atmosphere. In an agricultural context, the evaluation of the ecosystem service ""soil capacity to store and return water"" is delicate, insofar as the contribution of the farmer, through its agricultural practices in the broad sense (including tillage, irrigation, fertilization, etc...) is constitutive of the agricultural ecosystem.

New indicators of this service for an agricultural context have been evaluated throughout the national territory by using the STICS crop model for 30-years simulations in two situations: on the one hand, when irrigation practices on croplands are in line with actual practices and, on the other hand, when irrigation is suppressed (even on crops where it is traditionally practiced). Our simulations show that the amount of water transpired by the cash crop and the water yield, evaluated in irrigation-free situations, strongly correlated with the soil Available Water Content, and were little dependent on the type of climate or the length of crop rotation. We have also shown that for crop systems containing irrigated crops, the contribution of irrigation to the cash crop transpiration usually exceeds 40%, and can reach 90 % in some situations. The annual water yield, calculated on average over 30 years in the whole country, is not affected by the presence of intermediate crops in the rotation.

Soil ecosystem services appraisal and prioritization of soil remediation with a dynamic spatial modelling

Kris Van Looy, Griet Van Gestel, Nathalie Van Trier, Karolien Vermeiren, Nina Peeters, Nele Bal

Email: *kris.van.looy@ovam.be*
Affiliation: OVAM

Abstract

In Flanders, regional coverage information is collected on soil quality with focus on potentially contaminated sites in a land information register. For the decision making on further examination, remediation and/or management of these risk sites, and for the timing of the actions a prioritization dynamic spatial modelling tool was developed.

Dynamic spatial models are useful tools to support these decisions. The 'RuimteModel' simulates land use changes in Flanders at high spatial resolutions, for about 40 different land use categories, and for 50 years into the future. Ecosystem services are appraised based on different functions such as soil vulnerability for nutrients and groundwater, groundwater production areas, flood protection areas and biodiversity conservation areas (Natura2000). The appraisal is weighed by the potential impact of pollution; the more people use the site for living, work and recreation, the higher the potential impact. Further weighing is for the risk posed by the specific contamination and the soil properties of diffusion and spreading.

In the presentation, the advantages of spatial dynamic modelling of functions and services to support soil policy will be demonstrated. The tool helps to gain insight in complex issues, and allows to test various possible scenarios and solutions. It generates output in various forms, but, it is above all very visual and tangible and thus ensures that the model is a very useful instrument to involve different stakeholders in the decision making process.

Soil organic carbon stock changes predicted with Yasso07 and Yasso15 models after land use conversion from a past century of agriculture to future afforestation in Finland

Boris Tupek, Aleksi Lehtonen, Raisa Mäkipää, Jaakko Heikkinen, Taru Palosuo, Ari Rajala, and Kristiina Regina

Email: boris.tupek@luke.fi
Affiliation: Natural Resources Institute Finland

Abstract

The management of boreal landscape, which is a mosaic of agricultural fields, forests, and forested peatlands with largest terrestrial soil carbon pools, determines the ecosystem productivity and soil carbon losses or gains. Intensive agriculture depends on the fertility of land which shifts in accord with increasing temperature and precipitation over last decades. To support the optimal land management for the food production and soil carbon sequestration we aimed to combine the existing data on agricultural production with predictive capacity of soil carbon models. We used Yasso07 and Yasso15 soil carbon models to predict soil carbon stocks in Finland over the past land use change from forest to agriculture in comparison with alternative afforestation or continuous agriculture in future. Furthermore we evaluated soil carbon stock changes when running the models on annual and monthly time steps with alternative functions for precipitation. The models predicted largest soil carbon stock gains for the fields with higher moisture afforested by spruce in comparison to birch. Soil carbon stock changes more strongly depended on the amount and the quality of litter than by the variation of functions accounting for the weather dependence on the decomposition. Although the models needs further testing and development to improve the spatial distribution of soil carbon stocks, their ability to predict the soil carbon change could prove useful for indicating fields which will benefit most by afforestation.

Linking Big Data to Smart Soil and Smart Environment

SoilGrids: using big data solutions and machine learning for global soil mapping

Luís M. de Sousa, Gerard B.M. Heuvelink; Niels H. Batjes; Bas Kempen

Email: *luis.desousa@wur.nl*
Affiliation: ISRIC - World Soil Information

Abstract

The SoilGrids system (www.soilgrids.org) uses machine learning algorithms to predict soil type and basic soil properties at seven depths on global extent. The algorithms (i.e., random forest and gradient boosting) are trained with soil observations assembled from 150 000 locations across the globe and over 200 global environmental covariates (mainly derived from MODIS land products, SRTM DEM derivatives, climatic images and global landform and lithology maps). Software implementation is done in the R language for statistical computing. Currently the resulting maps are derived at 250 m spatial resolution and served under an Open Data Base License. This keynote presentation explains the statistical methodology behind SoilGrids and describes how big data and numerical complexity issues were solved using cloud computing and tiling. The prediction accuracy of resulting maps is reported using cross-validation statistics. Prediction accuracy varies between soil properties and depths, with usually between 55 and 85 per cent of the total variance explained. Future developments of SoilGrids are to extend the set of predicted soil properties, refine its spatial resolution and further improve prediction accuracy, as well as quantify prediction accuracy spatially explicitly by mapping prediction interval boundaries. Main uses of SoilGrids have been in Environmental Sciences, Ecology, Agriculture, Geology, Water Resources and Science Technology. The SoilGrids team is eager to connect with users to maximise the use of the product and tailor the product to specific user needs.

Cross-database evaluation of machine-learning regression models for predicting soil water content at field capacity

S.E. Acevedo and C.A. Bonilla

Email: *seaceved@uc.cl*
Affiliation: Pontificia Universidad Católica de Chile Department of Hydraulic and Environmental Engineering

Abstract

Typically, undisturbed soil samples are not reported in soil databases as most soil surveys focuses on soil classification, and disturbed samples provide most of the information required for that purpose. This is limiting condition when predicting the soil water content at field capacity (FC), because this is strongly dependent on soil macroporosity and structure. This paper reports the development of a series of pedotransfer functions (PTFs) based on FC values reported on a soil database with disturbed soil samples and how a linear adjustment can be applied in order to derive a more accurate estimate for FC on undisturbed soils. A hierarchical approach of FC estimations was developed using different basic soil properties. Specifically, four models were tested: Generalized Linear Regression (GLM), Classification and Regression Tree (CART), Multivariate Adaptive Regression Spline (MARS), and Artificial Neural Networks (ANN) coupled to linear regressions to recalculate water content on undisturbed soils from models based on disturbed soil data. The results demonstrate that MARS and ANN models had the best predictive performance overall using sand, clay and OM as input data.

Spatiotemporal modelling of global SOC changes 1992-2015 at 300 m resolution

Tomislav Hengl and Ichsani Wheeler

Email: *tom.hengl@envirometrix.net*
Affiliation: Envirometrix Ltd

Abstract

Soil is of increasing interest to the policy makers as a potential global solution for offseting greenhouse gas emissions from agriculture and for combating climate change (Lamb et al., 2016; Jackson et al., 2017). Soil organic carbon stocks and loss of soil organic carbon due to land use change is one of the three main criteria of the Land Degradation Neutrality. However, difference in the estimates of the total soil organic carbon stocks for our planet for 0–1 m have been significant (Scharlemann et al., 2014). Uncertainty about how much organic carbon is there in the soil is especially high for the northern latitudes (Mishra et al., 2013; Todd-Brown et al., 2013). The most up-to-date point data from Canada and Russian Federation now indicates that large pools of soil organic matter in tundra and taiga-like biomes have been under-estimated (Hugelius et al., 2013; Jackson et al., 2017). Likewise, Xu et al. (2018) has recently estimated that the actual coverage of peatlands is somewhat bigger than expected (currently estimated to be 2.8 % of the total land mask), and there seems to be still many unmapped pools of peat and organic material in tropics — especially in Latin America (Gumbricht et al., 2017) and in Africa (Fatoyinbo, 2017) — and in the mangrove forests (Atwood et al., 2017). All this indicates that there is a need for a new, updated estimate of how much soil organic carbon is there in the soil to start with, and how much has been potentially lost in the last 30+ years. In this paper we provide a data-driven estimate of the total soil organic carbon stock for standard depths 0–30 cm, 0–100 cm and 0–200 cm, for which we use an international compilation of soil profiles and predictive spatial modeling based on machine learning. We finally use the produced baseline estimate in an expert-based system to derive an estimate of the global soil carbon loss due to land cover change (1992–2016).

Accounting for soil hardness to resculpt root system architecture

Christopher K Black and Jonathan P. Lynch

Email: *ckb23@psu.edu*
Affiliation: Pennsylvania State University

Abstract

Because roots are laborious to measure directly, plant researchers often turn to simulation as a tool for refining their hypotheses about how roots respond to the environment. Although root growth models are powerful and allow high-thoughput exploration, they can only reveal biological mechanisms to the extent that they incorporate biologically reasonable assumptions.

The most commonly used root growth models have historically assumed uniform and unrestrictive soil conditions. However, real soils are heterogeneous and restrict root extension to varying degrees depending on their structure, texture, management history, and water status. To the extent that models lack mechanistic representations of the processes that drive changes in soil hardness and of the growth responses that these changes induce, it remains difficult to map simulation results onto meaningful predictions of real-world growth.

We have incorporated a physics-based soil hardness module into the structural-functional root system architecture model OpenSimRoot. The module takes as inputs soil texture and taxon, water content, and optionally bulk density and water release curve parameters if they are available; otherwise these are computed from generalized pedotransfer functions. Using the module, we have predicted depth gradients in penetrometer soil hardness across a wide array of soil types and bulk densities.

Accounting for the effects of hardness across a realistic depth gradient causes OpenSimRoot to generate very different maize root architectures than those simulated in uniform soil, underscoring that to use simulation as a phenotyping tool for deep-soil resource capture, mechanistic models and validation against field data are essential.

Advances in soil-plant-atmosphere modelling and measurements across scales

Accounting for plant hydraulic properties in Earth system models (ESMs)

Jerome Ogee

Email: *jerome.ogee@inra.fr*
Affiliation: INRA, UMR 1391 ISPA

Abstract

A tight coordination exists between the capacity of plants to capture CO2 and light for photosynthesis. Similarly plants tend to adjust their hydraulic architecture and stomatal density to coordinate water supply from root uptake and evaporative demand through transpiration. Supply-demand functions are commonly used in ESMs to estimate net photosynthesis and stomatal conductance but more rarely to describe the plant water status. In fact, most ESMs ignore plant (and soil) hydraulics and mostly account for the evaporative demand, while the response of photosynthesis or stomatal conductance to edaphic conditions is accounted for only empirically and remains a major uncertainty of the models. Yet plant and soil hydraulic constraints, and their direct effects on stomatal behaviour, could be helpful to better represent how soil water availability limits plant function. Plant hydraulic trait databases now exist that could greatly benefit the future generation of land-atmosphere climate models. Several examples of how this could be achieved will be given during the presentation.

Measuring water dynamics in the soil-plant-atmosphere continuum using radar

Susan Steele-Dunne

Email: *s.c.steele-dunne@tudelft.nl*
Affiliation: Delft University of Technology

Abstract

Vegetation acts as an interface between the earth's surface and the atmosphere, modulating exchanges of water, carbon and energy and responding to environmental stressors. Radar backscatter is sensitive to soil moisture, and vegetation water content as well as surface and vegetation geometry. Satellite radar observations offer a new perspective on water dynamics in the soil-plant-atmosphere continuum at scales from meters to tens of kilometres.

Results from a recent field experiment, centered on a new L-, C- and X-band radar system, will be used to illustrate how water dynamics influence radar backscatter at the field scale during a growing season. Spaceborne scatterometer data will be presented to argue that the phenomena observed at field scale are also observed at footprint scale.

We will argue that, to fully exploit the potential of satellite radar data, we need to update the representation of vegetation in scattering models from that of a static dielectric medium to one that reflects a complex living system interacting with its environment. Improved consistency between the representation of vegetation in SVAT models and radiative transfer models allows for better coupling, and facilitates assimilation. Both are needed to exploit radar as a tool for monitoring water dynamics in the soil-plant-atmosphere continuum.

Modelling soil hydric dynamic and soil nitrous oxide emissions under simulated rainfall in laboratory conditions at an intermediate scale of 10 m² x 0.3 m

Flavien Poincot, Lionel Cottenot, François Lafolie, Catherine Henault, Isabelle Cousin

Email: *flavien.poincot@inra.fr*
Affiliation: National Institute of Agricultural Research (INRA)

Abstract

Nitrous oxide (N2O) is the third main greenhouse gas involved in the anthropogenic greenhouse effect and is mainly produced and emitted by soils. Agriculture accounts for 60% of total anthropogenic N2O sources. Spatial variability of N2O emissions is high and our understanding of the determinants of this spatial variability remains incomplete. Soil hydric dynamic affects the soil aeration status as well as its gaseous diffusion capacity. Therefore, soil hydric behavior is a key variable to understand both N2O production and gaseous diffusion through the profile.

Our objective is to help to understand the spatial distribution of N2O emissions after a rainfall event.

We designed a laboratory experiment to study N2O emissions after a simulated rainfall event on a 10 m² x 0.3 m bare soil with a 5% slope. Compacted areas were realized, resulting in two soil bulk densities of 1.05 g.cm-3 and 1.55 g.cm-3 alternately distributed along the slope. Contrary to our first hypothesis, the resulting pattern of heterogeneously compacted areas did not explain the spatial distribution of measured N2O fluxes. We used a modelling approach to offer interpretations of our results.

We coupled the process-based model PASTIS (Lafolie, 1991) describing water flow and N transport to NOE-GTE (Rabot et al. 2015) a process-based model derived from NOE (Hénault et al., 2005) simulating N2O production and gaseous diffusion through the soil profile. We used this model to show how local compaction can affect spatial variability of N2O emissions after water input, both through production and transport processes.

Spatial and temporal variability in water infiltration patterns

Tobias L. Hohenbrink, Anne-Kathrin Schneider; Anne Arne Reck; Boris Zangerlé; Loes van Schaik Schröder;

Email: *t.hohenbrink@tu-berlin.de*
Affiliation: Technische Universität Braunschweig, Landscape Ecology and Environmental Systems Analysis; Technische Universität Berlin, Ecohydrology and Landscape Evaluation

Abstract

Water infiltration in structured soils can be dominated by preferential flow. Preferential water fluxes are difficult to measure in situ. However, infiltration experiments enable us to visualize at least the emerging infiltration patterns at the pedon scale. We present a data set containing 540 horizontal profiles from 180 Brilliant blue infiltration experiments.

We performed Brilliant blue infiltration experiments during six field campaigns from May 2015 to March 2016 on six agriculturally used fields (3 grasslands, 3 arable land sites) with 5 replications each. At each plot, we dug out 3 horizontal profiles (50 cm x 50 cm) in 3, 10 and 30 cm depth and counted all visible blue-stained and non-stained macropores. We took photos of each profile and converted the photos to binary images (stained pixels, non-stained pixels). We calculated spatial metrics, such as patch area or fractal dimension index, in order to quantify the infiltration patterns of each horizontal profile.

These metrics will be used to assess (i) the temporal variability of staining patterns emerging from the infiltration process, and (ii) the differences between arable land and grassland. Especially the identification of only a few metrics, which aggregate the most important flow process information, has a great potential for preferential flow modelling following the pattern-oriented modelling approach.

Connecting crop models with proximal soil sensing to improve agricultural management on field scale

Evelyn Wallor, Kurt-Christian Kersebaum, and Robin Gebbers

Email: *evelyn.wallor@zalf.de*
Affiliation: Leibniz Centre for Agricultural Landscape Research (ZALF)

Abstract

High spatial variability of soil properties restricts the benefits of process-oriented modelling for management recommendations on field scale due to rare information about the soil inventory and its distribution. In precision agriculture the lack of affordable methods for mapping relevant soil attributes is a fundamental problem. It restricts the development and application of advanced models and algorithms for decision making. The project "I4S - Integrated System for Site-Specific Soil Fertility Management" combines new sensing technologies with dynamic soil-crop models to improve the resolution of spatial and temporal patterns of soil state variable at field scale. Using sensors with different measuring principles improves the estimation of soil fertility variables such as plant available nutrients, water, organic matter and soil texture. Choosing the appropriate set of sensors will become an important aspect of decision making in precision agriculture.

Listening to earthworms burrowing and roots growing - acoustic signatures of soil biological activity

Lacoste, Marine, Ruiz, Siul; Or, Dani

Email: marine.lacoste@inra.fr
Affiliation: UR 0272 SOLS – INRA

Abstract

Biological activity plays an important role in natural and managed soil by generating and sustaining favorable soil structure. Plant roots and earthworms are particularly important in creating biopore networks that promote aeration and infiltration. Available observation methods for soil structure quantification are often limited to episodic snapshot that may miss these highly dynamic biophysical processes. The hypothesis is that AE generated during soil displacement by growing plant roots and burrowing earthworms could be quantified continuously and in situ, and allow a noninvasive monitoring of activity and soil structure dynamics. We monitored AE produced by earthworm activity and maize roots growing into soil using three separate experimental protocols (earthworm activity in glass cell, root growth in glass cell and soil column). AE emanating from biological activity were linked with time-lapse imaging in the glass cells. Acoustic waveguides where installed in soil columns. For the earthworm experiment, the daily AE rate was strongly linked with creation of new tunnels, and less correlated with earthworm movement in soil, due to re-use of pre-existing tunnels. For the plant roots, observed root growth and elongation trends were strongly correlated with AE event rate. The number of AE recorded from the soil columns with growing maize roots were several orders of magnitude larger than AE emanating from bare soil under similar conditions. The results suggest that AE monitoring may offer a window into largely unobservable dynamics of soil biomechanical processes such as root growth or patterns of earthworm activity - both important soil structure forming processes.

Soil modelling for the next generation of Earth System Model

Introducing soil structure in land-surface models: implications for water and energy fluxes

<u>Simone Fatichi</u>, Dani Or, Robert Walko, Harry Vereecken, Stefan Kollet, Michael Young, Teamrat Ghezzehei, Tom Hengl, Nurit Agam, Roni Avissar

Email: *fatichi@ifu.baug.ethz.ch*
Affiliation: Institute of Environmental Engineering, ETH Zurich, Zurich, Switzerland

Abstract

Soil structure is largely absent in most standard soil samples and in the subsequent parameterization of soil hydraulic properties deduced from soil maps and pedotransfer functions used in Earth System Models. Despite the critical role of soil structure (biopores formed by decaying roots, aggregates, etc.) in defining soil hydraulic functions, only a few studies have attempted to incorporate soil structure into models and mostly at the soil profile scale; yet, the role of soil structure in mediating large-scale fluxes remains understudied. The study proposes a systematic way for correcting the soil water retention and hydraulic conductivity functions—accounting for soil-structure—with major implications for near saturated hydraulic conductivity. Modification to the basic soil hydraulic parameterization is assumed as a function of biological activity summarized by Gross Primary Production. An ecohydrological model is used to carry out numerical simulations with and without the role of soil-structure on soil hydraulic parameters for 20 locations characterized by different climates and biomes. Including soil structure affects considerably the partition between infiltration and runoff and consequently leakage at the base of the soil profile (recharge). In several locations characterized by wet climates, a few hundreds of mm per year of surface runoff become deep-recharge accounting for soil-structure. Changes in energy fluxes, total evapotranspiration and vegetation productivity are less significant. Simulations at global scale carried out with an Earth System Model suggests that introducing soil-structure can affect energy and water fluxes in certain regions but these changes are unlikely to go beyond internal climate variability.

Coupled soilscape-landform evolution: Recent insights

Garry Willgoose, Dimuth Welivitiya, Greg Hancock

Email: *garry.willgoose@newcastle.edu.au*
Affiliation: School of Engineering, The University of Newcastle, Callaghan, NSW, Australia

Abstract

A standard variable for describing soil properties is the location of the soil profile in the landscape, and specifically the hillslope. This is the basis for the concept of soil catena. However, this assumes that this position in the landscape has been unchanged and that the landform has also not changed, through the history of the soil profile development. This is only a satisfactory approximation if the rate of adjustment of the soil profile is significantly faster than the rate of adjustment of the landform over which the soils drape. Recent work indicates that these rates of adjustment may overlap so soils are the result of a co-evolution of the soil and the landforms: the soil evolution changes the evolution of the landform and vice versa. Coupled models of soilscape and landscape evolution are emerging but the computational demands of these models are significant, so conceptual simplifications of the processes are required to allow understanding to be developed. This paper will discuss (1) some simple models of chemical weathering, (2) how they might couple with physical fragmentation processes, (3) how the fragmented materials couple with the erosion rates and (4) how the spatially varying, soil dependent erosion rates influence landform evolution resulting from erosion. Depending upon the dominant processes in the chemical weathering model the evolutionary pathways of the soilscape and hillslope profile change quite markedly. A number of different simulations will be shown using different weathering models and these simulations will show how different environmental conditions (and thus the dominant processes) may impact on soilscape and landform evolution. A standard variable for describing soil properties is the location of the soil profile in the landscape, and specifically the hillslope. This is the basis for the concept of soil catena. However, this assumes that this position in the landscape has been unchanged and that the landform has also not changed, through the history of the soil profile development. This is only a satisfactory approximation if the rate of adjustment of the soil profile is significantly faster than the rate of adjustment of the landform over which the soils drape. Recent work indicates that these rates of adjustment may overlap so soils are the result of a co-evolution of the soil and the landforms: the soil evolution changes the evolution of the landform and vice versa. Coupled models of soilscape and landscape evolution are emerging but the computational demands of these models are significant, so conceptual simplifications of the processes are required to allow understanding to be developed. This paper will discuss (1) some simple models of chemical weathering, (2) how they might couple with physical fragmentation processes, (3) how the fragmented

materials couple with the erosion rates and (4) how the spatially varying, soil dependent erosion rates influence landform evolution resulting from erosion. Depending upon the dominant processes in the chemical weathering model the evolutionary pathways of the soilscape and hillslope profile change quite markedly. A number of different simulations will be shown using different weathering models and these simulations will show how different environmental conditions (and thus the dominant processes) may impact on soilscape and landform evolution.

Scale-dependent parameterization of aquifer conductance to simulate groundwater - surface water interactions in regional hydrogeological models

Antoine Di Ciacca, Bertrand Leterme, Eric Laloy, Diederik Jacques, Jan Vanderborght

Email: *antoine.di.ciacca@sckcen.be*
Affiliation: SCK-CEN and KU Leuven

Abstract

Modelling water exchanges between groundwater and surface water is of great importance for water management and solute transport studies. In regional hydrogeological models, this is often accomplished with a Cauchy boundary condition (head-dependent flux) governed by a conductance parameter. Parameterization of the conductance is currently problematic because it rely on the assumption that all head losses occur in the surface water bed, therefore no conductance for the aquifer is considered. This appear to be unrealistic given the field observations and leads to the grid-size dependency problem observed by Mehl and Hill (2010). Therefore this parameter is often seen as a fitting parameter that needs to be estimated during model calibration. On the other hand, some analytical solutions exist (e.g. Hooghoudt and Ernst equations) for estimating the aquifer conductance. However, the assumptions made to derive these analytical solutions make them difficult to use in practice in hydrogeological models. To overcome these difficulties, a new expression of the conductance was derived. It used Ernst equation and 2D vertical field scale simulations of a stream-aquifer cross section. This expression take into account aquifer conductance by linking the drainage conductance to aquifer properties and geometry as well as the discretization of the regional model. It is therefore directly usable in hydrogeological models. The newly developed conductance expression was compared in a 3-D hydrogeological models upscaling study. It shows that the new expression appear to manage to capture quite accurately the grid-size dependency of the conductance and thus is an improvement to the existing approach.

On the static representation of soil in regional and global climate models

Daniel Hirmas, Daniel Giménez, **<u>Attila Nemes</u>**, Ruth Kerry, Nathaniel Brunsell, Cassandra Wilson

Email: *attila.nemes@nibio.no*
Affiliation: Norwegian Institute of Bioeconomy Research (NIBIO)

Abstract

It is commonly assumed in land surface models that soil hydraulic properties controlling water flux through the vadose zone, such as saturated hydraulic conductivity (Ksat), remain static over timescales relevant to climate simulations. We investigated continental-scale effects of climate on effective porosity (EP) of A and B horizons using openly available soil and climate data at the US national scale. We present observational evidence that climate influences macroporosity development, even in A horizons disturbed by tillage (Ap). In all cases, drier climates induced the formation of greater soil macroporosity compared to more humid climates, and changes occur over shorter timescales - likely within years to decades – as indicated by the Ap horizons. Applying the identified relationships, we calculated changes in Ksat from current and predicted effective porosities using a generalized Kozeny-Carman equation and end-of-century predictions of mean annual precipitation in the CMIP5 RCP6 scenario for 5 physiographic regions in the USA. We found that changes in Ksat may range from -55 to +34% for the five regions, with potential consequences to the balance between infiltration and surface runoff, which in turn influence erosion and flood risks, and the water cycle in general. It is likely that multiple mechanisms act in concert to express the climate's effect on soil macroporosity. The evidenced rate at which such effects occur suggests that these feedbacks should be incorporated into land-atmospheric parameterizations of regional and global climate models.

Functional Sensitivity Study of Pedotransfer Functions for use in Land Surface Models

Lutz Weihermüller, Niloofar Moosavi, Micheal Herbst, Carsten Montzka, Anne Verhoef, Dani Or, Harry Vereecken

Email: *l.weihermueller@fz-juelich.de*
Affilation: Agrosphere Institute, Forschungszentrum Jülich GmbH

Abstract

Pedotransfer functions (PTF) are used in land surface models (LSMs) and hydrological models to translate easily available soil properties, such as soil texture, into soil hydraulic parameters required in the functional descriptions of hydraulic properties. Various PTFs are in use and even more are available in the literature. In many LSMs so called class transfer functions are embedded, which predict the hydraulic parameters for the 12 USDA soil classes and most of them are based on the Brooks-Corey parameterization. In the work presented, we performed a sensitivity study of 13 PTFs, five for the Brooks Corey (BC) and eight for the Mualem van Genuchten (MvG) hydraulic model; four are class transfer functions (2x MvG and 2x BC). Water flow simulations were performed using HYDRUS-1D with run-off in a 200cm deep soil profile with various complexity ranging from homogeneous bare soil to variably layered soil covered with vegetation. Driving variables comprised 30 years of climate data from North-Rhine Westphalia (1982- 2011). The results were analysed in terms of instantaneous and cumulative net infiltration, actual evapotranspiration, deep drainage (sub-surface run-off), and root zone water content. The results indicate systematic differences in simulated fluxes between the runs with different PTFs, especially under extreme (wet or dry) conditions. The results might help to identify preferred PTFs for the use in LSMs.

Concepts and complications for implementing hydrologic processes in soil and landscape evolution models

Marijn van der Meij, Arnaud Temme, Michael Sommer

Email: *marijn.vandermeij@wur.nl*
Affiliation: Department of Environmental Sciences, Wageningen University and Research

Abstract

Water availability and water flow are among the main drivers for evolution of soils and landscapes. Water regulates transportation and transformation of soil material. In turn, soil and landscape properties determine where and when water will flow. This means that soils, landscapes and the hydrological system co-evolve over time.

The role of water is currently poorly represented in Soil-Landscape Evolution Models (SLEMs), which simulate how soils and landscapes change over centennial to millennial timescales. Often, only surface runoff is directly simulated, while processes such as preferential flow and subsurface lateral flow are only considered using proxies such as depth below surface, or are ignored completely. This limits the applicability of SLEMs in settings with a complex hydrological system where water flow varies through space and time, while pedogenesis in such settings often still is poorly understood.

The development of a more comprehensive hydrological framework for SLEMs often faces practical, conceptual or fundamental problems. We review the required development for improving hydrologic modeling in SLEMs, we indicate the problems encountered, and we provide solutions where possible. In this presentation, we will mainly focus on 1) the design of a model framework that can deal with varying timescales for different sets of processes, and on 2) the required, but currently scarce, data on evolution and fluctuations of soil hydraulic properties through time, and the formulation of time-dependent hydraulic pedotransfer functions using this data.

Permafrost, peat and frozen soils

Evolution of Permafrost in Alaska in 20th and 21st Centuries

Vladimir Romanovsky, Dmitry Nicolsky, William Cable, Alexander Kholodov, Santosh Panda

Email: *veromanovsky@alaska.edu*
Affilation: University of Alaska Fairbanks, USA

Abstract

The impact of climate warming on permafrost and the potential of climate feedbacks resulting from permafrost thawing have recently received a remarkable attention. Ground temperatures are a primary indicator of permafrost stability. Most of the research sites in our permafrost network are located along the North American Arctic Permafrost-Ecological Transect that spans all permafrost zones in Alaska and further into the high Canadian Arctic. Most of the sites in Alaska show substantial warming of permafrost since the 1980s. The magnitude of warming has varied with location, but was typically from 0.5 to 3.5°C. However, this warming was not linear in time and not spatially uniform. While permafrost warming was more or less continuous on the North Slope of Alaska with a rate between 0.2 to 0.5°C per decade, permafrost temperatures in the Alaskan Interior started to experience a slight cooling in the 2000s that has continued during the first half of the 2010s. There are some indications that the warming trend in the Alaskan Interior permafrost resumed during the last four years. By 2017, new record highs for the entire period of measurements of permafrost temperatures at 15 m depth were recorded at several locations. This warming has triggered near-surface permafrost degradation in mny locations with adverse consequences for the ground surface stability affecting ecosystems and infrastructure. In this presentation the observational data and modeling results will be combined to explain these documented changes in permafrost in the Alaskan. Some projections of changes in permafrost in 21st century will also be discussed.

The influence of river migration on the storage and cycling of soil organic carbon in permafrost affected floodplains

Joel Rowland, Jonathan Schwenk, Eitan Schwenk, Crosby, Benjamin

Email: *jrowland@lanl.gov*
Affiliation: Los Alamos National Laboratory

Abstract

Floodplain deposits and soils develop through a combination of lateral accretion, overbank deposition and in-situ production of organic materials. In the simplest case of single-threaded meandering river, the age of floodplain deposits range from those freshly deposited to those that are as old as the width of the floodplain divided by the mean rate that the channel migrates across the floodplain. In reality, the age of most floodplains represent a more complex mosaic of multiple channels that occupy and re-occupy portions of the floodplain with temporal irregularity. The continual exchange of sediment and organics to and from the river and floodplain by erosion and deposition leads to recycling and mixing of soil organic material. Therefore the age of organic materials stored in floodplain deposits may vary significantly from the age of the deposit itself. In permafrost dominated systems, the development of permanently frozen soils will influence the preservation of organic materials within floodplain deposits. The rate that permafrost develops in floodplains will depend on both the local climate and the sedimentological properties of the deposits. Aggregational settings and the presence of abundant water may also facilitate the development of excess ice within floodplain soils. The combination of lower erosion rates, leading to longer residence times, and the preservation of carbon in permafrost suggest that these high-latitude floodplains may hold more soil organic carbon per unit area than floodplains elsewhere on earth.

Modelling northern peatlands methane emissions for studying interactions between permafrost, peat soil carbon and atmosphere and feedbacks on climate

Elodie Salmon, Chunjing Qiu, Dan Zhu, Bertrand Guenet, Fabrice Jegou, Christophe Guimbaud, Philippe Ciais, Sébastien Gogo, Fatima Laggoun-Défarge

Email: *elodie.salmon@cnrs-orleans.fr*
Affiliation: Laboratoire de Physique et Chimie de l'Environnement et de l'Espace (LPC2E)
and Laboratoire des Sciences du Climat et de l'Environnement (LSCE)

Abstract

Since the end of the last glaciation period, northern peatlands have been functioning as long-term sources of methane (CH_4). For instance, it has been observed that constrains on soil physical properties such as temperature, soil water content or gas diffusivity control the methane fluxes between the soil and the atmosphere. Major uncertainties exist about the biogeochemical processes related to interactions between biogeochemical cycles of target elements (C, N, P, S), soil microorganisms, and the redox reactions under climatic change conditions. These processes have to be studied to better understand the carbon balance of peatland constrained by global change. Recent development of ORCHIDEE land surface model lead to simulate soil hydrology, permafrost thermodynamic and carbon cycle in northern peatlands. ORCHIDEE-PEAT scheme includes peat carbon cycle controlled by soil water content and temperature. A new version of ORCHIDEE-PEAT aims to add the CH_4 cycle processes. This new scheme includes methane production, transport by plants, ebullition process and diffusion in soil, oxidation to CO_2 and CH_4 fluxes to the atmosphere. The model was evaluated on 16 peatland sites distributed on both Eurasian and American continents in the northern boreal and temperate regions (from 41°N to 69°N). Model evaluation and future development will be presented.

The Canadian Model for Peatlands (CaMP): a national-scale peatland carbon accounting model

Cindy Shaw, Kelly Bona, Dan Thompson, Gary Zhang, Mihai Voicu, Kara Webster, Jagtar Bhatti, Werner Kurz

Email: *cindy.shaw@canada.ca*
Affiliation: Canadian Forest Service, Natural Resources Canada

Abstract

The Canadian Model for Peatlands (CaMP) was developed to address growing international pressure on Canada to better account for greenhouse gas emissions from peatlands in national and international reporting. The CaMP was designed as a module for the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) that is used to report on greenhouse gas emissions from Canada's managed forest area. This presentation will describe the CaMP emphasizing features developed specifically for peatland carbon accounting that are additional to the CBM-CFS3. These include descriptions of peatland types that are modelled and how they are represented in space across Canada, representation of a long-term and annually fluctuating water table, productivity of different vegetation layers including moss types, sedges, shrubs and small trees, their decay, and transfer between carbon pools. Preliminary results for CO_2 and CH_4 emissions from different peatland types will be shown. Future versions of the model will include anthropogenic (e.g., oil and gas development) and natural (e.g., wildfire) disturbances, effects of edaphic and climatic factors, and permafrost thaw.

New Perspectives on the Modelling of Colloidal Particle Fate in Soils

Upscaling remobilization using exposure-time

Tim Ginn

Email: *tim.ginn@wsu.edu*
Affiliation: Washington State Universitys

Abstract

Washington State University   Mass balance expressions are the foundation of quantitative analyses of transport and transformation of multiphase multicomponent mixtures in many fields. In a number of cases the processes governing such mixtures may depend on the time-of-exposure of one mixture component to another. Some examples include hydrologic age (water exposure time to earth materials), heterogeneous-phase reaction (solute exposure time to reactive surfaces), multidomain mass transfer (immoble-zone solute exposure time to immobile zone), and colloid retention (colloid time spent in immobile state). Upscaling these systems call for a method to keep track of the exposure time of one mixture to another, and this is achieved by including an additional dimension of exposure time and an advection operation in that direction, within systems of mass balance equations. The exposure time advection operator serves as a clock that allows accounting of memory within the transport and transformation constitutive expressions in a general manner. After presentation of the basic formulation approach, I describe a phase exposure-dependent exchange (PhEDEx) mobile-immobile mass transfer model that captures non-Fickian transport processes including multirate mass-transfer, most continuous time random walks, and time-fractional advection-dispersion. Finally I describe the application of this technique to describe some biocolloid transport data from column experiments, which is the challenge that started this whole idea.

Soil in catchment-scale models of water quality as affected by micropollutants and emerging contaminants

Martine van der Ploeg and **Yakov Pachepsky**

Email: *yakov.pachepsky@ars.usda.gov*
Affiliation: USDA-ARS, Environmental Microbial and Food Safety Laboratory

Abstract

Catchment-scale water quality, or CWQM models are employed to evaluate changes in water quality due to changes in climate, land use, and management practices, redistribution of water resources, to assess the spread of water borne epidemics, to trace and rank sources of emerging contaminants, and many other applications. This talk will be focused on current challenges in soil representation in those models.

1. Simulations of substantial lateral transport in large spatial cells rely on concepts of hydrologic connectivity and mixing depth. Both concepts involve the scale dependence that has been observed at small scales but so far is not understood for larger scales.

2. It is not clear whether qualitative changes in description of reactive transport with soils as adsorbents need to occur for catchment-scale modeling.

3. Aggregation of soil properties is carried out without accounting for preferential surface and subsurface flow directions and pathways.

4. The Travel Time Distribution require pedotransfer focused on lateral fate and transport.

5. Bottom sediments may contain several orders of magnitude more micropollutants than the water column, and the mass exchange of the subaqueous soils with water column appears to be the dominant control of water quality in some cases

6. Modeling fate and transport of micropollutants and emerging contaminants often ignores transport of solutes and suspended particles that facilitate or impede the transport.

7. Calibration and validation of CWQMs ignores temporal scale effects and scale mismatch in uncertainty for both simulated and measured concentrations of micropollutants and emerging contaminants, and sample size effects.

Modelling colloid-facilitated transport and geochemical effects on colloid transport

Diederik Jacques, C. Zhou, J. Makselon, I. Engelhardt, S. Thiele-Bruh,

Email: *djacques@sckcen.be*
Affiliation Belgian Nuclear Research Centre

Abstract

HPx is a reactive coupled transport model using HYDRUS1/2/3D as the transport solver (water flow, solute transport and heat transport) and PHREEQC-3 as the geochemical solver. Coupling these two codes resulted in a flexible and extendible coupled model as a powerful tool to simulate complex processes in variably-saturated porous media. Recently, two studies (Zhou et al., 2016, Makselon et al., 2017) used the model to calculate transport of colloids and contaminated attached to colloids through the subsurface. The first study simulated the transport of sulfonamides in the absence or presence of manure colloids from different origin. The model consists of the transport of dissolved organic matter including interaction of DOM with the solid phase (attachment and detachment, decay and straining), transport of sulfonamides and their interaction with the solid phase and the colloids. The model was successfully calibrated to experimental data. Model results show that mobile colloids act as carriers for sulfomoxole, while immobile colloids block sulfomoxole from sorbent on the soil. On the other hand, the high affinity of sulfadiazine and sulfamethoxypyridazine for sorbing on immobile colloids retarded their transport. The second study investigated the effect of flow interruption and ionic strength on the transport of surfactant-stabilized silver nanoparticles (AgNP). The model combined the DLVO theory with an extended colloid filtration theory and a colloid release model. The numerical model reproduced the measured AgNP and indicated that attachment to the air-water interface occurring during flow interruption was the process for AgNP retention.

Flow Interruption Facilitates Iron Oxide Colloid Retention Under Unfavorable DLVO Attachment Conditions

Jannis Florian Carstens, Jörg Bachmann, Insa Neuweiler

Email: *carstens@ifbk.uni-hannover.de*
Affiliation: Institute of Soil Science, Leibniz University Hannover

Abstract

The mobility of iron oxide colloids in porous media directly affects the co-transport or immobilization of adsorbed contaminants. Our aim was to determine the effects of flow interruption phases on iron oxide colloid transport and retention.

For that, breakthrough behavior of negatively charged, organic matter coated goethite (OMCG) colloids was investigated in saturated quartz sand columns. The classic DLVO and extended DLVO (XDLVO) models including Lewis acid—base parameters were applied based on measurements of sessile drop contact angles and zeta potentials.

Under continuous flow conditions, OMCG colloids were highly mobile, in agreement with unfavorable DLVO and XDLVO attachment conditions. In contrast, flow interruption led to considerable colloid retention which could not be reversed by re-establishment of flow. Further column experiments at more strongly unfavorable DLVO/XDLVO attachment conditions resulted in lesser retention during interruption phases. As the extent of retention was related to the attachment conditions, we suggest that colloids were retained at sites with locally attractive DLVO/XDLVO interactions during flow interruption. Such sites can originate from chemical heterogeneities and surface roughness. Under continuous flow conditions, retention at those sites was likely hindered by hydrodynamic drag. We compared breakthrough curves to model predictions and demonstrated that an attachment term with a stagnant fluid switch was required in the mass balance to reproduce the measurements.

We conclude that phases of flow interruption can facilitate considerable OMCG colloid retention under unfavorable DLVO attachment conditions. The transport of further colloid types is likely to be modified by discontinuous hydraulic conditions as well.

Co-transport of nanoparticles and contaminants in groundwater: a coupled reactive transport model

Tiziana Tosco, Carlo Bianco, Rajandrea Sethi

Email: *tiziana.tosco@polito.it*
Affiliation: Politecnico di Torino

Abstract

Colloids are frequently found in the subsurface, and in particular in groundwater, both as natural (eg. clays, metal oxides, mineral precipitates…) and anthropogenic particles (eg. nanomaterials released from customer products, or particles injected on purpose in contaminated sites for groundwater remediation). In both cases, their interaction with dissolved species is a key topic: colloids can act as a mobile solid phase, that accelerate the transport of strongly sorbing contaminants (colloid facilitated transport), moreover, the capability of nanoparticle to sorb dissolved compounds can be used on purpose, for example, for groundwater remediation (eg. goethite nanoparticles used for heavy metal sorption, graphene oxide used for the removal of aromatics contaminants, etc.), or for an optimized delivery of agrochemicals. On these premises, it is crucial to understand how particles and dissolved contaminants interact in groundwater, and to develop quantitative tools for the simulation of such processes.

The present work proposes a coupled geochemical and transport model for the simulation of the co-transport of colloidal particles and dissolved compounds. The model equations take into account colloid transport and deposition into the porous medium, transport and sorption of the solute onto the soil, sorption and desorption of the solute on both mobile and deposited particles. The model is implemented in the software MNMs (www.polito.it/groundwater/software) for 1D geometry and applied for the interpretation of co-transport column tests. The study was partly funded by the EU H2020 project Reground (GA n.) for the application to heavy metal removal from contaminated groundwater by injection of goethite nanoparticles.

Soil organic carbon dynamics modelling

The efficacy of soil carbon modeling: what types of information and data are needed to capture the dynamics, status, and fate of soil organic carbon?

Mathew Williams, Peter Finke, Alison Hoyt, Avni Malhotra, Kathe Todd-Brown, Gustaf Hugelius

Email: *mat.williams@ed.ac.uk*
Affiliation: University of Edinbrugh, UK

Abstract

Modeling soil organic carbon demands careful attention to temporal and spatial variations in factors that control the dynamics, status, and fate of carbon in soils. Regional to global models of SOC are most commonly validated against maps of SOC stocks derived from soil profiles, which that typically originate from soil surveys, such global compilations render statistical power from their >105 profiles but they require upscaling with spatially distributed information such as vegetation, climate, or landuse history that can lead to imprecise functions for carbon release and stabilization. By contrast, models at local scales and models designed to capture specific C cycle processes typically include C stock, fractionated SOC, isotopic, and/or CO_2 flux data derived from process- and research-based assessments, such assessments render their power from high precision constraints on functions for carbon release and stabilization but their functions are not as scalable to large regions. It is our goal to empower all SOC models with a wide variety of data-types in a variety of environmental/land use settings in a way that enables multiplicity of efforts through community data platforms. The pathway toward this goal includes 1) identification of key datasets aligned to specific questions, locations, and issues 2) prioritization for rescuing and disseminating data 3) creating both Digital Object Identifications DOI for new datasets and pathways to accessing published datasets. Examples of data-model comparisons include soil mineralogy controls on SOC stabilization, assessments of SOC persistence in landuse change/ disturbance scenarios, and broad-scale characterization of pedogenic processes controlling permafrost C stocks.

Soil process modelling - from empirical description to emergent behavior

Markus Reichstein, Marion Schrumpf, Bernhard Ahrens, Marleen Pallandtll

Email: *mreichstein@bgc-jena.mpg.de*
Affiliation: Max-Planck-Institute for Biogeochemistry, Jena, Germany

Abstract

For a long time, soil organic matter modelling has concentrated (successfully) on semi-empirical approaches for describing the fate of soil organic matter in response to abiotic factors such a moisture, temperature, soil chemical and physical properties and biotic factors. Yet, evidence has accumulated that important aspects on soil organic matter dynamics cannot be adequately described in a general way with these approaches. Instead models have to be further developed to describing interactions between soil organic matter (SOM), microbes and the soil matrix affecting transport and transformation of SOM. Particular emphasis should be on carbon-water interactions in this context. This talk will review and conceptualize the past model developments and give a perspective into the future.

A conceptual framework for long-term, landscape-scale SOM models incorporating vegetative and mineral-matrix zones of influence

Claudia Cagnarini, B.J. Cosby, E. Blyth, C. Evans, R.I. Griffiths, A. Keith, J. Laurence, N.P. I. Lebron, McNamara, J.J.P. Puissant, S. Reinsch, D.A. Robinson, E. Rowe, A.R.C. Thomas, J. Whitaker, B.A. Emmett

Email: *ccagnar@ceh.ac.uk*
Affiliation: Centre for Ecology&Hydroloy, UK

Abstract

Sustainable land management under changing climate requires regional/national models capable of simulating long-term landscape-scale changes in soil organic matter (SOM). The paradigm shift from SOM recalcitrance as "intrinsic property" to SOM persistence as "ecosystem interaction" suggests decadal-scale SOM models driven by landscape characteristics might capture more realistic spatio-temporal SOM dynamics. In our conceptual framework, landscape-scale drivers are integrated with pedon-scale processes in two zones of influence. SOM in the upper vegetative zone is affected primarily by plant inputs (above/belowground), climate, microbial activity and physical aggregation. Biotic transformations between states/pools are rapid but prone to surface disturbances increasing risk of SOM loss. SOM dynamics in the lower mineral-matrix zone are controlled primarily by mineral-phase and chemical interactions with SOM inputs from the vegetative zone. Biotic transformations are fewer and disturbances less likely producing more favourable conditions for SOC persistence. The net top-down exchange of SOM between the two zones is dependent upon soil connectivity, a variable (feedback) function of SOM content and dynamics in each zone. Vegetative zone boundary conditions vary spatially at landscape scales (vegetative cover) and temporally at decadal scales (climate). Mineral-matrix zone boundary conditions vary spatially at landscape scales (geology, topography) but change only slowly. Undisturbed, steady-state distributions of SOM states/pools and turnover develop in each zone that are characteristic of unique combinations of upper/lower boundary conditions. Sudden changes in upper boundaries (land-use change) produce transient SOM responses moving to new steady-states. Numerical models incorporating these concepts are needed for robust, sustainable land management of SOM.

SOM-aggregate dynamics in the plant-microbe-soil interaction model

Nadezda Vasilyeva and Artem Vladimirov

Email: *nadezda.vasilyeva@gmail.com*
Affiliation: Interdisciplinary Laboratory for Mathematical Modeling of Soil Systems,
V.V. Dokuchaev Soil Science Institute, Moscow

Abstract

To tackle soil evolution mechanisms providing stability and resilience to climate and land-use changes we develop a model of soil carbon dynamics in granulo-densimetric fractions with a feedback to soil aggregation process. Turnover rates of microbially-driven SOM transformations are dynamic and affected by SOM localization and physical factors. Aggregation process is a result of fast transformation cycle of labile SOM in rhizosphere.

In this study we continue to develop a multiscale model of SOM transformation with a self-organization of soil pore space as a result of microbial growth with effects of temperature, water and oxygen. The concept comprises consideration of SOM in granulo-densimetric fractions (by particles size and density). SOM transformations between fractions occur due to microbial activity. Spatial patterns of microbial activity in turn define waterstable aggregate size distribution.

Objects. Model parametrization was based on experimental data of several long-term bare fallow experiments (LTBF network for isolation of stable SOM) and laboratory measurements of soil respiration in series of moisture and temperature for LTBF (stable SOM) and grassland (labile SOM) soils.

Results. Revealed are 2 driving parameters which together with climatic data were sufficient to describe the differences in C dynamics between experimental sites. The first one is the characteristic C concentration (an overall scaling parameter that adjusts to C input). Second is the SOM stabilization parameter representing concentration of "adsorption sites" (on mineral or black carbon particles) that affects SOM decomposition rates. Discussed are long-term dynamics at different scenarios of climate and land use changes.

Advances in National Scale Upland Forest Soil Carbon Modelling with the CBM-CFS3

Cindy Shaw, Kelly Bona, Oleksandra Hararuk, Juha Metsaranta, Werner Kurz

Email: *cindy.shaw@canada.ca*
Affiliation: Canadian Forest Service, Natural Resources Canada

Abstract

The Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) is an ecosystem model used to estimate forest carbon dynamics at stand, regional-, and national-scales in Canada. These analyses are conducted in support of national and international reporting of greenhouse gas emissions and removals, analysis of forest sector climate change mitigation options, and other scientific and policy questions. Uncertainty analyses that both we and other researchers have conducted consistently point at soil carbon (C) pools as a large source of uncertainty in ecosystem carbon modelling. Reducing this uncertainty is important not only for the estimation of C stocks, but also for the estimation of C emissions from soil through disturbance or heterotrophic respiration. These emissions are often estimated in models as proportions of the C stocks. Thus, improving accuracy in a model's ability to estimate initial soil C stocks is important for the prediction of both ecosystem C stock and emissions. This presentation will show the evolution of upland forest soil C modelling with the CBM-CFS3 with emphasis on improving representation of spatial variation in upland forest soil C stocks by including moss C inputs for stands with thick peaty layers, and by linking model parameters to soil type or leading tree species. We will discuss how model development has led to improved representation of soil C dynamics and conclude by suggesting future research priorities that can advance soil carbon modelling in Canadian forest ecosystems.

A modelling approach for quantifying stable organic matter related to the soil biota activity

Oleg Chertov, Pavel Frolov, Sergey Bykhovets, Mrina Nadporoyhskaya, Cindy Shaw, Pavel Grabarnik, Irina Priputina, Olga Kalinina, Max Shahkov, Vladimir Shanin, Elena Zubkova

email: *oleg_chertov@hotmail.com*
Affiliation: University of Applied Sciences Bingen, Germany

Abstract

At present, scientific interest is focused on studying the carbon (C) balance in the biosphere due to climate change processes. Therefore advancing soil organic matter (SOM) dynamics modelling is critical for quantification of the belowground C cycle to terrestrial ecosystems. Most soil C models do not include stable SOM resulting from the activities of soil biota. We proposed a modelling approach based on the stoichiometric relations among the processes of SOM formation that are mediated by soil biota (Romul_Hum model. Ecol. Mod. 2017. 345, 113-140). Soil respiration, as a core rate variable in all SOM models, was associated with the production of micro-and meso-faunal excrement and necromass in soil food webs and earthworm casts as precursors of stable SOM. A food-web based module was developed, using a synthesis of published data. An anecic earthworm module was developed, with representation of processes in fresh casts. The contributions of these modules into stable SOM formation was integrated into the structure of the existing ROMUL model (Chertov et al., 2001). Testing and application of the new Romul_Hum model for a post-agrogenic soil chronosequence with mull Luvisols showed that about 15% of total C and 30-40% total N in SOM of the Ah horizon is fauna derived. In a Podzol, these values were 11% and 22%, respectively, in the Ae horizon, and 8% and 33%, respectively, in the mor forest floor. These results show that soil fauna are significant agents in stabilization of SOM and should be included in soil C models.

Unifying soil organic matter formation and persistence frameworks into a mathematical model: MEMS v1.0

Francesca M. Cotrufo, Andy D. Robertson, Emanuele Lugato, Matthew Wallenstein, Stephen M.s Ogle, Keith Paustian

Email: *francesca.cotrufo@colostate.edu*
Affiliation: Colorado State University, USA

Abstract

Recent advances in simulating soil organic matter (SOM) dynamics with mathematical models show promise but generally focus on improving individual components rather than the system as a whole. Furthermore, many SOM models are still structured around conceptual C pools defined by turnover times, limiting the use of novel empirical studies that elucidate relationships between soil physical fractions and environmental conditions. Here we present a new mathematical model (MEMS v1.0) for litter decomposition and SOM dynamics that is structured around our contemporary understanding of the mechanisms that drive SOM formation and persistence. Governed by specific site conditions (climate, soil and vegetation input chemistry) the MEMS model uses an explicit microbial pool with dynamic C use efficiency to determine how litter inputs are sequestered in soil, representing empirically defined pathways of SOM formation into discrete mineral-associated and particulate organic matter forms. Furthermore, C-saturation controls are simulated by formulating sorption and desorption processes around a Langmuir isotherm related to edaphic conditions (e.g., texture and pH). We used our new MEMS model to simulate steady-state conditions of soil C stocks for more than 8000 forest and grassland sites across Europe. This validation effort shows promising results and indicates that structuring a SOM model around empirically defined processes has great potential to simplify model parameterization and, more importantly, to be able to include advances in our understanding as they emerge.

POSTERS

POSTERS

Modeling of soil ecosystem functions and services in landscapes

Importance of soil experimental support for the prediction of migration of pesticides in fractured soils

Aleksandra Belik, Anna Kokoreva, Evgeny Shein, Victoria Kolupaeva, Pavel Pletenev

Email: belikalexandra@gmail.com
Affiliation: Lomonosov Moscow State University Moscow, Russia; Russian Scientific-Research Institute of Phytopathology, BolshiyeVyazemy, Moscow region, Russia; Federal Scientific Center of Hygiene of Rospotrebnadzor, Mytischi, Moscow region, Russia

Abstract

The experimental values of parameters in convection-diffusion equation allow for adjustment of models for prediction. The Eutric Albicum Glossic Retisol was selected for field experiment with pesticide cyantraniliprole (Kos=241cm3/g, DT50fieid=49 days). Soil samples for determination of residual pesticide were collected by drilling method at vertical interval of 5cm. Cyantraliprole did't migrate below 20cm. One year after treatment, up to 40% of the applied dose is stored in the soil profile. Tomography of soil columns 0-30cm, 30-50cm (d=10cm) was performed in a dry and saturated state. The macroscopic structure is clearly visible on tomography.

The adjustment of model was also carried out with the variation of dispersivity length (DL). There is no unified method to determine DL. Laboratory filtration experiments with soil monoliths due to small scale, lack of lateral transfer and possible near-wall effect are far from real soil conditions. We have proposed a field method for determining DL based on the motion of tracer. Tubes, filled with aqueous solution of tracer, were installed at the pre-saturated site of the soil at different depths. After filtration DL was determined as the difference between the average line of tracer displacement and the boundaries of infiltration streams. A soil scenario was obtained for PEARL-model, sufficiently describing processes in the investigated fractured soil. Model with field DL better described the pesticide behavior, reducing NRMSE for example for 15-20cm layer from 1.05 to 0.80.

The creation of soil variability as a function of vegetation and climate: experiments with LORICA

Arnaud Temme

Email: arnaudtemme@ksu.edu
Affiliation: Kansas State University

Abstract

Short-range spatial soil variability is important because it provides different opportunities for vegetation growth under practically identical climatic and geomorphic variables. As such, it limits the risk that a change in climate leads to sudden collapse of all vegetation - instead, response to adverse conditions will mean vegetation death in some places, but merely slower growth in others. As such, areas with more variability in relevant properties are better able to avoid catastrophic shifts and the associated difficulties in regrowth.

Although short-range variability has been shown to depend on, among others, parent material variability, tree fall dynamics and human land use patterns, we have an incomplete understanding of its creation, maintenance and reduction.

Soil-landscape models (SLEMs) are the only way that we can simulate the complex dynamics that affect soil variability. Such models function as soil geography's virtual laboratories, where experiments can be performed and hypotheses can be tested. Here I use SLEM LORICA to simulate soil variability under a range of vegetation and climate scenarios. Output variables are semivariograms of various soil properties and their change over time. Of particular interest is a co-evolution scenario in which vegetation banding produces soil variation that benefits its survival.

Testing the effect of adding field data when predicting soil hydraulic conductivity curves

Cristina P. Contreras, Carlos A. Bonilla

Email: cmcontre@uc.cl
Affiliation: Hydraulic and Environmental Engineering, Pontificia Universidad Católica de Chile

Abstract

Measuring soil water retention and hydraulic conductivity in the field is typically time-consuming and expensive. In addition, soil hydraulic conductivity can be measured in both, saturated and unsaturated conditions. For this reason, many models have been developed for predicting these properties, but not many have been tested under different soil and climate conditions. Thus, the main objective of this work was to evaluate the accuracy of fitting of the obtained data from undisturbed soil samples in the laboratory. Then, we compare these curves with those obtained when adding the points of hydraulic conductivity in the field.

We measured saturated and unsaturated soil hydraulic conductivity in sites located in central Chile, from 33° S to 51° S, and 70° W to 73° W. Additionally, undisturbed soil samples were collected to measure the hydraulic properties in the laboratory. The evaporation (HYPROP) and dew point (WP4C) methods were used to establish the soil water retention and hydraulic conductivity curves. Preliminary results showed that hydraulic conductivity was well predicted when the wet and dry parts of soil water retention curve were well predicted, that is, by combining the results from the evaporation and dew point methods. In this process, the estimation of the dry part of the curve was more difficult to obtain than the wet part. In this way, adding the field data to obtain the soil hydraulic conductivity curve is highly recommended to obtain more accurate results.

RADOLAN - a radar-based tool for the retrospective analysis of extreme erosion events

Deumlich, Detlef, Niessner, Dominique

Email: ddeumlich@zalf.de
Affiliation: Working Group "Hydropedology", Research Area 1 "Landscape Functioning", Leibniz Centre for Agricultural Landscape Research (ZALF)

Abstract

Frequently occurring rainstorm events can cause erosion damages, not only in hilly regions but also in areas of relatively low relief energy. In addition, effects of rain drop impact on the soil surface properties foster subsequent erosion. Such changes of the soil surface can be detected from aerial photographs and by comparing terrain surfaces before and after rainfall events using high resolution DEM. New technical developments opened up new possibilities for improving the identification of soil damages and allow faster reaction on possible negative developments.

The aim of this study was to identify factors of site and rainfall condition and to understand their combined effects on erosion. We analysed past erosion events by considering soil properties, relief, rainfall, and soil management. Since the topographic and soil surface conditions before an erosion event were difficult to reconstruct, either historical DEM data or the actual surface topography (i.e., the relief determined by airborne laser scanning in high resolution) were used for such a retrospective analysis. For estimating duration, amount and intensity of rainfall the ""radar-assisted analyses of precipitation in real time for Germany (RADOLAN)"" was used in cases where data of meteorological stations were not available. The retrospective analysis of soil erosion with the simulation model "Erosion-3D" was carried out for areas Uckermark, in northeastern Germany, to gain insight in the erosion processes, its causes, and recurrence intervals. The result of RADOLAN data combined with the site conditions allowed determining alternatives for soil management that helped mitigating the effects of soil erosion events.

Water balance of a landfill capping system determined by empirical and numerical approaches

Dr. Steffen Beck-Broichsitter, PD Dr. Horst H. Gerke; Prof. Dr. Rainer Horn

Email: Steffen.Beck-Broichsitter@zalf.de
Affiliation: Research Area 1 Landscape Functioning, Leibniz-Centre for Agricultural
      Landscape Research (ZALF),Germany

Abstract

Landfill capping systems in its function as engineered barriers are purposed to prevent or minimize the contact of precipitation or melting water infiltration with the waste body to limit the generation of leachate or gas emissions, which may reach the aquifer system or the atmosphere. Mineral capping systems without polymers can be an effective alternative to the standard engineering constructions considering soil physical knowledge with regard to a sustainable use of soil materials.

This study presents a temporary mineral capping system in Northern Germany and its functionality results in anisotropic water flow conditions in the nearly saturated zone generated by a compacted installation of the soil material to remove the infiltrated water out of the system through lateral drainage.

The effectiveness was described by a site-specific water balance under the given weather conditions taking into account a statistical-empirical approach (HELP 3.95 D) and a numerical model (FEFLOW 2/3 D) to describe the water balance parameters as well as the water flow in the saturated and unsaturated soil zone.

Therefore, observed and modelled lateral drainage rates of up to two-third or rather steady leachate rates of one-eighth of the annual precipitation indicate a) the functionality of the anisotropic approach and b) the hydraulic stability of the mineral capping system. Additionally, the numerical model was positively validated by a comparison of observed and modelled volumetric soil water contents with coefficients of determination up to 0.90.

Chemical composition modelling of soil solutions over the last two decades in a forest catchment

Emilie Beaulieu, Yves, Goddéris; Arnaud, Legout; Daniel, Viville; François, Chabaux; Marie-Claire, Pierret

Email: emilie.beaulieu@engees.unistra.fr
Affiliation: Laboratoire d'Hydrologie et de Géochimie de Strasbourg,
                   Université de Strasbourg/ENGEES- CNRS, France

Abstract

The chemical composition of surface water depends on many factors as biological, chemical and physical parameters. A recent study highlights important variations of soil solution chemical composition on a small forest catchment, in response to acid rain and nutrient change over the last 30 years. The ability to predict the evolution of natural ecosystems in the future mainly depends on our ability to reproduce their past and actual dynamic.

The aim of this study is to develop a numerical model describing continental weathering reactions based on experimental kinetic laws and combine with a dynamic global vegetation model (B-WITCH model). This coupling is applied on two different forested plots of the Strengbach catchment (Vosges, France; OHGE*) characterized by different vegetal cover (spruces and beeches). The measured data (meteorological, mineralogical and chemical) are used as input to B-WITCH model over 1987-2013 period in order to i/ reproduce chemical composition variations of soil solutions, and in a second time, ii/ identify and understand key parameters that control these chemical variations.

The model is able to reproduce the evolution of pH and concentration of chemical elements as Na, Mg and H_4SiO_4 but overestimates Ca and K concentrations under the root zone. Otherwise, the observed decrease of Ca and K in soil solutions is not reproduced by the model, that predicts a stable concentration evolution over all simulation period. These results highlight the decrease or the disappearance of cations source or the increase of cations sink. The two hypotheses are discussed with different simulation tests.

* Observatoire Hydro-Géochimique de l'Environnement - http://ohge.unistra.fr

Estimating soil aggregate stability from soil basic properties and climate variable using machine learning techniques

Javier, Rivera Carlos, Bonilla

Email: jirivera1@uc.cl
Affiliation: Department of Hydraulic and Environmental Engineering,
Pontificia Universidad Católica de Chile, Santiago, Chile

Abstract

Soil Aggregate Stability (AS) is an important indicator when predicting soil quality and degradation. This parameter is used to evaluate vulnerability to crusting and water erosion, carbon storage, conditions for seed germination and rooting, and soil ecosystem services. Thus, its estimation is essential for environmental modeling and land management evaluation. It is recognized that physical and chemical soil properties, organic matter, and environmental factors affect aggregation. Previous models for predicting AS have focused on soil properties rather than environmental factors even though climate is the most influential driver that promotes soil weathering. Thus, this study developed predictive models to estimate AS based on physical and chemical properties, organic matter content, and the aridity index (AI) for characterizing climate conditions. With this purpose, 109 soil samples were collected from a range of hyper-arid, arid, semiarid, dry sub-humid, humid sub-humid, and humid regions in Chile, including forest and cultivated soils. The AS was computed as the percentage of water stable aggregates using wet sieving apparatus. Artificial Neural Network (ANN), Support Vector Machines (SVM), Random Forest (RF), Generalized Boosted Model (GBM) and Generalized Lineal Model (GLM) were developed using clay, pH, organic matter, and AI as predictors. In order to evaluated model performance, a repetitive cross-validation procedure was applied using R2, RMSE, and MAE. Model accuracy results revealed that ANN, GMB, and RF performed better than other models. This paper provides a comprehensive comparison of the selected machine learning techniques and discuss their applicability as prediction tools.

Modeling of atrazine degradation: a gene – based model approach

Luciana Chavez Rodriguez, Holger Pagel; Marie Uksa; Johannes Wirsching, Ellen Kandeler, Christian Poll, Thilo Streck

Email: L.ChavezRodriguez@uni-hohenheim.de
Affiliation: Institute of Soil Science and Land Evaluation,
         Biogeophysics, University of Hohenheim

Abstract

The herbicide atrazine is highly persistent in natural environments despite the fact that, due to potential negative effects on human health and the environment, it has been banned in Germany decades ago. Using genetic data provided by current molecular biology techniques to inform biochemical models could facilitate the identification of microbiological controls for pesticide degradation and improve the predictability of degradation processes. We developed a new conceptual model for the degradation of atrazine in soils that explicitly considers the abundance and expression of specific functional genes triggering the activity of corresponding enzymes. In addition to the physicochemical control by sorption, the model accounts for energy limitation and concentration thresholds controlling microbial processes as possible mechanisms that might explain the build-up of persistent pesticide and metabolite pools in soils. Our new conceptual model will be tested against simpler models to find out to what extent genetic information can improve biogeochemical modelling.

Modelling of soil compaction risk at field and regional scale

Michael Kuhwald, Katja Augustin; Rainer Duttmann

Email: kuhwald@geographie.uni-kiel.de
Affiliation: Ludewig-Meyn-Strasse 14, 24118 Kiel, Germany

Abstract

Soil compaction by field traffic is one of the main threats to agricultural soils. For instance, compacted soils have a reduced hydraulic conductivity, which leads to an increased surface runoff and thus to an increased flood risk. To mitigate undesirable effects of field traffic, it is important to know where, when and to what extend soil compaction may occur.

This study shows a new approach to model the soil compaction risk at varying scales. The developed SaSCiA-model (Spatially explicit Soil Compaction risk Assessment) combines (i) soil, weather, crop type and machinery information, (ii) a soil moisture model and (iii) soil compaction models to compute daily maps of soil compaction risk. The model was applied at field and regional scale. At field scale, field traffic and soil moisture were monitored to generate spatially high-resolution input parameter. At regional scale, open access soil and weather data were used; present crop type was derived by satellite data (Landsat 8, Sentinel-2A).

The results demonstrate that soil compaction risk strongly vary in space and time throughout the year for both, field and regional scale. Applying the SaSCiA-model enable a detailed spatio-temporal analysis of the soil compaction risk, which may support farmers, stakeholders and consultants in their decision-making for a more sustainable soil management.

Modelling hydraulic properties of soil-like substrates upcycled from waste materials

Moreen Heiner, Prof. Gerd Wessolek, Dr. Thomas Nehls

Email: moreen.heiner@campus.tu-berlin.de
Affiliation: Berlin International Graduate School in Model and
 Simulation based Research (BIMoS) TU Berlin and
 Ökohydrologie & Landschaftsbewertung TU Berlin

Abstract

A peak of soil degradation can be found in urban areas: urban soils are sealed, compacted or highly altered reflecting their land use legacy. Nevertheless ecosystem functions of soils are required especially there. Often green infrastructures in cities are established at expense of intact ecosystems and soils outside of cities (e.g. exploiting peat lands). Aiming at decreasing degradation and destruction in rural areas, urban waste materials, such as composts, bricks and excavated soil from construction activity can be upcycled to soil-like substrates to be used in green infrastructures. Such substrates are able to feature plant growth and water retention and more over they can be designed according to their field of application (green roof, planted container etc.) by adjusting their mixing ratios.

Modeling soil hydraulic properties of binary mixtures is a key and lever to design soil-like substrates. It is crucial to study how the WRCs of binary mixtures change depending on mixing ratio in order to understand and predict hydraulic performance of such substrates and design substrates for specific purposes.

Obviously the WRC of binary mixtures is more complex than the superposition of the WRCs of the single components. It is the challenge of our project to mathematically identify, quantify, understand and describe the hydraulic impact of each component in a binary mixture.

As a first step of the project a retention data set on binary mixtures of sands with a pronounced difference in particle size is being used for verifying our model approach and validating suitable mixture models.

Effect of precrops and climate variability on subsoil water and nutrient uptake of spring wheat

Seidel, Sabine, Thomas Gaiser, Miriam Athmann, Timo Kautz, Wulf Amelung, Klemens Barfus, Frank Ewert

Email:sabine.seidel@uni-bonn.de
Affiliation: University of Bonn Institute of Crop Science and
              Resource Conservation (INRES) Crop Science Group

Abstract

Water and nutrients stored in the subsoil are valuable in sustainable crop production but the availability varies with management and seasonal weather conditions.

This study presents a simulation-based stochastic approach to investigate the impact of precrops on spring wheat growth and water and nutrient uptake under varying weather conditions. The effect of three precrops lucerne, chicory and tall fescue on spring wheat growth was investigated extensively in a two-year field trial. The data used for model calibration and validation included biopore observations, phenology, leaf area index, shoot biomass, grain and straw yield, N, P and K in shoot, grain and straw, root length densities, , as well as soil moisture and soil N, P and K content for several soil depths of several field plots. The modeling framework consisted of the modelling platform SIMPLACE and, to consider weather variability, synthetic daily weather data (100 years) based on observed data to simulate 100 spring wheat growth periods for each precrop. The model was annually reinitialized at sowing to provide identical initial conditions.

The experimental data showed that crop water uptake from deeper soil layers was enhanced after taprooted precrops and especially after lucerne. In the drier growth period, a high amount of soil N was taken up from the top soil layer, whereas N uptake from deeper soil layers was increased in the growth period with higher precipitation. Simulation runs prompt that, especially in the soil depths of 50 to 100 cm, crop water and nitrogen uptake after precrop lucerne is enhanced. We conclude that favorable topsoil conditions in terms of adequate soil nutrient stocks enhance subsoil and total nutrient uptake.

Modeling terron units with the addition of climatic variables for Denmark

Yannik, Roell Yi, Peng; Mette, Greve; Mogens, Greve

Email: yannik.roell@agro.au.dk
Affiliation: Aarhus University

Abstract

Terroir are regions where physical elements (soil, climate, and landscape) and culture can affect the taste of the product, which were initially used solely for wine production but now incorporates many other food products. An important first step in terroir development is determining areas that are similar in physical elements. The concept of terrons, defined as areas with similar soil and landscape by Carré and McBratney (2005), has been extended to include climate as a vital part of the terron definition. Terrons units are modeled and mapped 1) using fuzzy c-means with soil and climate to develop national regions and 2) using k-means with soil and landscape to develop regional terrons. In this study, Denmark was first divided into three national regions with 304 m resolution variables. Each of these regions are divided further into nine regional terrons (for a total of 27 regional terrons) with 30.4 m resolution variables. By simply changing the input variables that are critical for a specific crop, a workflow is proposed that outlines the necessary steps in modeling terrons for any crop.

Linking Big Data to Smart Soil and Smart Environment

The effect of pesticide application timing on pesticide leaching to drain lines: predicting the right application date based on a 3000-year simulation

Jeanne Vuaille

Email: jeannev@plen.ku.dk
Affiliation: Copenhagen University,
Department of Plant and Environmental Sciences

Abstract

Pesticides applied on drained agricultural fields can reach the aquatic environment through the drain lines, and lead to ecotoxicological issues. As climatic and field conditions are part of the factors recognized to be important in pesticide leaching, the effect of application timing on pesticide concentration in drains is investigated, towards a prediction of the right application date in terms of ecotoxicological risk.

Pesticide leaching is simulated over 3000 years with the soil-plant-atmosphere system model Daisy, where herbicides are applied every day on cereals within their corresponding application windows at two Danish sites. The hourly concentration leached to the drains is traced separately regarding the application date. Leaching events are described as hourly concentration exceeding the Regulatory Acceptable Concentration (RAC). To describe pesticide leaching according to application date, ecotoxicological criteria are defined. Based on these criteria, the yearly best and worst application dates are determined. Representative application dates of the typical choice of farmers are also identified, using guidelines from the herbicide user guide.

A significant difference between best and worst application dates regarding the number of years with RAC events demonstrates that a potential of risk reduction exists. Furthermore, the comparison of best and typical application dates reveals that selecting best application dates clearly mitigates RAC events occurring with the current application guidelines. Especially, a maximum reduction of 40 % in the number of years with RAC events is found (preliminary results). Several climatic and field conditions are subsequently shown usable as predicting variables on selecting the optimum application dates.

The effect of application timing on pesticides' environmental impact: How does application date affects pesticides leaching?

Maja Holbak

Email: maja.holbak@plen.ku.dk
Affiliation: Copenhagen University,
            Department of Plant and Environmental Sciences

Abstract

Pesticide leaching from drained agricultural fields to surface water bodies poses a toxic risk for living organisms, especially if pesticides are applied close to precipitation and drain events. We therefore hypothesize that pesticide leaching can be reduced by choosing the right application date according to precipitation (prior to application and predicted by weather forecasts) and soil water content in the top soil prior to application. To test our hypothesis, pesticide fate was simulated using the soil-crop-atmosphere system model Daisy. The model was calibrated based on data from the Estrup survey field, operated under the Danish Pesticide Leaching Assessment Programme. Simulations were conducted for 21 applications dates and leaching events were analyzed. Daisy successfully described leaching dynamics for the survey field wherefore it is argued that the model can be used to assess potential reduction in pesticide leaching. For the 21 application dates, a clear variation in leaching was observed, both in number and duration of events and especially in the total amount of leaching (6.3-17.8% of applied active substance). This difference is due to:

1) Different residence time on the soil surface, either intercepted on the canopy or in the Daisy soil surface mixing layer.

2) Difference in soil water content in the top soil prior to application and precipitation, which control whether biopore flow is activated carrying pesticides directly from the soil surface to drains.

We conclude that there is a possibility for reducing pesticide leaching by choosing the correct application date based on soil water content and precipitation.

Homogeneous areas map to stratify sampling in index-based insurance

Omar Valverde-Arias, Antonio Saa-Requejo, Maria Villeta, Jose L. Valencia, Alberto Garrido, Ana M.Tarquis

Email: omarobvalarias82@hotmail.com
Affiliation: CEIGRAM (Research Center for the Management
of Agricultural and Environmental Risks),
Universidad Politécnica de Madrid

Abstract

Extreme climatic events are a serious concern for agriculture and its related activities in the entire world. One of the main strategies for transferring agricultural risk is crop insurance. Recently, indexed insurance is becoming increasingly relevant, as risk management mechanisms in the agricultural sector. This is due to its economic advantages and easy to implement techniques. The indexed insurance does not need expertise or verifications of the occurrence of the accident in the field, but it does so by means of an index that is highly correlated with said losses. Therefore, the challenge in this type of insurance is to select an adequate index that correlates correctly with the extreme event that ensures, as well as to the sampling strategy to apply.

In this study we evaluate the determination of the area of influence where a certain value of the index will be representative, focusing on rice cultivation in the Babahoyo canton (Ecuador). To do this, a principal component analysis based on topographic, soil and climate variables has been carried out, thus defining a map of homogeneous agro-ecological zones. Based on this map, we have sampled the proposed index (NDVI) in rice cultivation comparing a stratify sampling versus a global sampling discussing the consequences in the index based insurance context.

Advances in soil-plant-atmosphere modelling and measurements across scales

Hydraulic Properties Estimation By Inverse Modeling of Drip Infiltrometer Experiment

Ali Mehmandoost Kotlar, B V Iversen, Quirijn de Jon Van Lier, Lis Wollesen de Jonge

Email: aliko@agro.au.dk
Affiliation: Department of Agroecology Aarhus University

Indirect methods to predict soil hydraulic properties have attracted considerable attention. This study evaluates the possible inverse modelling of data obtained from drip infiltrometer in order to estimate soil hydraulic parameters. In contrast to typical one or multi-step flow experiment, here the variation of measured pressure head and unsaturated hydraulic conductivity in a large soil column (20cm diameter and 30cm height) are used as data for inverse solution performed by Hydrus-1D. Providing constant flux on the surface of large soil samples and constant or varying pressure head at the bottom of columns applied under a porous plate are known boundary conditions. The verification of model is done through measured versus simulated temporal variation of pressure heads at the depth of 7, 10 or 13 cm as well as hydraulic conductivities at different pressure heads (less than 100cm). Although, saturated hydraulic conductivities simulated by Hydrus 1D can be different from observed Ks within the order of magnitude, unsaturated hydraulic conductivity at tensions near saturation (Kns) sound much more reliable parameter for bench marking. The water retention curves of each soil column are analyzed by Van Genuchten parameters obtained from inverse modeling. These results prove the good performance of drip infiltrometers experiment that is relatively fast process (usually less than 48hrs) for determination of soil hydraulic properties of large soil columns.

Hydrological regime of layered soils on the example of urbanozem in Moscow and remediated after oil spill soils in Komi Republic (Russia)

Aminat Umarova, Anastasia Gasina, Zakhar Ezhelev, Tatiana A. Arkhangelskaya, Maria Suslenkova, Marina Butylkina

Email: a.umarova@gmail.com
Affiliation: Soil Science Faculty,
            Lomonosov Moscow State University, Russia, Moscow

Abstract

Nowadays the areas of layered soils which formation is caused by human activity are increasing. The most massively differentiated profile of soils is formed when remediation is carrying out and in the city conditions when a transition and laying of considerable volumes of soils takes place that initiates formation of sharp boundaries of soil layers. It leads to different functioning of a soil cover and changing of the hydrological regime. However, its experimental determination is connected with a number of methodical difficulties. The method that gives the possibility to identify features and differences in functioning of soils with different structure is using of physically based mathematical models. The aim of our research is the prediction of hydrological regime of layered soils by method of mathematical modeling. The Hydrus-1d model has been used, experimentally determined parameters were: water retention curve, soil density, content of organic substance, particle size distribution. The objects of our research were (1) tundra gley peaty soil of the Russian North located in the Komi Republic which has undergone oil pollution in 1994 and there was held a remediation by replacement of the polluted layer with formation of the soil profile that spread by a heavy sand layer; (2) the layered soil constructions in Moscow that were created from sharply different soil substrata: humic horizon, peat, sand. Modeling of the hydrological regime has shown high probability of formation of the waterlogged layers on the horizon boundaries during the summer period.

Multivariate statistical analysis of SAR-derived soil moisture time series for soil hydrology research: preliminary case study

Andis Kalvans, Anete Berzina; Konrads Popovs

Email: andis.kalvans@lu.lv
Affiliation: University of Latvia

Abstract

The Sentinel -1a and 1b satellites provide consistent, high frequency time series of Earth Observations with C-band Synthetic Aperture Radar (SAR). It has been show that soil moisture volumetric content can be derived from the SAR data if vegetation is sparse. We undertake a preliminary, proof-of concept type of analysis, to test if soil moisture time series can be used to derive hydrological properties of the soil in moderate climatic conditions. The long term aim of this research is to evaluation the drainage conditions with high spatial resolution utilizing soil water models forced by meteorological data and calibrated against remote sensed soil moisture data.

It is found that in early spring 2018 soil moisture spatial variations are dominated by presence of the winter crops (winter wheat). The poor overwintering conditions due to excess moisture in autumn and winter of 2017/2018 had led to partial destruction and patchy distribution of the crop. As a result the soil moisture spatial variations across the field are dominated by the presence or absence of the crop. However the damage to the crop likely is directly linked to the insufficient drainage of the field. Thus the SAR-derived data do reflects the drainage conditions at least indirectly.

The soil moisture time series was provide by commercial LTD Baltic Satellite Service. The study is supported by the EIT Climate-KIC program operated by Riga Technical University (RTU), RTU Design Factory and RTU IdeaLAB and project No AAP2016/B041 at the University of Latvia.

Benchmarking models of root architecture and function

Andrea Schnepf, Christopher K., Black; Valentin, Couvreur; Benjamin M., Delory; Claude, Doussan; Axelle, Koch; Timo, Koch; Mathieu, Javaux; Daniel, Leitner; Guillaume, Lobet; Trung Hieu, Mai; Félicien, Meunier; Lukas, Petrich; Johannes, Postma; Eckart, Priesack; Jan, Vanderborght; Harry, Vereecken; Matthias, Weber

Email: a.schnepf@fz-juelich.de
Affiliation: Forschungszentrum Jülich GmbH, IBG-3

Abstract

3D models of root growth, architecture and function are evolving as they become important tools that aid the design of agricultural management schemes and the selection of beneficial root traits. However, while benchmarking is common for water and solute transport models in soil, 3D root-soil interaction models have never been systematically analysed. Several interacting processes might induce disagreement between models: root growth, sink term definitions of root water and solute uptake and representation of the rhizosphere. The extent of discrepancies is currently unknown. Thus, a framework for quantitatively comparing such models is required. We propose, in a first step, to define benchmarking scenarios that test individual components of the complex models: root architecture, water flow in soil and roots, solute transport in soil and roots. While the latter will focus mainly on comparing numerical aspects, the root architectural models have to be compared at a conceptual level as they generally differ in process representation. Therefore defining common inputs that recreate reference root systems in all models will be a key challenge. In a second step, benchmarking scenarios for the coupled root-rhizosphere-soil models can be defined. We expect that the results of step 1 will enable us to better interpret differences found in step 2. We expect that this benchmarking will result in improved models, with which we can simulate various scenarios with greater confidence, avoiding that future work is based on accidental results caused by bugs, numerical errors or conceptual misunderstandings and will set a standard for future model development.

Establishing testable hypotheses for soil organic carbon research

Andrew W. Bray, John H. Kim, Marion Schrumpf, Caroline L. Peacock, Steven A. Banwart

Email: a.w.bray@leeds.ac.uk
Affiliation: University of Leeds

Abstract

Soil organic carbon is integral to the control of soil moisture, soil structure, and soil nutrient cycling and is thus vital for a healthy soil. The types of organic carbon in soils are, however, complex and dynamic, and the processes that control organic carbon reactivity and cycling are only poorly understood.

International attention on the importance of soil organic carbon is growing, and new interdisciplinary research initiatives such as 4per1000, CIRCASA, FACCE-JPI, and the Global Research Alliance on Agricultural Greenhouse Gases have been established to investigate the relationships between organic carbon, soil, and climate. To maximise the effectiveness of these and future consortia, we propose that a concerted approach to close our knowledge gaps on soil organic carbon processes is needed.

Here we present our approach to devise a series of testable hypotheses for soil organic carbon research. Investigating these hypotheses will help us refine the tools we use to prescribe land management practices, predict soil organic carbon responses to changing climate, and give us vital information on the capacity of soils as a sink for atmospheric carbon sequestration.

Effect of combining different methods when describing the soil hydraulic conductivity curve

Carlos Avila, Sara Acevedo; Cristina Contreras; Carlos Bonilla

Email: cjavila@uc.cl
Affiliation: Department of Hydraulic and Environmental Engineering,
Pontificia Universidad Católica de Chile, Santiago, Chile

Abstract

Hydraulic conductivity is one of the so called hydrodynamic properties associated with the movement of water through the soil. The measurement of this physical property is costly and time consuming. Thus, many laboratories don't have the instrumentation to build the entire hydraulic conductivity curve. Therefore, the objective of this study was to evaluate the combination of four state of the art methods to improve the adjustment of parametric curves when predicting the hydraulic conductivity. Hydraulic conductivity was measured in disturbed and undisturbed soil samples with HYPROP (evaporation method), WP4C (dew point method), MiniDisk Infiltrometer, and KSAT (falling and constant head method). Parametric curves were fitted to the entire curve (obtained with all the methods) and compared to the results obtained with a combination of some of them. The estimated were compared by computing the RMSE and Akaike Information Criterion. This presentation will show the main results when combining these four methods and its convenience for laboratory analysis.

Oxygen diffusion and oxygen distribution as well as penetration resistance of biopore walls – Measurements on the mm scale

Haas, Christoph, Horn, Rainer; Gerke, Horst H.

Email: c.haas@soils.uni-kiel.de
Affiliation: Working Group "Hydropedology",
　　　　　　Research Area 1 "Landscape Functioning",
　　　　　　Leibniz Centre for Agricultural Landscape Research (ZALF)

Abstract

Vertically-continuous biopores such as earthworm burrows or decayed root channels play a major role for soil aeration. Roots have been observed recolonizing these biopores to propagate into deeper soil layers more rapidly. In order to make nutrients in these layers accessible and thus influencing the soil fertility, roots need to penetrate the biopore walls. These walls show often differing densities compared with the surrounding matrix. Unknown was the effect of the root/earthworm impact on pore functions. The problem was that methods were limited to determine pore functions of intact biopore walls. The objective was to determine the lateral oxygen diffusivity and the oxygen distribution through biopore walls of different genesis (short- or long-time colonization by an earthworm (Lumbricus terrestris), or root induced) at various matric potentials (namely -1 kPa, -3 kPa, -6 kPa and -30 kPa) as well as their penetration resistance. We coupled the oxygen diffusivity and oxygen distribution measurements to micro-penetration measurements in order to determine the lateral soil strength and therewith the mechanical impedance that the roots and earthworms are confronted with when they penetrate the pore wall. All measurements were conducted with a spatial resolution of 100 μm. The measurements of the oxygen diffusivity, the oxygen distribution and the micro-penetration resistance were also carried out on bulk soil samples to study the alteration of soil properties by earthworms and roots. The conclusion from the resulting comparisons revealed characteristic modifications of pore functions. Existing methods for determination of oxygen diffusion (Rappoldt, 1995) have been developed further.

A Simple Model to Estimate Nitrogen Mineralization and Leaching from Catch Crop Residues A Simple Model to Estimate Nitrogen Mineralization and Leaching from Catch Crop Residues depending on their Chemical Composition

Iris Vogeler, Ingrid Kaag Thomsen, Elly Møller Hansen

Email: Iris.Vogeler@agro.au.dk
Affiliation: Aarhus University

Abstract

A simple model was developed that can be used to predict the amount and rate of mineral nitrogen (N) release from crop residues depending on their biochemical composition and temperature. Mineralisation of the plant residue was assumed to follow an exponential decay function. The rate of decay was related to either the C:N ratio of the crop residue or the N concentration. The mineralization model was developed and parameterised based on an incubation experiment performed with residues of fodder radish (Raphanus sativus, L.) of different age, white mustard (Sinapsis alba, L.), and perennial ryegrass (Lolium perenne, L.). These were incubated in a loamy sand soil at temperatures of either 2 or 10oC, and at a water content around field capacity. The amount of N released was measured after 1, 2, 4, and 7 months. Residue C/N ratios ranged from 10 to 25, and N concentrations from 17 to 40 mg N/g dry matter (DM).

The simple mineralisation model was then linked with the Burns leaching equation for predicting the fraction of mineralized N either leached over the winter period or remaining in soil after winter (April) for potential uptake by the subsequent main crop. Simulations were carried out for a sandy and a loamy soil, for two different climates (wet and dry), two different residue N concentrations, and residue incorporation times (November and February). The simulations showed a high sensitivity of the residue N concentration on the mineralization rate and fraction leached.

Sensitivity and uncertainty analyses of models: much easier than expected!

Jan Wesseling, Joop Kroes, Thalita Campos Oliveira, Francisco Damiano

Email: jan.wesseling@wur.nl
Affiliation: WUR, Soil Physics and Land Management

Abstract

Every model is a simplification of reality. Simplification is often done by parametrization. Usually these parameter-values are uncertain. How do these parameter values affect the results of models? Once this is known, we also know the accuracy of the results and we can decide which parameters of the model need to be measured more accurately than others. To demonstrate how simple a sensitivity analysis can be, we considered the model Swap. We applied some standard packages in R for the creation of the required input files. A procedure was developed to perform the required computations on the HPC (High Performance Computer) grid of Wageningen University and Research. Finally the results of the computations are processed in R again.

Three examples are presented. First the influence of the saturated conductivity and the moisture content at saturation on 6 output variables is obtained for different groundwater levels under a soybean crop on the Argentinian pampa's. Results are presented as Impact Response Surfaces (IRS's). Then a Latin Hypercube sampling method is applied to compute the distribution of crop yields of an experimental field in Brazil. The final example is taken from Argentina again. The Sobol technique is applied to find the contribution of a number of parameters on the deviation of the computed crop yield.

It may be concluded that, when using existing R packages and a HPC grid, sensitivity and uncertainty analyses of a complicated numerical model can be performed fast and easy.

Evapotranspiration partitioning during crop development

Jos van Dam, Paul van Walsum; Joop Kroes; Martin Mulder; Marius Heinen

Email: jos.vandam@wur.nl
Affiliation: Wageningen University and Research centre,
             Department Environmental Sciences

Abstract

Plant transpiration is one of the largest components in the hydrological cycle, and closely related to photosynthesis. Therefore proper simulation of plant transpiration in the biosphere is very important. At the same time plant transpiration is a very complex process and relates to micro-meteorology, plant physiology, and soil water flow. Commonly fairly simple methodologies are used based on crop factors and atmospheric demand of the closest weather station. Ideally we should solve the water and energy balance simultaneously, using atmospheric, plant and soil water input data at a local site. However, this is only possible at a few locations and for a limited period. We should find a proper balance between detail of the transpiration methodology and available input data. We will present our experiences with the SWAP (Soil-Water-Atmosphere-Plant) model, including a new partitioning method. As SWAP simulates both soil water flow and plant growth, proper evapotranspiration partitioning during growing seasons is very important. The Penman-Monteith equation is starting point, which is applied to both plant and soil. Instead of using bulk crop factors, main and measurable properties as albedo, stomatal resistance, plant height and leaf area index are used to simulate potential transpiration and evaporation. Detailed simulation of soil water flow and root water uptake determines the reduction to actual transpiration and evaporation. We will show the simulated transpiration and crop yield with this method as compared to the crop factor method and to more detailed partitioning methods available in literature. Measurements of plant transpiration and soil evaporation separately are urgently needed to improve operational partitioning methods.

2D Numerical study on the effects of using dual permeability modelling for fractured clays

Juan Pablo Aguilar-López and Thom Bogaard

Email: j.p.aguilarlopez@tudelft.nl
Affiliation: Delft University of Technology - Hydrology Dept

Abstract

Dual permeability models are often used for simulating preferential flows on structured soils. Their conceptualization is based on the assumption that the whole porous media system may be represented by two different but connected subsystems; the matric and the preferential flow system. While, the latter subsystem is often used to represent a combination between soil domains with 'hollow' heterogeneities such as root holes, and cracks, it is still conceptualized as a continuum porous media. For some soils like fractured clays this might not be the case as the fracture domain may be completely hollow. This also affects the parametrization of the water retention functions as they were not conceived to characterize void domains in which capillary effects are almost negligible. Therefore, the present study aimed to adapt and better understand the implications of parametrizing the 'hollow' preferential domain as a porous material. This was done by comparing the performance of two finite element models of a fractured clay block until achieving full saturation; one solved as a single permeability solution and a second one representing the same system solved as a dual permeability solution. The infiltration rates, fracture to matrix exchange, pore water pressure and water content distribution of both models were compared for different parametrization approaches. The results show that a physically feasible parametrization choice of the system may result in unrealistic estimations and that simple mathematical modifications may allow to have a better approximation of the physical behavior of fractures while using dual permeability models.

Modelling of the saturated water conductivity of the macroporous soil media

Krzysztof Lamorski, Bartłomiej Gackiewicz, Cezary, Sławiński

Email: k.lamorski@ipan.lublin.pl
Affiliation: Institute of Agrophysics,
Polish Academy of Sciences, Lublin, Poland

Abstract

Saturated soil water conductivity (SSWC) is one of most important soil hydrological characteristics. Macroscopically observed SSWC is determined by the soil pore transport processes occurring at the microscale. In presented study SSWC is modelled based on X-ray CT scans of the soil cores. Soil material (10 soil cores) was sampled by two cores from topsoil of 5 different locations. Soil cores were scanned using X-ray micro-CT scanner and SSWC of samples together with other typically determined soil characteristics were determined. Voxel size achieved for X-ray CT scans was 20 µm, as a result, only macropores were observed in CT scans. Based on CT scans 3D representation of pore media was obtained. A new method of modelling the SSWC was proposed, which uses information about macropore network and treats macropores as voids. Remaining soil sample area, which is below achievable CT scan resolution, is treated as a pore medium (soil matrix) with some intrinsic permeability. Elaborated model allowed for estimation of SSWC of soil samples and for analysis of relation between macroporosity of soil cores and its SSWC. A good estimation of SSWC was obtained using proposed model ($R^2=0.73$, RMSE=$5.95*10-4$ m/s). The ratio of SSWC of soil core to SSWC of soil matrix has been found to be highly correlated with soil core macroporosity ($R^2=0.88$).

Incorporating spatiotemporal variability in infiltration processes in hydrological modelling at different scales

Loes van Schaik, Anne Zangerlé, Tobias Hohenbrink, Conrad Jackisch, Anne Schneider, Uwe Ehret, bori, Schröder

Email: l.vanschaik@tu-berlin.de
Affiliation: Ecohydrology and landscape assessment,
       Institute of Ecology, TU Berlins

Abstract

Preferential flow, i.e. macropore flow, fingered flow, and funneling, are widely recognized to determine the depth distribution of infiltration during high intensity rainfall events. Incorporating preferential flow in hydrological modelling remains a large challenge. On the one hand the translation of the preferential flow into a model concept which adequately represents the natural flow processes is very complicated. On the other hand the spatiotemporal variability of preferential flow at different scales complicates the parameterization.

In the CAOS project (catchments as organized system) we are developing a method to parameterize preferential flow in hydrological models at different spatial scales. In a first step the dominant type of preferential flow was determined. Subsequently the focus in the project was on biopores created by earthworms as these are the main cause for the preferential flow in a large part of the Attert Catchment. Using the plot scale ecohydrological model echoRD we showed that the spatiotemporal variability, which is inherent to biopore networks, can have a strong effect on seasonal infiltration processes.

For the catchment scale, species distribution models were developed, which describe both the spatial distribution of the earthworms as well as the temporal variation in abundance (activity) are used together with transfer functions to derive the spatiotemporal macropore distributions of effective macropores for the whole Attert catchment. This data will be used to parameterize the catchment scale CAOS-model which will then be validated with the hydrological measurement networks of the CAOS-research projects.

Development and evaluation of pedotransfer functions for saturated hydraulic conductivity using an international soil database

Marta, Ottoni, Theophilo Ottoni Filho, Maria Leonor Lopes, Assad Otto, Rotunno Filho

Email: marta.ottoni@cprm.gov.br
Affiliation: Geological Survey of Brazil

Abstract

Soil saturated hydraulic conductivity (Ks) is a key property in hydrological and environmental studies. The measurement of this property is cumbersome and the use of pedotransfer functions (PTFs) has been commonly developed to estimate Ks. The literature brings an extensive number of Ks PTFs, most of which were developed for temperate regions. The presence of soil structural variables in these models is more uncommon when compared to the use of granulometric fractions. The objective of this work was to develop Ks PTFs for a database of tropical and temperate soils that include soil texture and bulk density, as well as a strictly soil structural property, effective porosity [total porosity minus θ(300-cm suction)]. This study also evaluated the performances of the proposed PTFs using a testing database and comparing their predictions to those from seven Ks models used in the literature. The results showed that the proposed PTFs based on effective porosity were in general more accurate and reliable than the proposed PTF based on texture and bulk density, showing also greater reliability than the other models from the literature for different geographic/pedological scales and textural class groups. Soil texture and/or bulk density were generally poor predictors of Ks, particularly with fine textured soils. This study indicates the need to include new predictors in the Ks PTF formulation. In addition, standard and more representative Ks measurement methods, based on an adequate sample size as well, are also required to achieve more accurate Ks predictions

.

Saturated Soil Hydraulic Conductivity: Is the soil saturated? Does it need to be?

Michael Young, Atilla Nemes, Quirijn de Jon van Lier, Markus Berli, Robson Armindo, Jean Caron, Audrey Pfeil

Email: michael.young@beg.utexas.edu
Affiliation: University of Texas at Austin

Abstract

Laboratory and field methods to determine saturated soil hydraulic conductivity (Ks) often do not specify how to saturate samples or the volume of soil being tested. Depending on the application of the Ks value, full saturation (100% water-filled pore spaces) may or may not be important, or indicated either way. For example, standardized laboratory methods (constant and/or falling-head permeameter) should lead to comparable results; however, one recent study conducted across laboratories in Switzerland showed substantial inter-lab variability of Ks values, and one hypothesis is that variations in saturation level explained the variations in Ks. In field determinations, researchers almost always deal with unsaturated conditions, regardless of the measurement method. If unsaturated K is needed and based on estimates of Ks (e.g., by using VG-Mualem or BC-Mualem equations), errors in saturation level also would lead to substantial errors in unsaturated K.

In this work, which was inspired during (cerveza-saturated) discussions at the 4th Brazilian Soil Physics Meeting in 2017, we seek to raise awareness of when soil saturation level is important, whether the results are used in numerical models or other calculations used to solve a wide variety of scientific/engineering problems. We will discuss the use and importance of Ks in different disciplines and countries; how errors propagate through calculations; how saturation protocols are specified and verified; and how methods for laboratory-measured Ks can be fitted for practical uses. We hope to highlight the need to consistently account for the saturation level of samples being assessed for hydraulic conductivity.

"

Influence of the Water Absorbing Geocomposite on the soil-WAG-soil-satmosphere continuum

Michał Śpitalniak, Krzysztof Lejcuś, Jolanta Dąbrowska, Daniel Garlikowski

Email: michal.spitalniak@upwr.edu.pl
Affiliation: Institute of Environmental Engineering,
      Wrocław University of Environmental and Life Sciences, Wroclaw, Poland

Abstract

The impact of climate change on the environment, including people's lives, is noticeable. More and more frequent problems with access to water and occurring droughts indicate the need to prepare real solutions to mitigate their effects. Therefore, the scientists from Wrocław University of Environmental and Life Sciences developed, patented and commercialized an innovative type of soil amendment – a Water Absorbing Geocomposite (WAG). WAG is made of geotextile, synthetic skeleton and hydrogel. In this study, the impact of WAG on soil moisture, soil suction force and soil temperature was determined depending on the depth of WAG application. The tests were carried out in laboratory conditions. The research stand consisted of soil monolith with dimensions of 105x70x55 cm, in model configuration: soil-soil amendment (WAG)-soil-atmosphere. For measurement, TDR devices, soil suction tensiometers, a thermographic camera, an irrigation system and heating lamps were used. Four types of soil were used for the research: sand, sand with humus, humus and sandy loam. The WAG was placed at a depth of 20 cm and 10 cm. The soil was placed in a box equipped with sensors, and then the box was filled with water. After draining the water, the heating lamps were started for 72 hours. Thanks to the abovementioned procedure, water retention in various soil profiles with WAG amendment was examined and the results were statistically analyzed. The optimal depth of the WAG installation was established as the result of the conducted research.

Towards dynamic modelling of soil structure and its links with soil functions and processes

Nicholas Jarvis, Thomas Keller, Jennie Barron

Email: nicholas.jarvis@slu.se
Affiliation: Department of Soil and Environment,
　　　　　Swedish University of Agricultural Sciences, Uppsala, Sweden

Abstract

Sustainable agricultural production requires the maintenance and improvement of soil quality, which can be defined as the capacity of soil to deliver a range of key ecosystem services. Soil quality and sustainable agricultural production are strongly determined by soil structure, as it regulates most important soil processes and functions such as water and air movement, biological activity, carbon and nutrient cycling, greenhouse gas emissions, risks of pollutant leaching, root growth and water and nutrient uptake by plants. Some soil-crop models have been developed that account for the effects of structure on transport and turnover processes in soil, but the structure in these models is static. In reality, soil structure is dynamic at time scales ranging from seconds (e.g. compaction, tillage) to minutes (e.g. soil sealing), seasons (e.g. changes induced by root growth, activity of macro-fauna,) and even decades (e.g. changes in organic matter content). The lack of a model framework that dynamically links structure with function, particularly at decadal time scales, has hampered understanding of how changes in land use, soil management and climate have resulted in insidious losses of soil quality and land degradation (Vogel H-J. et al., 2018. A systemic approach for modeling soil functions. Soil, 4, 83-92). Here, we present a conceptual framework for a soil-crop model incorporating dynamic links between soil structure and function. We illustrate the approach with preliminary scenario simulations of long-term soil structure degradation under a perennial crop in a drying climate, which leads to increasing runoff coefficients

A stochastic analysis of the sensitivity of vadose zone hydrological model output to uncertainty in soil hydraulic properties

Quirijn de Jong van Lier, Everton Alves Rodrigues Pinheiro, Victor Meriguetti Pinto

Email: qdjvlier@usp.br
Affiliation: Universidade de São Paulo

Abstract

Richards equation-based hydrological models allow predicting movement of water and solutes in the vadose zone. Most numerical issues with these models have been solved and robust algorithms like Hydrus and SWAP are available to predict soil water balance components and associated quantities. Based on soil hydraulic properties and their stratification in a soil, infiltration, evapotranspiration, drainage, and surface runoff are among the frequently predicted quantities. Whichever method is used to obtain soil hydraulic properties, resulting parameters include an uncertainty, normally expressed as a confidence interval or standard error. In deterministic hydrology, this uncertainty and its effect on model outcomes is not considered. Using a stochastic approach, however, the hydrological variables as well as the associated uncertainty is predicted. To perform a stochastic analysis using a deterministic model like Hydrus or SWAP, many (n) simulations (n typically of the order of 10^3 or 10^4) should be performed with the model, obtaining an output value for each stochastic realization. We developed a software allowing to perform this procedure with the SWAP hydrological model. For a bare-soil scenario we analyzed the uncertainty in predictions of deep drainage, runoff and evaporation in some southeast-Brazilian soils based on hydraulic properties and their standard errors obtained by inverse modeling of evaporation experiments. Hydraulic properties are expressed in terms of respective Van Genuchten parameters, and we present and discuss the effect of uncertainty in these parameters on the uncertainty of mentioned output variables prediction.

Comparison of catchment scale 3D and 2.5D modelling of soil organic carbon stocks in Jiangxi Province, PR China

Rentschler, Tobias; Gries, Philipp; Behrens, Thorsten; Bruelheide, Helge; Kühn, Peter; Seitz, Steffen; Trogisch, Stefan; Scholten, Thomas; Schmidt, Karsten

Email: t.rentschler@uni-tuebingen.de
Affiliation: SFB 1070 Resource Cultures,
            University of Tübingen, D-72074 Tübingen, Germany

Abstract

As limited resources, soils are the largest terrestrial sinks of organic carbon. In this respect, spatial and depth-related quantification of soil organic carbon (SOC) offers substantial improvements in modelling of SOC stocks. Previous three-dimensional SOC models mostly use specific depth increments in multi-layered two-dimensional predictions. However, these are limited in vertical resolution, interpretability of soil as volume and accuracy of SOC stock predictions. This study evaluates an approach based on depth functions and non-linear machine learning techniques, i.e. MARS, random forests and SVM, to quantify SOC stocks as in 3D. The legacy datasets used for modelling comprise profile data of SOC and bulk density sampled at five depth increments (0 5, 5 10, 10 20, 20 30, 30 50 cm). The objective of this study is (i) to test the spatial prediction of soil profile depth functions based on multi-scale terrain covariates and (ii) to evaluate the results of the 3D approach by comparing it with multi-layered 2D predictions. The main findings are: (i) 3rd degree polynomials fitted best for SOC and bulk density ($R^2 > 0.95$; RMSE=0.1 % SOC and 0.07 g cm-3), and (ii) 3D SVM models correlated best with corresponding 2D predictions (R^2 decreasing with depth: 0.89 to 0.15). Final SOC stock estimations showed 74 Mg ha-1 SOC in the upper 50 cm of the soil compared to 62 Mg ha 1 calculated with multi-layered 2D predictions. Thus, we conclude that spatial prediction of depth functions of SOC with SVM is competitive and highly suitable for SOC stock modelling and offers much higher vertical resolutions.

THERMAS: the free software to estimate soil thermal properties at any water content from available data on texture, organic carbon content, and bulk density

Tatiana Arkhangelskaya, Alex Topaj, Elena Zakharova

Email: arhangelskaia@gmail.com
Affiliation: Lomonosov Moscow State University

Abstract

THERMAS is Windows-based software that consists of dynamic link library combined with the desktop application. The provided DLL can also be integrated with any external software as a built-in module. THERMAS estimates soil thermal properties, i.e. thermal diffusivity, volumetric thermal capacity, and thermal conductivity at any non zero water content.

THERMAS is based on the newly developed hierarchical pedotransfer functions to estimate the parameters of the water content–thermal diffusivity curve from available soil data: (i) from the textural class name; (ii) from sand, silt, and clay percentages; (iii) from sand, silt, and clay percentages and bulk density; (iv) from sand, silt, clay, and organic carbon percentages (Arkhangelskaya, Lukyashchenko, 2018). PTFs were developed from the data set of 77 undisturbed samples of mineral soils from the European part of Russia. The ranges of sand, silt, and clay within the data set were 1–97, 2–80, and 1–52%; wet bulk density varied from 0.86 to 1.82 g cm-3, organic carbon content ranged from 0.1 to 6.5%.

Volumetric thermal capacity is estimated using de Vries model (1963). If data on bulk density or organic carbon content are not available, they are roughly estimated by procedures described in Rawls (1983), Benites et al. (2007), and Ruehlmann & Körschens (2009). Thermal conductivity is obtained by multiplying thermal diffusivity and volumetric thermal capacity.

When using the desktop Windows application, the results of calculations are visualised in the working window and are also logged into a spreadsheet.

A model for the effective unsaturated soil hydraulic properties over the full moisture range

Tobias KD Weber, Wolfgang Durner; Thilo Streck, Efstathios Diamantopoulos

Email: tobias.weber@uni-hohenheim.de
Affiliation: University of Hohenheim

Abstract

For numerical simulations of transient water fluxes in variably saturated soils, the Richards equation is a standard process model. A prominent example of its application is found in simulations of transient coupled water-agrochemical processes in the soil-plant-atmosphere continuum. For this, effective models describing the soil hydraulic properties (SHP) are mandatory. Just recently, it has been acknowledged, that SHP functions need to represent the full moisture range, i.e. from saturated to completely dry soils. To achieve this, we developed a model for the water retention curve (WRC) as the sum of any given parametric capillary saturation function and a new model for the non-capillary saturation function. With it, a continuously differentiable, flexible, and physically coherent representation of the WRC is achieved. The expressions for the capillary and non-capillary saturation function are then used to calculate the respective hydraulic conductivity curve (HCC). This is achieved by adopting Mualem's integral for the capillary part of the HCC only and calculating the non-capillary HCC directly from the new non-capillary saturation function. The new HCC leads to consistent description of measured data, including the often observed change of slope beyond pF = 2. We demonstrate the suitability of the new SHP framework by describing measured WRC and HCC data of soil samples with a wide range of textures and origins at a wide range of moisture states. Compared to the classical van Genuchten-Mualem approach, it requires only one additional model parameter. The new SHP model framework describes both WRC and HCC adequately and coherently.

Soil modelling for the next generation of Earth System Models

The soil modeling approach for the development of a web-based smart geoSpatial Decision Support System in the LANDSUPPORT Horizon 2020 project

Angelo Basile and Fabio Terribile

Email: angelo.basile@cnr.it
Affiliation: National Council of Research (CNR)-
    Institute for Mediterranean Agriculture and Forest Systems (ISAFOM)

Abstract

A very large range of available models can be found for facing agriculture, forestry and environmental issues. These are typically designed to tackle specific problems and scales. Here we present the modeling chain of the LANDSUPPORT Horizon 2020 project concerning the construction of a multilevel web-based smart geoSpatial Decision Support System - strongly based on soil modelling - which shall provide a powerful set of tools to help decision making process in planning and management of sustainable agriculture and forestry, and for evaluating trade-off between land uses. Examples are the following: Carbon Stock (LULUCF); Risk of groundwater pollution; Biomass production in agriculture and forestry; Soil erosion; Land take, Rural fragmentation and urban sprawl; Ecosystem services evaluation and economic quantification; Agritourism.

These tools are feed by a multiscale and modular modelling system. Examples but not exhaustive of modelling approaches are: Richard's equation; transfer functions for solutes transport; carbon-, solar- and water-driven crop growth modules; automatic digital mapping and uncertainty engines.

Main technical innovation in modelling relays in the parallelization process through COMPSs/PyCOMPSs programming model allowing the integration of different models written in sequential code, the high efficient raster data management system (rasdaman) and the power of Geoserver GUI. Thanks to this high-level technology the user need not to be experts about models, therefore only few parameters are required over the GUI in order to apply "what-if" procedure even in very high computing demanding simulations.

Here we will present the overall modelling chain build on LANDSUPPORT with few examples of specific applications.

Soil drying study by means of X-ray computed microtomography

Anna, Yudina; Marina, Karsanina; Dmitry, Fomin; Konstantin, Romanenko; Konstantin, Abrosimov; Elena, Skvortsova; Kirill, Gerke

Email: anna.v.yudina@gmail.com
Affiliation: Dokuchaev Soil Science Institute

Abstract

The main question of our investigation was: which parameters of soil macro- and microstructure determine kinetics of soil drying? For this purpose soil drying curves were obtained by drying of pre-saturated samples at constant temperature (60 degrees Celsius) by Moisture Analyser MS-70 (A&D, Japan) with simultaneous record of sample temperature by temperature sensor. The tomographic analysis of soil monoliths was performed by micro-CT Skyscan-1172 (Skyscan, Belgium). Soil drying process can be divided into three stages. Each stages is characterized by different water status (capillary, film, absorbed water) and can be described by different hydraulic parameters. As a result, linkages between tomographic parameters of soil structure and soil drying kinetics was described.

Comparison of soil water availability in two land surface models

Azin Wright, Anne Verhoef, Pier Luigi Vidale, Sebastien Garrigues

Email: a.wright@pgr.reading.ac.uk
Affiliation: University of Reading

Abstract

Land surface models differ in the underlying representation of water, energy and carbon balance, which affects the model performance. Here, we explored the underlying formulations of two LSMs (JULES and C(H)TESSEL), with emphasis on their different soil hydraulic parameter (HP) configuration, canopy exchange and plant water stress configurations: CHTESSEL (Van Genuchten-Mualem HP, empirical stomatal conductance model (gs)), CTESSEL (Van Genuchten-Mualem HP, and mechanistic photosynthesis/gs model), JULESVG (van Genuchten-Mualem HP), and JULESBC (Brooks and Corey HP), the latter two both have the same mechanistic photosynthesis/gs model. The models were driven with WFDEI meteorological forcing data set for 1979 to 2012. CH/CTESSEL and JULESVG/BC models completely differ in their soil and vegetation ancillary data. Several large domains in Europe were selected: UK, France, Spain, Scandinavia, Germany, Russia, Eastern Europe and Southern Europe. Time series, kernel density plots, and related statistical assessments were produced based on the spatial average of modelled fluxes in each domain. The results show broad agreement between the 4 models, although occasionally there are considerable differences, depending on where we are in the growth cycle, and on the climatic conditions. In some instances, CHTESSEL and JULESVG models behave similarly, while the difference between CH/CTESSEL model and JULESVG/BC models is more pronounced. This shows that a model's behaviour can be changed to the extent of resembling a different model only by adopting an alternative HP. The overall conclusion is that soil hydraulic parameters are primarily responsible for the difference in behaviour between the two LSMs. The remaining difference between the models can be explained by the soil maps, phenology and treatment of water stress.

Water flow in heterogeneous macroporous geometries: Laboratory column experiment and simulation via two dual permeability models

Carlos Faundez Urbina, Jos van Dam, Rob Hendriks, Erik van den Berg, Harm Gooren.

Email: carlos.faundezurbina@wur.nl
Affiliation: Wageningen University and Research

Abstract

Macropore flow has negative impacts on agriculture and environment, because water and chemicals may bypass the porous and reactive soil matrix, reducing crop yield and contaminating surface and subsurface water. Heterogeneous macroporous geometries (HMG) consist of unevenly distributed macropores over depth. Although the relative macroporosity may be constant, its distribution may change with depth. The large variety of macropore distributions produces all kind of water flow and chemical transport conditions. Therefore we evaluated the model performance of the hydrological models SWAP and HYDRUS in a laboratory column experiment with artificial macropores, creating an HMG that allowed inverse and forward simulation of water flow. Three packed soil columns were set up with silty loam (62.4 cm) on top of sandy soil (5 cm). Well defined infiltration and drainage conditions were applied to the top and bottom boundary, respectively. Experiment I was performed for tuning up the matrix parameters. In experiment II a central macropore was drilled up to a depth of 62.4 cm and the macropore parameters which could not be obtained geometrically were calibrated. In experiment III four dead-end macropores were drilled up to a depth of 20 cm and 40 cm, and the models were run with the previously estimated parameters, updating the geometric parameters with the known HMG. Preliminary results show a good performance of both hydrological models with respect to the measured pressure head values over depth. The outflow is overestimated though. The reasons are different for SWAP and HYDRUS and will be discussed.

Modelling climate change impact on N2O emissions from agricultural soils

Eckart Priesack

Email: priesack@helmholtz-muenchen.de
Affiliation: Institute of Biochemicla Plant Pathology, Helmholtz Centre Munich

Abstract

Intensive agricultural land use is considered to be the major source of anthropogenic contribution to the increase in atmospheric N2O concentration during the last decades. A necessary reduction of N2O emissions from agricultural soils requires changes of agricultural management practices. Mathematical models can help to identify adapted land use and improved production systems by providing knowledge about the interaction between the determining processes of N2O production and the dynamics of state variables affecting N2O emissions. In particular the impact of climate change on N2O emissions can be better analyzed.

The aim of this study was to test modeling approaches for their ability to describe and quantify the long-term development of N2O emissions from agricultural fields observed at the TERENO Research farm Scheyern situated 40 km north of Munich, Bavaria. Data for model evaluation were obtained during 25 years (1992-2017) mainly by the closed chamber method. We applied two different modeling approaches, where one model assumes a fixed N2O/N2 ratio for N2O production and neglects the transport of N2O in the soil profile; whereas the other model explicitly considers N2O transport and assumes a dynamic reduction of N2O to N2

Generally, the modeling approaches were able to describe the observed long-term and seasonal dynamics of N2O emissions and events of higher N2O emissions due to increased denitrification activity after heavy precipitation and during thawing after soil freezing. It is concluded that the decrease of frost thaw-events due to higher temperatures during the cold season is the main reason for the decrease of N2O from the agricultural fields at the research farm Scheyern.

Including future accelerated erosion on a process-based carbon modelling framework

Emanuele, Lugato, Pete, Smith; Pasquale, Borrelli; Panos, Panagos; Cristiano, Ballabio; Alberto, Orgiazzi; Oihane, Fernandez-Ugalde; Luca, Montanarella; Arwyn, Jones

Email: emanuele.lugato@ec.europa.eu
Affiliation: EU Commission – JRC

Abstract

Process knowledge understanding of soil organic carbon (SOC) turnover is confounded by C feedbacks driven by soil erosion, not yet fully explored at large scale. However, in a changing climate, variation in rainfall erosivity (and hence soil erosion) may change the amount of C displacement, hence inducing feedbacks onto the land C cycle. Using a consistent biogeochemistry-erosion model framework to quantify the impact of future climate on the C cycle, we show that C input increases were almost entirely offset by higher heterotrophic respiration under climate change. Taking into account all the additional C fluxes due to displacement by erosion, we estimated a net source of 0.92-10.1 Tg C yr-1 from EU agricultural soils to the atmosphere, over the period 2016-2100. The accelerated erosion scenario resulted in 35% more eroded C than a simulation with current erosion rates, but its feedback on the C cycle was marginal. Our results challenge the idea that higher erosion driven by climate will lead to a significant C sink in the next future.

Lower-fidelity surrogate models for the numerical analysis of transport processes in variably-saturated porous media

Giuseppe Brunetti and Jirka Šimůnek

Email: giusep.bru@gmail.com
Affiliation: Universität für Bodenkultur, BOKU

Abstract

Many engineering related problems involve the use of computationally expensive physically-based models, which, however, are unsuited for model calibration frameworks requiring thousands of model executions. Lower-Fidelity Surrogate Modeling (LFSM) focuses on developing and using cheaper-to-run surrogates of the original simulation by simplifying the physics of the problem and reducing the model complexity. Despite their widespread use in other disciplines, their application to vadose zone related problems is still limited and unexploited. In this study, we present two recent applications of LSFM to agricultural and geothermal problems. In particular, we focus on the development of two pseudo-3D models for the numerical analysis of flow and transport in furrow irrigation/fertigation systems and transport processes in borehole heat exchangers. Both models involve the simplification of the governing equations and a dimensionality reduction to cut the computational cost while maintaining a satisfactory accuracy. In the furrow model, overland flow and solute transport in the open channel are approximated by the one-dimensional zero-inertia and advection equations, respectively, while the subsurface processes are assumed to be two-dimensional. A similar approach is used to describe water flow and heat transport in the borehole heat exchanger and the surrounding soil domain. The validation of the developed surrogate models against measured data from two experimental facilities in US and Japan confirms the accuracy of the modeling assumptions and opens new perspectives in the use of LFSM in vadose zone related problems.

Modeling the effects of litter stoichiometry and soil mineral N availability on soil organic matter formation

Haicheng Zhang, Daniel S. Goll; Stefano Manzoni; Philippe Ciais; Bertrand Guenet; Yuanyuan Huang

Email: haicheng.zhang@lsce.ipsl.fr
Affiliation: Le Laboratoire des Sciences du Climat et de l'Environnement,
　　　　　　IPSL-LSCE CEA/CNRS/UVSQ Saclay, Gif-sur-Yvette, France

Abstract

Land surface models used to study the C cycle rarely considered flexibility in the fraction of decomposed litter-C that is retained as SOM (as opposed to be respired) that is, a flexible decomposer C use efficiency (CUE). In this study, we adapted a model derived from optimal theory that assumes that litter decomposer communities adjust their CUE_d as a function of litter substrate C to nitrogen (N) stoichiometry to maximize their growth rates. This formulation is suitable for use in global land surface models. The validation of the new formulation of CUE is performed on data from laboratory incubation experiments. Results indicate that the model with flexible CUE gave significantly better prediction on the respiration rate of litter with different C:N ratios under different levels of mineral N availability, compared to a model with fixed CUE. Based on idealized simulations, we illustrate how litter quality affects SOM formation. Litter with a small C:N ratio tends to form a larger SOM pool than litter with larger C:N ratios, as it can be more efficiently processed by microorganisms. This study provides a simple but effective tool to quantify the effect of varying litter quality (N content) on SOM formation across scales. Optimality theory appears to be suitable to predict complex processes of litter decomposition into soil C, that are of importance to better understand how plant residues and manure could be harnessed to achieve soil C sequestration for climate mitigation.

Linking functional structural plant models with root water uptake models in earth system models.

<u>Jan Vanderborght</u>, Valentin Couvreur, Mathieu Javaux, Andrea Schnepf, Felicien Meunier, and Mauro Sulis

Email: j.vanderborght@fz-juelich.de
Affiliation: Agrosphere Institute, IBG 3,
 Forschungszentrum Jülich GmbH, Germany

Abstract

By coupling root architecture models with models that simulate flow and transport processes in the soil and root system, functional-structural plant models (FSPMs) are obtained. FSPM link the structure and properties of the plant to its functions, among which root water and nutrient uptake, which are important functions of the vegetation in the terrestrial systems. However, there is a large scale gap between water and nutrient flow towards a single root segment and the exchange processes between the land surface and the atmosphere that are represented in earth system models (ESM). In this contribution, we present different approaches that have been proposed to bridge this scale gap and analyze whether and how these differences influence the relations between simulated state variables and fluxes in ESMs. We also discuss how the different upscaling approaches influence the relation between the functional-structural properties of the root system and the vegetation parameters of ESMs.

Combining snowmelt and soil erosion modeling

Jannes Stolte and Torsten Starkloff

Email: jannes.stolte@nibio.no
Affiliation: NIBIO

Abstract

In cold climate regions, a significant fraction of annual soil erosion in agricultural land occurs in springtime during the snowmelt period, partly because of the occurrence of frozen soils and rainfall. Physically based and spatially distributed soil erosion models have proved to be good tools for understanding the processes occurring at catchment scale during rainfall erosion. However, most existing erosion models do not represent the snow dynamics properly. We have used a combined model approach by using the UEBGrid snow pack model and the LISEM soil erosion model for a catchment in Norway. Applying this model combination to simulate surface runoff and soil erosion showed that it is possible to satisfactorily simulate surface runoff and observed soil erosion patterns during winter. However, by using a combined model, many uncertainties in parameter estimations remained, making the calibration procedure difficult. Since both models are physical based, the need for a considerable amount of parameters is evident. This implies that, in order to produce good results, detailed meteorological, soil, plant and terrain parameters are required.

The soil-to-ocean dissolved organic carbon flux: developing component models for an Earth System model

Kasia, Sawicka, Ed C., Rowe; Tom R., Anderson; Christopher D.G., Barry; Douglas B., Clark; Christopher D., Evans; Don, Monteith; Amy E., Pickard; Bryan M., Spears; Jennifer L. Williamson

Email: katwic55@ceh.ac.uk
Affiliation: Centre for Ecology & Hydrology

Abstract

Dissolved organic carbon (DOC) fluxes from soil to aquatic systems are significant and increasing components of the global C cycle, influenced by land use change and atmospheric pollution, but are poorly represented in current Earth System models. The NERC-funded LOCATE (Land Ocean Carbon Transfer) project has developed a conceptual framework for aquatic DOC modelling which distinguishes compounds (T1) that are aromatic, coloured, strongly UV-absorbing and photolabile, and are derived only from topsoil, from compounds (T2) that are weakly or not UV-absorbing, and are derived from subsoil as well. We present two soil models to supply this framework with T1 and T2 fluxes into the aquatic system. An empirical statistical model predicts these fluxes as a function of precipitation, temperature, sulphur deposition, soil type and acid buffering capacity. A dynamic approach is currently in development, representing key processes: influences of pH and/or ionic-strength on DOC dissolution; effects of rainfall and soil hydrology on flow pathways through the soil profile; and effects of anthropogenic drivers such as nitrogen deposition on plant productivity, decomposition and DOM formation. Comparisons with large-catchment DOC flux observations suggest that the empirical approach is a good predictor for upland UK systems, and demonstrate the need to include sewage-derived DOC in lowland systems. The process-based approach is more generic, and so has potential to represent a wider range of systems across the globe. The models have been designed to work within JULES, the terrestrial component of the UK's Earth System Model, and to use only widely-available data.

The effects of soil nutrient processes on the dynamics of soil organic carbon: insights from the JSM model

Lin Yu, Bernhard, Ahrens; Thomas, Wutzler; Marion, Schrumpf; Sönke, Zaehle

Email: lyu@bgc-jena.mpg.de
Affiliation: Max-Planck Institute for Biogeochemistry

Abstract

Jena Soil Model (JSM) has been developing to simulate the dynamics of soil organic carbon (SOC) .It heritages the main features of the SOC model, COMISSION model (Arhens et al. 2015), which includes a continuous representation of SOC in the organic layer and the mineral soil, microbial interactions and sorptive stabilization. Compared with the original COMISSION, necessary soil processes of nitrogen (N) and phosphorus (P) have been included. In addition, enzyme allocations to different depolymerisation sources in JSM are optimized on the best investment-return rate of the most limiting elements (C, N, or P) of microbes; and the nutrient (N, P) acquisitions of plant, microbes, and soil adsorption sites (of phosphate) are simulated based on their relative competitiveness.

In this study, we calibrated the model against published soil organic matter data and performed model-experiments to invest the effects of nutrient processes on SOC dynamics. The model will be coupled with vegetation model in future, and the ultimate goal is to replace the soil module of current Earth System Models. "

Soil Salinity and Sodicity Modeling: impact of small scale processes on larger scale effects

Sjoerd E.A.T.M. van der Zee, Chunming Sui, Anton Leijnse, Pavan Cornelissen

Email: sjoerd.vanderzee@wur.nl
Affiliation: Wageningen University

Abstract

Soil salinity and sodicity are among the oldest soil and groundwater pollution examples. Where salinity affects a.o. crop water uptake, sodicity may additionally cause poorly reversible soil structure deterioration. Many models exist that address these two problems, such as UNSATCHEM and HYDRUS-1D. Inspired by soil physico-chemical theory by e.g. Bolt, Bresler, and Russo, these models have adopted a quite phenomenological approach to soil swell-shrink behaviour and in particular its effect on the soil hydraulic conductivity, if the Exchangable Sodium Percentage ESP increases too much. Though this approach is founded in experimental work, the current implementation leaves room for debate. This debate is needed, because parsimonious approaches of so-called mixed rootzone ecohydrological models (Rodriquez-Iturbe and Porporato, 2004) fail for sodicity modeling (Van Der Zee et al., 2014). Yet, much more complexity is still not well compatible with landscape and larger modeling. In this contribution, HYDRUS-1D is used to model salt and sodium accumulation, taking nonlinear cation exchange into account. These simulations revealed a number of shortcomings in the current way with which these processes are accounted for. These concern not only the way that the negative feedback on hydraulic conductivity is modeled, but also, for instance, the complexity to accommodate ploughing in such software. Remarkably, the simulations also reveal that the interplay between soil chemistry, soil physics, soil mechanics (as far as swell-shrink behaviour is concerned) and fluctuating conditions may lead to very regular behaviour.

Permafrost, peat and frozen soils

Geomorphic feedbacks limit ice wedge degradation in the high Arctic

Abolt, Charles, Young, Michael; Atchley, Adam; Harp, Dylan; Coon, Ethan

Email: chuck.abolt@beg.utexas.edu
Affiliation: Department of Geological Sciences,
            The University of Texas at Austin

Abstract

Pan-Arctic ice wedge degradation, leading to widespread development of high-centered polygon topography, has accelerated abruptly in the past three decades. This rapid geomorphic change profoundly alters tundra hydrology and influences carbon exchange between the ground and atmosphere. However, the pathways by which ice wedges degrade and the stability of high-centered polygons as geomorphic endmembers are incompletely understood, complicating efforts to project future landscape function. Here we use a modeling-based approach, informed by field observations, to investigate the role of geomorphic feedbacks on ice wedge degradation. We find that positive feedbacks related to trough inundation are weak and brought about by a different mechanism than previously assumed. In contrast, negative feedbacks on thaw decrease the sensitivity of partially degraded ice wedges to warm air temperatures. We conclude that recently developed high-centered polygons are durable landscape features. Climate projections should account for their long-term influence on mobilization of soil organic carbon.

The Canadian Model for Peatlands (CaMP): a national-scale peatland carbon accounting model

Cindy, Shaw, Kelly, Bona; Dan, Thompson; Gary, Zhang; Mihai, Voicu; Kara, Webster; Jagtar, Bhatti; Werner, Kurz

Email: cindy.shaw@canada.ca
Affiliation: Canadian Forest Service,
           Natural Resources Canada

Abstract

The Canadian Model for Peatlands (CaMP) was developed to address growing international pressure on Canada to better account for greenhouse gas emissions from peatlands in national and international reporting. The CaMP was designed as a module for the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) that is used to report on greenhouse gas emissions from Canada's managed forest area. This presentation will describe the CaMP emphasizing features developed specifically for peatland carbon accounting that are additional to the CBM-CFS3. These include descriptions of peatland types that are modelled and how they are represented in space across Canada, representation of a long-term and annually fluctuating water table, productivity of different vegetation layers including moss types, sedges, shrubs and small trees, their decay, and transfer between carbon pools. Preliminary results for CO_2 and CH_4 emissions from different peatland types will be shown. Future versions of the model will include anthropogenic (e.g., oil and gas development) and natural (e.g., wildfire) disturbances, effects of edaphic and climatic factors, and permafrost thaw.

Advances in hydrological modelling of drained peatlands

Evelyn Wallor, Niko, Roßkopf; Andreas, Herrmann; Jutta, Zeitz

Email: evelyn.wallor@zalf.de
Affiliation: Leibniz Centre for Agricultural Landscape Research (ZALF)

Abstract

Process-modelling of hydrological dynamics in drained and cultivated fen soil profiles is essential for a precise calculation of greenhouse gas emissions. Until now, several estimation procedures exist, basically depending on site-specific conditions like land-use, vegetation, water table and fen soil type. To some extent these approaches are vulnerable to under- and overestimation of local greenhouse gas emissions by neglecting heterogeneous properties along fen soil profiles potentially differing from horizon to horizon. Hydrological modelling of water dynamics in fen soils characterised by a progressed moorsh-forming process is restricted due to a lack of valid parameters describing available water retention functions. In the present study, a general applicable parameter set to solve the van Genuchten-Mualem water retention equation for fen soil horizons formed by drainage and cultivation has been developed based on a comprehensive dataset consisting of 405 horizontal data from fen soil profiles sampled at altogether 15 peatland areas in Germany. Different categorizations of the data were checked to account for various states of peat decomposition and to reduce the range of measured volumetric soil water contents at specific pressure heads. Finally, bulk density was used as a cluster variable to consider the intensity of moorsh-forming process within every horizon category. Subsequent parameter estimation was conducted by the RETC programme and validation of the estimated parameters was realized for in total four monitoring plots varying in land-use type, climate and fen soil profile, by modelling water dynamics using HYDRUS-1d.

Active layer thickness and soil carbon content in a continuous permafrost region in Kangerlussuaq, Greenland

Maud A.J., van Soest, Joanna E., Bullard, N. John, Anderson

Email: a.j.van-soest@lboro.ac.uk
Affiliation: Loughborough University, UK

Abstract

Extreme climate conditions in Arctic ecosystems have a strong influence on soil development as temperature and precipitation are controlling both physical and chemical soil properties. Permafrost affected areas are projected to undergo the greatest impact from global warming, which may have a major effect on soil-forming processes and on how these soils are used and managed. Regional warming is deepening the active layer of soils and thereby altering soil microbiology and nutrient dynamics. The inner part of the Kangerlussuaq area towards the ice sheet is generally characterised with continuous permafrost. However, although some local permafrost mapping for civil engineering purposes has been undertaken, there has been no systematic mapping of permafrost or permafrost-related features across the region. For this study, the active layer depth was measured at five sites along a transect between the modern ice margin and 40 km to the west. The focus was on capturing spatial variability within small lake catchments and the influence of aspect and topography on active layer depth. Soils were characterised in the field and laboratory to determine active layer depth, particle-size, organic matter and carbon content, nutrient content as well as vegetation cover. These data were overlain on the Arctic DEM to identify whether soil characteristics were systematically associated with particular topographic attributes (such as slope gradient, aspect, distance from ice). It is intended that a simple model to explain the spatial heterogeneity of the active layer thickness and soil carbon content can be explored using these relationships.

Modeling responses of groundwater to gullies in the Zoige peatland, China

Peng Gao, Zhiwei Li and Hanyou Lu

Email: pegao@maxwell.syr.edu
Affiliation: Department of Geography, Syracuse University, New York, USA

Abstract

Exactly how groundwater is affected by them is still not fully understood. In this study, we tackled this issue by coupling field measurement with model simulation using Visual MODFLOW. Groundwater processes and the associated water budget in May-September, 2017 were simulated in the Zogie peatland, located on the northeastern side of Qinghai-Tibet Plateau, China. Three peatland areas with a shallow (A1), deep (A2), and no gully (A3) were selected. Required peat parameters, Rainfall (P) and evapotranspiration (E) for modeling were obtained in different ways. MODFLOW produce water volumes and their temporal changes from six hydrological pathways, P, E, surface water, groundwater from a shallow gully (GS), a deep gully (GD), and boundaries, and peat storage water change (ΔS). Over the entire period, GS in A1 was lower than that GD in A2 (only taking 69%), while ΔS in A1 was higher than in A2 and the smallest in A3, suggesting that deep gullies can drain much more groundwater out of peatland and their associated peatlands have high degrees of storage water changes. Further modeling only for no-rain sessions showed (i) a similar result, suggesting that deep gullies generally have higher de-watering effect on peats; and (ii) alteration and reduction of peat storage water in A1 were higher than those in A2 and A3, suggesting water table changes are not only affected by gully disturbance but also E. Our modeling revealed the importance of restoring deep gullies and climate change will continuously deteriorate peat degradation by increasing E values.

Modeling the Space-Time Destiny of Pan-Arctic Permafrost DOC

Simon Bowring, Ronny Lauerwald; Bertrand Guenet; Philippe Ciais

Email: simon.bowring@lsce.ipsl.fr
Affiliation: Laboratoire des Sciences de Climat et de l'Environnement (LSCE/CNRS)

Abstract

Most global climate models inadequately represent the unique permafrost environment and its respective processes, significantly contributing to uncertainty in estimating their responses, and that of the planet at large, to warming. Likewise, the riverine component of what is known as the 'boundless carbon cycle' is seldom recognized in global climate modeling. Hydrological mobilization of organic material to the river network results either in sedimentary settling or atmospheric 'evasion'. Here, the production, transport and atmospheric release of dissolved organic carbon (DOC) from high-latitude permafrost soils into inland waters and the ocean is explicitly represented for the first time in the land surface component (ORCHIDEE) of a CMIP6 global climate model (IPSL). This work merges two schemes that are able to mechanistically simulate complex processes for A) snow, ice and soil phenomena specific to extreme high latitude environments; B) DOC production and lateral transport and atmospheric evasion as CO_2 through soils and the river network, respectively, at 0.5° to 2° resolution. The resulting tool is subjected to a range of parameter testing and inclusion of contentious feedback phenomena (e.g. priming). We present results for the Pan-Arctic, focusing on the Lena River basin, and show that our modeling approach is able to reproduce observed state variables and their emergent properties across a range of interacting bio-rhizo-hydro-cryo –sphere processes. All else equal, rising atmospheric CO_2 feeds back into significant increases in environmental DOC transport via primary production, while warming has a similar effect, but increases the atmospheric evasion component of bulk transported DOC.

Peat water content dynamics in a drier world

Stefano Ferraris, Maurizio Previati; Pietro Teatini; Davide Canone; Davide Gisolo

Email: stefano.ferraris@polito.it
Affiliation : DIST Interuniverity Dept. Politecnico nd University of Turin, ITALY

Abstract

With increasing dry periods because of global warming, the need of studying the drying behaviour of peat is a major issue. In this work, water content dynamics of peat has been monitored in view of validating models. A controlled laboratory experiment was performed on a monolith of approximately 0.7 m3 sampled from a drained cropped peatland located south of Venice, Italy. In the same site it was already done a comparison between a model and field data by Camporese et al. (2006). This further laboratory step is intended to have a larger variation of peat water content, in comparison with the field one.

The collected monolith was transferred to the laboratory and instrumented with tensiometers and TDR in order to monitor the soil-water relations (i.e., MP and VWC content). Also, the variations of the whole monolith weight (i.e., bulk volumetric water content) were measured under drying/wetting cycles and extreme drought conditions.

The results point out a strong spatial and temporal variability of the wetting and drainage processes, which are more evident in peat (especially under stressed conditions) than in mineral soils, because the matrix structure (and texture) of the former may be largely influenced by the original organic source and the dynamic degradation processes. Moreover, retention curve hysteresis was measured for ψ down to -1 m, i.e. in normal field conditions, with wetting and drying curves very far apart, with variability up to 8-10% and a behavior similar to those measured in the field by Camporese et al. (2006).

Modelling Holocene peatland development in north-eastern Scotland.

Ward, Swinnen, Nils, Broothaerts; Gert, Verstraeten

Email: ward.swinnen@kuleuven.be
Affiliation: KU Leuven, Division of Geography and Tourism,
           Department of Earth and Environmental Sciences, Leuven

Abstract

To study long-term peatland dynamics, several models have been developed in recent years. Unfortunately, these modelling efforts have been mostly restricted to peat bogs in arctic and boreal regions. For other peatland types such as blanket peatlands, these modelling tools are largely lacking.

In this study, a spatially-explicit model is presented, allowing to study blanket peatland development and carbon dynamics along topographically complex hillslopes on Holocene timescales. The model incorporates quantitative vegetation and climate reconstructions to study their relative role in peatland dynamics. Calibration and validation is based on a dataset of more than 900 peat thickness measurements along hillslope transects in the headwaters of the river Dee.

The model results indicate that the long-term peatland development is largely driven by hillslope topography, stressing the need for spatial models in peatland studies. The simulations result in early-Holocene peat growth initiation dates, which correspond to the existing radiocarbon dates for peat growth initiation in north-eastern Scotland. The simulated blanket peat growth initiation occurs before the mid-Holocene forest decline, indicating that, for the studied area, the peatland development and consequently the hillslope carbon storage is driven by the early-Holocene increase in temperature and precipitation, rather than by an alteration of the hillslope hydrology due to land cover changes. The model allows to study the sensitivity of blanket peatlands to environmental factors such as land cover and climate, providing a new tool to simulate the response of the Scottish peatlands to the future environmental changes under different change scenarios."

Liquid-Vapor-Air Flow in the Frozen Soil

Yijian Zeng, Lianyu Yu; Bob Su

Email: y.zeng@utwente.nl
Affiliation: ITC Faculty, University of Twente

Abstract

Accurate representing freeze-thaw (FT) process is of great importance in cold region hydrology and climate studies. With the STEMMUS-FT model (Simultaneous Transfer of Energy, Mass and Momentum in Unsaturated Soil), we investigated the coupled water and heat transfer in the variably-saturated frozen soil and the mechanisms of water phase change along with both evaporation and freeze-thaw process, at a typical meadow ecosystem over Tibetan Plateau. The STEMMUS-FT showed its capability of depicting the simultaneous movement of soil moisture and heat flow in frozen soil. The comparison of different parameterizations of soil thermal conductivity indicated that the de Vries's parameterization performed better than others in reproducing the hydrothermal dynamics of frozen soils. The analysis of water/vapor fluxes indicated that both the liquid water and vapor fluxes moved upward to the freezing front and highlighted the crucial role of water vapor fluxes during soil freeze-thaw cycles. Although the soil air pressure induced liquid/vapor fluxes play a negligible role in the total mass transfer, the interactive effect of soil ice and air can be found on the spatial and temporal variations of water/vapor transfer.

New Perspectives on the Modeling of Colloidal Particle Fate in Soils

Solute and colloid transport in unimodal and bimodal porous media

Bechet Beatrice, Lamy Edvina, Lassabatere Laurent, Andrieu Hervé

Email: beatrice.bechet@ifsttar.fr
Affiliation: IFSTTAR Nantes

Abstract

The coupled role of water saturation and pore size distribution of the porous media on deposition has not yet been systematically studied in the literature. The aim of this study was to investigate the influence of the pore size distribution on both solute and colloid transport. This influence has been studied under saturated and unsaturated flow conditions. Packed column experiments and mathematical modeling studies were performed on three porous media: a reference sandy medium with an unimodal pore size distribution; a macroporous medium created by the insertion of an artificial macropore in the center of a sandy column (bimodal pore size distribution medium); and an aggregate porous media with a inter-porosity between grains and a high intra-porosity of the grains. Experiments were carried out under chemically unfavorable conditions for colloid attachment to solid-water interfaces, using negatively charged latex microspheres (1 μm) to focus the study on colloid entrapment. The breakthrough data of solutes and colloids were measured and simulated using the HYDRUS-1D code, for which a specific methodology was proposed to account for two-region flow regionalization. Transport parameters for the mobile-immobile model (MIM) were determined by fitting HYDRUS numerical to observed tracer BTCs. The analyses of experimental and modeling results were conducted to assess the role of the pore-size distribution on the transport processes under both saturated and unsaturated conditions.

Modeling Episodic Release and Transport of Colloids and Colloid-Facilitated Contaminants with Transients in Solution Chemistry and Water Saturation

Bradford, Scott Alan and Simunek, Jirka

Email: scott.bradford@ars.usda.gov
Affiliation: United States Department of Agriculture,
Agricultural Research Service, US Salinity Laboratory

Abstract

Most colloid (e.g., clays, microorganisms, and nanoparticles) and colloid-facilitated transport studies have been conducted under steady-state water flow and saturation, and solution chemistry conditions. Results typically suggest limited mobility of colloids and contaminants in the subsurface because of retention to solid-water and air-water interfaces. Retention is well known to be sensitive to a wide variety of physical, chemical, and microbiological factors that may vary temporally in the subsurface environment. This presentation demonstrates the sensitivity of colloid and colloid-facilitated transport to transient solution chemistry (ionic strength, pH, and cation type), input concentration, and water velocity and saturation conditions. The conventional first-order detachment model cannot describe this behavior. We present a mathematical modeling framework that relates colloid release under transient conditions to changes in the solid-water and air-water interfacial areas that contribute to retention. Methods to predict these interfacial areas are demonstrated. Equilibrium and/or kinetic expressions for release with transients are developed and utilized to simulate colloid and colloid-facility release and transport over a wide range of conditions. Experimental and modeling results indicate that episodic colloid and colloid-facilitated transport in the subsurface is expected because of transient conditions.

Combined colloid transport modeling and time-lapse magnetic resonance imaging: a novel tool to appraise and improve models of colloid transport in soils.

Eric, Michel, Alizée, Lehoux; Pamela Faure; François Lafolie; Denis Courtier-Murias; Stéphane Rodts; Philippe Coussot

Email: eric.michel@inra.fr
National Institute for Agricultural Research, France

Abstract

The mechanisms of colloid transport, deposition and mobilization in the soil are often studied by means of column scale transport experiments and inferred from breakthrough curves (colloid concentration vs. time) measured in the column effluents. It is not possible to observe the process taking place inside the soil, and the columns act like black box systems.

Magnetic resonance imaging (MRI) is an appealing technique to open these black boxes: it is sensitive to the presence of colloids and can record within minute signal profiles inside decimeter-sized columns. In simple experimental situations, MRI profiles can be converted into colloid concentration profiles using ad hoc calibration curves. The space- and time-resolved concentration values are subsequently confronted with model outputs. In most environmentally relevant situations, the MRI data are complex and this convertion is not possible.

In this presentation, we show that it is nevertheless possible to take full advantage of these data by first computing a modeled MRI signal from the outputs of a colloid transport model and then comparing the modeled and experimental signal. We apply this method to MRI data recorded during colloid transport experiments performed in increasingly complex porous media ranging from saturated sand columns to undisturbed and unsaturated soil cores. In each situation we discuss how the combined MRI – modeling approach constitutes a powerful tool to test the model hypotheses, determine model parameters by inverse modeling and finally improve our understanding and modeling ability of colloid fate in soils.

Soil organic carbon dynamics modeling

Improvement of soil carbon scheme in a terrestrial ecosystem model for climate impact assessment

Akihiko, Ito, Motoko, Inatomi; Kazuya, Nishina; Tomohiro, Hajiam

Email: itoh@nies.go.jp
Affiliation: National Institute for Environmental Studies

Abstract

In terms of climate impact assessment, modeling of soil organic carbon (SOC) dynamics is critically important. In the Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP), we have assessed the future change in global SOC under different emission and climate scenarios and found that biome models differ greatly in the responsiveness to prescribed warming. We have developed a process-based model of terrestrial ecosystem, called VISIT (Vegetation Integrative SImulator for Trace gases), which includes a simple box-flow type soil carbon scheme. Obviously, the decomposition coefficient and its temperature sensitivity (regionally, moisture sensitivity) are critical parameters, but they were not adequately constrained by observations in most models. In this study, we compared SOC dynamics simulated by VISIT model using soil schemes with different complexities. The simplest one consists of two pools (detritus and humus) and rather complex one is composed on nine pools (six litter and detritus and three humus). We perform a sensitivity analysis on the temperature sensitivity parameter, for which we have used the Lloyd-Taylor type parameterization, considering the recent findings on the relationship between SOC stability and temperature sensitivity. Also, we assess the impact of SOC displacement by water erosion on ecosystem carbon budget. Finally, the simulated global distribution of SOC is compared with recent fine-mesh datasets. Since the model is incorporated into an Earth System Model, elucidating the SOC behavior is important to interpret the climate–carbon cycle feedback.

Control of encounter frequency on microbial dynamics and pesticide degradation from µm to cm scales

Alexandre Coche, Tristan, Babey; Alain, Rapaport; Laure, Vieublé-Gonod; Patricia, Garnier; Jean-Raynald, de Dreuzy

Email: alexandre.coche@univ-rennes1.fr
Affiliation: Univ Rennes

Abstract

Soil microorganisms perform several major ecosystem functions by degrading soil organic carbon. Deciphering the implied mechanisms at microbial spatiotemporal scales is a key point to understand the variability of soil functions at larger scales. Encounter between bacteria and their substrates appears to be particularly relevant in soils, where substrate and bacteria localizations can be highly heterogeneous and sparse.

The objective of this work is to formalize how spatiotemporal organizations control encounter and thus biodegradation of soluble organic µ-pollutants such as 2,4-D.

We develop several reactive transport models at µm-to-cm scale (Babey et al., 2017) aimed at investigating the impacts of initial localizations and concentrations of 2,4-D and its bacterial degraders on its biodegradation, under several transport processes. Sorption, diffusion, advection, and microbial processes are calibrated on cm-scale experiments performed on the degradation of 2,4-D in natural repacked soil cores (Pinheiro et al., 2015, Pinheiro et al., submitted).

In a context where 2,4-D can diffuse but bacteria cannot, passive advection-dispersion of 2,4-D and its degraders cannot explain the steep increase in 2,4-D degradation efficiency observed in irrigated experiments. This lack of effect of bacteria dispersal can be explained by a higher dilution of 2,4-D concentrations perceived by dispersed degraders, entirely counterbalancing the lower competition for the substrate.

Monod model gives a relation between the local substrate concentration, proportional to the frequency of encounter, and the effective degradation. Different parametrization of Monod model can lead both to very similar or very divergent biodegradation efficiencies, depending on the conditions of encounter.

Predicting gradations and transitions among organic and mineral soils using OPRAS, a dynamic model of sorption, aggregation and hypoxia

Edwin C Rowe and Edward Tipping

Email: ecro@ceh.ac.uk
Affiliation: Centre for Ecology & Hydrology

Abstract

To be generalisable, models must be based on representations of real mechanisms. We make use of emerging thinking that site conditions mainly determine organic matter protection to derive a dynamic model based on key energetic and molecular mechanisms. Organic matter is made inaccessible to oxidative degradation principally through: a) sorption, which hinders access by enzymes; b) micro-scale encapsulation within aggregates, which slows the diffusion of enzymes and of electron-acceptors; and c) meso-scale hypoxia, which reduces the energetic return from decomposition. An equilibrium model (also presented in this session) based on these concepts is here extended into a dynamic version that includes a simple treatment of climatic and soil texture controls on soil redox, allowing simulation of the development of and transitions among mineral, organomineral and peat soils. The model represents hypotheses that 1) the main influence on the formation and stability of organic soils is waterlogging, through a large precipitation surplus and/or impeded drainage; and 2) the C content of well-drained mineral soils is mainly determined by sorptive capacity, a function of fine-mineral content, and by aggregation, which is affected by soil management. The model can reproduce distributions of peat, mineral and organomineral soils across the UK using only limited texture and climate data. Scenario runs are used to explore effects of climate and management change on carbon stock in more organic soils, and show small net effects of climate change due to opposite effects of increased temperature and increased precipitation, but large effects of drainage or rewetting.

Explaining soil organic matter composition based on associations between OM and polyvalent cations

Ellerbrock, Ruth H. and Gerke, Horst H.

Email: rellerbrock@zalf.de
Affiliation: ZALF Müncheberg; PB1 HYP;
           Eberswalderstrasse 84; 15374 Müncheberg; Germany

Abstract

Organic matter (OM) is characterized by functional groups. Interactions between such functional groups and polyvalent cations could perhaps explain site-specific composition of soil organic matter (SOM). The objective of this study was to test a simplified model for the interactions between OM and polyvalent cations. The model considered (i) OM-cation, (ii) OM-cation-mineral, and (iii) OM-mineral associations and assumed the availability of the cation's coordination sites for the interaction with OM to depend on the type of association. The test was carried out using data from differently fertilized plots from three long-term field experiments. The composition of SOM and a pyrophosphate soluble fraction (OM-PY) was characterized by the relationship of the ratio of C=O versus C-O-C absorption band intensities obtained from the Fourier transform infrared (FTIR) spectra and compared with the content of exchangeable, oxalate-, and dithionite-extractable polyvalent cations. The assumed associations between the OM and cations and the availability of the coordination sites explained most of the variations in the C=O/C-O-C ratios of the SOM, and fewer variations in the OM-PY, when using the site-specific exchangeable and oxalate-extractable cation contents. The C=O/C-O-C ratios of the OM-PY were site-independent for samples from plots that regularly received farmyard manure. The results suggested that a simplified model that considers the polyvalent cation content weighted by the number of coordination sites per cation according to the type of association could be used to improve the explanation of site-specific differences in the OM composition of arable soils.

The importance of initializing soils in models for simulating the effect of tillage on N2O and SOC

Femke, Lutz, Steve, Del Grosso; Stephen Ogle; Christoph Müller; Jetse Stoorgvogel; Sara Minoli; Susanne Rolinski

Email: femke.lutz@wur.nl
Affiliation: Wageningen University;
             Potsdam Institute for Climate Impact Studies

Abstract

Tillage practices are often applied for weed suppression, incorporation of residues, soil aeriation and improving plant access to water. The resulting changes in physical properties have an effect on soil moisture and temperature, which affect several chemical processes such as global greenhouse (GHG) emissions. No-tillage is often suggested as mitigation strategy to reduce GHG emissions and to increase soil organic carbon (SOC). Many modeling and experimental studies have been conducted to evaluate the effects of no-tillage on GHG and SOC. Models need to be initialized, e.g. soil nitrogen and carbon pools, so that impacts of management change on ecosystem processes can be reliably represented. When operating at the field level, the initialization can be site specific, whereas for global simulations assumptions have to be made. However, the uncertainty of the initialization setting is rarely quantified and may be a significant contributor to the overall uncertainty in these applications. In this study, we evaluate different methods for initialization to assess the impacts of tillage on N2O and SOC. Therefore, the ecosystem models LPJmL and Daycent together with results from experimental studies are used to 1) estimate SOC and N2O emissions under tillage and no-tillage in global simulation settings, 2) estimate SOC and N2O emissions under tillage and no-tillage after initializing soil pools to observations and 3) compare effects of tillage vs. no-tillage on SOC and N2O in the global-initialization setting vs. site-specific initialization settings in simulations and against measured data. Preliminary results of this study will be demonstrated.

Spatial control of carbon dynamics in soil by microbial consortia

Holger, Pagel, Björn, Kriesche; Marie, Uksa; Christian, Poll; Ellen, Kandeler; Volker, Schmidt; Thilo, Streck

Email: holgerp@uni-hohenheim.de
Affiliation: Biogeophysics, Institute of Soil Science and Land evaluation,
          University of Hohenheim

Abstract

Integrating trait-based approaches to describe microbial and enzyme dynamics in macroscopic soil organic matter (SOM) models gained momentum to improve the understanding and prediction of C fluxes in response to environmental and climate change. At the same time, microscopic observations and pore scale models are increasingly used to quantify and elucidate the effect of soil heterogeneity on microbial processes. These developments empower capturing and predicting the emergence of spatial and temporal variability of microbial processes from small-scale microbial-physicochemical interactions in soil.

This study aims to quantify the control of carbon dynamics in soil by the small-scale distribution of microbial consortia in soil. We developed a new spatially explicit trait-based model that captures the combined dynamics of microbes and SOM considering features such as microbial life-history traits and dormancy as well as SOM accessibility. We performed Monte-Carlo scenario simulations for sets of spatial distributions of microbes that differ in small-scale spatial heterogeneity and functional composition of the microbial community. Realizations of spatial distributions of microbes were set up using a spatial statistical model based on Log Gaussian Cox Processes which was originally used by Raynaud and Nunan (2014) for the analysis of distributions of bacterial cells in soil thin sections.

Results of the simulations will provide a quantitative measure how strong the small-scale distribution of microbial consortia affects SOM turnover and shall give further insight into the spatial regulation of microbial processes in soil.

sModel-based Assessment of Grazing Impact on Soil Carbon Stocks and Dynamics of a Kenyan Rangeland

Kate Kuntu-Blankson, Rolf,Sommer; Ronald, F. Kuhne; Ilona, Gluecks; Sylvia, Nyawira; Johannes, Isselstein

Email: abapokuaa@gmail.com
Affiliation: Georg-August-Universitat Goettingen, Dept. of Crop Sciences:
         Forage Production and Grassland Management, Germany

Abstract

Significant increases in atmospheric carbon concentrations is a major driver of global warming and climate change. As the largest terrestrial ecosystem carbon sink, soils store approximately 2500 Pg. C in the upper 2 m depth. Rangelands, make up more than 40% of the global land surface and contain about 30% of global terrestrial soil organic carbon (SOC). Under proper grazing management conditions, rangelands have the potential to sequester significant amounts of additional carbon, and hence offset anthropogenic carbon emissions and contribute to mitigating climate change. Due to the heterogeneity of rangelands

worldwide and notable scarcity of data in particular in Africa, attempts to estimate the impact of grazing effects on carbon in these ecosystems are a challenge. Hence, recommendations for management across different regions cannot be made. In this work, we used the DAYCENT ecosystem model to study SOC stock dynamics for a rangeland in Eastern Kenya. Operated as a livestock ranch with wildlife grazing as background noise, vegetation in this area is a mix of C4 grasses and a few stands of acacia trees and shrubs. The effects of two soil types -sandy and clayey - and varying levels of grazing management

- high, moderate and light long-term grazing intensities based on percentage removal of standing biomass - on SOC dynamics and sequestration potentials over a period of 15 to 20 years were estimated. The presentation will summarise major results of this study and will provide recommendations on grazing regime strategies for rangeland policy planning in the East-African region."

Modelling crop yields, soil carbon stocks and greenhouse gas fluxes in sugarcane in Southeastern Brazil

Marcelo Galdos, Iracema Degaspari; Steve Williams; Steve DelGrosso; Keith Paustian; Heitor Cantarella

Email: m.galdos@leeds.ac.uk
Affiliation: University of Leeds

Abstract

Sugarcane-derived bioethanol is an important renewable energy source in the Brazilian transport sector. As pre-harvest burning is phased out, large quantities of straw are left on the soil. However, there is little information on the impact of sugarcane crop residues on crop yields, soil carbon stocks, and soil greenhouse gas emissions. Our objective was to use a field experiment and the Daycent Model to assess carbon storage in the crop and soil, and CO_2 and N_2O emissions from a sugarcane field, under different straw and nitrogen fertilizer rates. We conducted a field study in southeastern Brazil including plant cane in the 2013-2014 cropping season and two ratoon crops in the 2015-16 and 2016-17 seasons with three rates of mineral nitrogen fertilizer (0, 60 and 120 kg N ha-1) in and 14 Mg ha 1 of straw. The equilibrium period was simulated as Atlantic Forest vegetation, the previous land use. Nitrogen application in the presence of straw increased soil N_2O emissions, and leaving straw on the soil surface increased soil carbon stocks. These trends were represented accurately in the Daycent model. Our results highlight the importance of measuring and modelling both GHG fluxes and soil C dynamics in assessing the environmental and agronomic aspects of bioenergy cropping systems.

Modelling depth profiles of total organic carbon, δ13C and Δ14C using a mechanistic approach by separation of the rhizosphere and the mineral soil

Marijn Van de Broek, Marion, Schrumpf; Bernhard, Ahrens; Gerard, Govers

Email: Marijn.vandebroek@usys.ethz.ch
Affiliation: ETH Zürich

Abstract

"Over the past decades, our understanding of soil organic carbon (SOC) cycling has evolved to one where its persistence is mainly due to physical and chemical protection mechanisms. In line with this understanding, microbial-driven SOC models that explicitly account for these protection mechanisms have been developed during the past years. In general, however, these models are more complex compared to more simple, traditional SOC models. Therefore, additional calibration criteria are needed to successfully validate these models. While 14C has been widely used to calibrate and validate SOC models, stable carbon isotopes (δ13C) have to date not been used for the calibration of a mechanistic SOC model.

Therefore, we developed a microbial-driven SOC model which simulates depth profiles of total SOC, δ13C and Δ14C. The novelty of this model is that it separates SOC processes in the rhizosphere (with fast OC cycling due to high C inputs and limited protection mechanisms) and the mineral soil (with slow OC cycling due to the protection by organo-mineral interactions). Furthermore, the physical protection of OC in aggregates is simulated while microbial residues can be stabilized on mineral surfaces. The simulated depth profiles of δ13C reflect the increasing contribution of microbial residues to SOC with depth. In addition, simulated subsoil OC has a high age, while respired CO_2 has a modern 14C signature, in line with empirical observations. The proposed model allows to test hypotheses related to the response of SOC to environmental factors, through effects on microbial dynamics and preservation mechanisms of SOC.

Modelling moisture controls on soil organic carbon decomposition

Marleen, Pallandt, Bernhard, Ahrens; Holger, Lange; Marion, Schrumpf; Sönke, Zaehle; Markus, Reichstein

Email: mpalla@bgc-jena.mpg.de
Affiliation: Max Planck Institute for Biogeochemistry, Jena

Abstract

Soil carbon (C) is the largest terrestrial C pool, and even small relative changes in soil C stocks have large consequences for future release or removal of C to or from the atmosphere. There is a strong need for soil biogeochemistry models that reflect current process understanding to accurately represent the response of soil C to environmental change (e.g. Wieder, 2014). The feedback between climate and the turnover of C is strongly dependent on the hydrological cycle (Carvalhais et al., 2014), but large scale, model representations of the sensitivity of soil C to soil moisture, through decomposition and interactions with nutrient cycles, are largely semi-empirical and uncertain. Microbial decomposition rates are affected by soil temperature and soil moisture simultaneously through enzyme, substrate, and oxygen availability at the decomposition reaction site. In addition, different decomposition processes are likely affected in different ways (e.g. oxidizing reactions versus depolymerizations versus sorption). We present a modelling framework to investigate differences in top- and subsoil moisture changes as simulated by land surface models and its consequences for the different decomposition processes and the resulting emergent behaviour. For this purpose, we calibrated the DAMM model (Davidson et al. 2014) at multiple sites with high resolution time series of soil moisture, temperature and respiration data. We apply the resulting soil moisture rate modifier to vertical soil moisture gradients as simulated by land surface models to investigate whether soil moisture can have diverging effects on decomposition within a soil profile.

Impact of climatic factors on soil organic carbon stocks is soil and site specific in different United States ecoregions.

Mishra, Umakant, Daniel, Potma; Skye, Wills

Email: umishra@anl.gov
Affiliation: Argonne National Laboratory

Abstract

Soils are the largest carbon reservoir in terrestrial ecosystems, comprising about 1500 Pg to 1 m depth. Understanding of environmental controllers on soil carbon storage and dynamics is critical to reduce the uncertainty in predicting carbon climate feedbacks under changing environmental conditions. In the present study, we explored the effect of climatic variables, land cover types, topographic attributes, and bedrock geology types on soil carbon stocks (0 – 100 cm) in 20 North American ecoregions (EPA level II Ecoregions). Using 4558 soil profile data (RACA dataset) and high-resolution environmental data of soil forming factors, we identified dominant environmental controllers of soil carbon stocks in each ecoregion. Among 33 environmental variables we tested, 10 were dominant controllers in all ecoregions. The adjusted R^2 of the selected model, with 10 environmental controllers, in testing dataset was 0.5. Higher precipitation and lower temperatures were associated with higher levels of SOC stocks in 15 and 14 ecoregions, respectively. The impact of mean surface air temperature on SOC stocks was higher in Atlantic Highlands and Appalachian Forests. The impact of mean precipitation on SOC stocks was higher in Mediterranean California and Cold Deserts. Our results indicate that the impact of mean surface air temperature on soil carbon stocks is ecoregion specific. We hope our observed environmental controllers of SOC stocks may help to predict the impacts of changing environmental conditions on soil carbon stocks more reliably.

Coupling digital soil mapping and soil biogeochemical model for simulating national soil organic carbon dynamics under future climate scenarios

Songchao Chen, Manuel P. Martin; Nicolas P.A. Saby; Christian Walter; Dominique Arrouays

Email: songchao.chen@inra.fr
Affiliation: INRA Unité InfoSol

Abstract

There has been a growing interest in monitoring soil organic carbon (SOC) given its important role in delivering ecosystem services. Besides, soil is the largest carbon pool in terrestrial ecosystem thus the dynamic of SOC can significantly alter the atmospheric CO2 concentration as well as the global carbon cycling. Climate conditions strongly influence the rates and trends of SOC accumulation and transformation, thus it is an important issue to assess the dynamics of SOC under the context of global warming. At national and continental scales, models used to predict SOC changes under future climate scenarios can be divided into two groups: empirico-statistical model (digital soil mapping) and process-based model (soil biogeochemical model). Here we couple digital soil mapping and soil biogeochemical model to simulate national SOC dynamics under future climate scenarios. Assuming that land uses remains constant over time, CENTURY is used to simulate SOC stocks on a systematic grid of monitoring sites (sampling year around 2006) under two climate scenarios (RCP2.6 and RCP8.5) and for agricultural lands till 2100. Within the framework of digital soil mapping, a hybrid model integrating gradient boosted machines and geostatistics is used to map the spatial distribution of SOC for agricultural land at 2006 and 2100. The changes of SOC stocks between 2006 and 2100 are estimated under these two climate scenarios.

Effects of soil process formalisms and forcing factors on simulated organic carbon depth-distributions in soils

Sophie Cornu, Saba, Keyvanshokouhi; François, Lafolie; Jérôme, Balesdent; Bertrand, Guenet; Nicolas, Moitrier; Nathalie, Moitrier; Cédric, Nougier; Peter, Finke

Email: Sophie.Cornu@inra.fr
Affiliation: Aix-Marseille Univ, CNRS, IRD, Coll de France,
         INRA, CEREGE, Aix en Provence, France

Abstract

Soil OC sequestration is being considered as a possible solution to mitigate climate change, notably through land use change and tillage reduction. Subsoil horizons (from 30 cm to 1 meter) contribute to half the total amount of soil OC. Therefore, the slow dynamics of deep OC and the relationships between the OC depth distribution and changes in land use and tillage practices need to be modelled.

We developed a fully modular, mechanistic OC depth distribution model, OC-VGEN. This model includes OC dynamics, plant development, transfer of water, gas and heat, mixing by bioturbation and tillage as processes and climate and land use as boundary conditions. OC-VGEN allowed us to test the impact of 1) different numerical representations of root depth distribution, decomposition coefficients and bioturbation; 2) evolution of forcing factors such as land use, agricultural practices and climate on OC depth distribution at the century scale.

We used the model to simulate decadal to century time scale experiments in Luvisols with different land uses and tillage practices as well as projection scenarios of climate and land use at the horizon of 2100. We showed that, among the different tested formalisms/parametrizations: 1) the sensitivity of the simulated OC depth distribution to the tested numerical representations depended on the considered land use; 2) different numerical representations may accurately fit past soil OC evolution while leading to different OC stock predictions when tested for future forcing conditions (change of land use, tillage practice or climate).

Connecting the land with inland waters: Erosion-induced lateral SOC fluxes

Victoria, Naipal, Philippe, Ciais; Ronny, Lauerwald; Bertrand, Guenet; Yilong, Wang;

Email: victoria.naipal@lsce.ipsl.fr
Affiliation: Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA

Abstract

Currently, the introduction of lateral fluxes of carbon and nutrients in Land Surface Models (LSMs) is seen as an important step in linking the terrestrial- and aquatic carbon cycles and hereby reducing the uncertainty in the terrestrial carbon sink. Accelerated soil erosion, transport and deposition are important processes that drive these lateral fluxes on land. However, including soil erosion and the resulting redistribution of soil organic carbon (SOC) in LSMs is a challenge due to the fine scales on which they usually occur.

The aim of our study is to assess the impacts of lateral SOC fluxes by erosion on the terrestrial carbon budget using a process-based modeling approach that does not require the incorporation of soil erosion processes in LSMs. For this we use an emulator that represents the carbon cycle of ORCHIDEE LSM and is able to reduce the computational time of the complex LSM significantly. We couple this emulator to an adjusted version of the Revised Universal Soil Loss Equation (RUSLE) model that is scaled to be applicable at large spatial scales. This spatially explicit modeling approach runs at a 5 arc-minute resolution and a daily time-step. To evaluate the model we apply it on the Rhine catchment for the period 1850-2005, and investigate the effects of past soil erosion, deposition and transport on the SOC stocks and profiles.