AGU CHAPMAN CONFERENCE

Biosphere II, Tucson, Arizona, USA | 21–24 October 2013

Soil-mediated Drivers of Coupled Biogeochemical and Hydrological Processes Across Scales

AGU Chapman Conference on Soil-mediated Drivers of Coupled Biogeochemical and Hydrological Processes Across Scales

Biosphere II, Tucson, AZ, USA
21–24 October 2013

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Note: Attendees at the Chapman conference may be photographed by AGU for archival and marketing purposes. No photography will be permitted during scientific sessions.

Poster Presentation Guidelines

Poster sessions are active on Monday, 21 October, 5:00 P.M.-6:30 P.M., and Tuesday, 22 October, 4:00 P.M.-6:00 P.M.

The poster dimensions are 4 feet high by 8 feet wide. The size of posters should be not more than 4 feet wide by 4 feet wide to allow two (2) presenters to utilize one posterboard on each side. All boards will be marked with the appropriate poster number and category.

Those presenting their posters on Monday are asked to set up their posters on Sunday, 20 October. Posters must be removed by 6:30 P.M. on Monday, 21 October.

Those presenting their posters on Tuesday are asked to set up their posters on Tuesday morning, 22 October before sessions resume. Posters must be removed by 6:00 P.M. on Tuesday, 22 October.

Basic poster supplies will be available for your use. If you have special supply needs, please remember to bring them with you to Biosphere 2.

Thank You to Our Sponsors

The conveners wish to acknowledge the generous support for this conference from our sponsors.

AGU Chapman Conference on Soil-mediated Drivers of Coupled Biogeochemical and Hydrological Processes Across Scales

Meeting At A Glance

Sunday, 20 October

6:00 P.M.-6:30 P.M.	Welcome Reception (B2 Café/Patio)
6:30 P.M.-7:30 P.M.	Dinner (B2 Café/Patio)

Monday, 21 October

7:00 A.M.- 8:00 A.M.	Continental Breakfast (B2 Café/Patio)
8:00 A.M.- 8:05 A.M.	Welcome Address: Joaquin Ruiz, Director, Biosphere 2 and Dean, College of Science (Sahara)
8:05 A.M.- 8:30 A.M	Introduction by Conveners (Sahara)
8:30 A.M.-10:00 A.M.	Session I: Coupled Abiotic-biotic Drivers of Organic Matter and Nutrient Transformations and Transport Across Terrestrial-aquatic Interfaces I (Sahara)
10:00 A.M.-10:30 A.M.	Morning Break (Sahara)
10:30 A.M.-12:00 P.M.	Session II: Coupled Abiotic-biotic Drivers of Organic Matter and Nutrient Transformations and Transport Across Terrestrial-aquatic Interfaces II (Sahara)
12:00 P.M.-1:30 P.M.	Lunch (B2 Café/Patio)
1:30 P.M.-3:00 P.M.	Session III: Gas Flux Exchange in Soil-Plant Systems I (Sahara)
3:00 P.M.-3:30 P.M.	Afternoon Break (Sahara)
3:30 P.M.-5:00 P.M.	Session IV: Gas Flux Exchange in Soil-Plant Systems II (Sahara)
5:00 P.M.-6:30 P.M.	Poster Session (Lower Habitat Plaza)
6:30 P.M.-7:30 P.M.	Dinner (Lower Habitat Exhibit Hall)

Tuesday, 22 October

7:30 A.M.- 8:30 A.M.	Continental Breakfast (B2 Café/Patio)
8:30 A.M.-10:00 A.M.	Session I: Monitoring Strategies of Soil-mediated Processes and Drivers from Local to Catchment Scales over Time I (Sahara)
10:00 A.M.-10:30 A.M.	Morning Break (Sahara)
10:30 A.M.-12:00 P.M.	Session II: Monitoring Strategies of Soil-mediated Processes and Drivers from Local to Catchment Scales over Time I (Sahara)
12:00 P.M.-1:30 P.M.	Lunch (B2 Café/Patio)
1:30 P.M.-3:30 P.M.	Breakout Sessions (Sahara Room, B2 Café Patio, Gobi Room, High Rise Gallery, Casitas 1900 and 500)
3:30 P.M.-4:00 P.M.	Afternoon Break (Sahara)
4:00 P.M.-6:00 P.M.	Poster Session (Lower Habitat Plaza)
6:00 P.M.-7:00 P.M.	Dinner (Lower Habitat Exhibit Hall)

Wednesday, 23 October

7:30 A.M.- 8:30 A.M.	Continental Breakfast (B2 Café/Patio)
8:30 A.M.-10:00 A.M.	Session I: Soil Resource as a Primary Driver of Ecosystem Services I (Sahara)
10:00 A.M.-10:30 A.M.	Morning Break (Sahara)
10:30 A.M.-12:00 P.M.	Session II: Soil Resource as a Primary Driver of Ecosystem Services II (Sahara)
12:00 P.M.-1:30 P.M.	Lunch (B2 Café/Patio)
1:30 P.M.-3:30 P.M.	Visit to Landscape Evolution Observatory, Biosphere 2, or Free Time
3:30 P.M.-4:00 P.M.	Afternoon Break (Sahara)
4:00 P.M.-6:00 P.M.	Breakout Sessions (Sahara Room, B2 Café Patio, Gobi Room, High Rise Gallery, Casitas 1900 and 500)
6:00 P.M.-8:00 P.M.	Conference Banquet (Lower Habitat Exhibit Hall)

Thursday, 24 October

7:30 A.M.- 9:00 A.M.	Continental Breakfast (B2 Café/Patio)
9:00 A.M.-10:30 A.M.	Group Reporting and Synthesis (Sahara)
10:30 A.M.-11:00 A.M.	Morning Break (Sahara)
11:00 A.M.-12:30 P.M.	Wrap-up in Plenum
12:30 P.M.-1:30 P.M.	Lunch (B2 Café/Patio)
1:30 P.M.	Adjourn

SCIENTIFIC PROGRAM

SUNDAY, 20 OCTOBER

6:00 p.m. – 6:30 p.m. **Welcome Reception**

6:30 p.m. – 7:30 p.m. **Dinner**

MONDAY, 21 OCTOBER

7:00 a.m. – 8:00 a.m. **Continental Breakfast (Monday)**

8:00 a.m. – 8:05 a.m. **Welcome Address: Joaquin Ruiz, Director, Biosphere 2 and Dean, College of Science**

8:05 a.m. – 8:30 a.m. **Introduction by Conveners**

Coupled Abiotic-biotic Drivers of Organic Matter and Nutrient Transformations and Transport Across Terrestrial-aquatic Interfaces I - Oral
Sahara Room

8:30 a.m. – 9:00 a.m. **Claudia M. Boot** | Linking Lability and Composition of Dissolved Organic Matter Across the Terrestrial-Aquatic Interface *(Invited)*

9:00 a.m. – 9:15 a.m. **Rebecca Martin** | Hydrologic Controls of DOM Export From Agricultural Soil to Surface Water via Tile Drainage: The Roles of Flow Path and Processing

9:15 a.m. – 9:30 a.m. **Eve-Lyn S. Hinckley** | The Critical Zone as a Driver of Ecosystem N Retention and Transport in the Colorado Front Range

9:30 a.m. – 10:00 a.m. **Jonathan Sanderman** | Linking soils and streams: production, consumption, transformation and export of dissolved organic matter in two contrasting watersheds *(Invited)*

10:00 a.m. – 10:30 a.m. **Morning Break (Monday)**

Coupled Abiotic-biotic Drivers of Organic Matter and Nutrient Transformations and Transport Across Terrestrial-aquatic Interfaces II - Oral

Sahara Room

10:30 a.m. – 10:45 a.m.	**Philippe Baveye** | Fate of terrestrial carbon: We need to start at the microscopic scale
10:45 a.m. – 11:00 a.m.	**Taniya Roy Chowdhury** | Role of Geochemical and Microbially Driven Processes in Carbon Dynamics in Arctic Ecosystems
11:00 a.m. – 11:30 a.m.	**Rose M. Cory** | Going to the dark side: a novel pathway for abiotic oxidation of dissolved organic matter in arctic soil waters *(Invited)*
11:30 a.m. – 11:45 a.m.	**Jessica Davies** | Modelling Nutrient Transformations Through The Critical Zone: From Atmosphere To Plants, Soils To Stream At The Regional Scale

12:00 p.m. – 1:30 p.m. **Group Lunch (Monday)**

Gas Flux Exchange in Soil-plant Systems I - Oral

Presiding: Nicolas Bruggemann, Peter A. Troch

Sahara Room

1:30 p.m. – 2:00 p.m.	**Markus Reichstein** | Soil, climate extremes and the carbon cycle *(Invited)*
2:00 p.m. – 2:30 p.m.	**Dan Yakir** | Carbonyl sulfide (COS), a tracer to separate soil form canopy CO2 exchange *(Invited)*
2:30 p.m. – 2:45 p.m.	**Kadmiel Maseyk** | Soil, plant and ecosystem COS flux measurements: observations of a new tracer of the carbon cycle
2:45 p.m. – 3:00 p.m.	**Claire L. Phillips** | Using Radiocarbon to Investigate Soil Respiration Impacts on Atmospheric CO2

3:00 p.m. – 3:30 p.m. **Afternoon Break (Monday)**

Gas Flux Exchange in Soil-plant Systems II - Oral

Sahara Room

3:30 p.m. – 4:00 p.m.	**Jerome Ogee** | Global estimates of land photosynthesis inferred from the global budget of $\delta^{18}O$ in atmospheric CO_2: the crucial role of soil microorganisms *(Invited)*
4:00 p.m. – 4:30 p.m.	**Lisa Wingate** | Seasonal contribution of soil CO_2 invasion to the total $CO^{18}O$ flux from a pine forest ecosystem *(Invited)*
4:30 p.m. – 4:45 p.m.	**David D. Breshears** | Beyond the Big-leaf Homogeneity Assumption in Evapotranspiration Partitioning: Factoring in Canopy Cover Heterogeneity

4:45 p.m. – 5:00 p.m. **Sadredin Moosavi** | Use of a Selective Inhibitor Technique Reveals Controls on Hidden CH4 Biogeochemical Cycling Along Soil Moisture Gradients From Wetland to Upland in Boreal & Arctic Soils

5:00 p.m. – 6:30 p.m. **Coupled Abiotic-biotic Drivers of Organic Matter and Nutrient Transformations and Transport Across Terrestrial-aquatic Interfaces - Posters**

Lower Habitat Plaza

M-1 **Ling Ou** | Carbon sequestration of Louisiana crawfish ponds sediment

M-2 **Deb Jaisi** | A REVERSE PATHWAY OF PHOSPHORUS CYCLING IN AGRICULTURAL SOILS

M-3 **Kizhur Sandeep** | Soil-Sediment Linkages in the Catchment area of Lakes in Southern India

M-4 **Michael Schmidt** | Geochemical tools to infer charring temperature, aromaticity and the degree of condensation of fire-derived organic matter in soil, water, and sediment - a method comparison

M-5 **Praveen Kumar** | Passive Regulation of Soil Biogeochemical Cycling by Root Water Transport

M-6 **Owen P. McKenna** | Geomorphic controls over Nitrogen and Carbon Stocks in Desert Playas

M-7 **Linda H. Pardo** | A hydropedological approach to identifying sources and sinks of nitrogen in a steep, headwater catchment using nitrogen and oxygen isotopes

M-8 **Steven Hall** | Synergies Among Oxygen and Iron in the Carbon Cycle of Humid Tropical Forest Soils

M-9 **Steven Sadro** | The influence landscape position and catchment characteristics on the biogeochemistry of high-elevation lake-chains

M-10 **Scott W. Bailey** | Influence of landscape position and transient water table on soil development and carbon distribution in a steep, headwater catchment

M-11 **Michael Nguyen** | Probing Temperature-Dependent Organo-FeOx Interactions Using Quartz Crystal Microgravimetry, NMR Spectroscopy, and Thermal Analyses

M-12 **Carrie-Ellen Gabriel** | Examining physical and biological controls of SOM stability through depth in harvested red spruce forest soils

Kate M. Buckeridge | Spring thaw vegetation leachate does not stimulate soil microbial activity in Arctic thermokarst soils

M-13 **Asmeret A. Berhe** | Erosion of soil carbon and nitrogen in low-order catchments in the Sierra Nevada

M-14 **Dragos G. Zaharescu** | Role of Ecosystem Development in Rare Elements Cycling in an Ultra-oligotrophic System at Biosphere-2

M-15 **Ciaran J. Harman** | PERTH and the Dynamic Age Function: A theoretical and experimental framework for understanding residence and transit times in transient, complex flows

M-16 **Jennifer K. Presler** | Chemical Signatures of Biological Colonization in a Model Ecosystem

M-17 **Joshua Koch** | Runoff sources and flowpaths in a partially burned, upland, boreal catchment

M-18 **Fox Peterson** | Forest Composition links Soil SOM and DOC to ANPP in Complex Terrain

M-19 **Rebecca Lybrand** | Climate and landscape position controls on soil carbon cycling in the Santa Catalina Critical Zone Observatory

M-20 **David P. Huber** | Climate Controls on Soil Hydrological and Nutrient Partitioning in Dryland Ecosystems

5:00 p.m. – 6:30 p.m. **Gas Flux Exchange in Soil-plant Systems - Posters**

Lower Habitat Plaza

M-21 **Zhongwen Bao** | Numerical Analysis on the Factors Influencing the Soil/Atmosphere Diffusive Exchange of Persistent Organic Compounds

M-22 **Darin J. Law** | Evapotranspiration Partitioning: Competition between abiotic and biotic components of the water budget

M-23 **Guo-Yue Niu** | A Microbial Enzyme Based Soil Organic Carbon (SOC) Decomposition Model for Use in Climate Models

M-24 **Zachary M. Subin** | Representing the Effects of Hillslope-Scale Hydrology on Soil Carbon Distributions within an Earth System Model

M-25 **Samuel Dunn** | Production, consumption, and transport of methane in alpine and sub-alpine wetlands as a function of plant species

M-26 **Laura Gangi** | Identifying and quantifying determinants of the oxygen isotopic exchange between soil water and CO_2 by combining laser-based spectroscopy and gas-permeable tubing

M-27 **Stephan Glatzel** | Methane controls the greenhouse gas budget of rewetting fens

Anne E. Kelly | Deep soils allow anomalously high productivity and limit summer drought stress in California conifer forests

M-28 **Luke A. Pangle** | Climate-warming impacts on water and carbon fluxes in a seasonally semi-arid grassland ecosystem

M-29 **Katherine M. Powell** | Links between soil water availability and soil respiration in semi-arid ecosystems along the Colorado Front Range

M-30 **Shiliang Wu** | Interactions between Anthropogenic and Soil Emissions of Nitrogen Oxides

6:30 p.m. – 7:30 p.m. **Dinner (Monday)**

TUESDAY, 22 OCTOBER

7:30 a.m. – 8:30 a.m. **Continental Breakfast (Tuesday)**

Monitoring Strategies of Soil-mediated Processes and Drivers from Local to Catchment Scales Over Time I - Oral
Presiding: Yakov Pachepsky, Harry Vereecken
Sahara Room

8:30 a.m. – 9:00 a.m. **Guenter Bloeschl** | From the local to the catchment scale: challenges and ways forward *(Invited)*

9:00 a.m. – 9:30 a.m. **Jeffrey J. McDonnell** | The importance of boundary conditions on water flow and residence time at the hillslope scale *(Invited)*

9:30 a.m. – 9:45 a.m. **Willemijn M. Appels** | The role of soil depth, bedrock permeability, and lateral flow on hillslope groundwater recharge patterns

9:45 a.m. – 10:00 a.m. **Mark S. Seyfried** | Soil Temperature and Water Dynamics on Contrasting Aspects in the Rain-Snow Transition Zone at Reynolds Creek

10:00 a.m. – 10:30 a.m. **Morning Break (Tuesday)**

Monitoring Strategies of Soil-mediated Processes and Drivers from Local to Catchment Scales Over Time II - Oral
Sahara Room

10:30 a.m. – 11:00 a.m. **James W. Kirchner** | Universal fractal scaling in stream chemistry and its implications for solute transport and water quality trend detection *(Invited)*

11:00 a.m. – 11:30 a.m. **Peter A. Troch** | The Landscape Evolution Observatory (LEO) at Biosphere 2: Opportunities for collaborative Earth system research in a controlled environment *(Invited)*

11:30 a.m. – 11:45 a.m. **Jessica M. Driscoll** | Role of storage on hydrologic and chemical flux in soil-limited alpine catchments in the Southwestern USA

11:45 a.m. – 12:00 p.m. **Christoph Hinz** | State transitions in the artificial catchment Huehnerwasser (Chicken Creek): Ecosystems development 8 years after initialisation

12:00 p.m. – 1:30 p.m. **Group Lunch (Tuesday)**

1:30 p.m. – 3:30 p.m. **Breakout Sessions (Tuesday)**
Sahara Room, B2 Café Patio, Gobi Room, High Rise Gallery, Casitas 1900 and 500

3:30 p.m. – 4:00 p.m. **Afternoon Break (Tuesday)**

4:00 p.m. – 6:00 p.m. **Monitoring Strategies of Soil-mediated Processes and Drivers from Local to Catchment Scales Over Time - Poster**
Lower Habitat Plaza

T-1 **Wolfgang Schaaf** | Using the constructed catchment Chicken Creek to disentangle feedbacks between soils, surface structures, vegetation and hydrology during initial ecosystem development

T-2 **Michael P. Stockinger** | Active Catchment Area as a Controlling Factor of Spatial Patterns of Transit Time Distributions in a Small, Forested Catchment

T-3 **Adrian A. Harpold** | Snowmelt Infiltration Dynamics in Seasonally Snow-Covered Areas of the Western U.S

T-4 **Colin S. Campbell** | Effects of changing rainfall patterns on soil moisture storage and plant canopy dynamics in a subalpine meadow

T-5 **Damiano Pasetto** | Soil water potential assimilation to reconstruct saturated hydraulic conductivity at the Landscape Evolution Observatory

T-6 **Sebastian Gebler** | Modelling soil moisture patterns with ParFlow-CLM: A comparison of high resolution model simulations with a sensor network

T-7 **Min Chen** | Investigating the Role of Vegetation and Soil Moisture in Land Surface Hydrology

T-8 **Karl Vanderlinden** | Soil Water Diffusivity Estimation from Distributed Water Content Observations across a Rainfed Olive Orchard

T-9 **Eleni Yeshaneh** | Temporal Variation of Suspended Sediment Transport in the Koga Catchment, North Western Ethiopia and Environmental Implications

T-10 **Robert A. Root** | Toxic metal(loid) speciation is controlled by iron mineral (bio)weathering in phytostabilized mine tailings

T-11 **Yakov Pachepsky** | Modeling Flow and Transport in Field Soil with Pedotransfer and Scaling

T-12 **Alexander M. Yakirevich** | Augmentation of Monitoring Networks Using Information Theory and Ensemble Modeling with Pedotransfer Functions

T-13 **Elisabeth Bui** | Net redistribution of Cs-137 provides evidence of continental-scale interaction between hydrological and biogeochemical processes

T-14 **Ethan Kyzivat** | Stable Water Isotope Analysis of Subsurface Flow in Artificial Hillslopes

T-15 **Mark Seyfried** | Reynolds Creek Carbon Critical Zone Observatory: Improving prediction of soil carbon storage and flux from the pedon to the landscape scale

T-16 **Matthew C. Reid** | Gas Exchange in the Wetland Rhizosphere: Quantifying Spatial and Temporal Variability at Field Scales with Dissolved Gas Tracer Experiments

T-17 **Xavier Zapata-Rios** | PEDON SCALE SOIL MOISTURE AND WATER FLUXES DYNAMICS DURING EXTREMELY DRY YEARS IN A HIGH ELEVATION SNOW DOMINATED LANDSCAPE

T-18 **David Pal** | Determining Relationships Between Dissolved Hydrogen and Methane Porewater Concentrations and Static Chamber Flux Measurements in Vegetated Wetland Soils

T-19 **Ryan D. Stewart** | Improved understanding and prediction of runoff thresholds

T-20 **Kenneth Wacha** | Total Belowground Carbon Allocation in Intensely Managed Landscapes

T-21 **Guo-Yue Niu** | Analysis of an extreme rainfall-runoff event at the Landscape Evolution Observatory by means of a three-dimensional physically-based hydrologic model

T-22 **Anouk Gevaert** | Two-step soil saturation mechanism at hillslope scale

T-23 **Carlotta Scudeler** | Numerical simulations of isotope tracer experiments at the Landscape Evolution Observatory

T-24 **Steffen Klatt** | Assessing water, carbon and nitrogen fluxes on the landscape scale by coupling LandscapeDNDC, a regional multi-ecosystem biogeochemical model to the hydrological model CMF

T-25 **Nicholas Cowan** | A study of nitrous oxide (N2O) emissions on a field and farm scale

T-26 **Alex Furman** | Exploring Root Uptake Under High Frequency Irrigation Using Electrical Resistivity Tomography

T-27 **Rebecca Lever** | Quantifying pyrogenic carbon fluxes and mean residence time in eroding hillslopes

T-28 **John A. Trofymow** | Developing a 100-year Retrospective Carbon Budget for the Sooke Watershed, Vancouver Island, BC

T-29 **Joost L. Van Haren** | CO2 sequestration through weathering of basalt tefra in the Landscape Evolution Observatory (LEO)

T-30 **Tao Ma** | Hydrochemical constituents of interflow compared from artificial experimental monoliths and catchments

T-31 **Iftekhar Ahmed** | Bayesian Inference of Coupled Hydro-Biogeochemical Soil Organic Carbon Loss Model

T-32 **Christopher J. Kelley** | A decade of water and nitrate fluxes from a dryland agricultural headwater catchment: Linking hydrologic and biogeochemical drivers of the soil N cycle

T-33 **Maria Knadel** | Fusing Proximal Sensing Data for Optimal Locations of Soil Moisture Monitoring Stations

T-34 **Christina M. Haberer** | Oxygen transfer in the capillary fringe: Impact of physical heterogeneity and transient flow conditions

4:00 p.m. – 6:00 p.m. **Soil Resource as a Primary Driver of Ecosystem Services - Poster**

Lower Habitat Plaza

T-35 **Hartmut Holländer** | Impact of modellers' decisions on hydrological a priori predictions

T-36 **Sheng Ye** | Derivation of Subsurface Stormflow Parameterization from Regional Analysis of Streamflow Recession Curves: A Possible Climate Dependence?

T-37 **Adam Trueman** | Vegetation as a spatiotemporally heterogeneous control on landscape evolution: A critical zone approach to Landscape Evolution Modelling

T-38 **Jason P. Field** | Bridging from Soil to Ecosystem Goods and Services Provided by the Critical Zone

T-39 **Samuel Prentice** | QUANTIFYING HILLSOPE SOIL THICKNESS USING FINE SCALE TERRAIN MODELLING

T-40 **Carmen Burghelea** | CONTRIBUTION OF ARBUSCULAR MYCORRHIZA TO PLANT UPTAKE OF LITHOGENIC NUTRIENTS IN AN ENCLOSED EXPERIMENTAL ECOSYSTEM AT BIOSPHERE 2

	T-41	**Martha Gebhardt** | Soil biotic indicators for improving native plant establishment in disturbed Southwestern grasslands
	T-42	**Jinsung An** | Chemical speciation of fluorine in solid materials by the combined use of X-ray photoelectron spectroscopy and sequential extraction scheme
	T-43	**Junseok Lee** | Total and soluble fluorine concentrations in soil after occurring hydrogen fluoride spill
	T-44	**Liu Yunjia** | Arsenic Speciation in the Copper Tailings with the Effects of Magnetite Removal
	T-45	**Diane Hagmann** | Effect of heavy metal contamination on selected extracellular enzyme activities in soil
	T-46	**Karin A. Block** | Interaction of Bacteriophage ϕ6 with Montmorillonite and P. syringae Biofilm Aggregates
	T-47	**Adrianna Trusiak** | Disassembly of Phage ϕ6 by Montmorillonite Clay
	T-48	**Michael Young** | Soil development, time, and ecosystem function in water-limited systems

6:00 p.m. – 7:00 p.m. **Dinner (Tuesday)**

WEDNESDAY, 23 OCTOBER

7:30 a.m. – 8:30 a.m. **Continental Breakfast (Wednesday)**

Soil Resource as a Primary Driver of Ecosystem Services I - Oral

Presiding: Michael Young, Dani Or
Sahara Room

8:30 a.m. – 9:00 a.m.	**Hangsheng (Henry) Lin** | New Frameworks for Decoding Complex Soil Systems *(Invited)*
9:00 a.m. – 9:30 a.m.	**Dan O. Breecker** | Soil carbonate accumulation: chemical, biological and physical controls *(Invited)*
9:30 a.m. – 9:45 a.m.	**Chelsea L. Arnold** | Linking loss of water storage capacity in high elevation meadow soils to changes in soil structure and organic matter stock after extreme drought
9:45 a.m. – 10:00 a.m.	**Craig Rasmussen** | Using statistical methods to quantify and predict catchment scale soil variability

10:00 a.m. – 10:30 a.m. **Morning Break (Wednesday)**

Soil Resource as a Primary Driver of Ecosystem Services II - Oral
Sahara Room

10:30 a.m. – 11:00 a.m. **David Dunkerley** | Water partitioning at the dryland soil surface: roles of precipitation intensity variation and plant-mediated water fluxes *(Invited)*

11:00 a.m. – 11:15 a.m. **Elmarie Kotzé** | Influence of rangeland management practises on organic matter contents and aggregation dynamics of clayey soils in the semi-arid grassland biome, South Africa

11:15 a.m. – 11:30 a.m. **Laura Turnbull** | Mechanisms Regulating the Fate of Nitrogen in Drylands

11:30 a.m. – 11:45 a.m. **Ann Tan** | Topographic Influence on Spatial and Temporal Patterns of Grassland Productivity

12:00 p.m. – 1:30 p.m. **Group Lunch (Wednesday)**

1:30 p.m. – 3:30 p.m. **Visit Landscape Evolution Observatory, Bioshere 2 or Free Time**

3:30 p.m. – 4:00 p.m. **Afternoon Break (Wednesday)**

4:00 p.m. – 6:00 p.m. **Breakout Sessions (Wednesday)**
Sahara Room, B2 Café Patio, Gobi Room, High Rise Gallery, Casitas 1900 and 500

6:00 p.m. – 8:00 p.m. **Conference Banquet**

THURSDAY, 24 OCTOBER

7:30 a.m. – 9:00 a.m. **Continentatal Breakfast (Thursday)**

9:00 a.m. – 10:30 a.m. **Group Reporting and Synthesis**

10:30 a.m. – 11:00 a.m. **Morning Break (Thursday)**

11:00 a.m. – 12:30 p.m. **Wrap-up in Plenum**

12:30 p.m. – 1:30 p.m. **Group Lunch (Thursday)**

ABSTRACTS

listed by name of presenter

Ahmed, Iftekhar

Bayesian Inference of Coupled Hydro-Biogeochemical Soil Organic Carbon Loss Model

Ahmed, Iftekhar[1]; Karim, Abdullah[1]; Boutton, Thomas[2]; Strom, Kyle[3]; Fox, James[4]

1. Civil & Environmental Engineering, Prairie View A&M University, Prairie View, TX, USA
2. Ecosystem Science and Management, Texas A&M University, College Station, TX, USA
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The thematic focus of this USDA-CBG collaborative applied research is sustainable integrated monitoring of soil organic carbon (SOC) loss from multi-use lands using state-of-the-art stable isotope science under uncertain hydrologic influences. In this study, SOC loss and water runoff are being monitored on a watershed scale using natural rainfall events, and total organic carbon/nitrogen concentration (TOC/TN) and stable isotope ratio (δ13C, δ15N) measurements with different land-use types on a south Texas urban watershed. This paper investigates the mid-project interdisciplinary research results to uncover practical yet scientific ways to monitor SOC loss by (i) creation of statistical models to assess the relationship between rainfall-runoff and SOC release during soil erosion in space and time, (ii) capturing the episodic nature of rainfall events and its role in the spatial distribution of SOC loss from erosion, (iii) stable isotope composition guided fingerprinting (source and quantity) of SOC by considering various types of erosion processes common in a heterogeneous watershed, to be able to tell what percentage of SOC is lost from various land-use types (Fox and Papanicolaou, 2008), (iv) creating an integrated watershed scale statistical soil loss monitoring model driven by spatial and temporal correlation of flow and stable isotope composition (Ahmed et. al., 2013), and (v) creation of an integrated decision support system (DSS) for sustainable management of SOC under hydrologic uncertainty to assist the end users. References: Ahmed, I, Karim, A., Bouttom, T. W., Strom, K. B. (2013). Monitoring Soil Organic Carbon Loss from Erosion using Stable Isotopes Proc., Soil Carbon Sequestration, May 26-29, Reykjavik, Iceland. Fox, J.F. and Papanicolaou, A.N. (2008). An un-mixing model to study watershed erosion processes. Advances in Water Resources, 31, 96-108.

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An, Jinsung

Chemical speciation of fluorine in solid materials by the combined use of X-ray photoelectron spectroscopy and sequential extraction scheme

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Chemical speciation of fluorine (F) in solid materials should be considered to assess its reliable risk to human and environment. However, studies related to F speciation scheme have not been extensively performed. In this respect, certified reference materials (CRM) with having high fluorine contents (i.e., slag (JK S9) = 17.3%, phosphate rock (Western 694) = 3.2%, Cupola dust (SX62-07) = 0.73%) and plant samples exposed to hydrofluoric acid are analyzed by X-ray photoelectron spectroscopy (XPS) to investigate the different bond type of fluorine in various solid materials. Concurrently, the proportion of fluorine distributed in solid materials is also assessed by sequential chemical extraction (SCE) approach. The combined use of XPS and SCE enable us to assess the fluorine fractionation in various solid materials with different fluorine contamination sources. Acknowledgement This research was supported by a grant from the Korea Basic Science Institute (project No. E33300).

Appels, Willemijn M.

The role of soil depth, bedrock permeability, and lateral flow on hillslope groundwater recharge patterns

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The hillslope scale patterns of groundwater recharge are poorly known. On hillslopes with a thin soil mantle overlying bedrock, complex interactions of percolation of water through the soil, permeability contrasts between the soil and the underlying bedrock and lateral redistribution of water result in large spatial variability of infiltration of water into the bedrock. Here, we combine new measurements and a new modeling approach to investigate how patterns of soil depth, bedrock topography, and bedrock permeability affect those spatial patterns of groundwater recharge. We explore the following questions: what are the effects of the spatial distribution of soil depth and bedrock permeability on groundwater recharge; what are the characteristics lengths of water delivery to, infiltration in, and lateral flow along the bedrock layer; how can we derive spatial distributions of bedrock permeability without stripping away the soil mantle? We focus our work on the well-studied Panola Mountain experimental hillslope site where (sub)surface

topography and soil depth distribution have been collected previously. Here we report new measurements of permeability of the soil mantle immediately above the bedrock and within the bedrock itself to aid the development of a conceptual model to explore how the recharge pattern varies during different precipitation events. We found that the ratio between the rate of water delivery and bedrock permeability controlled the effective fill rate of the depressions in the bedrock topography and the average amount of recharge into the bedrock. By comparison, the run-on distance was mainly determined by the interaction between soil depth distribution and bedrock topography. On the Panola hillslope, the correlation length of the soil depth distribution is larger than that of the bedrock permeability distribution. As a result, the spatial pattern of bedrock permeability was found to shorten run-on distances on the hillslope, most strongly for events with a low water delivery rate.

Arnold, Chelsea L.

Linking loss of water storage capacity in high elevation meadow soils to changes in soil structure and organic matter stock after extreme drought

Arnold, Chelsea L.[1]; Berhe, Asmeret A.[1]; Ghezzehei, Teamrat A.[1]

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High elevation meadow soils provide essential ecosystem services such as filtering, storing and slowly releasing water in mountain watersheds. Extreme dry years can cause the water table in these meadows to drop below historic levels. Drying induced changes in soil structure then follow as a result of consolidation by capillary suction. Subsequently, consolidation leads to loss of macroporosity and water holding capacity in these soils. Utilizing a modified triaxial system, we investigate the historic limit of dryness that meadow soils in the Central Sierra Nevada have experienced in order to determine if the extreme dry summer of 2012 irreversibly changed the structure of meadow soils. We further relate the changes in soil structure and water holding capacity to measured changes in soil organic matter stock during the same time period.

Bailey, Scott W.

Influence of landscape position and transient water table on soil development and carbon distribution in a steep, headwater catchment

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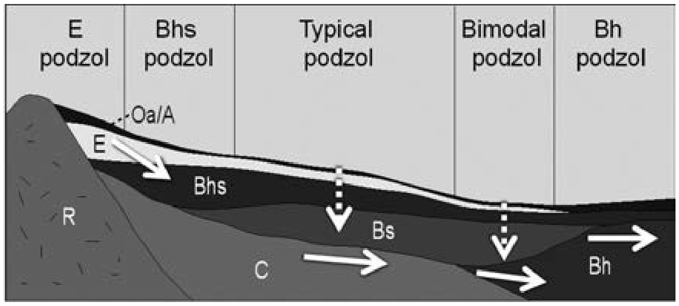
Upland headwater catchments, such as those in the Appalachian Mountain region, are typified by coarse, well-drained soils, flashy hydrologic response, and low stream baseflow, suggesting minimal groundwater storage. Model formulations of soil genesis, nutrient cycling, critical loads and rainfall/runoff are typically based on vertical percolation, soil horizons parallel to the land surface, mineral weathering inputs limited to the rooting zone and drainage from lumped catchment reservoirs (e.g., the subsoil) as the dominant source of stream flow. However, detailed study of the hydrologic reference catchment at Hubbard Brook Experimental Forest, NH, USA shows striking spatial patterns of soil development that reflect the influence of transient water tables within the solum in nearly all landscape positions and transportation of weathering products from deeper in the lithosphere to the rooting zone. Shallow bedrock and variations in hydraulic conductivity promote lateral flow and development of a translocational soil catena at the hillslope scale. We distinguished several soil groups based on presence of diagnostic horizons indicative of differing patterns of podzolization and carbon storage. Typical podzols were found in well drained positions on steep back slopes and spurs and have limited exposure to groundwater in the solum. E, Bhs, and Bh podzols, named for the dominant mineral horizon present, were formed by lateral, hillslope scale processes, each with a distinct frequency and depth of watertable development. Lateral podzols had up to 50% greater carbon content, and higher concentration of metals associated with spodic materials than typical podzols. Dissolved organic carbon concentrations in groundwater varied from 13 mg/L in E-podzols to 1.5 mg/L in Bh-podzols. Spatial patterns in stream chemistry reflect distribution of soils at the subcatchment scale. Modelling shows that precipitation events producing threshold responses in transient watertables in the different soil groups has changed over the 50+ years of the Hubbard Brook record, suggesting a mechanism that could alter the distribution of soils and retention/release of carbon and other solutes over time.



Hydropedologic catena at Hubbard Brook Experimental Forest. Dashed and solid arrows indicate portions of the catena where soil forming processes are controlled by vertical percolation and lateral groundwater flow, respectively.

Bao, Zhongwen

Numerical Analysis on the Factors Influencing the Soil/Atmosphere Diffusive Exchange of Persistent Organic Compounds

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Abstract Soil/atmosphere exchange of persistent organic compounds (POPs) acts as an important transport process influencing the environmental fate of POPs, especially while soils function as a second source via volatilization. Dry/wet deposition from atmosphere to soil and re-volatilization from soil to the atmosphere by diffusion are the major processes. This study focuses on modeling of vapor phase exchange of POPs across the soil/atmosphere interface using the numerical code MIN3P which was validated with analytical solutions. Phenanthrene (Phe) as a representative of hydrophobic legacy compounds was selected to elucidate the relevant processes and parameters influencing soil/atmosphere exchange. Time scales considered in the model amount to 100 a of gas deposition and re-volatilization. Because of the high eddy diffusion coefficients the atmospheric boundary layer is well-mixed and overall fluxes of Phe are limited by the soil side. Temperature variation is a key issue influencing the dynamical exchange of POPs in soil/atmosphere media. Sorption, seepage water flow rates, biodegradation and soil properties (i.e. soil texture, water saturation) are decisive for the concentration gradients which develop during accumulation and re-volatilization. Sorption causes strong retardation of re-volatilization and biodegradation. During the deposition process of Phe, sorption limits the spreading in short term while biodegradation functions in long term after the top soil is fully loaded. Diffusion decides the re-volatilization of Phe due to the increase of temperature. Warming events, such as temperature increase from night to daytime, lead to a release of sorbed phase Phe, an increase of partial pressure. The model goes across the soil/atmosphere boundary and also allows to test sensitivity of the cross compartment fluxes as a function of the dynamic concentration gradients in atmospheric boundary layer (ABL). The conceptual model of 1D soil/atmosphere exchange of Phe is shown in Fig. 1.

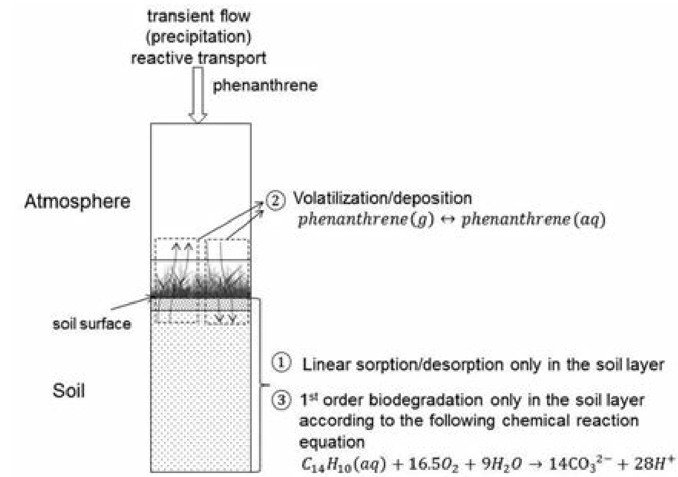

Fig. 1 : Conceptual model of soil/atmosphere exchange of phenanthrene with regions identified

Baveye, Philippe

Fate of terrestrial carbon: We need to start at the microscopic scale

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It is becoming increasingly recognized that soil microbial processes, and the effect of soil structure and water retention on them, need to be described explicitly in any attempt to predict the fate of terrestrial carbon, and the release of CO2 by soils. Current models of soil organic matter dynamics divide soil organic matter into conceptual pools with distinct turnover times, assuming that a combination of biochemical and physical properties control decay without explicit description. Albeit robust in their application, such models are not capable to account for changes in soil structure or microbial populations, or accurately predict the effect of wetness or priming. A new class of carbon fate models is needed, which explicitly accounts for microbial dynamics, physical processes and are spatially explicit to embrace the microscopic heterogeneity in soils. In the case of fungi, we demonstrate how such a model can provide contrasting results to existing approaches. We present a model with spatially explicit representation of microbial and Carbon dynamics, and physical structure to investigate how micro-scale processes manifest at the core scale with particular emphasis on evolution of CO2. The fungal model is based upon previous work by Falconer et al. (2012) and includes the following processes: uptake, translocation, recycling, enzyme production, growth, spread and respiration. The model is parameterised through a combination of literature data and parameter estimation (Cazelles et al., 2012).The Carbon model comprises two pools, particulate organic matter which through enzyme

activity is converted into dissolved organic matter. The fungal and carbon dynamics occur within a 3D soil structure obtained by X-ray CT. In addition Lattice Boltzmann modelling is used to predict the water distribution within soil structures. Results show that CO2 is affected not only by the amount of Carbon in the soil but also by microbial dynamics, soil structure and the spatial distribution of OM. The same amount of OM can result in substantially different respiration rates, with surprisingly more released CO2 associated with increased clustering of OM. With increasing soil C content, respiration increases non-linearly, and more rapidly so above a critical threshold. This type of model is of great benefit towards understanding underground ecology, offering a predictive framework and stimulating hypothesis-driven experimentation. We demonstrate the novel insights that this approach can offer for C dynamics. We discuss the benefits and the challenges that need to be overcome before this class of model can be incorporated in large-scale carbon-climate models. References, Cazelles, K., W. Otten, P.C. Baveye, and R.E. Falconer. 2012. Soil fungal dynamics: Parameterization and sensitivity analysis of modelled physiological processes, soil architecture and carbon distribution. Ecological Modelling 248, 165-173. Falconer, R. E., A. Houston, W. Otten, and P. Baveye. 2012. Emergent behaviour of fungal dynamics: influence of soil architecture and moisture distribution. Soil Science 177 (2), 111-119.

Berhe, Asmeret A.

Erosion of soil carbon and nitrogen in low-order catchments in the Sierra Nevada

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3. University of Nevada, Reno, Reno, NV, USA

Erosion in the Sierra Nevada Mountains transports topsoil, and associated carbon and nitrogen, imposing significant controls on dynamics of soil organic matter (SOM) in the eroding watershed. Recently, the implications of lateral distribution of sediment on carbon (C) and nitrogen (N) dynamics in eroding upland forested ecosystems have been receiving growing recognition. The amount and nature of the eroded C and N exported from eroding watersheds depends on the amount and stability of these essential elements in eroding slope profiles, the type and rate of erosion, and anthropogenic disturbances. Sediment traps located at the point where first-order streams leave the watershed provide insight into the amount and composition of material removed by soil erosion. Here, we will present data on the amount and composition of soil material eroded from eight first-order watersheds in the mixed-conifer zone of the Sierra National Forest in the Kings River Experimental Watershed. Our results show that there is large variability in nature of exported material across eight headwater catchments that is not directly related to watershed size or climatic variability.

Block, Karin A.

Interaction of Bacteriophage ϕ6 with Montmorillonite and P. syringae Biofilm Aggregates

Block, Karin A.[1]; Hawkins, Holly[1]; Trusiak, Adrianna[1]; Katz, Al[2]; Gottlieb, Paul[3]; Alimova, Alexandra[3]; Steiner, Jeffrey C.[1]

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Viruses are important components of soils that control microorganism populations and serve as delivery vehicles for genetic material through transduction. Viruses are known to aggregate with clays, often resulting in virus inactivation. As a result, the interaction between soil minerals, viruses and the microbiome has profound implications in biogeochemical cycling and the health of plants and animals. Bacteriophage ϕ6 is a member of the Cystoviridae family of viruses, the only family of lipid enveloped phage. The ϕ6 host cell is Pseudomonas syringae, a common plant pathogen. Prior work has shown that montmorillonite and P. syringae heteroaggregate and that biofilms form within three hours of mixing the bacteria with montmorillonite. The role of montmorillonite in mediating the infection of P. syringae by ϕ6 is explored by monitoring the survivability of P. syringae after the addition of ϕ6 to suspensions of montmorillonite platelets and P. syringae at different time points. It is observed that when ϕ6 is added to the montmorillonite suspension prior to addition of P. syringae, the ϕ6 phage is inactivated and biofilm growth is comparable to growth without phage. However, when the ϕ6 is added to the montmorillonite suspension after the formation of biofilms (t = 4 h), the ϕ6 retains its infectivity of P. syringae. While the inactivation of ϕ6 by montmorillonite is a result of electrostatic and/or van der Waals interactions between the platelets and phage, in biofilm - montmorillonite heteroaggregates, the biofilm likely limits physical contact between the montmorillonite platelets and virions and thus prevents loss of ϕ6 infectivity.

Bloeschl, Guenter

From the local to the catchment scale: challenges and ways forward *(Invited)*

Bloeschl, Guenter[1]

1. Hydraulic Water R Engineering, Vienna University of Technolog, Vienna, Austria

While the mechanistic, upward modelling approach allows to portray hydrological processes in much detail, coupling these processes across many magnitudes of space and time scales remains a challenge. One way of shedding light on the process interactions across scales is the comparative hydrology approach which aims at learning from the similarities and differences between catchments in different places, and interpreting these in terms of the underlying climate and landscape controls. This presentation will illustrate the comparative hydrology approach by a number of examples of hydrologic response in Austria. The time scales considered range from hours to millennia. In a region in southern Austria, for example, the geology consists of phyllites that are deeply weathered and have led to deep soils and therefore deep flow paths. A complex landscape has evolved with tortuous flow paths both on the hillslopes and in the valleys which in turn retard runoff response and impedes the evolution of an efficient drainage network. In contrast, in a region in Eastern Austria the geology consists of marl and clay which has led to shallower soils and faster flow paths. As a result of frequent convective events in the region and the flashy soil characteristics, the catchment form has adapted to the flashy response and produced an efficient drainage network which in turn enhances the flashiness of the hydrologic response. These are examples of the co-evolution of landform and hydrological processes. These findings are used as the basis for assessing current modelling concepts across space and time scales. Emerging space-time patterns are discussed and how they could be used to assist in hydrological modelling, in particular, to give guidance on suitable model structures and parameter patterns. The role of comparative hydrology in identifying feedbacks and interactions that would be difficult to obtain from point measurements alone is discussed as are advances in measurement strategies across scales.

Boot, Claudia M.

Linking Lability and Composition of Dissolved Organic Matter Across the Terrestrial-Aquatic Interface *(Invited)*

Boot, Claudia M.[1]; Hall, Ed K.[1, 2]

1. NREL, Colorado State University, Fort Collins, CO, USA
2. Fort Collins Science Center, United States Geological Survey, Fort Collins, CO, USA

Terrigenous DOM moves from terrestrial to aquatic habits where it fuels secondary production in a wide range of aquatic habitats. However, at any one time, only a fraction of the DOM pool is accessible to microbes (i.e. labile) and the proportion of labile to recalcitrant DOM varies with abiotic factors including temperature, moisture and nutrient content. In this context, global change, including shifts in seasonality and reactive N inputs, has the potential to alter DOM composition and its associated flux and transformation. To assess the effects of season and reactive N inputs on DOM properties we studied a long-term (15 years) fertilization experiment in old growth sub-alpine forest in, Rocky Mountain National Park. We sought to determine how season and reactive N inputs influenced soil DOM composition and lability in ambient and N fertilized plots. Surface soil samples were collected in July and September, 2012, DOM was extracted and characterized by with a mass spectrometry (MS) based meta-metabolomics approach. Soil extracts were incubated with natural lake bacterial communities and respiration was monitored. Using ultra performance liquid chromatography (UPLC) coupled with MS we measured approximately 3200 features in the soil DOM pool. Principle components analysis indicated season is a stronger driver of DOM composition than fertilization, with PC1 describing 61% of the variability between July and September 2012. Soil DOM from July and September, fertilized and ambient treatments, was incubated with bacterial communities from the adjacent body of water, Loch Vale, to understand how the compositional differences relate their decomposition properties. With this effort to understand the relationship between DOM composition and lability, and how the relationship is influenced by season and N fertilization, we can begin to understand the effects global change factors on C and N dynamics in a sub-alpine ecosystem. These findings can then be used to inform global biogeochemical models, and generate hypothesis to test for universal mechanisms in other ecosystems.

Breecker, Dan O.

Soil carbonate accumulation: chemical, biological and physical controls *(Invited)*

Breecker, Dan O.[1]

1. Geological Sciences, University of Texas at Austin, Austin, TX, USA

Pedogenic calcium carbonate (CaCO3) occurs in soils on nearly half of Earth's land surface. Its accumulation is important for understanding Earth's carbon cycle, the weathering of silicate minerals, the hydrology of dryland soils, soil phosphorous budgets, desertification and paleoenvironmental reconstruction. I discuss recent progress, current challenges and some ideas about advancing the quantification of soil CaCO3 accumulation. Recent work based on stable isotope compositions of soil CaCO3 collectively suggests that accumulation occurs during droughts, typically when the soil is hot and dry. In contrast, simulations using HYDRUS 1D with UNSATCHEM predict soil CaCO3 accumulation under wetter conditions when plants are growing. A current challenge is to resolve this discrepancy, which suggests some process might be missing from the model. Indeed, the model maintains thermodynamic equilibrium whereas dryland vadose and groundwaters are typically supersaturated with respect to calcite. Furthermore, organic matter coatings are known to inhibit calcite precipitation, a process not considered by the model although it has been suggested to explain the observed supersaturation of dryland waters. I suggest that given the abundance of organic matter in soils, such coatings likely inhibit CaCO3 precipitation until drought conditions drive sufficient supersaturation. The idea that organic matter inhibits CaCO3 accumulation leads me to propose a new conceptual model for soil carbon. The model involves a delicate balance between organic and inorganic carbon in which accumulation of one favors decumulation of the other. Organic matter poisons calcite nucleation sites and lowers pH, which inhibits calcite accumulation and favors dissolution. Simultaneously, the presence of solid CaCO3 increases pH, which stabilizes extracelluar oxidative enzymes (OE) and thereby results in efficient decomposition of organic matter. I suggest that this competition occurs vertically within soils, horizontally across landscapes and climatic zones and through time with changes in climate, land use and vegetation. If this model is accurate, then the dynamics of inorganic and organic carbon in soils are best investigated together. This will require an interdisciplinary effort involving vadose zone hydrologists, organic and inorganic geochemists, microbiologists and pedologists. For example, examination of pedogenic CaCO3 surfaces with X-ray photoelectron spectroscopy might indicate the importance, or lack thereof, of organic matter coatings. Studying spatial gradients in microbial community composition and OE activities would also help test the proposed conceptual model. Amending soil physics models to accommodate pedogenically-driven changes in porosity and hydraulic conductivity would advance soil carbon modeling. Comparing simulated with measured temperatures of soil CaCO3 formation would help validate and improve numerical calcic soil models. Coupling numerical models of organic and inorganic carbon might pave the way for accurately simulating past and future changes in soil carbon over much of Earth's land surface. A challenge remains finding the appropriate natural soils and chrono- and climosequences with which to compare model output. Experimental pedology should be considered as one way forward.

Breshears, David D.

Beyond the Big-leaf Homogeneity Assumption in Evapotranspiration Partitioning: Factoring in Canopy Cover Heterogeneity

Breshears, David D.[1]; Villegas, Juan C.[2]; Espleeta, Javier E.[3]; Morrison, Clayton T.[1]; Huxman, Travis E.[4]

1. Univ Arizona, Tucson, AZ, USA
2. Univ de Antioquia, Medellin, Colombia
3. Univ of Washington, Seatle, WA, USA
4. Univ of California - Irvine, Irvine, CA, USA

Whereas quantifying evapotranspiration (ET) was a fundamental environmental advance of the past century, partitioning evapotranspiration into the component processes of soil evaporation (E) and plant transpiration (T) is currently required to improve mechanistic understanding of ecohydrological controls over plant productivity, biogeochemical cycling and climate feedbacks. Existing theory for unpartitioned ET, developed for homogeneous vegetation cover, uses spatial aggregation of vegetation (e.g., via Leaf Area Index—LAI) into a homogeneous "big-leaf". However, in many ecosystems, there is substantial heterogeneity between patches with plants that generate T, and interplant spaces that often generate most E. Given the majority of terrestrial systems are highly heterogeneous, ET partitioning needs alternatives to homogeneity assumption to overcome potentially incorrect estimations of surface-atmosphere exchange. To initiate conceptual discussion, here we hypothesize a framework relating patterns of canopy cover to their influence on ET partitioning via vegetation effects on main E and T drivers. More specifically, we hypothesize that, when holding LAI constant, at low levels of cover increases in canopy cover result in disproportionately high increases in T relative to changes in E, and at higher cover disproportionately low increases in T relative to changes in E occur due to canopy self-shading. Additionally, changes in LAI and other ecosystem characteristics are expected to either amplify or mute the extent of these effects, but are not expected to modify their direction. Collectively, the effects of canopy cover on E and T result on a net effect on either E or T, such that the net partitioning is determined by a combination of canopy cover, canopy architecture, soil water status, and climate. This hypothesized conceptual framework for ET partitioning is consistent with the very limited relevant published data, and suggest that the framework may be applicable across different vegetation types. Overall, our conceptual model highlights that combining canopy cover with previously considered variables into the fundamental approach for ET partitioning is a concept that, while yet not quantitatively developed, merits further discussion and consideration.

Buckeridge, Kate M.

Spring thaw vegetation leachate does not stimulate soil microbial activity in Arctic thermokarst soils

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2. University of Tennessee, Knoxville, TN, USA
3. University of Florida, Gainsville, FL, USA
4. University of California, Santa Barbara, CA, USA

Vegetation leachate is an important stimulant to microbial activity in aquatic systems, but it is not known how this leachate impacts soil microbial activity. We investigated leachate impacts at thaw in a disturbed, nutrient-limited arctic landscape. When upland permafrost thaws, thermokarst (land subsidence as a result of thawing) results in large slope collapse and landscape erosion; such events are increasing with a warming climate. Thermokarst scars are common in the Arctic, allowing us to analyze a chronosequence of ecosystem recovery since disturbance (5, 25, 54 and 150 y). Despite the low nutrient availability in undisturbed arctic tundra, intermediate ecosystem recovery (54 y) is characterized by strongly enhanced above-ground biomass (shrubbiness); the nutrient source for this biomass is unknown. We hypothesized that nutrient inputs from upslope vegetation leachate during the annual spring thaw, combined with differential microbial stimulation between recovery stages could be a potential mechanism contributing to this enhanced aboveground biomass. In winter, we sampled frozen soil cores (n=5) from the surface horizon of each of the 4 recovery stages of the thermokarst chronosequence and from undisturbed tundra directly above the thermokarst scar. In addition, we collected live (dormant) plants and surface litter from the snow-covered undisturbed tundra, with which we made water-extracted (0-2 oC) vegetation leachate. To test the response of soil microbes to thaw pulses of vegetation leachate, we added this leachate (or water) to the frozen soil cores, and stepped them up in temperature from -10 oC to +2 oC over the course of 6 days. During the course of the incubation we measured soil respiration as an indicator of microbial activity. At the end of the incubation we measured changes in microbial biomass and extractable soil C, N and P and soil gross N mineralization. We calculated expected recovery of the leachate C, N and P addition in the microbial and soil pool. Leachate addition had surprisingly little effect on microbial activity, and was much less important than time since thermokarst disturbance for microbial activity and soil nutrient status over thaw. Microbial activity and biomass nutrient contents were highest in the shrubby, intermediate recovery stages. Most of the P in the vegetation leachate was recovered in the microbial biomass, in the older thermokarst soils (i.e. 150 y), indicating these soil microbes were strongly P-limited at thaw. There were no other significant impacts of leachate on microbial activity, microbial C or N, or soil C, N or P pools. Although the leachate provided a substantial input of C, N and P, we suspect leachate quality was poor, as supported by the very low proportion of C added that was respired in the samples with leachate alone. Despite the very large effect that vegetation leachate has on aquatic processes, in this study it provided much less of an impact on soil processes, regardless of the age of the landscape.

Bui, Elisabeth

Net redistribution of Cs-137 provides evidence of continental-scale interaction between hydrological and biogeochemical processes

Bui, Elisabeth[1]; Chappell, Adrian[1]

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Soil redistribution at the Earth surface is a key geomorphological process that is the result of interactions between soil, land, and atmospheric processes. It is most reliably traced by cesium-137 (137Cs) and inventories have been used around the world to estimate net (ca. 30-40 year) soil redistribution by wind, water and tillage, typically at the local scale, since the late 1970s. Recently 137Cs was used to estimate net soil redistribution at the catchment scale for the continent of Australia. Here we use that mapping to provide new insights into the interaction of fluvial and eolian processes over Australia. The Lake Eyre Basin (LEB) in central Australia is at the heart of these interactions. Fluvial processes move eroded soil and sediment down toward Lake Eyre, the lowest point in Australia. Large-scale fluvial activity in the LEB is triggered by La Nina events. During El Nino years, dust-raising wind systems redistribute this sediment from the lake and fluvial beds in the LEB across Australia where it accumulates behind distant forests that act as wind breaks. Soil nutrients in the deposited dust fertilize these forests. Carbon in sediment can be a source of atmospheric CO2 if it decomposes during its journey through the aquatic continuum or in the atmosphere, before it enters the marine environment and becomes a sink of atmospheric CO2. This scale of mapping and large area assessment provides new insights into contemporary geomorphological and biogeochemical processes which can inform current natural resources management issues such as erosion, land use change, and conservation of biodiversity. Erosion of topsoil is not as dire an environmental problem as many suggest. Severe erosion is limited to cropped areas and responds rapidly to soil conservation measures. However, it is clear that agricultural practices need to be carefully managed to minimize erosion loss, especially on highly erodible soils. Extensive areas of contemporary eolian deposition exist that correspond to unique bioregions, characterised by broad, landscape-scale natural features and environmental processes that influence the functions of entire ecosystems. Policy making for biological conservation in Australia to date has not taken account of large-scale spatial biogeochemical cycling patterns and thus is overlooking key processes in the maintenance of healthy functioning ecosystems and biodiversity on this unique dry continent.

Burghelea, Carmen

CONTRIBUTION OF ARBUSCULAR MYCORRHIZA TO PLANT UPTAKE OF LITHOGENIC NUTRIENTS IN AN ENCLOSED EXPERIMENTAL ECOSYSTEM AT BIOSPHERE 2

Burghelea, Carmen[1]; Zaharescu, Dragos[1]; Dontsova, Katerina[1]; Maier, Raina[1]; Chorover, Jon[1]; Huxman, Travis[2]

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Mycorrhizal fungi are microscopic soil organisms living in symbiosis with plant roots; they are capable of regulating resource allocation between abiotic and biotic components in soil/rock-plant systems. They are key players in many ecosystem functions, including nutrient cycling and formation of soil structure. The most common root associated mycorrhizae are the ectomycorrhiza and vesicular arbuscular mycorrhiza (VAM). While ectomycorrhiza has been shown to enhance weathering and bio-uptake of nutrients by actively secreting low molecular organic compounds, the mechanisms of mineral driven weathering by vesicular arbuscular mycorrhiza (VAM) are poorly understood. The present study addresses the role of VAM in lithogenic element uptake by plants growing on nutrient limited mineral substrate. Specifically, we compared the biological uptake of a number of nutrients (P, K, Ca, Mg, Si, Na, Fe, Mn, Cu, Zn, B, Mo, Ni, Co and Al) and trace elements (Ti, V, Se, Sr, Ba, Be, Cr, As, Ag, Cd, Sn, Sb, Tl, Pb) by buffalo grass (Buchloe dactyloides), a perrenial western North American grass. Plants were grown in column experiments on different rock media for 4 months, after which they were sacrificed. The columns contained two types of volcanic rock, basalt and rhyolite, and two types of biological treatment, plants inoculated and uninoculated with VAM (Glomus intraradices). To detect changes in plants uptake of lithogenic elements, the aboveground and belowground biomass was acid digested and analyzed for element concentrations by ICP-MS. We compared the total uptake of elements by biomass of plants infected and non-infected with mycorrhiza for each type of rock. Root-shoot partitioning of elements was also evaluated. The results of this mesocosm experiment showed that buffalo grass was able to grow in the rock without addition of a fertilizer, deriving necessary nutrients from dissolution of the minerals in the rock. Nutrient and trace element uptake by the grass was enhanced when plants were infected with VAM. Differences between mycorrhizal and non-mycorrhizal treatments were significant for both basalt and rhyolite, but elements that had increased uptake differed between the rocks reflecting their mineralogy and elemental composition (Fig 1A & B). Roots accumulated significantly larger amounts of lithogenic elements than the shoots of plants and differences between biomass removal of the elements among VAM and non-VAM treatments were greater for the root uptake. Results of this study indicate that VAM helps grasses grown in nutrient deficient conditions access nutrients needed to satisfy their physiological requirements.

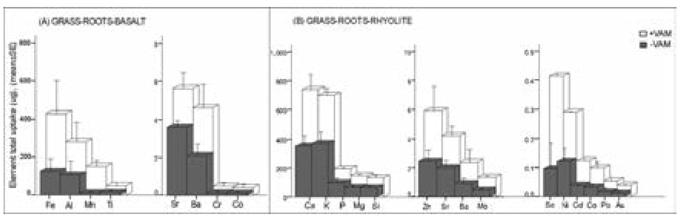

Fig. 1 Comparison of total uptake of lithogenic elements by plants infected with mycorrhiza (+VAM) and non-infected (-VAM) showing significant differences in element uptake by plant roots on basalt (A) and rhyolite (B).

Campbell, Colin S.

Effects of changing rainfall patterns on soil moisture storage and plant canopy dynamics in a subalpine meadow

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Soil moisture has been shown to be a critical controlling factor determining net primary productivity (NPP) of water-limited ecosystems. Changing climatic conditions in the western United States are predicted to change the frequency and duration of rainfall, thus altering soil moisture stores and dependent plant community longevity and diversity. The object of this study was to investigate the role of soil in determining the effects of these changing rainfall patterns in subalpine ecosystems on the Wasatch Plateau, UT, USA. A series of long-term replicated sites were established to control precipitation intensity and frequency in historically grazed and ungrazed areas, and monitor soil moisture and plant productivity. Results showed extreme rainfall events increased the duration of soil water potential above wilting point, especially in the ungrazed sites, compared to the control. Limiting soil water availability through frequent but diminished rainfall had little or no effect on biomass accumulation early in the season, but considerable effects in the late season due to decreasing soil water availability.

Chen, Min

Investigating the Role of Vegetation and Soil Moisture in Land Surface Hydrology

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2. Department of Hydrology and Water Resources, China Three Gorges Unveristy, Yichang, China

Soil moisture is an important variable in the climate system, and is intrinsically linked with the climate and vegetation. Both soil properties and vegetation exert great influence on the land surface hydrological cycle via infiltration and transpiration. In this study, we analyzed a three-year (2005-2007) dataset of daily soil moisture at the Stanley semi-arid catchment in the southeastern Australia, using two different land surface models (LSMs), i.e. a soil moisture model (HYDRUS) and a bio-hydrological model (IBIS). In the first set of the analyses, the choice between a constant leaf area index (LAI) and a temporally varying LAI for predicting daily soil moisture dynamics was investigated. Calibration results from both models consistently suggested that a constant LAI, rather than a full seasonal cycle of vegetation dynamics, was sufficient to reproduce daily soil moisture at our site. We did, however, find that soil parameters were changed if the LAI seasonality was input. Those soil parameter sets that were most sensitive to the long-term mean LAI were the most sensitive to the seasonal cycle. Moreover, we found a strong correlation between antecedent rainfall measurements and remote sensing vegetation data, which suggested a simple and effective way to obtain LAI values (either a long-term average of a full seasonal cycle) via regression rather than physical modelling of LAI. In the second set of the analyses, the two LSMs were evaluated and compared using the Monte-Carlo GLUE method. The IBIS soil moisture calibration was better for the surface 30 cm, because its soil component is more appropriate for the surface condition. The HYDRUS calibration was superior for the full 90 cm profile, due to a better fitting vegetation component. Both models performed satisfactorily under average semi-arid hydroclimatic conditions, while model deficiencies only became significant when simulating the soil moisture response to extreme precipitation events. Better calibration of soil moisture resulted in less uncertainty in the three-year total water partitioning among the hydrologic variables modelled (surface runoff, evapotranspiration and deep drainage). This was consistent for both surface and full profile. For the surface, the total evapotranspiration, and total surface runoff plus deep drainage for the best-performing soil moisture simulations were quite consistent between IBIS and HYDRUS. Though the combined total of the surface runoff and deep drainage was well identified (due to the soil water balance constraint), the partitioning between surface runoff and deep drainage was less well identified. The study indicated that LSMs may be able to accurately predict hydrology if soil moisture is accurately estimated.

Cory, Rose M.

Going to the dark side: a novel pathway for abiotic oxidation of dissolved organic matter in arctic soil waters *(Invited)*

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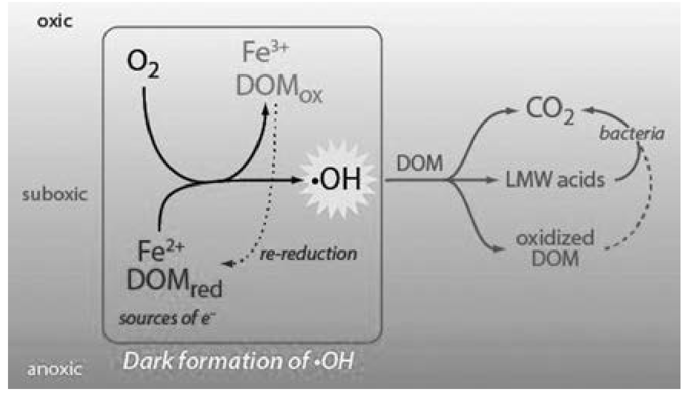
Hydroxyl radical (•OH) is a reactive oxidant of dissolved organic matter (DOM) in aquatic environments. The currently accepted view is that •OH is important for DOM cycling only in sunlit environments in which •OH is photochemically formed, but new work suggests that •OH may be a formed in the dark via abiotic oxidation of reduced DOM or ferrous iron, Fe(II). These findings suggest that dark •OH formation may be important in soil C dynamics where reduced DOM and Fe(II) are produced by anaerobic microbial respiration. We investigated this novel pathway of dark •OH formation in soil waters of the Alaskan Arctic across a vegetation toposequence representing the dominant low-arctic landscapes of hilltop heath to mid-slope tussock tundra to lowland wet sedge. More reduced, iron and DOM-rich soils had the highest •OH formation, consistent with the proposed model of dark •OH formation from the oxidation of ferrous iron and reduced DOM by oxygen. We found that the formation of •OH from these samples is related to the reduction of oxygen by both reduced iron and DOM. At landscape scales, abiotic oxidation of organic matter by •OH in soils may be at least as important to carbon cycling as is bacterial respiration of DOM in surface waters. The controls on this •OH oxidation are linked to the cycle of reducing and oxidizing soil conditions, which in turn are governed by hydrological residence time and flushing.



Dark formation of hydroxyl radical from reduced dissolved organic matter and iron. Reduced dissolved organic matter (DOM) and ferrous iron are produced during anaerobic microbial respiration and are stable under anoxic conditions. When these reduced species come into contact with O_2, the reduced DOM and ferrous iron will reduce O_2 by three electrons to form •OH. The •OH formed is expected to irreversibly oxidize DOM, forming CO_2 and low molecular weight, bio-available products in the process. After the reduced DOM and iron are oxidized by oxygen, they may again be reduced if anaerobic conditions are re-established.

Cowan, Nicholas

A study of nitrous oxide (N2O) emissions on a field and farm scale

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Of the 3 dominant GHGs (CO2, CH4 and N2O) the estimated anthropogenic fluxes of N2O have the largest uncertainty associated with them. Agricultural activities are believed to be the largest source of global anthropogenic N2O with emissions forecast to rise due to an increase in livestock numbers and the growing use of artificial fertilisers. Many individual agricultural sources of N2O are poorly defined with very large associated uncertainties. A lack of understanding of these emissions prevents accurate estimates of N2O fluxes to be made on a large scale. The aim of this study is to use modern measurement methodology to improve understanding of N2O fluxes from many different agricultural sources on the field and farm scale. This work will add to the increasing number of studies which contribute to the improvement of the IPCC guidelines for calculating N2O emission factors from which national and global N2O inventories are calculated. Using high accuracy chamber methods and eddy covariance, individual sources of N2O are measured and monitored regularly over the period of a year. The flux measurements made are cross validated amongst different methods and across different scales. Field and landscape (farm) scale measurements are carried out and then results will feed into a simulation model of carbon and nitrogen biogeochemistry in agro-ecosystems such as DNDC and DAYCENT. This will provide an N2O budget on the landscape scale, that can then be used for upscaling the results to the national level by using regional scale models. The compilation of the dataset describing the landscape

involves measuring fluxes from arable and grazed fields on a regular basis as well as other known sources of N2O such as manure heaps and drainage streams from agricultural land. Flux measurements from soils are accompanied by measurements of soil ammonium and nitrate concentrations, pH, soil moisture content, total carbon and nitrogen content and combined with detailed meteorological and farm management data. Once gathered, the measurements will be used to complete a farm scale N2O inventory of a working livestock farm at Easter Bush Farm estate. Easter Bush farm estate is a working livestock farm owned and run by the Scottish Agricultural College. The farm estate covers 1,013 hectares (2,500 acres) of land in lowland Scotland. The farm contains over 200 cattle, 1400 sheep and has capacity for 120 pigs. 80 hectares of land will be monitored frequently for N2O emissions at the farm estate. This land will consist of a number of arable fields (mostly barley) and fields grazed by sheep and cattle. The activities at the farm are closely recorded by the farm management to provide a detailed account of fertiliser use and land management. The project focusses on measuring many known sources of N2O whilst also searching for new sources to define. The management of the farm will be monitored and all data will be used to create N2O emission factor estimates through a variety of simple and complex models. Results obtained from models will be compared with measurement data for verification.

Davies, Jessica

Modelling Nutrient Transformations Through The Critical Zone: From Atmosphere To Plants, Soils To Stream At The Regional Scale

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The interactions between biogeochemical and hydrological processes are highly coupled and intertwined with the physical properties of the soil. Hence, if we are to understand and quantify the stores and fluxes of nutrients within the critical zone it essential that an integrated approach to modelling is taken. Within the Long-Term Large-Scale (LTLS) project, development of an integrated model is underway which will simulate the pools and fluxes of carbon, nitrogen and phosphorus (C, N, and P) between atmospheric, vegetation, soil and aquatic systems for the whole of the United Kingdom for a period spanning from the onset of the industrial revolution up until the present day. Throughout this time span, humans have transformed the nutrients in our landscape through industrialization, agricultural intensification and urbanization. It is important to consider all compartments of the critical zone simultaneously in order to trace the effects of deposition, fertilization, cultivation and land use change. It is also crucial that C, N and P are considered concurrently, as their integration controls the generation of biomass and consequent production of soil organic matter – consideration of C (or indeed C + N) alone in attempting to understand ecosystem function is insufficient as N and P are the most commonly limiting elements. The LTLS integrated model incorporates enhanced versions of the N14C [1] and RothC [2] models (simulating terrestrial biogeochemical cycling in semi-natural and agricultural land areas respectively), with hydrology derived from the Grid-to-Grid [3] model. The flux of sediments from terrestrial to freshwater compartments is driven by the hydrology, land-use and biogeochemical subsystems and subsequent riverine processes are also simulated. Here, the task of linking terrestrial biogeochemical cycling in semi-natural land types with soil erosion processes at regional spatial scales and monthly to centennial temporal scales is focused on. A methodology for integrating these processes is presented and issues in doing so discussed. Preliminary results in this endeavor are presented. [1] Tipping, E. et al., 2012 Ecological Modelling, 247. 11-26. [2] Jenkinson, D. S. and Coleman, K., 2008. European Journal of Soil Science, 59: 400–413. [3] Bell, V.A. et al, Journal of Hydrology, Volume 377, Issues 3–4, 30 October 2009, Pages 335-350.

Driscoll, Jessica M.

Role of storage on hydrologic and chemical flux in soil-limited alpine catchments in the Southwestern USA

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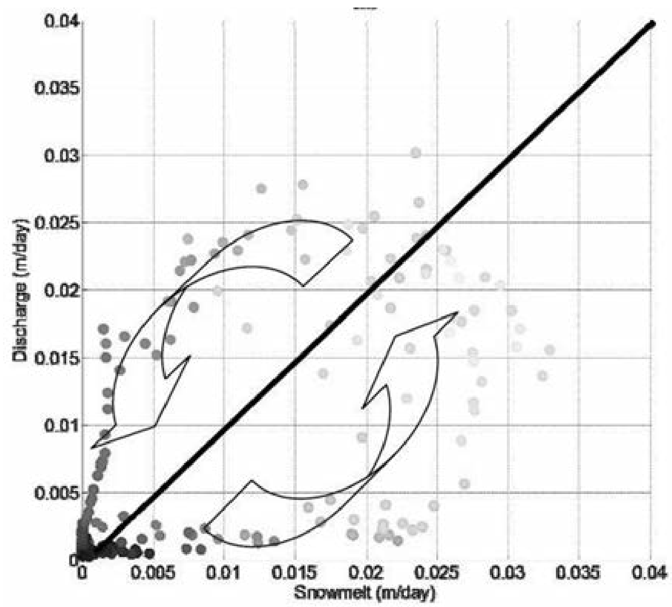
2. INSTAAR, Colorado Univeristy, Boulder, CO, USA
3. Environmental Science, University of California at Riverside, Riverside, CA, USA

Montane regions of the water resource-limited Western United States receive the majority of their annual precipitation in winter and early spring as snow (Serreze et al., 1999). This hydrologic input is physically and chemically buffered through hydrologic connectivity at the catchment scale (Laurenson, 1961, McGuire and McDonnell, 2006). Catchments with larger storage capacity have longer average flowpaths (Frisbee et al., 2011, Broxton et al., 2009), connecting hydrologic inputs to deep storage systems. Hydrologic connectivity to these deep flowpaths is directly related to higher concentration of weathering products, due to longer residence time (Garrels and Mackenie 1967). Catchment response to daily input variability was measured in two alpine headwater catchments, Green Lake 4 (GL4), in the Colorado Front Range and Emerald Lake Watershed (ELW) in the Southern Sierra of California. Disconnected physical input and output rates, or input rate independent of output rate is an indicator of hydrologically significant storage. Testing the role of physical storage at the catchment scale requires measuring the input and output rates at the same temporal scale, at a small enough resolution to measure short-term connectivity. Snowmelt-dominated headwater catchments provide a single hydrologic input controlled by maximum snow water equivalent, topographic and hydrometerologic conditions. A spatially distributed snowmelt model derived from the extrapolation of point measurements of these conditions is an improvement from extrapolation of precipitation point measurement values for total input to the catchment area. These hydrologic fluxes, at a daily step, over the snowmelt seasons from 1996-2006 were compared. In ELW, 2006 shows a hysteresis relationship (Figure 1), which may be due to filled storage capacity from the previous year. Given the similar geologic terranes, we expect hydrochemcial variability to be controlled by flowpaths through storage reservoirs. The hydrochemical evolution of waters at the output over the snowmelt season show greater flux of primary weathering products, in GL4 relative to ELW and similar variability of secondary mineral weathering products in both catchments.



Dunkerley, David

Water partitioning at the dryland soil surface: roles of precipitation intensity variation and plant-mediated water fluxes *(Invited)*

Dunkerley, David[1]

1. School of Geography and Environmental Science, Monash University, Melbourne, VIC, Australia

The partitioning of water arriving at the dryland soil surface involves dependencies on many aspects of the precipitation, biota, and the soil material itself. There are important interactions and feedbacks in the linkages among water, soil and biota that are incompletely explored. Rainfall simulation has been employed in both field and laboratory in order to explore some of these. Field experiments on crusted dryland soils at Fowlers Gap in arid Australia have shown that the temporal intensity profile of rainfall exerts a substantial influence on water partitioning. For instance, a rainfall event with a late intensity peak can yield a runoff ratio more than 3.5 times that found in constant intensity rainfall, while the maximum flux of overland flow can be more than 5.7 times larger. Importantly, however, the flux of water arriving at the soil surface is mediated by standing vegetation and by litter resting on the soil surface, as well as by the intensity of the rainfall. Laboratory studies have shown, for instance, that stemflow on plants also depends not only on the intensity of incident rainfall, but on the intensity variation through time. Events with early intensity peaks can yield ~ 50% more stemflow than arises from rain of constant intensity. However, peak fluxes of stemflow are maximized by late intensity peaks, and can be an order of magnitude larger than in constant intensity rainfall. High stemflow fluxes are known to be capable of driving the partitioning of water into Hortonian overland flow, though this has primarily been seen in wet tropical forests, and little is known from dryland ecosystems. Consequently, a complex picture of interactions and feedbacks emerges in the system precipitation – soil – biota, that has clear implications for building a full understanding of plant water availability. A further reason for wishing to understand these interactions more fully is than many appear subject to change as global environmental change leads to altered rainfall event properties and temporal distributions.

Dunn, Samuel

Production, consumption, and transport of methane in alpine and sub-alpine wetlands as a function of plant species

Dunn, Samuel[1, 2]; von Fischer, Joe[1, 2]

1. Graduate Degree Program in Ecology, Colorado State University, Fort Collins, CO, USA
2. Biology, Colorado State University, Fort Collins, CO, USA

Methane is a greenhouse gas that is produced by microbes under anoxic conditions. Previous work has coupled photosynthesis and methane emissions using stable and radio isotopes of Carbon Dioxide within a greenhouse setting. However, a full understanding of the transfers and conversions of fixed carbon from the plant, through the rhizosphere, and to the atmosphere as methane is lacking. The coupling of the methane and below ground carbon cycles within model simulations will allow for a finer understanding of the role of ecosystem production in methane emission and the potential effects of a changing climate. In order to parameterize this model, flux rates and carbon conversion efficiency need to be measured in situ. Using 13C-CO2, 13C-Acetate, and 13C-CH4, we conducted a pulse-chase experiment in high alpine and sub-alpine wetlands dominated by Carex aquatilis and other common wetland grasses to determine the temporal importance and relative contribution of different pools within the methane cycle for measured emissions. We measured the flux and isotopic composition of methane from the labeled plots at a high temporal resolution (~ every 3 hours) over the course of 48 hours after tracer addition. Flux of 13C-CH4 from the plots amended with dissolved 13C-CH4 peaked approximately 5 hours after addition and decreased significantly within 24hours. The decay of this isotopic enrichment tightly followed an exponential decay curve suggesting density dependent diffusion of methane from the soil to the atmosphere. Flux of labeled methane from the plots amended with dissolved 13C-Acetate peaked 13 hours after injection and decayed very slowly. Flux of labeled methane from plots amended with 13C-CO2 appeared around 13 hours after addition and was not detectable within another 12 hours. Overall methane flux rates from all plots were very similar in magnitude and varied over the course of the day with temperature.

Field, Jason P.

Bridging from Soil to Ecosystem Goods and Services Provided by the Critical Zone

Field, Jason P.[1]; Breshears, David D.[1]; Law, Darin J.[1]; Brooks, Paul D.[1]; Chorover, Jon[1]; Pelletier, Jon D.[1]; Troch, Peter A.[1]; López-Hoffman, Laura[1]; Rasmussen, Craig[1]; Papuga, Shirley[1]; Harpold, Adrian[1]; Biederman, Joel A.[1]; Barron-Gafford, Greg A.[1]; McIntosh, Jennifer C.[1]; Litvak, Marcy[2]

1. University of Arizona, Tucson, AZ, USA
2. University of New Mexico, Albuquerque, NM, USA

Over the past decade, ecologists have sought to better quantify the consequences of changes in ecosystems by focusing on the “ecosystem goods and services” that they provide humanity and the specific ways in which they increase human well-being. These goods and services have been subdivided into “supporting”, “provisioning”, “regulating” and “cultural”. This framework has been further expanded in numerous ways, including identifying options associated with differentiating between location-centric vs. location-flexible stakeholders, between portable and non-portable services, and between fast, patchy ecosystem change versus gradual, homogenous ecosystem change, both of which can be driven by climate change. The critical zone itself provides services that overlap with ecosystem services, and soils are a primary driver of such ecosystem services. Drawing on potential issues within the Jemez River Basin and Santa Catalina Mountains Critical Zone Observatory, we highlight the role of soils in four examples: (1) How will changes in winter precipitation and snowpack affect CZ water resources?; (2) How will changes in drought affect CZ water resources?; (3) How will a snow-rain shift affect CZ productivity- and carbon-related services?; and (4) What will determine post-disturbance recovery and changes in associated CZ services? These examples highlight more generally a central role for soils and associated ecohydrology in determining critical zone goods and services, much in the way that they do for many ecosystem goods and services.

Furman, Alex

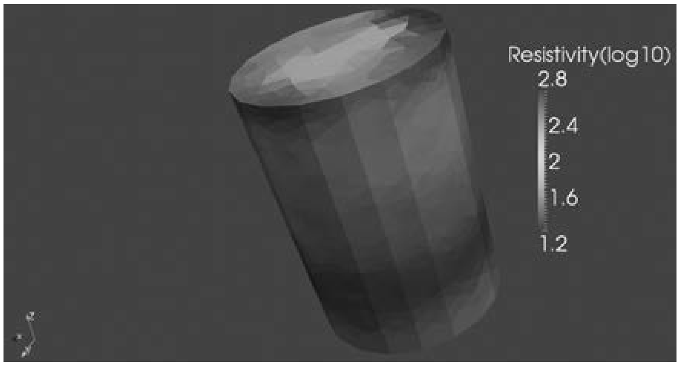
Exploring Root Uptake Under High Frequency Irrigation Using Electrical Resistivity Tomography

Furman, Alex[1]; Garre, Sarah[2]; Assouline, Shmuel[3]; Gunther, Thomas[4]

1. Civil & Env. Engineering, Technion IIT, Haifa, Israel
2. Gembloux Agro-Bio Tech, Université de Liège, Gembloux, Belgium
3. Soil Water and Environmental Sciences, Agricultural Research Organization – Volcani Center, Bet Dagan, Israel
4. Leibniz Institute for Applied Geophysics, Hannover, Germany

Root uptake and its relation to environmental factors, and primarily soil water content, are perhaps the least understood component in terrestrial water balance and is of high importance for water resources management, ecology and agriculture. In this research we explore the spatial and temporal distribution of soil water in high resolution using electrical resistivity tomography (ERT). Bell peppers were planted in a chamber and irrigated in two different schemes, differing only in irrigation frequency (daily and eight-daily irrigation, where the daily dose is equal for both treatments). This irrigation difference results in very different spatio-temporal distribution of the soil water in the root zone, which in turn derives spatio-temporal differences in root uptake. Experiment was conducted under a screen-house in Mediterranean summer conditions, i.e. very high evapotranspiration. Resistivity surveys, using 96 electrodes placed around the growth chamber and at soil surface (Figure 1) were taken over 10 times daily. Plants subjected to high frequency irrigation generally were faster in growth and matured about a week earlier. This is primarily attributed to the higher water content that exists in the root zone, and primarily during the climatically stressing noon hours. Inverted images (e.g. Figure 2) provide an interesting insight into the spatio-temporal distribution of the root uptake. This in turn can now be correlated to the spatial location of the roots, and to the soil induced water content dynamics.

Picture of experimental setup including growth chambers equipped with 96 electrodes each



An example of soil resistivity distribution

Gabriel, Carrie-Ellen

Examining physical and biological controls of SOM stability through depth in harvested red spruce forest soils

Gabriel, Carrie-Ellen[1, 2]; Kellman, Lisa[2]; Ziegler, Susan[3]

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2. Earth Sciences, St. Francis Xavier University, Antigonish, NS, Canada
3. Earth Sciences, Memorial University, St. John's, NF, Canada

Understanding how environmental factors affect soil organic matter (SOM) stability is important, particularly in the context of changing landuse such as forest harvesting. Following a harvesting disturbance, soil temperature and moisture dynamics are altered, and organic matter (OM) inputs change, resulting in a potential increase in SOM decomposition and mobilization. The objective of this study is to investigate mechanisms that alter SOM stability in a temperate forest soil where SOM losses have been documented following harvesting. To accomplish this, we examine temperature-driven changes in respiration and water extractable organic matter (WEOM) from soils differing only in their harvest history, through depth and under C amendment conditions that closely mimic those found in the field setting. Composite field moist soil genetic horizons (Ae, Bf and BC) were sampled at a paired mature (110yr) and young (35 yr) red spruce forest, incubated for 28 days at 5, 15 and 25 C at optimum moisture, and sampled for CO2 and δ13C-CO2 weekly. Before and after the incubation, soils were analyzed for elemental composition, and stable isotope ratios of C and nitrogen (N). Following the incubation period, dissolved organic carbon (DOC) and UV-vis absorbance of WEOM was determined for each horizon after which the specific UV-vis absorbance (SUVA, 254 nm) and spectral slope ratios were calculated. Results indicate a difference in SOM between the two sites. A modest increase in elemental C and N in the Ae horizon but a marked decrease in C and N for Bf and BC horizons was detected in the young relative to the mature site. An order of magnitude difference in specific decomposition rates between the shallow horizons (Ae and Bf) and the deeper soil (BC) was observed, with the Bf horizons generating the highest rates. In Bf and BC horizons, specific decomposition rates were generally higher at the younger site compared to the mature site, whereas in the Ae horizons the opposite trend was observed. For both sites, evolved δ13C -CO2 matched that of the bulk soil in the Ae horizon, but the signature that emerged from the Bf and BC horizons was more 13C enriched than that of the bulk soil. SUVA of WEOM was highest in Ae horizons, especially for the young site, but dropped off sharply through depth in the Bf and BC horizons. This was also reflected in the spectral analysis, and suggested that low molecular weight molecules dominate at depth for both sites. These results are consistent with a change through the profile of the source of SOM for resident decomposers following harvesting, reflecting changes to plant inputs at the surface, but a microbial source at depth. Microbes can readily access substrates in the Bf horizons that are not present as DOC. At the younger site, SOM from the Bf and BC horizons is more susceptible to decomposition across the temperature range compared to the mature site. These findings have implications for understanding key processes governing SOM stability following forest harvesting.

Gangi, Laura

Identifying and quantifying determinants of the oxygen isotopic exchange between soil water and CO_2 by combining laser-based spectroscopy and gas-permeable tubing

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The oxygen isotope signature of CO_2 ($\delta^{18}O$-CO_2) enables partitioning the carbon gross fluxes of terrestrial ecosystems related to soil respiration and plant assimilation, as CO_2 attains a distinct $\delta^{18}O$ value during equilibration with ^{18}O-depleted soil water and ^{18}O-enriched leaf water, respectively. However, the interpretation of the measured $\delta^{18}O$-CO_2 from soils is still challenging because the signal is influenced by different parameters, e.g. the $\delta^{18}O$ of soil water ($\delta^{18}O$-H_2O), CO_2-H_2O equilibration rate (depending on soil moisture, soil porosity and tortuosity as well as the catalytic activity of carbonic anhydrase), and soil physical properties which may vary in time and space. Furthermore, the contribution of additional factors, e.g. respiration by plant roots, is largely unknown. In our study, we measure the ^{18}O-exchange between soil water and CO_2 *on-line* within soil columns filled with well characterized medium sand and local soil material, respectively. Gas-permeable microporous polypropylene tubing is installed at different depths in the soil columns and purged with zero air at a low flow rate. The $\delta^{18}O$ of CO_2 and water vapor, which is transported from the soil into the tubing, is monitored simultaneously by laser-based spectroscopy. The isotopic signature of water vapor is then used to infer $\delta^{18}O$-H_2O, using well-established calibration equations, and, together with the $\delta^{18}O$-CO_2, the degree of ^{18}O-exchange between soil water and CO_2 as well as CO_2 diffusion through the different soil layers. We expect that (i) variations in $\delta^{18}O-H_2O$, soil water content, and soil physical properties such as porosity, (ii) changes in carbonic anhydrase activity, and (iii), depending on the rate of CO_2-H_2O equilibration, respiration by plant roots will be reflected in the $\delta^{18}O-CO_2$. This new methodology represents a promising tool to measure stable isotope fluxes between soil and atmosphere *in situ*. It could provide useful information for an improved parameterization of models simulating the $\delta^{18}O$ of soil CO_2 fluxes, including CO_2 invasion from the atmosphere into the soil.

Gebhardt, Martha

Soil biotic indicators for improving native plant establishment in disturbed Southwestern grasslands

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Arid and semi-arid ecosystems account for approximately 40% of terrestrial land surface and consequently play a significant role in the global water and biogeochemical cycles. In the Southwest U.S., land use change and non-native plant invasions are widespread and increasing, typically resulting in losses of native plant biodiversity that cascade to changes in hydrological and biogeochemical cycling. Furthermore, projected warmer and drier conditions in this region have the potential to disrupt the function and stability of ecosystems and soil resources through direct effects on soil microbiota and plant-microbe interactions. Using a fully factorial experiment, we examined the interactions and feedbacks among plant species, soil amendments, and soil microbial communities to relate these interactions into parameters for native plant restoration success in heavily disturbed soils in southern Arizona. Field soil was collected from the site of a proposed mine in the Santa Rita mountains, Arizona. Two reclamation amendments, biochar and wood chip mulch, were combined with soil sterilization (autoclaving) to give six treatments that correlate with proposed practices and soil stockpiling. Ten plant species native to southern Arizona and four community mixtures were grown in six different soil treatments for 11 weeks in a growth chamber to evaluate plant growth rate and establishment, and bacterial, archaeal, and fungal community structure, activity, and biomass. Initial results from quantitative PCR (qPCR) indicate sterilized soils had significantly lower starting microbial biomass than unsterilized soils across all soil amendments. Similarly, soil moisture content and water holding capacity were lower in autoclave-sterilized soils. In the woodchip and non-amended soils, total aboveground biomass was higher in the unsterilized soils while an opposite trend was observed in the soils with biochar. Both the annual and the perennial forb species studied, Eschscholzia mexicana and Baileya multiradiata, had less than 28% establishment success. The addition of woodchips had a significantly negative effect on plant growth and establishment success for all ten species. Woodchip addition lowered pH compared to other soil treatments, reduced water holding capacity, and changed C:N ratios in soils, which together could account for low plant establishment. Ongoing analyses will determine the relative importance of nutrient availability and soil microbial community structure and activity across soil treatments and identify key microbial taxa and functional groups associated with successful native plant establishment.

Gebler, Sebastian

Modelling soil moisture patterns with ParFlow-CLM: A comparison of high resolution model simulations with a sensor network

Gebler, Sebastian[1]; Hendricks-Franssen, Harrie-Jan[1]; Kollet, Stefan[1]; Vereecken, Harry[1]

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Land surface models are used for a better understanding of hydrological processes and water and energy fluxes in the soil-vegetation-atmosphere system. However, the prediction of the spatial and temporal heterogeneity of model states and fluxes with land surface models on small scales and high resolutions is still a challenge in hydrological modelling. This work focuses on the comparison of soil moisture and soil temperature measured by a sensor network with simulated values by ParFlow-CLM, for different levels of model complexity and spatial resolution. Developed at the Lawrence Livermore National Laboratory, ParFlow is designed to simulate fully saturated as well as variably saturated subsurface flow fully coupled with overland flow on large scales and for high spatial resolutions. ParFlow is especially designed to run in parallel on high performance computers. The Community Land Model (CLM) is embedded as a module in ParFlow which substitutes the soil column of CLM to improve the representation of groundwater and overland flow. Like other land surface models CLM describes complex processes using simplifying assumptions and empirical approaches (e. g. neglecting lateral exchange processes). CLM was originally designed for lateral resolutions of 500 m x 500 m up to hundreds of kilometers. In our project the integrated model ParFlow-CLM is currently applied with lateral resolutions of 10 m x 10 m, 2 m x 2 m and 1 m x 1 m to the 27 ha grassland TERENO test site at Rollesbroich located in the Eifel (Germany). This study aimed at investigating the effects of different spatial resolutions and different grid scales on ParFlow-CLM simulations. Within the scope of this work the impact of different lateral and vertical model resolutions as well as different soil layer complexities of ParFlow-CLM are investigated and quantified for the Rollesbroich study site to find the impact on the spatiotemporal soil moisture patterns. Amongst others (i. e. lysimeter devices, eddy covariance towers, discharge measurements etc.) the Rollesbroich study site is equipped with a wireless sensor

network (SoilNet) measuring soil water content and temperature delivering long term as well as temporally and spatially high resolution information, which allows a detailed model evaluation. It is expected that an analysis and quantification of the effects of model complexity and resolution will improve the understanding of structural model uncertainties and identify possible scaling discrepancies of the model simulations on sub catchment scale. This will lead to more accurate simulation results for planned high resolution ParFlow-CLM Data Assimilation studies for Rollesbroich and other similar study sites.

Gevaert, Anouk

Two-step soil saturation mechanism at hillslope scale

Gevaert, Anouk[1, 2]; Troch, Peter A.[1]; Teuling, Ryan[2]

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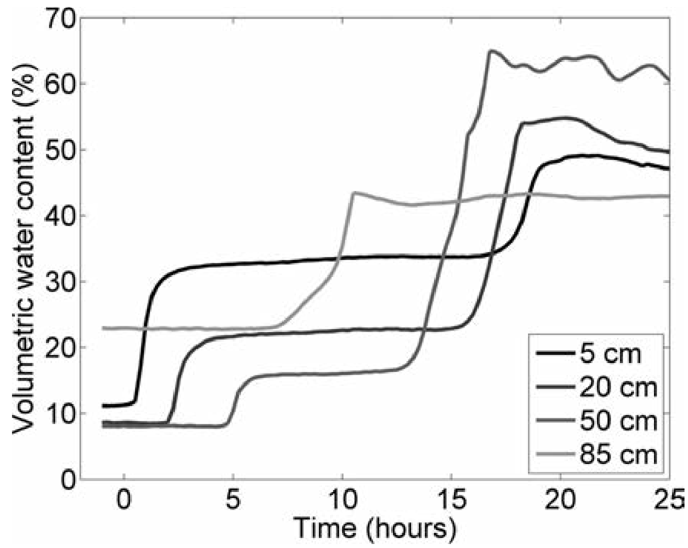
2. Wageningen University, Wageningen, Netherlands

Hillslope response to rainfall events is controlled for an important part by runoff, which is generally subdivided into infiltration and saturation excess runoff. This research aims to improve understanding of the mechanisms of saturation excess overland flow on hillslope scale. The experiment consists of a 22-hour rainfall event with a constant intensity of 12 mm/hr that was conducted on a convergent hillslope built at Biosphere 2. This event saturated a large part of the hillslope and produced overland flow in the central trough lasting from 17-19 hours after the start of the experiment until more than 24 hours after the rain was stopped. Soil moisture data showed a two-step wetting process in saturated areas as shown in Figure 1. After initially steady conditions, the arrival of the infiltration front led to a sharp first step in soil moisture to wetter, but still unsaturated, conditions. This step moved from the soil surface to the bottom of the soil column at a constant speed. Once the first step reached the bottom of the soil, a second sharp step in soil moisture propagated from the bottom of the soil column to the surface. This step led to saturated conditions and thus marked the arrival of the saturation front. A conceptualization of the steps dividing the hillslope into initial conditions and the two steps showed that saturation started at the bottom of the soil column in the central trough. From there, the second saturation step spread upwards and to either side of the trough. On hillslope scale, saturation was observed to generally expand in the upslope direction. The propagation of the second saturation step is linked to changes in subsurface and overland flow. An abrupt increase in subsurface flow took place in the period the second step reached 50 cm depth in and along the central trough while overland flow started around the time the second step reached the surface. The results of this study provide insight into runoff generation and the development of saturated areas in a hillslope in space and time.



Volumetric water content for a location in the central trough at four depths measured from the surface. Time is relative to the start of the rainfall event.

Glatzel, Stephan

Methane controls the greenhouse gas budget of rewetting fens

Glatzel, Stephan[1]; Franziska, Koebsch[1]; Hahn, Juliane[1]; Koch, Marian[1]; Jurasinski, Gerald[1]

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Peatlands are able to store carbon dioxide (CO2) for extended periods of time. On the other hand, they are methane (CH4) sources. As nitrous oxide release is uncommon in wet ecosystems, the balance between CO2 uptake and CH4 release determines the radiative forcing of the ecosystem. Especially directly after rewetting, fens may emit huge amounts of CH4. Generally, coastal peatlands are considered being less important with respect to greenhouse gas emissions as salt or brackish waters contain relatively high amounts of sulphate, which leads to the inhibition of methanogenesis because sulphate reducers outcompete the methanogens. Due to climate change and associated sea level rise more frequent or permanent inundation of coastal ecosystems is expected. Here, we report CO2 exchange by eddy covariance and CH4 emissions determined with dynamic closed chambers between 2009 and 2011 and (at least during the two last years of study) quasi-continuous eddy covariance CH4 measurements in a coastal peatland during the process of rewetting. Over the course of the study period, seasonal (May-Oct), CO2 storage amounted to 294 to 352 g C m-2, indicating a small sink for the entire year. Interestingly, the rising water table (close to 0 in 2009, 70 cm aboveground in 2011) did not considerably alter CO2 net ecosystem exchange. A sharp drop in gross ecosystem production (GEP) was mirrored by a strong decrease in ecosystem respiration (Reco) during the first year of rewetting. During the third, even wetter year, GEP and Reco were just a little higher that in 2010, resulting in a seasonal storage of 352 g C m-2. In contrast, CH4 emissions changed dramatically in magnitude as the ecosystem shifted from a rich brackish fen over a rich, shallow, much less brackish lake to a rich, shallow, brackish lake. When measurements started in 2008, the fen had been under moderate rewetting for about a decade with water levels between 0.4 m above surface in winter and 0.4 m below surface in summer. Conductivity increased up to 15 mS/cm. In 2009, estimated annual methane emissions were negligible ranging from 0.1 to 3.4 g CH4 m-2 a-1 depending on dominant plant species. During the second year of study the emissions increased hundredfold while the relative contribution of the dominant plant species and the relative seasonal pattern remained almost unchanged. The estimated annual emissions (80 to 290 g CH4 m-2 a-1) were then well in line with findings from other rewetting projects reporting relatively high methane emissions during the first years of rewetting. In 2011, the estimated annual emissions ranged between 31 and 177 g CH4 m-2 a-1. Our data show that CH4 controls the radiative forcing in freshly rewetted fens flooded by sweet water. We expect an increase in salinity and decreasing methane emissions. Together with the results above we will present the latest data from the ongoing measurements and evaluate whether this notion can be supported.

http://www.auf-loe.uni-rostock.de/mitarbeiter/stephan-glatzel/

Haberer, Christina M.

Oxygen transfer in the capillary fringe: Impact of physical heterogeneity and transient flow conditions

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Oxygen transfer across the capillary fringe (CF) to anoxic groundwater is of primary importance for a wide variety of biogeochemical processes occurring in the interface region between the unsaturated and the saturated zone. Mass transfer of O_2 in the CF is thereby controlled by diffusive/dispersive transport as well as mass exchange between entrapped air and groundwater. In addition, transient flow conditions and the presence of physical heterogeneity in the porous medium strongly affect the O_2-fluxes to anoxic groundwater. We performed quasi 2-D flow-through laboratory experiments (Fig. 1) to study the effect of a coarse-material inclusion, located in proximity of the water table, on flow and O_2-transfer in the CF. Flow and transport were monitored under both steady-state and transient flow conditions, the latter induced by a fluctuating water table. We visualized the complex flow field using a dye tracer solution, measured O_2-profiles across the CF, and determined O_2-fluxes at the outlet of the flow-through chamber. Our results show that O_2-transfer was significantly affected by the coarse-material inclusion during the different phases of the experiment. At steady state, the O_2-flux across the CF was considerably enhanced due to flow focusing in the fully water-saturated coarse-material lens. During drainage, the capillary barrier effect prevented water to drain from the fine material overlying the coarse lens. The entrapped O_2-rich aqueous phase contributed to the total amount of O_2 supplied to the system when the water table was raised back to its initial level. In case of imbibition, pronounced air entrapment occurred in the coarse lens, which caused O_2 to partition between the aqueous and gaseous phases. The amount of O_2 transferred to the anoxic groundwater was up to 7 times higher in the heterogeneous system compared to an equivalent experiment performed in a homogeneous porous medium. Our results show that knowledge about the interaction of porous medium heterogeneity, transient flow dynamics, and mass transfer processes is needed to improve our understanding of the exchange of volatile compounds across the CF and to predict redox conditions and reactive transport in underlying shallow groundwater systems.

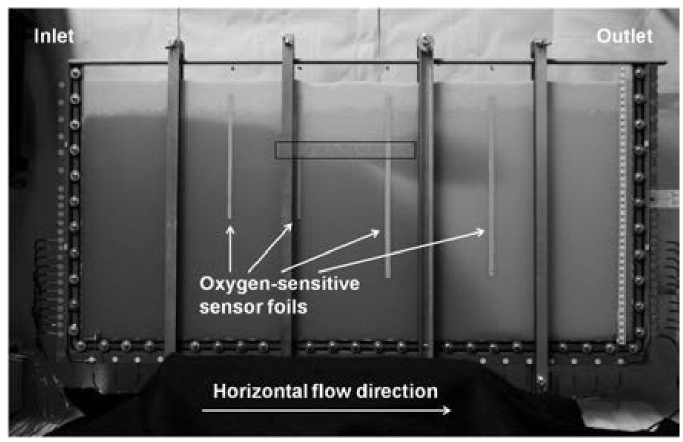

Fig. 1. Experimental setup with inner dimensions of 80 cm × 40 cm × 0.5 cm (L × H × W). To visualize the flow field New Coccine (CAS: 2611-82-7, Conc. = 75 mg L^{-1}) was used as a red dye.

Hagmann, Diane

Effect of heavy metal contamination on selected extracellular enzyme activities in soil

Hagmann, Diane[1]; Mathieu, Carolyn[1]; McGlone, Cherrelle[1]; Krumins, Jen[1]; Goodey, Nina[1]

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The overall goal of this research is to investigate the enzyme activities of soils collected from a heavy metal contaminated area where study sites lie along a gradient of increasing metal load. Our hypothesis is that heavy metal contamination impacts the microbial communities in the soil and consequently the extent of nutrient cycling. We have selected three enzymatic activities as representative of C, P, and N cycling. We have so far optimized the phosphatase and cellobiosidase activities using the substrates 4-MUB-cellobioside and 4-MUB-phosphate for analyzing contaminated soil. The following assay conditions were investigated: the preparation of the soil slurry (sonication versus blending), assay temperature, pH, and the amount of soil required for the assay. Enzyme activities were determined by following the kinetics of product formation using fluorescent substrate analogues and the enzyme activities were expressed in pmoles of product formed per /g of dry soil /hr. We also investigated the relationship between particle size of the soils and enzyme activity using sieves with different pore sizes. Herein we present data that show the effects of assay conditions on the phosphatase and cellobiosidase activities and results from assaying our contaminated study sites for enzymatic activity.

Hall, Steven

Synergies Among Oxygen and Iron in the Carbon Cycle of Humid Tropical Forest Soils

Hall, Steven[1]; McNicol, Gavin[1]; Silver, Whendee L.[1]

1. Environmental Science, Policy, and Management, UC Berkeley, Berkeley, CA, USA

Humid tropical forests harbor a large portion of global soil carbon (C), yet they simultaneously support the highest rates of litter decomposition of any biome. Variation in soil oxygen (O2) availability concomitant with high precipitation has been proposed as a mechanism underlying soil C accumulation in these ecosystems, as these wet upland soils share characteristics of both terrestrial and aquatic environments. Here, we examined how soil carbon (C) pools and turnover varied with long-term mean O2 concentrations, which decreased across a toposequence from ridges, slopes, to riparian valleys. We also assessed relationships between C turnover and reactive iron (Fe) and aluminum (Al) minerals, which are thought to stabilize C. We separated C in soil samples (n = 30) according to density and occlusion using sodium polytungstate solution and sonication, yielding a free light, occluded light, and mineral-associated fraction. We analyzed radiocarbon (14C) content in the heavy fraction to provide a proxy for turnover time. Concentrations of Fe and Al were measured in citrate-ascorbate and ammonium oxalate extractions. Mineral-associated C concentrations in surface soils (0-10 cm depth) were significantly greater on ridges (48 ± 2 mg g-1) than on slopes or riparian valleys (33 ± 3 mg g-1), whereas the light C fractions did not differ. In subsurface (10 – 20 cm) soil, occluded light fraction C was greater in valleys (4.7± 1.8 mg g-1) than ridges or slopes (2.7± 0.5 mg g-1). These results suggest that O2 limitation may promote the accumulation of occluded light C in riparian valleys, but not mineral-associated C. Radiocarbon content of mineral-associated C was similar among all topographic positions in 0 – 10 cm soil (79 ± 5 ‰ Δ14C), reflecting accumulation of bomb-enriched 14C. A simple model suggested turnover times of approximately 100 years for mineral-associated C. Subsurface (10 – 20 cm) soils on slopes, however, were significantly depleted in Δ14C (40 ± 14 ‰) relative to ridges and valleys. This may reflect the removal of soil via landslides occurring over decadal scales, exposing soils with older C. Mineral-associated C concentrations and their Δ14C content increased with oxalate-extractable Fe and Al, whereas Δ14C declined with citrate-ascorbate extractable Fe ($p < 0.01$). These extractants could reflect Fe pools with distinct effects on C cycling. Complexes between oxalate-extractable Fe and organic matter lead to accumulation of C that cycles over decadal scales. The citrate-ascorbate extraction reflects Fe that is potentially reducible by microbes, and thus can support anaerobic respiration. Total soil C concentrations decreased with citrate-ascorbate Fe at the landscape scale, potentially reflecting the importance of microbial Fe reduction in limiting C accumulation under anaerobic conditions. Thus, O2 availability may exert complex effects on soil C storage in humid tropical forests: occluded light C accumulates in soils with low O2 concentrations, whereas the availability of reducible Fe oxides to sustain anaerobic respiration may limit the accumulation of mineral-associated C. These findings illustrate couplings between hydrology, geomorphology, and mineralogy that impact C cycling in humid tropical forest soils.

Harman, Ciaran J.

PERTH and the Dynamic Age Function: A theoretical and experimental framework for understanding residence and transit times in transient, complex flows

Harman, Ciaran J.[1]; Kim, Minseok[1]

1. Department of Geography and Environmental Engineering, Johns Hopkins University, Baltimore, MD, USA

In many natural systems (from soil to hillslope to catchment scale) it is difficult to characterize and model transport due to the complexity and variability of flow processes. An alternative approach is to consider the transport through a defined control volume in terms of the transit time and residence time distributions. However, observations of transit time distributions have largely been limited to approximating the transit time distribution as time-invariant. A new theoretical framework has recently been developed (Botter et al 2010, 2011) to represent solute transport under time-varying flow conditions at hillslope and watershed scales. This framework provides a rigorous alternative to the convection-dispersion equation, which cannot feasibly be applied to complex flows. However the framework is incomplete, as the form and controls on a key element of this framework, the 'age functions', are not specified from theory and must be investigated empirically. Based on a modified version of this framework, we have developed an experimental method, named the PERiodic Tracer Hierarchy (PERTH) for making direct observations of the age function. This approach does not involve selecting a functional form for model fitting, but rather estimates the age function directly from the data. The method involves setting up a periodic flow condition in the system. This periodic condition creates multiple instances of a single 'effective' transient condition that can be probed by repeated application of tracers at different moments during the event. We deploy tracers in a hierarchical manner to simultaneously A) account for the problem of tracers injected several times over-printing each other in the output breakthrough curves B) obtain observations of the age function at multiple temporal resolutions and C) look at both fast and long-time-

scale behavior. We will present the new framework, and the experimental method, along with preliminary proof-of-concept model results.

Harpold, Adrian A.

Snowmelt Infiltration Dynamics in Seasonally Snow-Covered Areas of the Western U.S

Harpold, Adrian A.[1]; Molotch, Noah P.[1]

1. Institute of Arctic and Alpine Research, University of Colorado-Boulder, Boulder, CO, USA

Water released from melting snowpacks is critical for streamflow generation, biogeochemical cycling and transport, and the productivity of forests late into the growing season. Snowmelt infiltration dynamics are governed by melt water inputs controlled by the snowpack energy balance, as well as losses from the soil profile mediated by the soil hydraulic properties, terrain, and evapotranspiration (ET) demand. Despite the importance of snowmelt to the water budgets of headwater catchments, it remains unclear how snowmelt infiltration dynamics are related to the timing and size of seasonal snowpacks. In this study we apply data from over 200 Snow Telemetry (SNOTEL) stations across the Western U.S. with at least four years of soil moisture, temperature, and snowpack records, for a total of nearly 1000 station-years. We ask the research question: "When and where are snowmelt infiltration dynamics principally controlled by the magnitude and timing of seasonal snowpacks?" Our results showed that roughly half of all station-years had peak soil moisture coincident (within 3 days) with snow disappearance. This synchronicity likely results from snowpack infiltration rates exceeding soil profile loss rates (e.g. percolation, runoff, and ET) during times when melt is still occuring (e.g. before snow disappearance). Roughly a fifth of the station-years had peak soil moisture within >3 days after snow disappearance, which is often due to late season precipitation. Greater than a quarter of the station-years had peak soil moisture >3 days prior to snow disappearance, which suggested that losses from the soil profile began to exceed snowmelt infiltration rates. Peak soil moisture preceding snow disappearance was more prevalent in warmer and/or more southerly stations and is consistent with earlier, large losses due to ET or drainage in those environments. Our results highlight two important ramifications regarding the synchronicity of snowpacks and the delivery of snowmelt water to the soil profile: 1. Snowmelt infiltration raises soil moisture stores up until high ET losses or saturation (e.g. melt rates generally exceed percolation rates) and 2. Some stations had more consistent partitioning of early season snowmelt (e.g. able to draw down soil moisture stores during snowmelt) in very wet and dry winters. Because forests ability to transpire melt water also depends on factors other than water availability, such as temperature and light, not all locations were able to utilize early season melt water for transpiration. More work is needed to understand how these observations of snowmelt infiltration dynamics could alter water availability for vegetation and the cycling of carbon and nutrients in montane forests, particularly in light of the earlier and faster snowmelts expected in the coming decades.

Hinckley, Eve-Lyn S.

The Critical Zone as a Driver of Ecosystem N Retention and Transport in the Colorado Front Range

Hinckley, Eve-Lyn S.[1, 2]

1. Institute of Arctic and Alpine Research, Boulder, CO, USA
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Over a decade of research in the alpine zone of the Colorado Front Range has shown that nitrogen (N) deposition originating from low elevation, developed areas has changed ecosystem stoichiometry, microbial transformation rates, and aquatic community structure. Markedly less research has occurred in mid-elevation forests, which sit at the current snow line and are vulnerable to climate change impacts on precipitation and temperature, increased N loading, and disturbance by wildfire and pine beetle outbreaks. Tracer experiments using 15N-nitrate and lithium bromide (LiBr) during spring snowmelt and the summer monsoon season (the major hydrologic events in these systems) point to the governing roles that aspect and soil properties (e.g., organic matter content, macroporosity, and depth to saprolite) play in determining the fate of atmospheric N. This research, conducted in a mid-elevation forested catchment within the Boulder Creek Critical Zone Observatory, demonstrates stark contrasts between south- and north-facing slopes with respect to the fate of atmospheric N. South-facing slopes, characterized by higher insolation, shallow soils (0.25-0.3 m), and preferential flow paths, rapidly transport water and reactive N to depth during major hydrologic events. In contrast, north-facing slopes, characterized by lower insolation, thicker soils (0.4-0.45 m), and periods of sustained water flow through a connected soil matrix, have greater ecosystem N retention and lower N losses to groundwater and streams. The largest biological sink for N was the microbial community, which sequestered approximately 50% of applied 15N in north-facing slope soils, and 16-34% of applied 15N in south-facing slope soils during the snowmelt period when populations were largest. The results from this research lend important insight into how critical zone structure affects coupling of hydrologic response and biogeochemical processes at point, hillslope, and catchment scales. In addition, it leads to interesting new questions about whether 'legacy effects' of the current critical zone will buffer patterns of ecosystem N fates as climate, N deposition, and disturbance continue to alter this landscape over short time-scales.

process "outcompete" abiotic processes leading to a stable state, in particular from the water balance point of view for comparable geomorphic situations.

Hinz, Christoph

State transitions in the artificial catchment Huehnerwasser (Chicken Creek): Ecosystems development 8 years after initialisation

Hinz, Christoph[1]; Gerwin, Werner[1]; Schaaf, Wolfgang[1]; Elmer, Michael[1]; Fluehler, Hannes[2]; Hollaender, Harmut[3]; Huettl, Reinhard[1, 4]

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4. GFZ German Research Centre for Geosciences, Potsdam, Germany

In 2005 an artificial catchment with an area of 6 ha was constructed in Lusatia (150 km southeast of Berlin, Germany). It consists of 1-2 m thick clay lining covered by 2-4 m quaternary sandy and loamy sediments that were placed with droppers and dozers used in lignite mining. The catchment is gently sloped and has a small lake at the bottom. During the initial phase of development the catchment changed very rapidly due to sediment transport, drainage network formation, and soil crusting very similar to geomorphic processes observed in arid and semi-arid landscapes void of dense vegetation. Hydraulic properties changed rapidly after few wet and dry cycles, indicative of particle mobilisation and trapping in the subsurface. Accordingly, the hydrological regime was controlled by rapid surface runoff enhanced through crust formation and at the same time a shallow ground water system developed. This surface runoff regime peeked about two years initialisation as shown by a maximum area of drainage channels. A major, fairly rapid transition occurred between three and five years after placement, in which the sediment transport ceased and vegetation coverage of the drainage channel exceeded 90%. The transition represents the onset of a transpiration dominated regime that is further enhanced by change of the plant composition of the vegetation with tree recruitment from the surrounding forming significant clusters in the catchment. This transition in the third year was also seen in a significant increase in soil fauna and plant diversity. We propose a simple framework that explains the catchment evolution as a result of competing feedbacks influenced by the initial conditions and the atmospheric drivers such as rainfall intermittency and intensity. The first stage of the evolution is dominate by abiotic feedbacks triggered by rainfall and subsequent fluid flow causing particle mobilisation on the surface and in the subsurface leading to flow concentration or in some instances to densification of surface and subsurface substrates. Subsequently, abiotic-biotic feedbacks start to compete in the sense that biological activity generally stabilizes substrate by preventing particle mobilisation and hence contribute to converting the substrate to a habitat. We suggest that these competing feedbacks may generate alternative stable states in particular under semi-arid and arid climatic conditions, while in temperate often energy limited environments biological process "outcompete" abiotic processes leading to a stable state, in particular from the water balance point of view for comparable geomorphic situations.

Holländer, Hartmut

Impact of modellers' decisions on hydrological a priori predictions

Holländer, Hartmut[1, 2]; Bormann, Helge[3]; Blume, Theresa[4]; Buytaert, Wouter[5]; Chirico, Giovanni B.[6]; Exbrayat, Jean F.[7, 8]; Gustafsson, David[9]; Hölzel, Herwig[1]; Krausse, Thomas[10]; Kraft, Philipp[7]; Stoll, Sebastian[11]; Blöschl, Günter[12]; Flühler, Hannes[11]

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7. University of Giessen, Giessen, Germany
8. University of New South Wales, Sydney, NSW, Australia
9. Royal Institute of Technology KTH, Stockholm, Sweden
10. University of Technology Dresden, Dresden, Germany
11. ETH Zurich, Zurich, Switzerland
12. TU Vienna, Vienna, Austria

A group of catchment modellers predicted the hydrological response of a man-made 6 ha catchment in its initial phase (Chicken Creek) without having access to the observed records. The prediction exercise was organized in three steps: (1) for the 1st prediction modellers received a basic data set describing the internal structure of the catchment (somewhat more complete than usually available to a priori predictions in ungauged catchments). They did not obtain time series of stream flow, soil moisture or groundwater response. (2) Before the 2nd improved prediction they inspected the catchment on-site and attended a workshop where the modellers presented and discussed their first attempts. (3) For their improved 3rd prediction they were offered additional data by charging them pro forma with the costs for obtaining this additional information. Table 1 summarizes the relative discharge prediction "success" for the first three years of this catchment. The 1st prediction was a difficult task because the modellers were confronted with three special features of the newly constructed catchment, (i) the initially dry soil, (ii) the impact of an unusually intensive snowmelt event, (iii) which enhanced the gully formation on the not yet stabilized bare surface. The 1st predictions for the 2nd year were somewhat better. The real progress was made with the 2nd prediction after the field visit and the discussions among the modellers during the 1st workshop. Adding additional data for the 3rd prediction improved those made for the 2nd but not those for the 3rd year and even decreased the predictive accuracy of several models in the last step. The differences between the 1st and 2nd prediction were definitely larger compared to those between the 2nd and 3rd prediction. This underpins the value of soft information (field visit, workshop discussions, and experience). However, local measurements such as infiltration tests – provided for the 3rd prediction – certainly contributed to the improved predictions as well. They were apparently better suited to define the soil parameters than those estimated based on pedotransfer functions.

Table 1. Rating of prediction progress compared to measurements in the course of consecutive model improvements (0 = poor to 3 = good).

Prediction stage	Development stage of the catchment		
	1st year highly dynamic surface processes, gully formation and snowmelt event	2nd year increasing role of feedbacks, crust formation, emerging plant cover	3rd year partly stabilized surface, approaching quasi-steady state
1st prediction	0	1	1
2nd prediction	0	2	3
3rd prediction	0	2	2

Huber, David P.

Climate Controls on Soil Hydrological and Nutrient Partitioning in Dryland Ecosystems

Huber, David P.[1]; Lohse, Kathleen A.[1, 2]; Germino, Matthew J.[3]

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2. Geosciences, Idaho State University, Pocatello, ID, USA
3. Forest and Rangeland Ecosystem Science Center, United States Geological Survey, Boise, ID, USA

Globally, ecosystems are undergoing dramatic changes due to altered climate and invasion of exotic plant species. Changing climate is expected to alter the magnitude, seasonality and variability of precipitation over the next century while shifts in vegetation alter fire regimes and ecosystem function. Both changing hydroclimate and shifts between woody and herbaceous vegetation alter the availability and distribution of water in a landscape. Numerous studies have raised concerns that changes in hydroclimate will alter carbon (C) and nitrogen (N) partitioning but to date, the majority of ecosystem scale climate change studies have focused on temperature and carbon. This is especially true for dryland ecosystems, which represent more than a third of the terrestrial surface. Despite the fact that nutrient dynamics are critical to dryland ecosystem function and are sensitive to hydroclimate, no long-term experimental studies have examined how N partitioning varies with water availability in dryland environments. We use an existing long-term ecohydrologic experiment (Est. 1993) located in southeastern Idaho to evaluate ecosystem response to changing precipitation patterns and shifts in vegetation. The experiment consists of 3 replicated blocks of 2 vegetation types (a sagebrush steppe assemblage and monocultures of crested wheatgrass, CWG) and 3 irrigation treatments representing shifts in precipitation seasonality. Samples were collected during the 2011 and 2012 growing seasons. We predicted that differences in soil water availability first, and stoichiometry second, which vary between treatments, would control soil nutrient availability and process rates. Preliminary result show water availability has a significant effect on N cycle dynamics but varies greatly with both space and time. Regression analysis was stratified by wet versus dry years. For wet years, multiple regression of net N mineralization shows that 42.2% of the variability is explained by vegetation type and soil moisture (F=13.75, P=4.536e-05), with precipitation treatments having little influence. In addition, nitrification rates and available NO3- pools are significantly lower in CWG versus sagebrush treatments (P<0.05). During dry years, vegetation treatments show no significant differences in N process rates. These findings suggest that sagebrush and CWG exert strong and differential controls over seasonal N dynamics. For dry years, 65.6% of the variability in N mineralization rates is explained by precipitation treatments, total N, and pH (F=8.62, P=0.0002), suggesting that plant mediated control on N partitioning is dependent on adequate water availability and varies with longer (i.e. annual) moisture patterns. This inter-annual variability in precipitation and N partitioning likely minimizes differences in the integrated long-term N processing signal between treatments by prohibiting any net directional trend. Observations of total soil N pools and δ15N values to a depth of 1 m support this neutral N partitioning signal with no significant differences between precipitation or vegetation treatments.

Jaisi, Deb

A REVERSE PATHWAY OF PHOSPHORUS CYCLING IN AGRICULTURAL SOILS

Jaisi, Deb[1]; Joshi, Sunendra[1]; Li, Xiaona[1]

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Commercial phosphorus (P) fertilizers are applied to agricultural crops in order to increase crop yields. Because crops cannot uptake all applied P, residual P accumulates in soil over time and may remain as recalcitrant P. To understand bioavailability and exchange of inorganic phosphate (Pi) in different soil phases, we performed sequential extraction of soil samples collected during six growth stages of a corn crop and phosphate oxygen isotope ratios (δ18Op) of each Pi phase measured. Our results showed that the δ18OP values of HCl-Pi were similar to that of NaOH-Pi, HCO3-Pi, and H2O-Pi phases. This result confirms that the fertilizer P applied in the farm undergoes interspecies transfer and becomes gradually unavailable as it ultimately precipitates as apatite mineral. This trend is opposite to that of non-agricultural environments where weathering and dissolution of minerals supplies P to plants and microorganisms. These results are expected to have significant implication on current nutrient management practices.

Kelley, Christopher J.

A decade of water and nitrate fluxes from a dryland agricultural headwater catchment: Linking hydrologic and biogeochemical drivers of the soil N cycle

Kelley, Christopher J.[1]; Keller, C. K.[1]; Smith, Jeffrey L.[2]; Hyuck Orr, Cailin[1]; Evans, R. D.[3]

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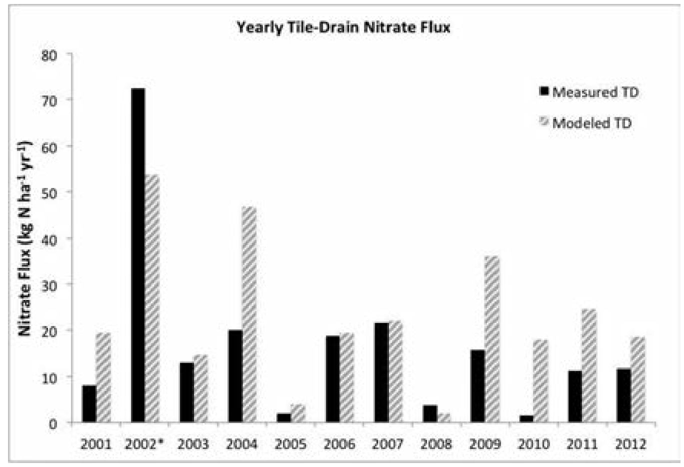
3. SBS, Wash. State Univ., Pullman, WA, USA

Long-term monitoring sites are crucial to understanding connections among climate, soil hydrology, and biogeochemical controls on nutrient export from agroecosystems. For over a decade we have monitored seasonal and interannual variations in water and N discharge from a tile-drain section of the Cook Agronomy Farm (CAF), a Long Term Agroecological Reserve (LTAR) in the Palouse Basin of eastern Washington State. We used field-measurement and modeling methods to capture lower and higher-end estimates of monthly and yearly water and nitrate fluxes. Mean precipitation during the study was 495 mm (SD 74). Mean measured and modeled TD water fluxes were 80 mm (SD 40) and 158 mm (SD 60) respectively. Mean measured and modeled TD nitrate fluxes were 12 kg N/ha/yr (SD 7) and 20 kg N/ha/yr (SD 13) respectively (see figure attached). Based on the measured and modeled nitrate fluxes between 14 and 21% of the yearly applied fertilizer is leached from the CAF each year. Previous research applying stable N and O isotope ratios of nitrate concluded there were two sources of nitrate in TD discharge. The high-discharge season (January - May) source of nitrate was nitrified ammonium fertilizer (~96% of the yearly leached nitrate). The low-discharge season (June - December) source was mineralized soil organic nitrogen (SON) (~4% of the yearly leached nitrate). We hypothesize that the source of leached nitrate shifts from nitrified fertilizer to mineralized SON because of changes in soil-water flow paths rather than changes in the soil nitrogen cycle processes. We suggest that both mineralization of SON and nitrification of fertilizer occur year round. During the high-discharge season, nitrate contribution from mineralization of SON to the tile-drain is imperceptible compared to leaching of nitrified fertilizer from the top ~15 cm of soil. Then during the low-discharge season vertical transport pathways shut down as the upper profile dries, at which point mineralized SON becomes the sole source of leached nitrate though the tile drain. If our hypothesis is correct, changes in precipitation rates or timing that alter typical runoff/ infiltration patterns can dramatically change the timing and rate of nitrogen losses. Our research has implications for decreasing management costs, improving nitrogen use efficiency, and managing nitrogen losses in dryland agriculture.



*These values are know to over-estimate fluxes, based on sampling bias of peak events.

Kelly, Anne E.

Deep soils allow anomalously high productivity and limit summer drought stress in California conifer forests

Kelly, Anne E.[1]; Fellows, Aaron W.[1]

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Understanding the processes that link biomass, production, and soil depth is critical to understanding the structure, function, and water use of present ecosystems. An accurate mechanistic model is critical to predicting future species distributions in a changing climate. Research on the montane conifer forest in California has found high biomass, high productivity, and high evapotranspiration that are well above values predicted by bioclimatic models. Traditional temperature/precipitation models (e.g., Whitaker 1975) predict steppe or open woodland where sequoia groves are found. Evapotranspiration (ET) models predict potential evapotranspiration below measured actual evapotranspiration in many locations, especially in summer drought conditions in large-statured conifer forest. The only way to resolve this apparent paradox of lush, productive forests in a Mediterranean climate is if vegetation is able to access deep soil water throughout the dry summers. In this study, we measured actual evapotranspiration at eddy flux tower sites across ten diverse California ecosystems and extrapolated ET across California using the MODIS Normalized Difference Vegetation Index (Goulden et al. 2012). We used gridded PRISM temperature and precipitation data along with the ET map to determine soil water storage. We found that soil water storage and effective rooting depth across much of California is much higher than previously thought, with especially large discrepancies in the conifer forests. We also examine the case study of a site in a Sierra Nevada mixed conifer forest that exhibits year-round growth, high ET, and little drought stress despite dry summers and snowy winters. We show using direct and indirect methods that rooting depth and soil water storage at this site far exceed conventional prediction. Because of the strong heterogeneity of soil depth and soil water storage across California, our results show potentially important limitations on future ecosystem distributions with climate change.

Kirchner, James W.

Universal fractal scaling in stream chemistry and its implications for solute transport and water quality trend detection *(Invited)*

Kirchner, James W.[1]

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The chemical dynamics of lakes and streams affect their suitability as aquatic habitats and as water supplies for human needs. Because water quality is typically monitored only weekly or monthly, however, the higher-frequency dynamics of stream chemistry have remained largely invisible. To illuminate a wider spectrum of water quality dynamics, rainfall and streamflow were sampled in two headwater catchments at Plynlimon, Wales, 7-hourly for 1-2 years and weekly for over two decades, and were analyzed for 45 solutes spanning the periodic table from H+ to U. Here we show that in streamflow, all 45 of these solutes – including nutrients, trace elements, and toxic metals – exhibit fractal 1/f^alpha scaling on time scales from hours to decades (alpha=1.05±0.15, mean±standard deviation). We show that this fractal scaling can arise through dispersion of random chemical inputs distributed across a catchment. These 1/f time series are non-self-averaging: monthly, yearly, or decadal averages are roughly as variable, one from the next, as individual measurements taken hours or days apart, defying naive statistical expectations. (By contrast, the stream discharge itself is non-fractal, and is self-averaging on time scales of months and longer.) In the solute time series, statistically significant trends arise much more frequently, on all time scales, than one would expect from conventional t-statistics. However, these same trends are poor predictors of future trends – much poorer than one would expect from their calculated uncertainties. Our results illustrate how 1/f time series pose fundamental challenges to trend analysis and change detection in environmental systems.

Klatt, Steffen

Assessing water, carbon and nitrogen fluxes on the landscape scale by coupling LandscapeDNDC, a regional multi-ecosystem biogeochemical model to the hydrological model CMF

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2. Institute of Landscape Ecology and Resources Management, Justus-Liebig-University of Giessen, Giessen, Germany
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The rise in global population causing a growing food demand can only be satisfied by an intensification of food production systems. This will affect the terrestrial carbon and nitrogen cycles significantly resulting in environmental consequences such as increased water use, surface water eutrophication, changes in soil carbon stock and fertility and various greenhouse gas (GHG) emissions as agricultural systems are major sources of anthropogenic GHG (e.g. CO2, CH4, N2O). Ecosystem models are suitable tools to study the intrinsic carbon, nitrogen and water cycle from microbial processes to plant growth. LandscapeDNDC is a biogeochemical process based simulation system capable of modelling carbon and nitrogen cycling for various ecosystems such as forest, arable and grassland ecosystems. It was derived from the DNDC family of biogeochemical models. It uses a generalized process description for the soil biogeochemistry. As such it unites various DNDC models leading to one general model being capable of simulating biogeochemical processes in grassland, cropland and forest ecosystems. This allows for transient simulations of alternating ecosystems (land use change). Furthermore, different species types can be simulated sequentially (conventional agricultural or forest management) as well as concurrently (multi-cropping and agroforestry). The simulation system permits regional scale applications by processing many time-synchronized grid cells where each cell has its individual model setup / configuration. Being synchronized with respect to time facilitates coupling with external regional models, e.g. hydrological models superimposing lateral transport of water and nutrients on LandscapeDNDC's domain. A coupling of LandscapeDNDC to the catchment modelling framework CMF allowing simulations of carbon and nitrogen cycling on the landscape scale has been performed. To illustrate the capabilities of LandscapeDNDC, we will present a study that illustrates results of a regional coupled biosphere – hydrosphere simulation including: - Various ecosystem types - Agricultural & forest management and practice - Transient simulation of land use change - Multi-cropping and agroforestry - Nutrient (nitrate) transport due to water fluxes in the saturated and unsaturated zone and their consequences to plant growth and the soil biogeochemistry, nitrification / denitrification, GHG emissions etc.; - Nutrient eutrophication

Knadel, Maria

Fusing Proximal Sensing Data for Optimal Locations of Soil Moisture Monitoring Stations

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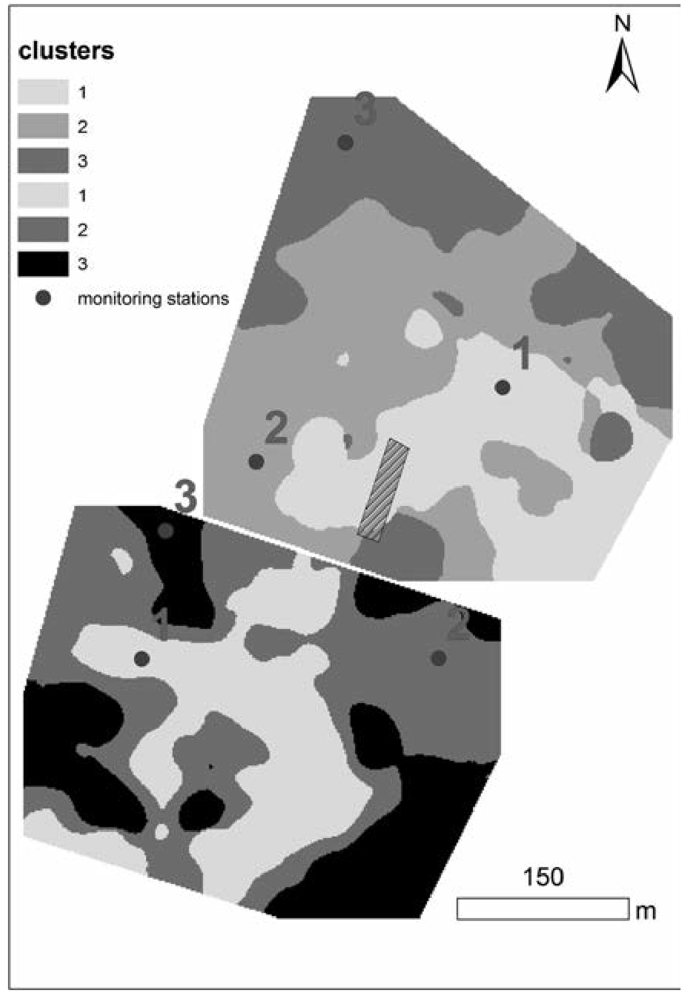
The local water balance and ground water recharge are governed by soil texture, soil moisture and vegetation development. The complicated nature of these factors and their high spatial variability is challenging when representative sampling and monitoring areas at different scales need to be selected. The aims of this work were threefold: (1) to characterize soil variability with soil and vegetation sensors, (2) to identify hydrologically uniform regions based on the c-means clustering of the multiple sensory data, (3) to select optimal locations for monitoring networks of wireless sensors to capture soil moisture spatial and temporal variability. Mobile sensors are attracting increasing attention due to their large potential for generating extensive amounts of data with high spatial resolution. A sensor fusion approach including in-situ and proximal sensing techniques of soil and canopy for the detection of patterns in the soil-vegetation systems and for soil moisture and canopy monitoring was applied in this study. The instrumentation included: Veris mobile sensor platform [with electrical conductivity, temperature and near infrared spectroscopy (NIRS) sensors], MobilTdr - time domain reflectometry (TDR) mobile sensor for soil water content analysis and MobilLas canopy optical instrument generating vegetation spectral indices. NIRS was used to collect soil spectra for predicting soil total organic carbon (TOC) and texture. Kriging maps of both soil and vegetation sensory data and additional maps of selected digital elevation model (DEM) derivatives were generated for two agricultural fields in Skjern River catchment, Denmark. Management Zone Analyst software was used to cluster variables relevant to hydrological parameters of the fields. Three clusters representing hydrologically uniform units were obtained in each field. Within each of the three units monitoring networks of manual TDR probes were installed for further soil moisture analysis (Figure). The fusion of high resolution sensory data on soil and vegetation properties provided a detailed characterization of within-fields variation of soil and vegetation properties and a delineation of fairly uniform hydrological regions.



Koch, Joshua

Runoff sources and flowpaths in a partially burned, upland, boreal catchment

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Climate change is resulting in significant changes in boreal catchments, including permafrost thaw and increased fire. Predicting the effect of these changes on aquatic ecosystems and critical subsistence species will require greater understanding of boreal catchment hydrology and the processes responsible for runoff generation and solute production. Runoff from boreal catchments is complex, involving flow through a patchy matrix of organic and mineral soils with varying hydraulic conductivities. Flow is constrained in some places by the presence of permafrost and aided by preferential flow through soil pipes and areas that remain saturated. Soil residence times and flushing exert substantial control on catchment carbon cycling and the flushing of carbon, nitrogen, and mercury into the river network. In order to constrain the sources of runoff to the stream we studied two catchments in the White Mountains of interior Alaska. We rely on permeameter measurements and infiltration tests, porewater and surface water chemistry, stream tracer additions and end member mixing models. We find that approximately 25% of infiltration moves quickly through shallow organic flowpaths, while the remainder of the water infiltrates into deeper soils that are seldom saturated and often do not contribute to streamflow. Kilometer-scale tracers show that runoff is evenly distributed along stream reaches in the early summer, but once the active layer thaws, inflows are greatest near surface water bodies and beneath steep slopes. In a late-summer tracer study, these waters displayed a uranium isotope signature consistent with thawing permafrost, indicating the existence of deep flow through the mineral soils. Trends in end member mixing models suggest that in fine, loess soils, burned hillslopes may contribute disproportionately to runoff, potentially due to the formation of macropores and pipe flow. These results have implications for biogeochemical cycles: labile carbon is predominantly exported early in the summer when subsurface flowpaths are still frozen. Carbon still reaches the stream rapidly in the late summer, but is more recalcitrant. Nitrogen commonly limits aquatic biogeochemical processes and is predominantly used by biota on hillslopes and in small surface tributaries, seldom making it to higher order streams. Catchment runoff and hydrologic connectivity between hillslopes and streams can vary substantially from one year to the next; questions remain as to how storage on annual timescales affects redox conditions and the form of exported carbon, nitrogen, and mercury.

Kotzé, Elmarie

Influence of rangeland management practises on organic matter contents and aggregation dynamics of clayey soils in the semi-arid grassland biome, South Africa

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Rangelands cover half of the worlds land surface. In the arid to semi-arid environments of South Africa more than 75% of the land is used for livestock production, and these rangelands are often subjected to degradation mainly driven by poor land management. The grassland biome of South Africa is a major resource for livestock farming, and the soils are increasingly threatened by overgrazing. Soil organic matter (SOM) is specifically a main factor in rangeland ecosystem functioning, as it improves soil structure, enhances water infiltration and thus prevents erosion through aggregate stabilization. Literature shows that only a few studies compared the effects of continuous and rotational livestock ranching on SOM properties in semi-arid areas, and the results of these studies were mostly inconsistent. Therefore the need was identified to research this topic further. The aim of this study was to investigate how the soil properties respond to intensified rangeland management under different property rights and management systems. For this purpose we sampled various types of rangeland management systems under communal (continuous grazing), commercial (rotational grazing) and land reform (mixture of grazing systems) farming, and within each of these systems we differentiated good, moderate and poor rangeland conditions along a gradient of increasing grazing pressure with decreasing distance to the water points. In order to achieve this goal, soil analyses included the assessment of total C and N as indices of organic matter, various plant nutrients, bulk density as well as aggregate fractionation. Results showed that soils from the commercial farms exhibited higher values for especially C and N when compared to the other farm types. Further, the communal farms with continuous grazing were generally depleted in all the measured nutrients. As was suspected, the depletion increased with intensified grazing pressure, i.e., from good to poor rangeland conditions. Along that line there was an increased breakdown of macroaggregates with losses of the C and N stored therein. However, the commercial farms also exhibited a decline of macroaggregates and their associated C content nearby the water points. We conclude that aggregate fractionation is a sensitive indicator for detecting the beginning of soil degradation in these ecosystems; yet, degradation was less pronounced under the rotational grazing of the commercial farms than under communal property right conditions. The latter do not have fenced camps and therefore cannot practice rotational grazing, where soils and rangeland vegetation may restore with adequate resting time.

Kumar, Praveen

Passive Regulation of Soil Biogeochemical Cycling by Root Water Transport

Quijano, Juan C.[1]; Kumar, Praveen[1]; Drewry, Darren[2]

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2. Jet Propulsion Laboratory, Pasadena, CA, USA

Surface and sub-surface moisture dynamics are strongly influenced by the ability of vegetation to take up and redistribute soil-moisture using hydraulic redistribution (HR). These dynamics in turn affect soil biogeochemical cycling through controls on decomposition and mineralization rates and ion transport. The goal of this study is to explore this coupling between HR and biogeochemistry using a numerical model. We examine decomposition and mineralization of organic matter and analyze whether differences in decomposition rates induced by HR influence the long-term storage of carbon in the soil and the movement of nitrate (NO3-) and ammonium

($NH4^+$) in the rhizosphere. These dynamics are studied in a framework that incorporates the interaction between multiple plant species. The net effect of HR on decomposition is controlled by a trade off between the resultant moisture and temperature states. This trade off is conditioned by the availability of fine roots near the surface, and it impacts the long term storage and vertical distribution of carbon in the soil. HR also impacts the transport and uptake of ions from the soil. It reduces the leaching of nitrate considerably, and, therefore facilitates the uptake of nitrate by vegetation roots. Furthermore, the magnitude and patterns of the feedbacks induced by HR are also influenced by the presence of different plant species that coexist. These results suggest that the alteration of soil moisture by plants through associated processes such as HR can have considerable impact on the below-ground biogeochemical cycling of carbon and nitrogen. Quijano, J.C., P. Kumar, and D. Drewry, Passive Regulation of Soil Biogeochemical Cycling by Root Water Transport, To Appear in Water Resources Research, 2013, DOI: 10.1002/wrcr.20310.

Kyzivat, Ethan

Stable Water Isotope Analysis of Subsurface Flow in Artificial Hillslopes

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3. Hydrology and Water Resources, University of Arizona, Tucson, AZ, USA
4. Hydrology and Quantitative Water Management, Wageningen University, Wageningen, Netherlands

Stable water isotope analysis is a valuable tool in estimating water transit time, the amount of time it takes for water to move through a hillslope or catchment and leave the drainage basin after a precipitation event. This process is paramount to our understanding of the biogeochemical and ecological effects of water fluxes on our changing environment. By further examining these effects, we aim to improve water resource management, especially in semi-arid environments where water scarcity is common. We incorporated isotope analysis by labeling test water with deuterium and tracking its movement during an artificial precipitation event at the Landscape Evolution Observatory of the Biosphere 2. The LEO's unique ability to control the parameters of rainfall events and its dense array of sensors and samplers permit the careful observation of the timing of water moving through the hillslope. We applied three rainfall pulses to the hillslope to determine the transit time distribution as well as the spatial and temporal variability of water in the hillslope. This presentation will present primary results of the hydrologic response of the hillslope under the prescribed conditions.

Law, Darin J.

Evapotranspiration Partitioning: Competition between abiotic and biotic components of the water budget

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Most studies focus on competition between coexisting plant species. From an ecohydrological perspective in water limited environments plants are also competing not only with the other biotic components but also with the abiotic components of the system in that they are trying to acquire water for transpiration before it is lost to soil evaporation. In an ecohydrological paradigm this evapotranspiration partitioning is a split between "green" water and "blue" water and consequently can result in water loss being dominated by transpiration uptake or by soil evaporative loss. Such ET partitioning is extremely relevant for the prospects for native grass species competing with exotic grass species in both biotic and abiotic context and the nature of such interactions could change dramatically under future climate conditions (warmer, drier, high vapor pressure deficit), and even potentially resulting in plant mortality in extreme cases. Despite the fundamental importance of the issue for semi-arid grassland systems studies comparing ET partitioning for native vs. exotic grasses under ambient and warmer-drier climate are generally lacking. Here we show that evapotranspiration partitioning differs dramatically between a native and a coexisting exotic grass species such that water loss under ambient climate for the native grass is E dominated whereas for the exotic grass it is T dominated. Under warmer drier conditions, while there are shifts in the water loss (exotic shift toward E domination native actually increases T briefly), none of the plants survived the protracted experimental dry-down in the warmer climate and the native grass died much sooner than the exotic. The implications of this work are three fold: (1) our results highlight the important role of considering ET partitioning itself, not just plant physiological response in evaluating native vs. exotic responses to current climate. (2) Our results highlight the extreme sensitivity of both natives and exotics to mortality under drier and slightly warmer climate because the frequency distribution of drought duration is non-linear. Even small differences in survival time can become very important under future climate conditions. (3) Most

generally because mixed native exotic plots had responses intermediate between native and exotic pots our results highlight the need to consider and integrate ET partitioning as a form of abiotic competition that determines "green" vs. "blue "water with more traditional ecological perspective that usually focuses solely on plant/plant competition.

Lee, Junseok

Total and soluble fluorine concentrations in soil after occurring hydrogen fluoride spill

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This study investigates the range of total fluorine (F) concentrations and soluble F fractions in soil after occurring anhydrous hydrogen fluoride (HF) spill from a chemical plant. HF can be precipitated and then accumulated in soil, which may cause the chronic exposure of F to human via particle ingestion during the agricultural activities. It is clear that the continuous monitoring of F concentration of soil in the vicinity of accident site is necessary. Surface soil samples (n = 60) are collected and their total and soluble F concentrations and properties (i.e., organic matter content, total phosphorus, cation exchange capacity, soil texture) are determined. Correlations between the soil characteristics and both F concentrations are investigated and the ratio of soluble to total F concentrations of soil is compared to those of previous studies. The effect of exotic F on the change of the readily available fraction of F in soil is discussed. This study aims to provide the information of contamination range and type of soil in the vicinity of the site where accidental HF spill occurred. Acknowledgement This study received substantial support from the Geo-Advanced Innovative Action (GAIA) project (Grant 2012000540014) of the Korea Environmental Industry & Technology Institute (KEITI).

Lever, Rebecca

Quantifying pyrogenic carbon fluxes and mean residence time in eroding hillslopes

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Erosion is a ubiquitous important global process that redistributes approximately 75 Gt of soil annually and has been shown to serve as an important terrestrial carbon (C) sink. The role of soil erosion in redistribution of carbon and other essential elements has not been adequately investigated in much of the current literature. Additionally, fire plays a significant role in controlling C and pyrogenic carbon (PyC) dynamics within the soil system. Here we present a new model to determine the mean residence time of PyC by explicitly considering the role of erosional transport in post-fire eroding systems. The method is based on modification of a simple first order model of soil organic carbon dynamics that was, in the past, mainly used to model C dynamics in static landscapes that do not experience significant lateral distribution by soil erosion. With this method we aim to demonstrate the important role that erosion plays in lateral distribution of PyC and its estimated mean residence time in soils of dynamic landscapes.

Lin, Hangsheng (Henry)

New Frameworks for Decoding Complex Soil Systems *(Invited)*

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Soils are complex systems with open boundaries, enormous heterogeneity, webs of interactions, wide-ranging scales, self-organizing features, and evolutionary changes over time. Instead of traditional reductionist approaches, three new conceptual/theoretical frameworks for decoding soil complexity will be discussed in this presentation. First, soils are considered as so-called medium number systems with organized complexity, where structure is an underlying control of vast heterogeneity. Such systems are qualitatively different from unorganized complexity (large number systems, where statistical methods work) or organized simplicity (small number systems, where deterministic approaches have been widely applied). Second, soil complexity is viewed as driven by a combination of moving and living forces, where classical moving forces has been championed by the Newtonian worldview, but living forces are creative, organizing and/or maintaining in ecosystems that are not necessarily in motion. Soil profiles on earth are in situ "semi-living" entities that 1) blend together enormous living and non-living components in complex ways (without the system being moved from one place to another) and 2) exhibit metabolic-like features from thermodynamic and biological points of view, with features of self-organization and growth over time in situ. Third, a framework for unifying soil formation and soil functions is suggested, which can facilitate the linkage between the Dokovchiav-Jenny's theory of soil formation with the Darcy-Buckingham's law of water flow in soils, whereby different types of soils may exhibit contrasting flow mechanisms, pathways, and patterns.

Lybrand, Rebecca

Climate and landscape position controls on soil carbon cycling in the Santa Catalina Critical Zone Observatory

Lybrand, Rebecca[1]; Heckman, Katherine[2]; Rasmussen, Craig[1]

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The objective of this research was to identify climate and topographic controls on soil organic carbon (SOC) cycling across soils in different semiarid ecosystems. The project was performed within the Santa Catalina Critical Zone Observatory in southern Arizona that spans significant range in climate, i.e., mean annual temperature range of

>10°C and annual precipitation range of >50 cm yr-1, with a concomitant change in dominant ecosystem from desert scrub to mixed conifer systems. Surface (0-10 cm) and subsurface (30-40 cm) soils were collected from granitic regolith profiles across divergent and convergent landscape positions. Physical SOC distribution in the regolith was quantified using a density and sonication technique to obtain the "free" (non-mineral associated), "occluded" (SOC putatively located within aggregates), and "mineral" (SOC associated directly with mineral surfaces) C pools. The radiocarbon data indicated that the free fractions were composed of the youngest SOC across all ecosystems and landscape positions considered. Conversely, the mineral or occluded fractions contained the oldest SOC depending on the ecosystem. Desert scrub soils stored relatively little C (<1% SOC by weight), with all fractions dominated by fast-cycling SOC. The relatively oldest C was located in the mineral fraction, indicating organo-mineral interactions as the dominant C storage mechanism in this ecosystem. In contrast, the conifer systems contained more SOC (>3%) with the oldest SOC found in the occluded fraction indicating an important role for aggregation as a SOC stabilization mechanism in these sites. A strong landscape position control on SOC distribution was also found in this system in that the fraction of occluded SOC was two times that of the divergent sites. Furthermore, the divergent soils contained ~twice as much SOC in fast-cycling free light fractions relative to the convergent landscape positions where the majority of carbon was associated with occluded and mineral fractions. The physical distribution, chemistry, and mean residence time of convergent SOC suggest a landscape level mechanism that includes the downslope transport and burial of SOC in convergent soils. Bulk SOC at the mixed conifer convergent soil-saprolite interface (~120 cm in depth) indicated a modern Δ14C signal (0.0‰, -16.3‰), suggesting the downward transport of dissolved organic carbon to this location. Indeed, Δ14C of dissolved organic carbon collected from nearby lysimeters confirmed a modern Δ14C signature (19.1‰, 43.5‰). The combined data sets provide the basis for understanding ecosystem and landscape position level variation in SOC stabilization and for constraining how shifts in climate may affect SOC storage across this range of semiarid environments.

Ma, Tao

Hydrochemical constituents of interflow compared from artificial experimental monoliths and catchments

Gu, Weizu[1]; Ma, Tao[2]

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. Groups of hydrochemical constituents of Interflow from artificial experimental monoliths and catchments LS with area of 1 m2, L1 of 32 m2, and Hydrohill of 512 m2, with same kind of soil and that of rainfall show a decending order in concentration, contrary to land surface area of ascending order. It reveals an effect of scale. An example is shown in Fig.1 The diel variations of pH and most ions of interflow from unsaturated zone are contrary to that of event rainfall. For anions, its peak concentrations happened mostly during evening and midnight while that of cations during both a.m and midnight (Fig.2). If it will reveal the role of metabolism? Compare these variations with that from Morningglory, an artificial catchment without soil but debris, without saturated zone, with area of 4573 m2, can be reasoned as the role of soil. It follows that any natural catchment is inherently a dynamic system coupling with various processes in addition to the narrow hydrological process.

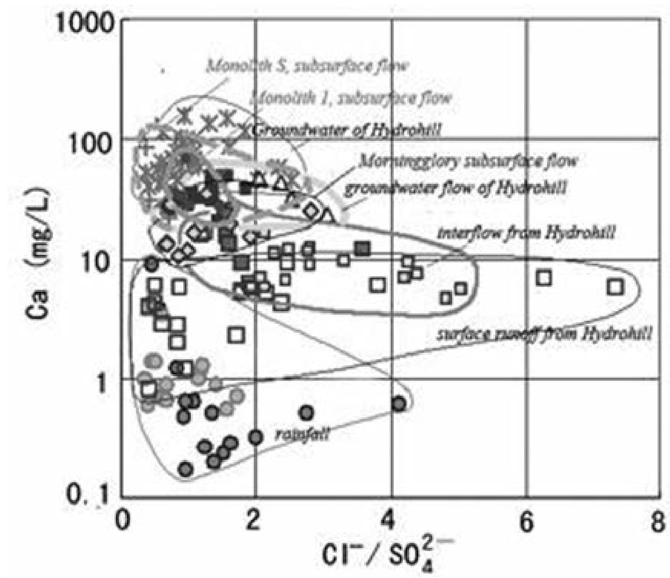

Fig.1 scale effect

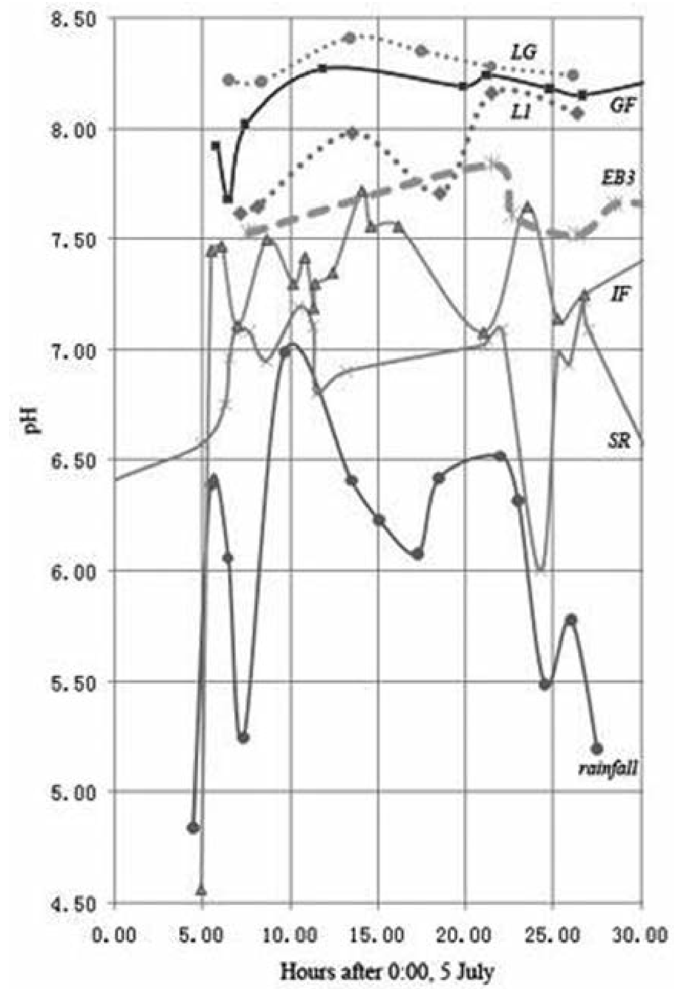

Fig.2 Diel variation of interflow (IF) reveals multi-coupling of processes in watershed

Martin, Rebecca

Hydrologic Controls of DOM Export From Agricultural Soil to Surface Water via Tile Drainage: The Roles of Flow Path and Processing

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Soils are an important source of dissolved organic matter (DOM) to surface water, and the quantity and quality of DOM delivered to surface water can vary as hydrologic connectivity in watersheds expands and contracts, novel sources of DOM are mobilized, and flow paths shift. Agricultural land use alters many aspects of water quality; however, controls over the quantity and quality of DOM exported from agricultural soils to surface water have received limited attention. This is despite evidence that agricultural management alters soil water DOM characteristics and streamwater DOM chemistry at the catchment scale. To understand the role of hydrology in controlling the concentration and quality of DOM exported to surface water via tile drainage, we characterized soil solution dissolved organic carbon concentration ([DOC]) and DOM chemical quality in a small (12 ha) agricultural catchment in eastern Washington, and in tile drain discharge over a three year period that included a range of hydrologic conditions. We used spectroscopic properties, including specific UV absorbance at 254 nm (SUVA) and fluorescence index (FI) to characterize DOM chemical composition. In this system, water that is exported via the approximately one meter-deep tile drain has followed a flow path through both the organic-rich surface soil and mineral subsoil, although residence time in the soil column can vary greatly – on the order of hours to months. We hypothesized that DOM would be mobilized from the topsoil and exported with minimal processing during wet, high flow conditions when the hydrologic connectivity in the basin is greatest; in contrast, DOM exported during low flow conditions would reflect concentrations and quality observed in the sub-soil. Both the concentration and quality of DOM varied with soil depth, although variability was quite high across the field, particularly in shallow soils. In topsoil and subsoil water samplers, [DOC] averaged 8.53 (SE ± 2.70) and 4.56 mg C L-1 (±0.52), FI averaged 1.48 (SE ± 0.09) and 1.58 (± 0.01), and SUVA averaged 9.73 (±13.49) and 2.34 mg C m-1 (±0.19), respectively. In tile drain discharge, the concentration and chemical characteristics of DOM were correlated with tile flow rate; [DOC] ranged from 0.65 to 15.69 mg C L-1, increasing with discharge; FI decreased with discharge (range 1.46 to 1.62); and SUVA increased (range 0.92 to 4.06 L mg C-1 m-1). In the winter, DOM characteristics were generally within the range observed in shallow and deep soil water samples; however, in the summer [DOC] in tile drain discharge was often lower than that observed in soil water, indicating removal processes occur en route to the tile drain outlet. These results indicate strongly contrasting effects of flow path on DOM export during hydrologically active, biologically inactive, winter conditions and hydrologically inactive, biologically active, summer conditions, and emphasize the need to consider both residence time and environmental conditions in the context of flow path to understand DOM transport across the terrestrial-a aquatic interface.

Maseyk, Kadmiel

Soil, plant and ecosystem COS flux measurements: observations of a new tracer of the carbon cycle

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Atmospheric carbonyl sulfide (COS) is a promising new measurement-based tracer to separate soil and plant fluxes of CO2 during biosphere-atmosphere gas exchange. The uptake of COS and CO2 by vegetation is closely coupled during photosynthesis, providing an opportunity to establish independent estimates of gross photosynthesis and soil respiration at ecosystem and larger scale from measurements of COS and CO2 . To develop this approach, it is necessary to both establish the ratios of COS to CO2 uptake from the canopy and characterise soil fluxes. We have explored the dynamics of COS ecosystem-atmosphere exchange in a wheat field at the Southern Great Plains using the latest instrumentation for trace gas research. We have made eddy covariance (EC) measurements of ecosystem COS fluxes and automated chamber measurements of soil fluxes, providing us with unparalleled information on in situ soil COS flux behavior. Measurements were made over a two-month period that covered the growing season, senescence and post-harvest periods, and which yielded some unexpected results. We found that during the growing season, there was a strong uptake of COS by the canopy of between ~ 10 and 40 pmol m-2 s-1, with a strong diel signal. Ecosystem COS sink strength diminished as the plants approached the grainfilling period, and after senescence and over the harvested field, we observed a strong source of COS to the atmosphere of up to +40 pmol m-2 s-1. Contrary to what is commonly assumed, we observed that overall the soil was a net source of COS, but both sink and source behaviour was observed in a strongly temperature dependent response. Further investigations into the soil COS fluxes indicate that roots, not soil microbes, appear to be responsible for the COS production, and hypothesise that processes associated with senescence and plant internal reallocation of resources underlie the interesting seasonal pattern of COS fluxes we observed. We have also made measurements in a Mediterranean oak system, including unique data on the COS to CO2 uptake ratio during photosynthesis under field conditions. These results reveal that this ratio is not constant in time but show diurnal and synoptic scale variability that appears largely environmentally. We also observed a temperature dependence of soil COS fluxes that was similar to that observed in the wheat field at lower temperatures, but with a stronger dependence on soil water content. Ongoing measurements that will also be presented include ecosystem and component fluxes in a freshwater marsh ecosystem. This information is necessary for parameterising regional scale modelling and interpretation of boundary layer atmospheric COS concentration measurements. Overall, these high-resolution COS measurements at high precision are opening up new opportunities for exploring and constraining carbon cycle processes.

McDonnell, Jeffrey J.

The importance of boundary conditions on water flow and residence time at the hillslope scale *(Invited)*

McDonnell, Jeffrey J.[1]

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The effects of boundary conditions on flow and transport at the hillslope scale are poorly understood. Formative experiments in the field in the 1960s controlled boundary conditions when examining flow and transport by covering the soil surface and removing vegetation and/or lining the soil base with concrete or similar impermeable material. Results from these studies still define our conceptual framework for streamflow generation at the catchment scale. Here I re-examine some of these benchmark works and interpretations in light of new results focused on boundary controls at the hillslope scale. Two examples are presented: one focused on upper soil boundary (atmosphere-vegetation partitioning) and the other focused on the lower boundary (the soil bedrock interface). These results show that boundary conditions are perhaps the defining feature of water movement at the hillslope (and catchment) scale and that partitioning at these interfaces influences most, the age, origin and pathways of water movement from the soil surface to the stream. I illustrate these effects with examples from hillslopes in the USA Pacific Northwest and Mexico and show how these boundary controls also have potential ramifications for related issues of slope stability, surface-groundwater interactions and water quality.

McKenna, Owen P.

Geomorphic controls over Nitrogen and Carbon Stocks in Desert Playas

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Playas are ephemeral desert wetlands situated at the bottom of closed catchments. Desert playas in the Southwestern US have not been intensively studied despite their potential importance for the functioning of desert ecosystems. The objective of this study is to assess geomorphic and ecological variables that control carbon and nitrogen stocks in playas. We hypothesize that the

magnitude of carbon and nitrogen stocks depend on: (a) catchment size, (b) catchment slope, (c) catchment biomass, (d) catchment plant cover and (e) spatial arrangement (e.g. patch size distribution), and (f) catchment soil texture. We chose thirty playas from across the Jornada Basin (Las Cruces, NM) ranging from 0.005-0.60 km2 in area and with varying catchment characteristics. We used a 5m digital elevation map (DEM) to calculate the catchment size and catchment slope for these thirty playas. We measured biomass, percent cover, and patch size using the point-intercept method with three 10m transects in each catchment. We used the Bouyoucos-hydrometer soil particle analysis to determine catchment soil texture. Stocks of organic carbon and nitrogen were measured from soil samples at four depths (0-10 cm, 10-30 cm, 30-60 cm, 60-100 cm) using C/N combustion analysis. Using a 5m DEM we calculated the catchment sizes of the thirty playas, these ranged from 0.10-26.99 km2. We used the same data to calculate the slope of each catchment, these range from 0.015-0.21 m elevation/ 5m distance. In terms of nitrogen and carbon storage, we found soil nitrogen values ranging from 0.007-0.114 %, and soil carbon values ranging from 0.002-1.36 %. The results of a regression analysis show both nitrogen and carbon decrease linearly as a function of soil depth (nitrogen: y= -0.015x+0.071, R2=0.30; carbon: y= -0.19x+0.89, R2=0.24). The results of an additional regression analysis show a positive relationship between catchment size and nutrient stock size (% of soil sample) for both nitrogen and carbon (nitrogen: y= 7.0*10-5x +0.027, R2=0.14; carbon: y= 0.0014x + 0.29, R2= 0.25). These data support our hypothesis that catchment size is one of factors controlling carbon and nitrogen stock in desert playas.

Moosavi, Sadredin

Use of a Selective Inhibitor Technique Reveals Controls on Hidden CH4 Biogeochemical Cycling Along Soil Moisture Gradients From Wetland to Upland in Boreal & Arctic Soils

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Use of a selective inhibitor technique for observation of soil carbon trace gas fluxes measured along moisture gradients can offer insight into biogeochemical processes hidden from net emission measurements collected by flux chamber or remote sensing approaches. Net emissions from wetland systems almost universally indicate these environments are major methane (CH4) sources while upland systems appear to be small CH4 sinks. Use of the selective inhibitor methyl fluoride (CH3F) reveals a more complicated scenario in which methanogens and methanotrophs respond differentially to both long and short-term changes in soil conditions. Dry, upland soils rich in organic matter appear to have a latent potential to become, at a minimum, short-term CH4 sources when exposed to precipitation events. The extant methanotrophic population, accustomed to the limited CH4 supply available from the atmosphere may be limited in its ability to respond to this spike should the increased moisture conditions favoring methanogenesis persist. Similarly, the large source of CH4 from organic-rich wetland soils masks a significant component lost to CH4 oxidation in a narrow zone at the top of the water table. While CH4 production appears possible over a broad range of the soil profile from those components which remain flooded, measurements in soil cores suggest that the methanotrophic population responsible for amelioration of CH4 emission to the atmosphere resides in the soil layer where the water table is typically found and does not quickly track water table movements outside this band. Deviations in the elevation of the water table caused by extreme weather events or climatic change, either directly due to changes in precipitation and evapotranspiration or indirectly via changes in the level of surface waters, thus have the potential to disrupt the balance between CH4 production and consumption triggering unexpectedly large changes in methane flux to the atmosphere. The scale and duration of such changes across the landscape remains to be identified. Given that CH4 oxidation consumes from 10-25% in arctic systems, 40-60% in boreal systems and as much as 90% in subtropical rice paddies, this potential feedback to weather events resulting from climate change should not be ignored. Field experiments along moisture gradients from open water to upland systems in boreal and arctic soils will be examined along with results from 50 cm deep peat cores from boreal soils exposed to changes in the water table in microcosm.

Nguyen, Michael

Probing Temperature-Dependent Organo-FeOx Interactions Using Quartz Crystal Microgravimetry, NMR Spectroscopy, and Thermal Analyses

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Soils are becoming increasingly important in climate change discussions. Soil respiration accounts for the second largest flux of carbon dioxide globally. It is unknown whether warming will turn the soil reservoir into a carbon source or alter its ability to act as a sink. One mechanism by which soil organic carbon is stored is through the formation of organo-mineral complexes. 50-75% of all natural organic matter (NOM) in soils has been found associated with mineral surfaces. These org-min interactions can protect carbon from decomposition for timescales of decades to millennia. This study utilizes spectroscopic, thermal, and surface-sensitive techniques to examine the formation as well as the physical and chemical changes in org-min complexes caused by climate-relevant temperature changes (25, 30, 35°C). Iron oxide (Fe2O3) was chosen as the representative soil mineral substrate. Soil humic and fulvic acids purchased from the International Humic Substances Society were chosen as the representative NOM. Nuclear magnetic resonance spectroscopy (1H NMR) was used to identify the interacting functional groups. Our initial results suggest that aromatic (phenolic) components of NOM preferentially interact with Fe2O3. Thermogravimetric analysis (TGA) is being used to determine the thermostability of org-min complexes. Differential scanning calorimetry (DSC) is being utilized to measure the thermodynamics and binding energies associated with org-min complexes. Quartz crystal microgravimetry is being used to quantify the extent and kinetics of adsorption/desorption between NOM and mineral substrates. Preliminary QCM experiments conducted with Al2O3 and soil humic acid suggest that 1) NOM adsorption follows Langmuir kinetics, 2) the extent of adsorption at 25, 30, and 35°C are not significantly different, and 3) the initial rate of adsorption was only significantly different at 35°C. TGA, DSC, and QCM experiments are currently being conducted with Fe2O3 and soil humic acid. The results of this study will help to predict how soils dominated by iron rich minerals will respond to increasing temperatures.

Niu, Guo-Yue

A Microbial Enzyme Based Soil Organic Carbon (SOC) Decomposition Model for Use in Climate Models

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The scheme of SOC decomposition in most climate models is based on the first-order decay, and the dependence of the decay rate on temperature is based on a Q10 relationship (e,g, Q10=2.0, meaning the decay rate increases 2 times for every 10 K increase in temperature). However, this scheme is inconsistent with current understanding of decomposition mechanisms. SOC decomposition should depend on the activity of microbial communities and temperature sensitivity is more complex depending on acclimation of the carbon use efficiency by microbes. We present a microbial enzyme based SOC decomposition model. In the model up to five pools of soil carbon are defined including SOC, dissolved organic carbon (DOC), microbial biomass carbon (MIC), and enzyme (ENZ). The model assumes enzyme-catalyzed degradation of organic compounds and to simulate the pulse response to rainfall (or the "Birch effect") DOC is further divided into two pools including a bio-available pool that allows catalyzed C to accumulate during dry periods for later use by microbes in wet periods. This model has been successfully tested against soil CO2 efflux and NEE collected in a natural savannah ecosystem at the Santa Rita of the AmeriFlux network.

Niu, Guo-Yue

Analysis of an extreme rainfall-runoff event at the Landscape Evolution Observatory by means of a three-dimensional physically-based hydrologic model

Niu, Guo-Yue[2, 1]; Pasetto, Damiano[3]; Scudeler, Carlotta[3]; Paniconi, Claudio[3]; Putti, Mario[4]; Troch, Peter[2, 1]

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We present a detailed analysis, by means of a three-dimensional physically-based hydrological model, of the first experiment conducted at the Biosphere 2 Landscape Evolution Observatory (LEO). The experiment was driven by an intense rainfall event and produced a hydrological response characterized by predominant water outflow along the lower lateral boundary of LEO (seepage face), together with overland flow that began 15 hours after the start of rainfall and that caused erosion of the superficial soil and formation of a small channel. In the first simulations, using soil parameters estimated from an analysis of particle size distribution (e.g., porosity θs = 0.39 m3 m−3) and varying saturated hydraulic conductivity (Ks), the model did not produce any overland flow. In subsequent simulations, reducing either θs or Ks at the seepage face (Ks,sf) facilitated overland flow production. To systematically search for the optimal parameters, we then performed over 10,000 sensitivity simulations by varying Ks, θs, and Ks,sf for two values of the n parameter in the van Genuchten soil hydraulic characteristics (n = 2.26 and n = 1.72, obtained by fitting the van Genuchthen relationship measured at LEO and in laboratory, respectively). It was found that simulations with Ks,sf < Ks produced a higher probability of best realizations than those with Ks,sf = Ks for both values of n. In addition, the best realizations for both n values with Ks,sf < Ks result in smaller errors than those with Ks,sf = Ks. The simulation results are consistent with our in-situ observations that the seepage face, consisting of gravels and a perforated plate, became partially filled with fine soil particles transported and deposited by saturated subsurface flow. The optimized n (2.26) and Ks (1.1×10−4 m s−1) values for LEO are higher than those from laboratory measurements with the same soil (n = 1.72 and Ks = 2.0×10−5m s−1), suggesting a possible "scale" effect.

Ogee, Jerome

Global estimates of land photosynthesis inferred from the global budget of $\delta^{18}O$ in atmospheric CO_2: the crucial role of soil microorganisms *(Invited)*

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Quantifying terrestrial carbon storage and predicting the sensitivity of ecosystems to climate change relies on our ability to obtain observational constraints on photosynthesis and respiration at large scales (ecosystem, regional and global). Photosynthesis (GPP), the largest CO_2 flux from the land surface, is currently estimated with considerable uncertainty (1-3). Robust estimates of global GPP can be obtained from an atmospheric budget of the oxygen isotopic composition ($\delta^{18}O$) of atmospheric CO_2, provided that we have a good knowledge of the $\delta^{18}O$ signatures of the terrestrial CO_2 fluxes (1, 4). The latter reflect the $\delta^{18}O$ of leaf and soil water pools because CO_2 exchanges "isotopically" with water [$CO_2+H_2{}^{18}O \leftrightarrow H_2O+CO^{18}O$]. This exchange can be accelerated by the enzyme carbonic anhydrase (CA). In leaves, where CA is present and abundant, this isotopic equilibrium is reached almost instantaneously. As a consequence, and because soil and leaf water pools have different $\delta^{18}O$ signatures, CO_2 fluxes from leaves and soils carry very distinct $\delta^{18}O$ signals and can thus be tracked from the fluctuations in the $\delta^{18}O$ of atmospheric CO_2 (δ_a). The accelerated isotopic exchange between CO_2 and water due to CA activity has recently been shown to be a widespread phenomenon in soils as well (4). Across a range of ecosystems, we found that CO_2 hydration was 10 to 1000 times faster than the un-catalysed rate, with highest values in the hottest ecosystems. At the global scale, accounting for soil CA activity dramatically shifts the influence of soil and leaf fluxes on δ_a, thus changing the estimates of terrestrial gross CO_2 fluxes. In this talk we will present the current state of understanding of the environmental and ecological causes behind the variability in CA activity observed in soils and illustrate how this variability can influence our estimates of global GPP inferred from δ_a budgets. **References**

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Ou, Ling

Carbon sequestration of Louisiana crawfish ponds sediment

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Carbon (C) sequestration is considered an effective method to mitigate climate change and improve soil quality. Many studies have examined agricultural soils for their ability to sequester, but few studies have investigated C accumulation in sediments under aquaculture. In Louisiana, crawfish farming has grown to include more than 1,200 farms occupying more than 50,000 ha of land. This study examined C sequestration in crawfish aquaculture pond sediments. The study compared SOC (soil organic C) amounts under crawfish ponds and adjacent agriculture fields. There were two crawfish farming systems: monocropping and crop rotation. Soils depths sampled were 0-5, 5-10, 10-15 and 15-20 cm. A significant difference ($P<0.05$) was found in the top layer for SOC concentration in crawfish monocropping systems (25.8 g kg-1) compared to adjacent crop fields (20.8 g kg-1). However, no significant differences were found in other soil/sediment layers for C concentration or C mass. Crawfish ponds do not appear to have an advantage over upland cropping systems with regard to soil C sequestration. In addition, according to pond depth and pond age with SOC correlation, input and output of C, a possible C equilibrium in aquaculture ponds, management practices and effects of SOC on pond quality and production, C sequestration of Louisiana crawfish ponds or other aquaculture ponds is not promising.

Pachepsky, Yakov

Modeling Flow and Transport in Field Soil with Pedotransfer and Scaling

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Scale dependence in soil flow and transport parameters has been demonstrated by using measurement techniques with different support volumes. Pedotransfer functions to estimate soil hydraulic conductivity from soil texture and bulk density were developed from data of measurements on relatively small samples. Simulations of flow and transport in field soils may involve using coarse grids and corresponding large computational cells. We tested the hypothesis that upscaling saturated hydraulic conductivity from the small sample support volume to the support volume of large computational cells can provide useful estimates of this critical parameter for numerical simulations of flow and transport using large computation cells. We tested this hypothesis with groundwater and solute concentration monitoring data from field scale tracer experiment in which chloride tracer was introduced in soil with the pulse of irrigation water and the irrigation continued for four months causing predominantly lateral tracer transport in variably saturated soil and groundwater. The power law upscaling of pedotransfer-predicted hydraulic conductivities resulted in the model accuracy comparable with the accuracy of the calibrated model. Support size-based scaling of saturated hydraulic conductivity appears to be useful in finding the effective hydraulic conductivity of computational cells in soils within the two-orders of magnitude linear scale range.

Pal, David

Determining Relationships Between Dissolved Hydrogen and Methane Porewater Concentrations and Static Chamber Flux Measurements in Vegetated Wetland Soils

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Methanogenesis and wetland methane emissions have been studied for multiple decades, repeatedly demonstrating the importance of methane and wetlands to global climate change. Acetate, hydrogen and carbon dioxide are significant substrates for methane production. Studies have shown that almost one third of all methane produced in wetland soils is produced by the hydrogen-dependent methanogenesis pathway. While hydrogen is a precursor to methane production in soils, few studies have examined subsurface hydrogen dynamics and gas exchange in wetland soils. Methane emissions are primarily controlled by volatilization through plants and this loss pathway may also prove to be a significant loss mechanism for hydrogen in soils. It is important to be able to quantify hydrogen losses from wetland soils in order to more accurately understand methane substrate availability and production rates. Our objective is to better understand the relationship between hydrogen, atmospheric methane flux and porewater concentrations and explore how this relationship may have a control on methanogenesis in soils. In this study we present dissolved methane and hydrogen data from subsurface "peeper" measurements and the related above-ground static chamber flux measurements from tidal Spartina spp. and Phragmites australis soils. "Peepers" are subsurface dialysis-based porewater sampling devices that allow for the measurement of dissolved gas profiles, and other dissolved chemicals, in saturated, vegetated or unvegetated, sediments. Static chambers measure fluxes through the same vegetation and soil types as the "peepers" to understand how vegetation and soils affect gas emission rates. By combining "peeper" measurements with static chamber flux measurements we can understand how methane and hydrogen volatilization rates are affected by subsurface gas concentration profiles in the upper and lower soils. Additionally, by studying methane and hydrogen simultaneously, we can demonstrate the relative importance of hydrogen volatilization rates as a control for methane production and any relationships between methane and hydrogen flux. In order to better conceptualize vertical methane profiles we can evaluate gas loss and volatilization models along with porewater substrate availability as controls on methanogenesis in discretized mathematical models.

Pangle, Luke A.

Climate-warming impacts on water and carbon fluxes in a seasonally semi-arid grassland ecosystem

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A challenge in ecohydrological research is to understand how interactions between climate, vegetation function, and soil-moisture dynamics control intra- and inter-annual variation in hydrologic partitioning and carbon fluxes in specific environments. We present results from the Terracosm experiment—a manipulative climate change experiment in western Oregon, USA—that examined the responses of evapotranspiration, soil moisture, potential groundwater recharge, and net-ecosystem carbon exchange in response to an experimental temperature increase of 3.5 degrees Celsius that was applied symmetrically throughout the day, and asymmetrically such that daily minimum temperatures increased more than daily maximum temperatures. The results were strongly influenced by the seasonal trends of precipitation and temperature, plant function, and resulting soil moisture dynamics. Warmer temperatures enhanced evapotranspiration during the spring, which was driven by greater vapor-pressure deficit and accelerated timing of peak-seasonal photosynthetic rates, and contributed to earlier drawdown of soil-water storage entering the summer drought period. A negative feedback mechanism resulted, whereby evapotranspiration during the summer was actually lower under climate-warming treatments than under ambient temperature, due to earlier onset of plant senescence and water-limited evaporation. Despite warming-enhanced evapotranspiration during the spring, potential groundwater recharge was mostly unaffected in this Mediterranean climate where precipitation and temperature are temporally out of phase. In addition to accelerating the timing of peak-photosynthetic rates during the spring, warming treatments enhanced annual-gross photosynthesis, but ultimately shifted the grasslands towards a more carbon-negative condition due to proportionally greater enhancements of ecosystem respiration. This unique manipulative experiment revealed the important linkages between precipitation, temperature, plant function and soil moisture that controlled how critical-zone water and carbon fluxes responded to projected temperature increases associated with global climate change.

www.teraglobalchange.org; people.oregonstate.edu/~pangle

Pardo, Linda H.

A hydropedological approach to identifying sources and sinks of nitrogen in a steep, headwater catchment using nitrogen and oxygen isotopes

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Spatial heterogeneity in soil hinders scaling up from individual measurements to the catchment scale. Recent advances in understanding of the complex relationship between soil development and hydrology have facilitated the development of a novel way to classify soils into hydropedological units (HPU) at the Hubbard Brook Experimental Forest, N.H. The HPUs represent arrangement of soils along hillslope catenas. Typical podzols form under vertical percolation while E-podzols, Bhs-podzols, and Bh podzols are influenced by lateral development processes in positions that develop transient watertables. Bimodal podzols represent a transition between typical and Bh podzols. Aquepts are found in seeps with permanently high water tables. . The HPUs also vary in extent and nature of carbon (C) and nitrogen (N) cycling. In particular, E-podzols and Bhs-podzols tend to have the highest levels of nitrate and dissolved organic carbon (DOC) in soil solution and groundwater. In order to evaluate C and N cycling patterns and improve our understanding of sources and sinks of C and N, we measured NO_3^-, NH_4^+, DON, DOC, $\delta^{15}N$-NO_3^-, $\delta^{18}O$- NO_3^-, and pH in soil lysimeters, groundwater wells, and streams during events of different magnitude and type. As higher $\delta^{18}O$- NO_3^- are associated with atmospheric deposition, we expected that $\delta^{18}O$ in nitrate would decrease along flowpaths as residence time in the catchment increased and would increase with duration of event as stored solution was flushed from the system. We expected that for HPUs that are paired (one upslope, one downslope), the downslope HPU would reflect less input from deposition and processing of N mediated by soil, but found this difference to vary with HPU. Preliminary $\delta^{18}O$- NO_3^- data ranged from -7 to +26‰ with a broader range for Tropical Storm Sandy (Aug 2012) than for samples collected at the end of snowmelt (April 2013). Similarly, $\delta^{15}N$-NO_3^-, which ranged from -13 to +7‰, had a much broader range during the large summer storm event than for the late snowmelt samples. The HPU classification holds considerable promise both for improving predictions of C and N loss or retention and for scaling up to the catchment or landscape scale in the northern forest of the U.S.

Pasetto, Damiano

Soil water potential assimilation to reconstruct saturated hydraulic conductivity at the Landscape Evolution Observatory

Pasetto, Damiano[1, 2]; Niu, Guo-Yue[3, 4]; Paniconi, Claudio[1]; Putti, Mario[2]; Troch, Peter A.[4]

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3. Biosphere 2 - Earth Science, University of Arizona, Tucson, AZ, USA
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The Biosphere 2 Landscape Evolution Observatory (LEO) has been developed to investigate hydrological, chemical, biological, and geological processes in a large-scale and controlled infrastructure. The experimental hillslopes at LEO are instrumented with a large number of different sensors (water potential, water level, soil moisture, etc) that allow detailed monitoring of local dynamics and changes in the hydrological state and structure of the landscapes, such as the development of soil heterogeneity. Sensor failure in such an evolving system can have a dramatic impact on observability of flow dynamics and estimation of soil properties with a numerical model. In this study we assess the ability to retrieve the saturated hydraulic conductivity of the soil under scenarios of heterogeneity (different values of correlation length) and varying degrees of sensor failure. The analysis is conducted by way of numerical simulations using the physically-based hydrological model CATHY to emulate the flow experiment. The Ensemble Kalman filter technique permits us to assimilate the measured data into the numerical simulation and in so doing estimate/correct both the state and parameters of the model. We consider a synthetic scenario that reproduces the first hydrological experiment at LEO (22 h of rainfall at ~12 mm h−1). We assume that the 'true' hydraulic conductivity is a particular random realization of a stochastic field with lognormal distribution and exponential correlation length. During the 'true' run, we collect water potential measurements (using Decagon dielectric sensors) at an hourly interval. The perturbed observations are then used in the assimilation process to retrieve the spatial values of the conductivity. The results show, for instance, that there is only a slight deterioration in the solution of the inverse problem when the full configuration (496 sensors) is reduced to 360 and 132 sensors.

Peterson, Fox

Forest Composition links Soil SOM and DOC to ANPP in Complex Terrain

Peterson, Fox[1, 2]; Lajtha, Kate[2]

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As permitted by Henry Vereecken, I will submit my abstract by 6-22; I have family matters to attend to. Please read this abstract from our recent article submitted to JGR Biogeosciences for an idea of what we will present: Factors influencing soil organic matter (SOM) stabilization and dissolved organic carbon (DOC) content in complex terrain, where vegetation, climate, and topography vary over the scale of a few meters, are not well understood. We examined the spatial correlations of LiDAR and GIS derived topography, measured soil characteristics, and vegetation composition and structure versus SOM fractions and DOC pools and leaching on a small catchment (WS1) in the H.J. Andrews Experimental Forest, located in the western Cascades Range of Oregon, USA. We predicted that aboveground net primary productivity (ANPP), litter fall, and nitrogen (N) mineralization would be positively correlated with SOM, DOC, and carbon (C) content of the soil. We also predicted that site characteristics that increased C inputs would increase C stores and losses in the soil. While we found that ANPP was correlated with litter fall (increased C inputs) and DOC export, we did not find the expected relationships between ANPP, litter fall, SOM stores per unit area, C content of the soil, or DOC pools. Similarly, soil rock content was not well correlated with ANPP, SOM pools, or DOC export, and only demonstrated decreases at very high (> 30%) percentages of rocks in the upper 50 cm. However, exposed, dry sites had lower SOM stores and content and DOC stores and export than moist wet sites. We conclude that many factors, such as stand history, plant adaptation to drought, and even soil erosion in complex terrain can obscure expected patterns between carbon storage in soils and plant productivity.

Phillips, Claire L.

Using Radiocarbon to Investigate Soil Respiration Impacts on Atmospheric CO2

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While soil respiration is believed to represent the largest single source of CO2 emissions on a global scale, there are few tools available to measure soil emissions at large spatial scales. We investigated whether radiocarbon (14C) abundance in CO2 could be used detect and characterize soil emissions in the atmosphere, taking advantage of the fact that 14C abundance in soil carbon is elevated compared to the background atmosphere, due to the legacy on thermonuclear weapons testing (i.e. bomb-C). Working in a temperature hardwood forest system in Northern Wisconsin during 2011-12, we made semi-high-frequency measurements of CO2 at nested spatial scales from the soil subsurface to 150 m above ground level. These measurements were used to investigate seasonal patterns in respired C sources, and to evaluate whether variability in soil-respired 14C could also be detected in atmospheric measurements. In our ground-level measurements we found large seasonal variation in soil-respired 14CO2 that correlated with soil moisture, and was likely related to root activity. Atmospheric measurements of 14CO2 in the forest canopy (2 to 30m) were used to construct Keeling plots, and these provided larger spatial-scale estimates of respired 14CO2 that largely agreed with the soil-level measurements. In collaboration with the NOAA we also examined temporal patterns of 14CO2 at the Park Falls tall-tower (150m), and found elevated 14CO2 levels during summer months that were likely due to increased respiration from heterotrophic sources. These results demonstrated that a fingerprint from soil-respired CO2 can be detected in the seasonal patterns of atmospheric 14CO2, even at a regionally-integrating spatial scale far from the soil surface.

Powell, Katherine M.

Links between soil water availability and soil respiration in semi-arid ecosystems along the Colorado Front Range

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2. U.S. Geological Survey, Denver, CO, USA
3. Geography, University of Colorado, Boulder, CO, USA

Arid and semi-arid regions represent a large fraction of the world's terrestrial ecosystems, and as water-limited environments, they are sensitive to changes in soil water content which may result in large carbon efflux from soils in response to precipitation events. Previous research has demonstrated that soil temperature and soil water content are the primary controls on soil respiration (Rs), however few studies relate soil water potential to Rs, although it may be a better metric for representing how water is available to soil microbes and vegetation. Therefore, resolving how episodic changes in soil water content, specifically measures of water potential, cause arid/semi-arid ecosystems to shift from a carbon sink to a source is important for improving future estimates of terrestrial ecosystem fluxes in these areas. Our study focuses on above and belowground fluxes of carbon dioxide and water at two grassland sites and one montane forest site in Colorado. Continuous (hourly) soil CO2 concentration profile measurements, at 5cm, 10cm and 20cm (15cm in the grasslands) are coupled with continuous (30 minute), collocated soil water content and soil

temperature (Ts) measurements. Soil water availability is determined by using tensiometers at each site to relatie volumetric water content to matric potential values. To quantify belowground heterogeneity, soil samples were collected from each site to determine texture (by sieves and settling columns) and organic matter content (by loss on ignition). All of the sites have ongoing eddy covariance-based surface measurements of water, carbon and energy fluxes, including net ecosystem exchange (NEE). To estimate Rs at the surface, discrete fluxes of CO2 are measured with a portable photosynthesis system (chamber) and a soil "gas snake"(Heinemeyer et al. 2012) - a flexible tube with openings along the bottom, connected to a gas analyzer, that lies on the soil surface around the base of the vegetation. To characterize changes in aboveground biomass, vegetation samples are routinely collected from each of the sites and leaf area index (LAI) and dry biomass are determined. Measurements of Rs, soil water content, soil water potential, precipitation, Ts will be summarized on daily, monthly, seasonal, and annual timescales for each site. Time-series plots of Rs will be compared with aboveground fluxes of carbon as well as soil water, Ts, precipitation, air temperature (Ta), photosynthetically active radiation (PAR), humidity, evapotranspiration (ET), and LAI. Preliminary results show soil CO2 concentration increases were well correlated with soil water content increases at the same soil depth following precipitation events and infiltration. More measurements and calculations will be required to determine monthly and seasonal responses and to make further comparisons with aboveground fluxes and biomass changes.

Prentice, Samuel

QUANTIFYING HILLSOPE SOIL THICKNESS USING FINE SCALE TERRAIN MODELLING

Prentice, Samuel[1]

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Digital elevation models (DEMs) are the dominant input to spatially explicit digital soil mapping (DSM) efforts due to their increasing availability and the tight coupling between topography and soil variability. Accurate characterization of this coupling is dependent on DEM spatial resolution and soil sampling density, both of which may limit analyses. For example, DEM resolution may be too coarse to accurately reflect scale-dependent soil properties yet downscaling introduces artifactual uncertainty unrelated to deterministic or stochastic soil processes. We tackle these limitations through a DSM effort that couples moderately high density soil sampling with a very fine scale terrestrial lidar dataset (20 cm) implemented in a semiarid rolling hillslope domain where terrain variables change rapidly but smoothly over short distances. Our guiding hypothesis is that in this diffusion-dominated landscape, soil thickness is readily predicted by continuous terrain attributes coupled with soil catena hillslope segmentation. We choose soil thickness as our keystone dependent variable for its geomorphic and hydrologic significance, and its tendency to be a primary input to synthetic ecosystem models. In defining catenary hillslope position we adapt a logical rule-set approach that parses common terrain derivatives of curvature and specific catchment area into discrete landform elements (LE). Variograms and curvature-area plots are used to distill domain-scale terrain thresholds from short range order noise characteristic of very fine-scale spatial data. The revealed spatial thresholds are used to condition LE rule-set inputs, rendering a catenary LE map that leverages the robustness of fine-scale terrain data to create a generalized interpretation of soil geomorphic domains. Preliminary regressions show that continuous terrain variables alone (curvature, specific catchment area) only partially explain soil thickness, and only in a subset of soils. For example, curvature explains 40% of soil thickness variance at <300 cm at scales up to 20 m, while soil thickness >300 cm shows no clear relation to curvature. Further efforts will be aimed at refining the regression model by integrating the spatially-constrained generalized LE map classes, as well as simulating DEM error for uncertainty analysis.

Presler, Jennifer K.

Chemical Signatures of Biological Colonization in a Model Ecosystem

Presler, Jennifer K.[1]; Zaharescu, Dragos[1]; Burghelea, Carmen[1]; Dontsova, Katerina[1]; Chorover, Jon[2]; Maier, Raina[2]; Huxman, Travis[3]

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Ecosystem formation relies on interactions between biotic and abiotic factors to stabilize a habitat, create soil, and make favorable conditions for plants and animals. An oligotrophic ecosystem can form as plants and microbes extract exploitable elements from a substrate otherwise poor in available nutrients, e.g. rock. In order to understand how different components of plant -microbes- -fungal communities interact with bedrock to create soil and form a primordial ecosystem, a modular experiment was designed at Biosphere-2. The experiment involves 4 granular rocks, i.e. basalt, granite, rhyolite and schist, and biological combinations of rock microbes, plants (Bouteloa dactyloides, grass and Pinus ponderosa, pine), and associated mycorrhizae: arbuscula mycorrhiza - Glomus intraradices and ectomycorrhiza - Rhizopogon evadens. A plant-free, un-inoculated control was also included. Columns were irrigated with nanopure water and monthly samples of water runoff were collected and analyzed for water consumption, pH, conductivity, dissolved organic and inorganic C, total N, major nutrient and trace element leaching and uptake. Here we present data from the first 4 months of the experiment. The biological treatments affected porewater chemistry differently for each rock. pH slightly decreased in all rocks and treatments over time, while ecosystem colonization significantly lowered pH with respect to control for basalt and rhyolite, and raised it on schist. Electrical conductivity, a measure of total element dissolution, was positively correlated with increased ecosystem complexity for all rocks except schist, where it decreased. Treatments dissociated with time. Significant chemical signatures of ecosystem interaction with bedrock were discovered through analysis of porewater elements. Inorganic carbon (IC), a measure of below ground biomass respiration, had increased production in the planted components on all bedrocks except schist. This appeared to show a seasonal trend, with clear separation between the vegetated and un-vegetated treatments over time. However, there was a unique dependence of IC on pH for schist, suggesting a strong pH influence on below-ground processes on this rock. Also on this rock, the presence of grass mycorrhiza had a significant effect on dissolved organic carbon compounds. Conversely, pine mycorrhiza had the opposite effect on basalt. Phosphorus, an essential nutrient for growth, energy and DNA production seemed to have been less available on granite and schist as indicated by a comparatively lower loss under biological treatment. While on basalt pine mycorhiza decreased P loss, grass mycorrhiza on rhyolite had an opposite effect. Our results showed that element leaching depends strongly on treatment and rock type. For example, phosphorus...the sentence from up. The study exemplifies that there is a high variability in terms of element release and uptake on different bedrock under ecosystem colonization and mycorrhiza plays an important role in this variability.

http://www.b2science.org/earth/people/res/dontsova/geobiology

Rasmussen, Craig

Using statistical methods to quantify and predict catchment scale soil variability

Rasmussen, Craig[1]; Holleran, Molly[1]

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Quantifying catchment scale regolith physicochemical variation has the potential to yield important insights to the evolution and function of the subsurface critical zone. The objective of this study was to quantify and predict soil properties within a forested catchment in southern AZ, USA. The catchment, Marshall Gulch (MG), is part of the Jemez River Basin-Santa Catalina Mountains Critical Zone Observatory (CZO). MG is 5-hectare, mixed-conifer forested catchment situated on granitic parent material, with a mean elevation of 2400m, mean annual temperature of 10°C and mean annual precipitation of 75 cm. The study was designed using a combination of principle component analysis (PCA) of available geospatial data and a conditioned Latin Hypercube Sampling (cLHS) scheme. Geospatial data determined by the PCA to account for 95% of landscape variance included modeled soil depth, slope, soil wetness index, normalized difference vegetation index (NDVI), and National Agriculture Imagery Program (NAIP) bands 3/2. The cLHS scheme was performed using these geospatial data and determined 20 optimal sample locations for collecting soil material down dug to the depth of refusal, and sampled according to genetic horizon. Soils were characterized using methods of X-ray Fluorescence (XRF), X-ray Diffraction (XRD), particle size, color, pH, electrical conductivity (EC), C/N isotopes, and loss on ignition (LOI). Regression models predicting soil depth (cm), carbon (kg m-2), clay (%), Na flux (kg m-2), pH, and volumetric strain were developed using the 20 sample locations, the six geospatial data layers determined from the PCA, and reverse step-wise multiple linear regression. Results indicated strong correlations of soil properties with the drainage systems in the MG catchment. Deeper soils, higher clay content, higher carbon content, and greater Na loss were observed and modeled within the drainages of the catchment relative to adjacent slopes and ridgelines. Regression R2 values ranged from 0.35 (soil depth, cm) to 0.50 (carbon, kg m-2) and all models exhibited p-values <0.05. Regression model residuals were extrapolated spatially using an optimized Inverse Distance Weighting (IDWopt), followed by cross validation and determination of spatial autocorrelation using Moran's I. Cross validation mean errors approached zero and residual errors were randomly distributed throughout the catchment as determined by Moran's I, indicating unbiased models with no spatial autocorrelation in predicted residuals. Spatial maps of prediction residuals were added to soil properties predicted with the regression models to yield final interpolated maps of profile data at the scale of the entire catchment. Overall we found soil properties varied predictably with topography and landscape position throughout the catchment, yielding strong correlations to the convergent drainages within the study site. These data provide a clear basis for modeling water, carbon, and sediment transport within the catchment, in addition to laying the foundation for quantifying catchment scale soil-water and carbon storage capacities.

Reichstein, Markus

Soil, climate extremes and the carbon cycle *(Invited)*

Reichstein, Markus[1]

1. Department for Biogeochemical Model-Data Integration, Max-Planck-Inst. for Biogeo., Jena, Germany

In this presentation I will highlight the importance of the soil for global biogeochemical questions and pose the question, whether the complexity of the soil is adequately considered in global biogeochemical analysis and modeling. Vertical heterogeneity and vegetation-soil feedback, the role of soil (micro-)biota in the carbon cycle and bio-chemical and physico-chemical limitations of soil processes will be discussed as important topic in this context. Moreover I argue that the soil is an important determinant of how ecosystems and their biogeochemical cycle respond to climate extremes, which have recently attracted attention for carbon cycle impact. Finally as synthesis I will present global residence times of ecosystem carbon, confront these with

modeling results and discuss the difference in light of the above consideration.

Reid, Matthew C.

Gas Exchange in the Wetland Rhizosphere: Quantifying Spatial and Temporal Variability at Field Scales with Dissolved Gas Tracer Experiments

Reid, Matthew C.[1]; Pal, David S.[1]; Jaffe, Peter R.[1]

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Wetlands exist at the interface of terrestrial and aquatic systems, and their anaerobic soils are biogeochemical "hot spots" for element cycling that produces trace gases of environmental importance including methane (CH4), nitrous oxide, and halomethanes. The balance between biochemical production and uptake in soils depends, in part, on mass transfer to other compartments of the environment. Chemical transport along the soil – plant – atmosphere system is an important pathway for these biogenic gases and controls mass fluxes from sediments to the atmosphere, but is highly heterogeneous in space and time and remains poorly described in ecosystem-scale budgets. Plant gas transport is governed by uptake processes at root surfaces, but quantitative information on uptake kinetics is limited by the lack of non-invasive techniques to monitor rhizosphere processes. The objective of this study is to improve predictions of gas fluxes through vegetation by integrating in-situ measurements of rhizosphere gas exchange with scaling strategies based on root and vegetation community distributions. Here we describe the first field application of a dissolved gas tracer push-pull test (PPT) to make in-situ kinetics measurements of dissolved gas root uptake in the wetland rhizosphere. PPTs involve the injection of a solution containing dissolved sulfur hexafluoride, helium, and bromide tracers into saturated wetland sediments and subsequent sample withdrawal from the same injection point. Tracer ratios in the extracted solution were combined with analytical advection-dispersion-reaction models to determine first-order uptake rate coefficients. Measurements were conducted across several months and in different vegetation zones of a New Jersey tidal marsh to assess seasonal and spatial variations in soil – root gas exchange rates. Tracer-derived rate coefficients were combined with root and vegetation distributions to scale vegetation-mediated gas exchange estimates to the patch scale, and were validated against a set of CH4 porewater and flux measurements. Measurements revealed order-of-magnitude differences in dissolved gas root uptake rates between seasons, marsh vegetation zones, and soil column depths. Rate coefficients scaled to CH4 approximated measured fluxes, providing a process explanation for CH4 transport through plants. These experiments yield new and quantitative insights into the fate and transport of trace gases in wetland soils, and provide a more complete understanding of the biogeochemical processes central to the ecosystem services provided by wetlands.

Root, Robert A.

Toxic metal(loid) speciation is controlled by iron mineral (bio)weathering in phytostabilized mine tailings

Root, Robert A.[1]; Hammond, Corin[1]; Valentin, Alexis[1]; Herbertson, Linnea[1]; Maier, Raina M.[1]; Chorover, Jon[1]

1. SWES, University of Arizona, Tucson, AZ, USA

Legacy mine tailing sites in (semi-)arid environments present a significant health risk to nearby communities from off-site wind and water transport of (toxic) metal-laden particles. Compost-aided phytostabilization, for revegetation of mine wastes, has been employed as an in situ strategy to reduce contaminant dispersion and diminish physical erosion. The changes in microbial composition and metal(loid) speciation that accompany the requisite addition of water and organic matter into the desert tailings remain poorly known and this motivates our work. Field, mesocosm, and laboratory studies revealed that rhizosphere microbiota experienced a 5-log increase in bacterial 16S rRNA copy number in the amended compared to control tailings and an attendant transition from sulfidic minerals to ferric (oxy)hydroxide and jarosite type minerals with concomitant sequestration of As in the solid phase. We conclude that the disequilibrium imposed by phytostabilization results in an accretion of heterotrophic biomass that is concurrent with a time series of geochemical transformations, which controls the species, fate, and bioavailability of toxic metal(loid)s including Zn, As, and Pb.

Green house and field-scale compost-aided phytostabilization for revegetation of mine tailings.

Roy Chowdhury, Taniya

Role of Geochemical and Microbially Driven Processes in Carbon Dynamics in Arctic Ecosystems

Roy Chowdhury, Taniya[1]; Graham, David[1]; Tang, Guoping[2]; Chourey, Karuna[3]; Hettich, Robert[3]; Phelps, Tommy[1]; Elias, Dwayne[1]; Wullschleger, Stan[2]

1. Biological Sciences, Oak Ridge National Laboratory, Oak Ridge, TN, USA
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3. Chemical Sciences, Oak Ridge National Laboratory, Oak Ridge, TN, USA

Permafrost-affected soils occupy only 16% of the earth's surface but store nearly 50% of the terrestrial global C. The organic matter in these systems will be subjected to increased microbial degradation as the active layer deepens and permafrost thaws and remains unfrozen for extended periods due to soil warming. The unique nature of these frozen materials, consisting of organic, mineral, and mixed organic/mineral materials, as well as saturated seasonally thawed active layers and permafrost layers with massive, pore, and vein ice, makes the ideal assessment of temperature response of C fluxes very challenging. In turn, the proportion of greenhouse gases like methane (CH4) and carbon dioxide (CO2) released in response to soil warming depend on the microbial response to warming, organic matter availability and the geochemistry. This study aims at understanding the underlying feedback processes between soil geochemistry and microbial activity towards an enhanced understanding of Arctic systems. Intact frozen soil cores were collected from the Center, Ridge and Trough areas of a low-centered polygon on the Barrow Environmental Observatory (Barrow, Alaska). A typical soil core consisted of a 0-20 cm deep organic (O) horizon, 20–50 cm deep mineral (B) horizon and 50–90 cm deep permafrost. Significant amounts of ferrous iron in O and B horizons constituting the active layer and permafrost indicated anaerobic soil chemistry. Therefore, microcosms were constructed to incubate soils using ecologically relevant temperatures of -2, +4 or +8 °C under anaerobic conditions. Both CH4 and CO2 production exhibited distinct temperature response curves. To estimate the dependence of organic C degradation on electron acceptor concentrations, the data were fit to predictive models. CO2 production could be explained by Monod kinetics exhibiting a shorter lag phase in contrast to CH4 production that followed exponential kinetics, with a longer lag phase characteristic of physiological adaptation. Production rates for both CH4 and CO2 were substantially higher in microcosms of O horizon (~40 % total C) at all temperatures, compared to B horizon samples (~20 % C) or permafrost (~12 % C) that produced CO2 but negligible CH4. Metaproteomincs revealed abundance of signature proteins from methanogens and iron storage in the biomass extracted from untreated frozen soils in both permafrost and active-layer. Following incubations, however, methanogenic proteins were found only in active-layer samples, consistent with the temperature induced headspace gas measurements. This suggests that thawing and warming of the low-centered polygon soil potentially increases microbial biomass with associated significant changes in microbial community structure. Additionally, microbial biomass production, fermentation, iron reduction and methanogenesis potentially explain most of the C and electron flow in these closed systems. The microcosm incubation studies presented herein provide a starting point for mechanistic understanding of C fluxes in future climate in the Arctic.

Sadro, Steven

The influence landscape position and catchment characteristics on the biogeochemistry of high-elevation lake-chains

Sadro, Steven[1, 2]; Nelson, Craig E.[2]

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In catchments where lakes are connected in a sequential lake-stream network, or lake-chain, terrestrial loading and aquatic processing simultaneously take place along downstream flow paths. While the concentrations of solutes are generally thought to increase with increasing path length, it is less clear how biogeochemically reactive materials such as nutrients and dissolved organic matter may change. Furthermore, the extent to which landscape position, catchment characteristics, or hydrological connectivity affect material processing remains largely unexplored. To examine these dynamics, we conducted a survey of high-elevation lake-chains from 14 different catchments in the Sierra Nevada (California). We sampled a total of 76 lakes and the stream segments connecting them to evaluate spatial patterns within and among lake-chains for a wide range of biogeochemical variables. In addition to taking a snapshot of concentrations under baseflow conditions, we explored material processing by taking the difference between inlet and outlet samples of lakes or downstream and upstream samples for stream reaches. These data help illustrate controls over material transport and transformation within lake and stream networks of headwater catchments. There were distinct spatial patterns to the characteristics of dissolved organic matter (DOM) in high-elevation Sierran lakes. Dissolved organic carbon (DOC) concentration was related to a number of landscape characteristics, most notably to slope and the extent of vegetation cover within catchments. Landscape influence on DOM was strongest during spring snowmelt when DOC was highest and the fluorescence index, a relative measure of allochthonous and autochthonous fulvic acids in the dissolved organic matter pool, indicated organic matter was largely of terrestrial origin. There were strong gradients in dissolved nitrogen species along downstream flowpaths delineated by changes in rock and shrub cover. Nitrate tended to decline and dissolved organic nitrogen (DON) to increase linearly across the alpine zone where shrub cover

increased to ~20-25% and rock cover decreased to ~70%. Landscape patterns in bacterioplankton abundance mirrored these downstream increases in DOM. Patterns of material processing within lakes and streams were more complex. Lakes tended to be sources for Chlorophyll-a and bacterioplankton cells, exporting them to stream reaches where their concentrations tended to decline along downstream flowpaths. However, nutrient and organic matter processing was much more variable, with some lakes and streams acting as sources and others as sinks. While landscape position or catchment characteristics accounted for some of this behavior, the majority of the variability remained unexplained. Despite the relative lack of coherence in material processing, our results emphasize that many biogeochemically reactive variables changed predictably along gradients in catchment characteristics or with landscape position.

Sandeep, Kizhur

Soil-Sediment Linkages in the Catchment area of Lakes in Southern India

Sandeep, Kizhur[1, 2]; Shankar, Rajasekhariah[1]; Warrier, Anish K.[1, 3]

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We investigated the rock magnetic properties (χlf, χfd, χARM and IRM's at different field strengths) of sediment cores from five lakes (Pookot Lake (PK), Thimmannanayakanakere (TK), Shantisagara (SS), Ayyanakere (AK) and Kurburkere (KK)) as well as surface and sub-surface soil samples from the respective catchment areas of the lakes in southern India. The principal objectives of the study were to understand pedogenesis in tropical regions and establish soil-lake sediment linkages, which will be useful in paleoclimatic studies of lake sediments. The study revealed the absence of lithogenic/anthropogenic magnetic grains, bacterial magnetite and greigite in soil and sediment samples. Seasonal studies of the soil samples showed that the time lag between pedogenic magnetite formation and topsoil erosion is negligible. The PK profile, which receives high rainfall (~ 4000 mm/year), does not exhibit any magnetic enhancement of topsoil. There is hardly any difference between the magnetic susceptibility (χlf) values of surface and sub-surface samples, which reflects the deeply weathered nature of the soil profile. The SS profile exhibits lessivage of magnetic minerals, resulting in a thick magnetically enhanced zone. It displays the highest χlf values among the five profiles studied. The TK and AK soil profiles do not exhibit any magnetic enhancement. In fact, χlf values increase towards the profile-bottom, suggesting top-soil erosion, besides contribution of magnetic minerals from parent rocks. In the TK profile, there is a clear distinction between surface and sub-surface samples, the former being magnetically coarse grained. The KK profile exhibits moderate to strong χlf values and a mild magnetic enhancement at the surface. The pedogenic magnetite formed in the lake catchment is transported and deposited on the lake-bed during each monsoon season, recording and preserving the climatic signal of that year. The magnetic susceptibility record of sediment cores from the five lakes provide the Holocene climatic history of the region. High χlf values indicate periods of high rainfall and vice versa. The climate varied significantly during the Holocene and the trend of variation was not similar across the five sites. The organic carbon and nitrogen contents derived from hydrophytes and terrestrial plant detritus also varied significantly, depending upon the climatic conditions. The C/N ratio of organic matter was used to differentiate between organic matter derived from aquatic algae/plankton and land plants. There is a high correlation between organic carbon and nitrogen (r=0.93), indicating that both the elements are organically bound. The low C/N ratios indicate deep lake conditions because of the abundant planktonic growth, implying a warm and wet climate and vice versa.

Sanderman, Jonathan

Linking soils and streams: production, consumption, transformation and export of dissolved organic matter in two contrasting watersheds *(Invited)*

Sanderman, Jonathan[1]; Lohse, Kathleen A.[2]; Baldock, Jeffrey A.[1]; Amundson, Ronald[3]

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In headwater streams, the concentration and reactivity of dissolved organic matter (DOM) primarily reflect the combined influence of terrestrial biogeochemical cycling of organic matter and the hydrologic routing of water through the landscape. In this talk, I will present isotopic (13C and 14C) and spectroscopic (UV and 13C nuclear magnetic resonance) data from two contrasting first-order watersheds in coastal California to demonstrate the importance of both soil biogeochemical processes and hydrologic connectivity in controlling stream water DOM concentration, age and reactivity. Soil pore water DOM is regulated by the interplay between biological productivity and organic matter supply, exchange reactions with the soil matrix, and microbial utilization [Sanderman et al., 2008]. In particular, exchange reactions between the solid and dissolved phase were important in regulating pore water DOM chemistry. Despite differences in the distribution of OM stocks and litter chemistry, similar shifts in DOM chemistry were observed with soil depth at both sites. In a moderate relief mixed grassland watershed (3.9 ha), hydrometric observations indicated that runoff generation shifted from throughflow to shallow macropore flow to overland flow during large

winter storms. At base flow, only old and highly processed deep soil OM and DOM sources were connected to the stream, resulting in low concentrations of old and highly altered DOM in stream water; whereas when saturated overland flow dominated during storms, a direct connection between surface and shallow DOM-rich source areas and the stream resulted in high concentrations of younger and fresher DOM in stream water. In this hydrologically dynamic system, stream DOM composition exhibited a temporally variable composition representative of almost the entire range in organic chemistry as found within the soil itself [Sanderman et al., 2009]. In a higher relief redwood-Douglas fir dominated watershed (16 ha), a very narrow range of stream DOM concentration and chemistry was found across stream flows spanning three orders of magnitude. Here, a network of large subsurface soil pipes limited the buildup of pore pressures and thus limited the extent of shallow saturated areas contributing to stream flow. Due to the lack of shallow flow contributing to runoff, DOM concentrations were consistently low with a characteristic chemistry of highly altered deep soil OM. Within the soil, biogeochemical transformations greatly alter the character of DOM as water percolates through the soil but the hydrologic connectivity between the soil and the stream appears to be the dominant control on stream water DOM composition in headwater streams. References: Sanderman J, Baldock JA, Amundson R (2008) Dissolved organic carbon chemistry and dynamics in contrasting forest and grassland soils. Biogeochemistry 89: 181-198 Sanderman J, Lohse KA, Baldock JA, Amundson (2009) Linking soils and streams: Sources and chemistry of dissolved organic matter in a small coastal watershed. Water Resources Research 45: W03418

Schaaf, Wolfgang

Using the constructed catchment Chicken Creek to disentangle feedbacks between soils, surface structures, vegetation and hydrology during initial ecosystem development

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Over a period of eight years, we investigated the initial development of the constructed catchment Chicken Creek, south of Cottbus, Germany (Gerwin et al., 2009). Since the boundary conditions and inner structures of the hillslope are well known and documented (Gerwin et al., 2011), the site offers unique possibilities to study the relevant processes of ecosystem development interacting with various structures and patterns. We observed considerable changes within the catchment (Elmer et al., 2013). Both internal and external factors could be identified as driving forces for the formation of structures and patterns in the artificial catchment. Initial structures formed by the construction process and initial substrate characteristics were decisive for the distribution and flow of water. External factors like episodic events triggered erosion and dissection during this initial phase, promoted by the low vegetation cover and the unconsolidated sandy substrate (Schaaf et al., 2013). With time, secondary structures and patterns evolved and became more and more important. Invading biota and vegetation succession initialized feedback mechanisms resulting in pattern and habitat formation, and generally in increased differentiation, heterogeneity and complexity that are typical characteristics of ecosystems (Schaaf et al., 2011). The processes and feedback mechanisms in the initial development of a new landscape may deviate in rates, intensity, and dominance from those known from mature ecosystems. It is therefore crucial to understand these early phases of ecosystem development and to disentangle the increasingly complex interactions between the evolving terrestrial and aquatic, biotic, and abiotic compartments of the system. Elmer M, Gerwin W, Schaaf W, Zaplata MK, Hohberg K, Nenov R, Bens O, Hüttl RF (2013): Dynamics of initial ecosystem development at the artificial catchment Chicken Creek, Lusatia, Germany. Environ Earth Sci 69, 491-505. Gerwin W, Schaaf W, Biemelt D, Fischer A, Winter S, Hüttl RF (2009): The artificial catchment "Chicken Creek" (Lusatia, Germany) - A landscape laboratory for interdisciplinary studies of initial ecosystem development, Ecol Eng 35, 1786-1796. Gerwin W, Schaaf W, Biemelt D, Winter S, Fischer A, Veste M, Hüttl RF (2011): Overview and first results of ecological monitoring at the artificial watershed Chicken Creek (Germany). Phys Chem Earth 36, 61-73. Schaaf W, Bens O, Fischer A, Gerke HH, Gerwin W, Grünewald U, Holländer HM, Kögel-Knabner I, Mutz M, Schloter M, Schulin R, Veste M, Winter S, Hüttl, RF (2011): Patterns and processes of initial terrestrial ecosystem development. J Plant Nutr Soil Sci 174, 229-239. Schaaf W, Elmer M, Fischer A, Gerwin W, Nenov R, Pretsch H, Seifert S, Winter S, Zaplata MK (2013): Monitoring the formation of structures and patterns during initial development of an artificial catchment. Environ Monit Assess 185, 5965-5986.

Schmidt, Michael

Geochemical tools to infer charring temperature, aromaticity and the degree of condensation of fire-derived organic matter in soil, water, and sediment - a method comparison

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Fire-derived, pyrogenic carbon (PyC) is a persistent organic carbon fraction with a slow turnover in the environment because it is relatively resistant against chemical and biological degradation. It thus represents an important carbon fraction with a sequestration potential in the global carbon cycle. PyC is naturally produced on a large scale during wildfires and anthropogenically in the form of biochar, when organic waste is pyrolyzed. Aromaticity and the degree of condensation are the two main quality properties of PyC that probably largely determine its persistence against degradation. The two parameters should theoretically be dependent on pyrolysis conditions, such as charring temperature, pyrolysis time or feedstock. In this study, we used four different feedstocks and two different pyrolysis procedures to produce a thermosequence of 40 chars, ranging from 100 – 1000° C. The chars were then analyzed with six different state-of-the-art methods: solid state 13C nuclear magnetic resonance (13C NMR), diffuse infrared Fourier transform spectroscopy (DRIFT), X-ray diffraction (XRD), synchrotron-based near-edge X-ray absorption fine structure analysis (NEXAFS), benzene polycarboxylic acid analysis (BPCA) and pycnometry. They allowed to infer the aromaticity and the degree of condensation of the material. Using multivariate statistical methods, aromaticity and the degree of condensation could successfully be linked to charring temperature because characteristic patterns of the two properties could be observed by different methods throughout the whole thermosequence. Moreover, we show, which methods are most suitable for a quality assessment of PyC and discuss their advantages and limitations.

Scudeler, Carlotta

Numerical simulations of isotope tracer experiments at the Landscape Evolution Observatory

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The Biosphere 2 Landscape Evolution Observatory (LEO) is a research infrastructure designed to study and quantify different hillslope processes, some of them related to subsurface flow and solute transport. It consists of three identical sloping convergent landscapes inside an environmentally controlled facility at Biosphere 2, the University of Arizona. The hillslopes are instrumented with a dense network of sensors and samplers for detailed measurement of subsurface flow, water potential, soil moisture, and tracer concentrations. Tracers can be introduced into the system at a constant or time-varying rate via the rainfall simulator that has been engineered to deliver water at a rate between 0.003 and 0.045 m/h. In this study we used deuterium to label water that entered one of the landscapes at known rate and concentration. The analyses are performed with a physically-based hydrological model that solves Richards' equation for water flow and the advection-dispersion equation for solute transport. The simulations are used for interpretation of the observation data, such as what is the impact of the unsaturated zone and the initial hillslope water storage on the amount of tracer measured at the seepage outlet? Is there evidence that geochemical reactions are altering the expected mass balance of the system? and for assessment of the numerical performance of the model, such as what is the sensitivity of a standard finite element discretization to spatio-temporal resolution and different types of boundary condition? What are the accuracy gains – especially in terms of mass balance – in using more advanced algorithms for velocity calculation and solute propagation?

Seyfried, Mark S.

Soil Temperature and Water Dynamics on Contrasting Aspects in the Rain-Snow Transition Zone at Reynolds Creek

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Understanding how complex terrain effects hydrological and biogeochemical processes has become increasingly important as the global climate changes because we need to know how water and carbon fluxes are integrated across the

landscape up to relatively large (i.e., regional) domains. Soils modulate both fluxes and are therefore central to this understanding. Spatial variations of incoming solar radiation, which are a primary driver of terrain effects, are well understood and quantified. Although terrain effects on soils are well documented in a qualitative fashion, very little quantitative description has been done. We are particularly interested in soil temperature and water content because they exert strong controls on both water and biogeochemical fluxes. We measured soil water (θ) and temperature (Ts) profiles at three paired locations in mountainous, complex terrain in SW Idaho, USA (~43°latitude). Each pair consisted of a soil profile of temperature and water content from a depth of 5 cm to bedrock (50 to 110 cm) on opposing north and south facing slopes at the same elevation. These profiles are co-located with meteorological stations (including snow depth) and precipitation and streamflow are measured nearby. The sites are located near the rain/snow transition elevation for the area (1600 m) on steep slopes (25 to 40°) with sparse vegetative cover. Soils on north facing slopes are deeper with greater organic matter accumulation but otherwise less profile development. We expected to measure large Ts contrasts during summer, when solar radiation is greatest and heat accumulates in the soil and that differences would subside and possibly reverse during the winter, when differential snow cover would insulate north facing soils more than the south facing soils. We measured dramatic differences between the two slopes, with a difference of 9°C (at 50 cm) in August. Differences between slopes were smaller in winter, about 4° C, but did not reverse. For perspective, the Ts difference between two opposing slopes at identical elevations that we measured is practically the same as the difference between Ts measured on nearly level ground but separated by 1000 m in elevation. Due to the measured temperature differences, greater year-round carbon mineralization and respiration and greater ground heat flux to the surface are expected from south-facing soils. We expected θ on north facing soils to decline more slowly and later in the year the south facing soils because the evaporative demand is greater on south facing slopes. We did not observe this and, in fact, θ on the two slopes responded similarly during spring and early summer. This is attributed to two factors. First, spring rains were sufficient to maintain relatively high soil water storage on both slopes. Second, the denser vegetative cover on the north-facing slopes counters the lesser evaporative demand. We are further quantifying these findings via process-based modeling.

Seyfried, Mark

Reynolds Creek Carbon Critical Zone Observatory: Improving prediction of soil carbon storage and flux from the pedon to the landscape scale

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Most of the world's terrestrial carbon is found in the critical zone, where it is predominantly stored as soil carbon. This important carbon reservoir is sensitive to climatic and land use change and may act as a source or sink for atmospheric carbon dioxide. Despite its importance, soil carbon remains a critical source of uncertainty in both carbon cycling and global climate models. That uncertainty arises due to both an incomplete understanding of the processes dictating soil carbon fate and the challenge of up-scaling often highly spatially and temporally heterogeneous soil processes to the landscape or global level. The Reynolds Creek Carbon Critical Zone Observatory (RCC CZO) will address the grand challenge of improving prediction of soil carbon storage and flux from the pedon to the landscape scale. Reynolds Creek Experimental Watershed is particularly well suited for this effort because it extends over strong gradients in climate and vegetation with associated dramatic differences in both soil organic and inorganic carbon. These gradients facilitate both observation-based science and experimental investigations in which the gradients act as primary variables. This new CZO will also be supported by unique long-term, spatially- extensive, meteorological, soil monitoring, and atmospheric datasets that will both inform and constrain conceptual and numerical models of soil carbon behavior. Research efforts will be focused along a series of intensively instrumented (eddy flux towers, soil respiration, moisture, temperature, and a suite of climatic monitoring) sites along the elevation gradient. Extensive characterization of above and below ground biomass, soil carbon amounts, distribution and characteristics will be undertaken at these sites as well as in a distributed manner across the watershed, producing a massive watershed-scale dataset that can inform soil carbon research for generations. Experimental research will include long-term manipulations of precipitation regime and fire (chronosequence) investigations. Modeling of soil physical, chemical and biological processes will inform our efforts to reveal mechanistic linkages between soil carbon behavior and key environmental variables. Sophisticated climate-hydrologic models will be used to spatially distribute those controlling variables at a sufficiently high resolution (5 m) to capture the natural heterogeneity on the landscape. This data will allow application of ecosystem-soil carbon simulations that can be tested against the landscape-scale datasets and used to inform our understanding of soil carbon behavior and direct our research activities towards the areas of greatest uncertainty.

Stewart, Ryan D.

Improved understanding and prediction of runoff thresholds

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Clay soils with shrink-swell characteristics – called vertic soils - are found all over the world. The formation of shrinkage cracks profoundly affects the hydrology of these soils, making it difficult to accurately understand and model processes such as infiltration, preferential flow, and runoff. Data collected from a set of instrumented runoff plots located in the Secano Interior region of Chile demonstrate the complicated mechanisms by which water moves through and interacts with vertic soils, and show that the wetting and sealing processes are highly complex. However, an emergent property was also clearly observed, as all of the plots showed similar runoff thresholds in terms of cumulative precipitation. This may in turn simplify future efforts to predict infiltration and runoff across scales.

Stockinger, Michael P.

Active Catchment Area as a Controlling Factor of Spatial Patterns of Transit Time Distributions in a Small, Forested Catchment

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Knowledge of catchment response times to precipitation forcing and of transit times of water can be used to characterize a catchment's hydrological behavior. The aim of this study was to use one gauging station together with multiple δ18O-isotope monitoring locations along the main stream and tributaries of a small river to characterize the spatial heterogeneity of a catchment's hydrological behavior. We present a method suitable for small catchments to estimate the Transit-Time Distribution (TTD) of precipitation to any stream point using δ18O tracer data, independent of whether the stream point is gauged or ungauged. Hourly runoff and precipitation data were used to determine the effective precipitation for the Wüstebach catchment (Eifel, Germany), a small, forested TERENO/TR32 test site. Based on average soil water content the modeling period of 2 years was split up in two summer and two winter seasons in order to ensure a good fit of the model. Given the small size of the Wüstebach catchment (38 ha) and its homogenous spruce tree cover, we assumed the derived effective precipitation to be representative for the whole catchment. For subsequent modeling of stream water δ18O data we used effective precipitation as an input variable and corrected for smaller hydrologically active residual area (HARA) during summer months, when parts of the catchment become hydrological inactive. Results show a different behavior of the catchment's response time for different catchment wetness conditions, governed by storage characteristics. Winter and summer seasons, respectively, show similar response times, with summers reacting generally faster due to the shrinking catchment size. The TTDs across the isotope observation points show locations more influenced by shallow source waters than other points, with higher contributions of deep/slow groundwater. The model results are verified by independent evaluations of sub-catchment soil properties distributions.

Subin, Zachary M.

Representing the Effects of Hillslope-Scale Hydrology on Soil Carbon Distributions within an Earth System Model

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Soil moisture is a crucial control on soil carbon cycling, and its impact on soil carbon accumulation is highly nonlinear due to anoxia and interactions with aboveground vegetation. Earth System Models (ESMs) generally only represent the average soil moisture state in grid cells at scales of 50-100 km, and as a result are not able to adequately represent the effects of subgrid heterogeneity in soil moisture, especially in regions with large wetland areas. We addressed this deficiency by developing a subgrid hillslope-hydrological model embedded within the Geophysical Fluid Dynamics Laboratory (GFDL) land-surface model. One or more representative hillslope geometries are discretized into land model tiles along an upland-to-lowland gradient in each grid cell. Each tile has its own surface fluxes and vertically-resolved state variables for soil physics and biogeochemistry. Inclusion of deep layers down to bedrock allows for physical inclusion of groundwater transport. The hydrological model is coupled to the Carbon, Organisms, Respiration, and Protection in the Soil Environment (CORPSE) model, which represents soil carbon accumulation and decomposition including dynamic microbial activity, protected carbon pools, and vertical redistribution of carbon through leaching. Soil carbon is vertically resolved in the model, allowing more realistic interactions with hydrology in wet areas. We present sensitivities in global and regional soil carbon distribution

to subgrid hydrological heterogeneity and its representation, including alternative parameterizations of hillslope geometry (e.g., concave upwards vs. neutral slope profiles), macroporosity, and surface runoff / inundation. The inclusion of subgrid hydrology can increase the equilibrium 0-2 m global soil carbon stock by a factor of ~3, including large realistic increases in peatland-rich areas such as the Hudson Bay Lowlands and Western Siberia, in addition to potentially excessive increases in moist and seasonally inundated areas such as the Amazon. We conclude that the model allows for more realistic simulation of geographical variability in soil carbon while also increasing the sensitivity of biogeochemical cycling to the hydrological parameterization. Future work will include simulating export of dissolved organic matter to rivers, and investigating the interaction of hydrology and soil carbon cycling under present conditions at both the regional and global scales. This model will allow us to investigate future changes in land carbon fluxes caused by the effects of changing hydrological regime on soil carbon cycling, as well as increasing the accuracy of ESM carbon cycle simulations in wetland-rich regions such as the circumpolar zone.

Tan, Ann

Topographic Influence on Spatial and Temporal Patterns of Grassland Productivity

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Natural landscapes are topographically heterogeneous even at relatively local scale; this heterogeneity affects plant performance. For a restoration project to be successful then, the relationship between topography and plant growth most be considered to dictate locations of planting. However, while understanding the nature this relationship is critical in successful restoration projects, not much is known about it – how exactly do terrain attributes such as aspect and curvature affect plant establishment and success? We focus on a parameter of success, biomass production, by evaluating the influence terrain attributes has on plant production at two different scales: 1m and 12m on three small hills in Sedgwick Natural Reserve (SNR), located in south-central California, through field harvesting and remote sensing on average rainfall years. To describe the topography, we used a 1m spatial resolution ground-based lidar digital elevation model (DEM) to calculate several key terrain attributes: curvature, aspect, and the Compound Topographic Index (CTI), which indicates areas of potential water accumulation in complex landscapes. Biomass was determined in two separate ways: harvest and remote sensing. We harvested 83 1x0.5m2 randomly distributed quadrats of aboveground plant matter at the end of the 2011-2012 growing season. Because of the annual nature of the vegetation, biomass obtained at the end of the growing season approximates aboveground net primary productivity (ANPP) for that year. We also used the Normalized Difference Vegetation Index (NDVI) as a biomass proxy, obtained from monthly 12m resolution AVIRIS (Airborne Visible / Infrared Imaging Spectrometer) flights from March to August 2009. The terrain attributes were then regressed against field and remote sensing generated biomass values. We found a correlation between aspect and plant productivity. In March, the south facing slopes had higher NDVI values than the north facing slopes. From April to August, the relationship reversed, and the north facing slopes have higher NDVI values. There is no correlation between the terrain attributes that described water flow (curvature and CTI) and plant productivity at both resolutions. Our findings imply limited water redistribution or lack of clear recognizable vegetation response to such water transfers during average rainfall years. This is unsurprising as precipitation is often too low to cause saturated flow redistribution at SNR's clayey soils and the abundant gopher holes makes overland flow rare. The changing relationship between NDVI and aspect through time lead us to believe we captured the ecosystem transition from a solar insolation limited phase (October – March), to a water limited phase (March – August). Future work focuses on quantifying the seasonal variation in solar insolation and its impact on temperature and evapotranspiration on different aspects. Our study highlights the importance for land managers to consider both topography and the interannual variability of precipitation when planning restoration work, as the relationship between productivity and topography is both spatially and temporally dependent.

Troch, Peter A.

The Landscape Evolution Observatory (LEO) at Biosphere 2: Opportunities for collaborative Earth system research in a controlled environment *(Invited)*

Troch, Peter A.[1]

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The University of Arizona Biosphere 2 consists of a unique large-scale experimental apparatus housing six model ecosystems, a team of multidisciplinary scientists, a broad science education and public outreach program, and a modern conference center. On of these six model ecosystems is the Landscape Evolution Observatory (LEO).LEO consists of three identical, sloping, 333 m2 convergent landscapes inside a 5,000 m2 environmentally controlled facility. These engineered landscapes contain 1-meter depth of basaltic tephra, ground to homogenous loamy sand that will undergo physical, chemical, and mineralogical changes over many years. Each landscape contains a spatially dense sensor and sampler network capable of resolving meter-scale lateral heterogeneity and sub-meter scale vertical heterogeneity in moisture, energy and carbon states and fluxes. The density of sensors and frequency at which they can be polled allows for measurement to be made that are impossible in natural

field settings. Embedded solution and gas samplers allow for quantification of biogeochemical processes, and facilitate the use of chemical tracers to study water movement at very dense spatial scales. Each ~600 metric ton landscape has load cells embedded into the structure to measure changes in total system mass with 0.05% full-scale repeatability (equivalent to less than 1 cm of precipitation). This facilitates the real time accounting of hydrological partitioning at the hillslope scale. Each hillslope has an engineered rain system capable of raining at rates between 3 and 45 mm/hr in a range of spatial patterns. The rain systems are capable of creating long-term steady state conditions or to run complex simulations. The precipitation water supply storage system is flexibly designed in order to facilitate addition of tracers in constant or time-varying rates to any of the three hillslopes. This presentation will give an overview of the research conducted on one of the hillslopes during the commissioning phase (November 2012-September 2013).

http://leo.b2science.org/

Trofymow, John A.

Developing a 100-year Retrospective Carbon Budget for the Sooke Watershed, Vancouver Island, BC

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To address the role that deforestation through reservoir creation as well as forest harvest and natural disturbance, have had on watershed level forest C budgets, historic spatial, inventory and disturbance data were assembled for lands of the Sooke watershed in the Greater Victoria Water Supply Area (GVWSA). A retrospective carbon (C) budget for the watershed for the period 1911 to 2012 is being developed using the spatially-explicit version of the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3). CBM-CFS3 is an inventory-based C budget modelling tool that has been used to simulate forest C dynamics at national, regional, and operational scales and has the capability to include lateral transfers of dissolved organic C (DOC) to aquatic systems. In 1911 the 8500 ha Sooke watershed was dominated by old-growth and mature Douglas-fir forests, when land clearing around the existing 396 ha Sooke Lake began, with dam completion and formation of the 480 ha Sooke reservoir in 1915. Dams were raised and the reservoir was subsequently expanded in 1970 to 600 ha, 1980 to 650 ha, and again in 2002 to 850 ha, resulting in further land clearing for the reservoir and dam infrastructure. While some localized forest harvest occurred in the 1920s and 1930s, more widespread forest harvest began in 1954 and over the next 43 years ~2000 ha of forest was cut and replanted or permanent roads installed. While conversion of forest to reservoirs means a decrease in forest area able to sequester C, reservoir sediments can also potentially serve as a sink for terrestrial C transported in streams, which might otherwise be respired if it remained in the stream. Such an aquatic DOC flux is an important gap in terrestrial C budget models and currently in CBM-CFS3 the flux assumed to be nil. Water quantity and DOC monitoring data from three subwatersheds in the Sooke will be used to estimate annual C fluxes to the reservoir and data used to parameterize DOC transfers in the model. Alternative disturbance scenarios and sensitivity analysis of DOC fate will be examined with the model to determine the relative importance of disturbance regimes and lateral DOC transfers on watershed level C budgets.

Trueman, Adam

Vegetation as a spatiotemporally heterogeneous control on landscape evolution: A critical zone approach to Landscape Evolution Modelling

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Feedbacks between Earth's biotic and abiotic components have had and continue to have a profound influence on the evolution of Earth's atmosphere, biosphere, lithosphere and hydrosphere. Of particular interest to both geomorphologists and ecologists is the role such feedbacks have upon Earth's surface – the region that couples Earth's hydrosphere, biosphere, atmosphere and lithosphere (now commonly termed the critical zone). The influence of vegetation has long been recognised within the critical zone (e.g. Lyell, 1830; Belt, 1874; Gilbert, 1877; Dokuchaev, 1883), whilst recent work has also suggested that terrestrial vegetation can have a profound impact on channel morphologies (see Gibling & Davies, 2012) and global biogeochemical cycles (e.g. Berner, 1997). However only a selection of these complex ecogeomorphic feedbacks have begun to be understood through harnessing recent technological advances such as cosmogenic dating and computer modelling. For example, numerous recent studies (e.g. Dietrich et al, 1995; Heimsath et al., 2001; Heimsath et al., 2009; Gabet & Mudd, 2010) have supported one of two different long-standing soil-production functions (SPFs) that relate soil production to soil depth – the humped and the exponential decay SPFs. These studies have been supplemented by recent studies which suggest that soil production rates are influenced by vegetation structure/function (e.g. Gabet & Mudd, 2010; Roering et al., 2010) Despite these recent advances in our understanding of ecogeomorphic feedbacks in the critical zone, there has been relatively little work on determining the influence vegetation dynamics may have upon SPFs and landscape evolution as well as the corresponding feedbacks on the vegetation amount and pattern. Progress is hampered by modern Landscape Evolution Models (LEMs) which commonly simulate vegetation change relatively simplistically through their ecological components experiencing little spatial/temporal variability in root and canopy structure, seasonality and/or function. Therefore application of these LEMs is limited when studying the influence vegetation dynamics may have upon processes within the critical zone. Through utilising a modelling-based approach, this study aims to improve our understanding of how vegetation dynamics in both space and time can influence soil production and landscape evolution. This poster will present an overview of our current understanding of ecogeomorphic interactions within the critical zone as a basis for the work currently being undertaken concerning the development and coupling of a spatiotemporally dynamic vegetation component within an existing LEM. Finally, preliminary model results associated with hypotheses investigating the influence spatiotemporal vegetation dynamics on soil production rate and landscape evolution will be presented, emphasizing that different SPFs can emerge as the result of different process interactions.

Trusiak, Adrianna

Disassembly of Phage ϕ6 by Montmorillonite Clay

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Bacteriophage are viruses that modulate microorganism populations in soils and can transfer genetic material by transduction. Viruses aggregate with clay minerals, potentially creating viral reservoirs in soils. Therefore, the interaction between clay minerals and viruses can affect bacterial populations, as well as biogeochemical cycling and the health of the greater ecosystem. The literature offers conflicting results on the effect of clay on the infectivity of phage. In this work, the interaction of the enveloped phage ϕ6 with montmorillonite clay is examined by TEM and biochemical analysis. It is observed that virions rapidly aggregate with the montmorillonite resulting in a loss of viral infectivity. Analysis of micrographs show that virions attach to both the negatively charged clay faces and positively charged edges. The virions exhibit partial disassembly of the lipid envelope (see Fig. 1) and many virions have the envelope totally removed leaving only the nucleocapsid (NC) intact. Band intensities in SDS-PAGE gels of virus-montmorillonite pellets and supernatant preparation confirms that the viral particles are almost 100% sequestered into the aggregates. Loss of viral infectivity increases rapidly when the platelet concentration exceeds the virion population (See Fig. 2).

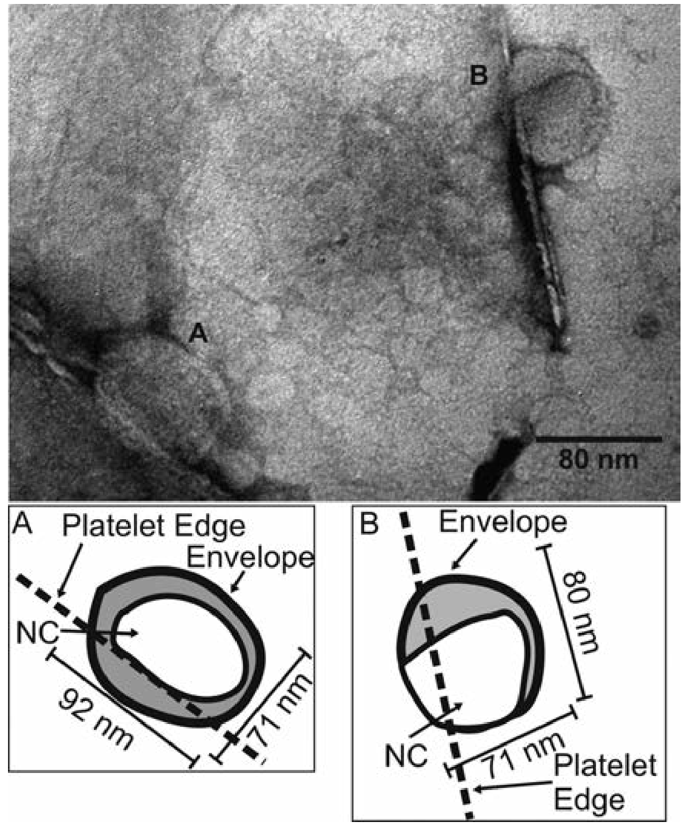

Fig. 1. Platelet with two ϕ6 virions attached to edges.

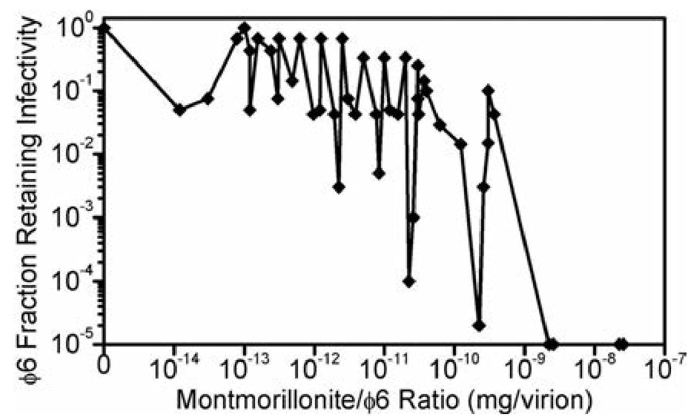

Fig. 2. ϕ6 infectivity as a function of montmorillonite concentration

Turnbull, Laura

Mechanisms Regulating the Fate of Nitrogen in Drylands

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2. School of Life Sciences, Arizona State Unviersity, Tempe, AZ, USA
3. Department of Ecology and Evolutionary Biology, Corenll University, Ithaca, NY, USA

Like in other areas of the world, drylands are receiving increasing inputs of nitrogen (N) from the atmosphere due to combustion and agriculture, with ~ 2 kg N ha-1 yr-1 being deposited in the open deserts of the southwestern US and up to ~ 30 kg N ha-1 yr-1in urban regions. The processes governing N retention in drylands are likely to be fundamentally different compared to mesic ecosystems. Our conceptual framework posits that novel loss pathways will limit the retention of N deposition in deserts, and that the strength of these loss pathways is tied to the distinct temporal and spatial patchiness that characterizes drylands globally. We bring together data from multiple studies to explore the significance of potential N-loss pathways in the deserts of the southwestern USA and explore how spatial heterogeneity in vegetation and soil properties affects their relative magnitudes. Results suggest that biotic processes may ultimately play a smaller ecological role in the way deserts function relative to abiotic processes. N losses through gas emissions potentially represent a substantial fraction of N deposition – up to 15-20% of annual N deposition, particularly after summer rainfall. Results show that N losses are significant during high-magnitude rainfall-runoff events, with particulate forms dominating total N loss. Similarly, wind erosion is significant and accounts for up to ~2-15 kg N ha-1 yr-1 in desert grasslands. These aeolian and hydrological transport vectors are most efficient where gaps between vegetation are highly connected. While these results provide initial insight into the roles of N-loss pathways, research integrating ecology, biogeochemistry, hydrology and geomorphology is required to explore further the potential feedbacks between these processes and the effects of ecosystem heterogeneity on the fate of Nitrogen in drylands.

Van Haren, Joost L.

CO2 sequestration through weathering of basalt tefra in the Landscape Evolution Observatory (LEO)

Van Haren, Joost L.[1]; Dontsova, Katerina[1]; Barron-Gafford, Greg[1]

1. Biosphere 2, University of Arizona, Oracle, AZ, USA

Weathering of primary silicates is one of the mechanisms involved in carbon removal from the atmosphere, affecting the carbon cycle at geologic timescales. Basalt is one of the most reactive rocks and thus a strong contributor to geologic weathering fluxes. The Landscape Evolution Observatory (LEO), a state of the art facility at Biosphere 2, Tucson, AZ, consisting of three identical 350m2 and 1m deep slopes, allows conducting controlled experiments investigating the interactions between atmosphere, hydrosphere, lithosphere, and biosphere at an unprecedented scale. This study presents results of the initial experiments where granular basalt that serves as a soil medium in LEO was exposed to rainfall. Soil solution and drainage were collected and analyzed to determine changes in solution composition. Gas-phase CO2 concentrations in the soil were monitored using custom gas samplers and Vaisala CO2 probes and CO2 gas fluxes on the surface was determined using soil chambers. The goal of the study was to determine the impact of precipitation on incipient CO2 driven weathering reactions and inorganic C sequestration in the basalt and how are these reactions distributed along hillslope flow paths. Results indicate very strong relationship between water inputs and soil CO2 concentrations and fluxes. Within hours of a rainfall event the surface CO2 flux increased three fold, while soil CO2 concentration was reduced from near atmospheric to <100ppm. In addition significant sequestration and leaching of inorganic carbon was observed, along with significant weathering of basalt and development of heterogeneity in solution-phase composition.

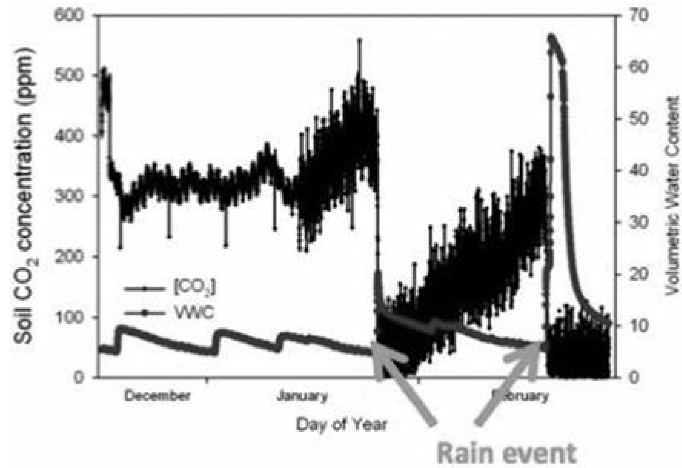

Figure 1. Soil CO2 concentrations as a function of the moisture content.

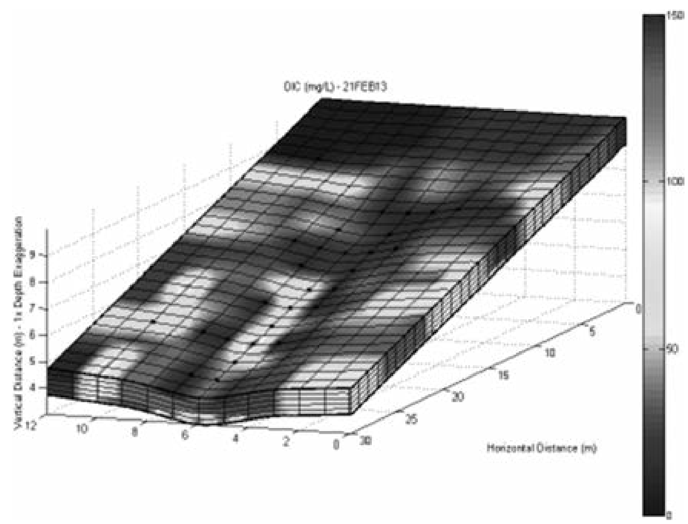

Figure 2. Spatial distribution of DIC concentrations on the LEO hillslope after rainfall.

Vanderlinden, Karl

Soil Water Diffusivity Estimation from Distributed Water Content Observations across a Rainfed Olive Orchard

Espejo-Pérez, Antonio J.[1]; Giráldez Cervera, Juan V.[1]; Vanderlinden, Karl[2]; Pedrera Parilla, Aura[2]; Martinez García, Gonzalo[1]

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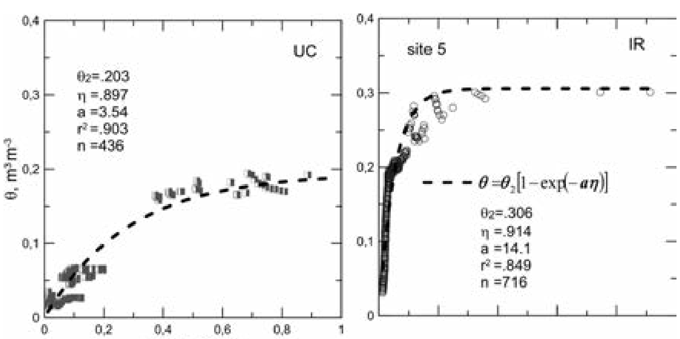
2. Centro Las Torres-Tomejil, IFAPA, Alcala del Rio, Spain

Soil water sensor networks provide detailed insight into the spatio-temporal water dynamics across agricultural fields and landscapes, while the high resolution observations offer possibilities for estimating soil hydraulic properties. Such information is useful to design and develop soil management strategies that optimize simultaneously the conservation of soil and water, e.g. in water erosion-prone olive orchards. In this work a simple method is presented to estimate spatially distributed soil water transmission parameters using data from a network of water content sensors installed across a rainfed olive orchard. A total of 99 sensors were installed under the canopy, and at adjacent inter-row locations, of eleven olive trees across a 6.8 ha experimental catchment in Southern Spain. Sensors were located across the soil profile at depths from 5 to 45 cm, at 10-cm intervals. The Mediterranean climate, characterized by a lack of rainfall during an extended period from late spring to early autumn, results in a prolonged uninterrupted drying period. Under such conditions the gravitational component of Richard's equation becomes negligible as compared to the suction gradients, and soil water flow can be approximated by the diffusion equation for horizontal flow in semi-infinite unsaturated porous media. Introducing the Boltzmann transform for the time and depth coordinates of profile water content data from drying periods, the diffusion equation becomes an ordinary differential equation from which the diffusivity can be estimated, assuming an exponential relationship between the soil water content and the Boltzmann coordinate. Soil water diffusivity and its variation were successfully estimated within the catchment with the proposed method. Diffusivity directly influences soil water dynamics and its spatial variation elucidated differences between areas under olive canopies and inter-row areas, indicating that the sensor network was able to capture the effect of individual trees on soil water dynamics across the field.



Relationship between soil water content (θ) and the Boltsman coordinate (η) for a location under the tree canopy (UC) and an adjacent inter-row location (IR) . The dashed line represents the exponential fit, with θ2 the initial "wet" soil water content, n the number of data points and a a fitting parameter

Wacha, Kenneth

Total Belowground Carbon Allocation in Intensely Managed Landscapes

Wacha, Kenneth[1]; Papanicolaou, Thanos[1]; Wilson, Christopher G.[1]

1. Civil Engineering, IIHR - Hydroscience & Engineering, Iowa City, IA, USA

Currently, biogeochemical models lack the ability to accurately simulate the evolution of total belowground carbon allocation (TBCA) especially in agricultural landscapes such as in the U.S. Midwest. This limitation induces high uncertainty in assessing sequestration potential when performing carbon budgets within the critical zone. Many of these models were developed in forest and grassland systems under the assumption the systems are homogenous and equilibrated. When comparing agricultural landscapes to forested areas, the soil in the former is not permanently covered by plants thereby intensifying the effects of rainsplash/runoff on soil erosion, soil carbon redistribution and litter incorporation. Adding more complexity, tillage that occurs in agricultural landscapes not only vertically redistributes soil carbon through incorporations of roots and surface litter within the soil column, but also accelerates soil carbon and litter mobilization laterally atop the soil surface. Additionally, tillage-induced erosion has long-term implications on soil carbon storage and overall TBCA by breaking apart soil aggregates, thereby increasing the likelihood for enhanced microbial activity, mineralization and fluxes of carbon dioxide to the atmosphere. Therefore, to accurately simulate TBCA dynamics in agricultural landscapes it is necessary to account for a series of hydrological and biogeochemical processes related to TBCA which have not been studied in detail before. In this study, some of these limitations were addressed by complementing hillslope event-based and seasonal carbon observations within the Clear Creek Observatory with the development of a coupled modeling framework focused on soil carbon redistribution due to vertical mixing and downslope/lateral mobilization. Few studies have provided updated geospatially distributed results of soil carbon while taking into consideration all of the aforementioned processes and attributes. The framework builds on the coupling of an off-the-shelf spatially distributed erosion hillslope model (Papanicolaou et al., 2010) with the biogeochemical model DAYCENT. This coupling was deemed important to account for the collective effects of rainsplash/runoff and tillage-induced erosion on TBCA across the three dimensional domain by predicting routing of clay-size fractions and enrichment ratios. Such results are lacking, especially on event-based and first-order stream scales watersheds in intensely managed landscapes. Specifically, key physical and biogeochemical parameters were monitored throughout several growing seasons. Soil samples and respiration measurements were taken along various hillslope positions, and sediment was collected at the watershed outlet. All samples were analyzed for isotopic signatures of 13C and 15N. Rainfall simulation experiments were performed on representative hillslope profiles, rainfall intensities, and soil types to capture redistribution and runoff rates, evolution of soil micro-roughness, and enrichment ratios on an event-based scale. Experimental measurements were used to test the model on event and seasonal scales to identify how signals of carbon propagate in space and time.

http://www.iihr.uiowa.edu/tpapanicolaou/clear-creek-watershed/

Wingate, Lisa

Seasonal contribution of soil CO_2 invasion to the total $CO^{18}O$ flux from a pine forest ecosystem *(Invited)*

Wingate, Lisa[1]; Ogee, Jerome[1]

1. INRA, Villenave D'Ornon, France

The oxygen isotope composition of CO_2 in the atmosphere is strongly influenced by the oxygen isotope exchange of CO_2 with leaf and soil water pools across the Earth's surface. Until recently it was thought that this isotopic exchange was considerably slower in soils compared with leaves. However field estimates have shown that soil isotopic exchange may be up to 1000 times faster than previously estimated for some ecosystems, because of the enzyme carbonic anhydrase. In this talk we will present seasonal gas exchange observations from a pine forest in South West France that demonstrate the important contribution of the soil oxygen isotope signal at the ecosystem scale. We found that over the entire season the oxygen isotope signal of ecosystem CO_2 exchange, derived from nocturnal Keeling plots, was most similar to the oxygen isotope composition of the soil CO_2 efflux. Using the isotope-enabled ecosystem model MuSICA, and the isotopic signals observed in leaf, stem and soil chambers we could estimate the nocturnal flux rate contribution of each component to the net ecosystem exchange over the season. In addition we investigated the temporal activity of soil carbonic anhydrase activity over the growing season and to what extent it varied with soil surface CO_2 concentration, temperature and soil moisture. Conclusions from this analysis will be presented and recommendations for future experimental studies made.

Wu, Shiliang

Interactions between Anthropogenic and Soil Emissions of Nitrogen Oxides

Wu, Shiliang[1]

1. Michigan Tech, Houghton, MI, USA

Nitrogen oxides (NOx) play an important role in affecting atmospheric composition and air quality. Microbial processes in soil make significant contributions to NOx in the atmosphere. Anthropogenic activities, such as increased fertilizer application, intensified use of fossil fuel (which would lead to enhanced NOx emissions and nitrogen deposition), could dramatically affect the nitrogen availability in the soil and therefore the soil NOx emissions. On the other hand, the increase of soil NOx emissions could significantly compromise the efforts in domestic NOx emission reductions. Based on both modeling work and field data, this study will examine the potential effects of anthropogenic activities on soil NOx emissions as well as the relative importance of various NOx sources and their interactions in the context of global change.

Yakir, Dan

Carbonyl sulfide (COS), a tracer to separate soil form canopy CO2 exchange *(Invited)*

Yakir, Dan[1]; Berkelhammer, Max[2]; Miller, John[3]

1. Environmental Sciences, Weizmann Inst Sci, Rehovot, Israel
2. Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO, USA
3. Earth System Research Laboratory, Global Monitoring Division, NOAA, Boulder, CO, USA

The potential use of COS as tracer of CO2 flux into leaves, associated gross primary productivity (GPP), and soils, associated with ecosystem respiration (Re), stimulated research on COS-CO2 interactions during biosphere-atmosphere exchange. This is based on the observation that COS co-diffuse with CO2 into vegetation and soils, but without an emission outflux. Recent advances in laser spectroscopy and the availability of high precision field deployable quantum cascade laser systems resulted with accumulation in recent years of new results from laboratory-scale control experiments, field studies, atmospheric measurements and, consequently, from large scale modeling studies, all of which demonstrate the potential in the COS application to carbon cycle research. These studies also highlighted the key uncertainty associated with soil uptake of COS. Soil uptake is based on dissolution and hydrolysis in soil moisture, which can be enhanced by carbonic anhydrase (CA) that can exist in soil and litter. Our recent measurements over the diurnal cycle and across a range of ecosystems indicated that soils act mostly as COS sink, equivalent to 2-6% of canopy uptake during peak activity period (temperate summer). The results also indicated that COS uptake is influenced by soil moisture and temperature, and net emission can be observed under certain conditions. The importance of CA activities has been demonstrated in soils in CO2 studies using stable isotopes (18O), and for COS in leaves using anti-sense lines, but quantifying its importance for soil COS uptake is still lacking. Diel evolution of the co-variation between COS and CO2 in the ambient surface air shows that it reflects the interplay among the effects of soil, leaf and atmospheric dynamics. Extending observations to background atmospheric measurements of the seasonal drawdown in CO2 and COS demonstrates that comparing drawdowns of CO2 with that of COS could provide additional constraints on the differential responses of photosynthesis and respiration to local and regional forcing. Such separation is critical to improve prediction of future responses of the terrestrial biosphere to changing environmental conditions.

Yakirevich, Alexander M.

Augmentation of Monitoring Networks Using Information Theory and Ensemble Modeling with Pedotransfer Functions

Pachepsky, Yakov[1]; Yakirevich, Alexander M.[2]; Guber, Andrey[3]; Gish, Timothy[1]; Kuznetsov, Mikhail Y.[2]; Cady, Ralph E.[4]; Nicholson, Thomas J.[4]

1. BARC, USDA-ARS, Beltsville, MD, USA
2. Department of Environmental Hydrology & Microbiology, Ben-Gurion University of Negev, Sede Boqer, Israel
3. Department of Plant, Soil and Microbial Sciences, Michigan State University, East Lansing, MI, USA
4. ORR, US NRC, Rockville, MD, USA

Improving understanding of chemical transport in soils includes comparison and discrimination of different chemical transport models. The objective of this work was to apply a Kullback-Leibler divergence-based method to augment a subsurface monitoring network (SMN) for discrimination of conceptually different subsurface flow and transport models. This method is based on computing the total information gain using prior probabilities of model correctness. The ensemble modeling with pedotransfer functions is employed to estimate the variance of the predicted values. The method was applied to determine the location where additional observations are needed to discriminate models in the tracer experiment conducted at the USDA-ARS OPE3 research site where a pulse of KCl solution was applied with irrigation water and soil and shallow groundwater were subsequently monitored for four months. A three-dimension model was developed to simulate the flow and chloride transport, and pedotransfer functions were used to calibrate and build an ensemble of models. Models were discriminated that included or ignored the effect of subsurface soil lenses on the chemical transport. The determination of monitoring locations to augment existing ones was conducted on a 2D grid. Explicable and stable solutions were found for the monitoring network augmentation. The outcome of this study provides an approach to future data collection aimed at reducing uncertainties in the conceptual models of flow and transport in variably saturated soils.

Ye, Sheng

Derivation of Subsurface Stormflow Parameterization from Regional Analysis of Streamflow Recession Curves: A Possible Climate Dependence?

Ye, Sheng[1]; Li, Hong-yi[3]; Huang, Maoyi[3]; Ali, Melkamu[4]; Leung, Lai-yung[3]; Wang, Shao-wen[1]; Sivapalan, Murugesu[1, 2]

1. Geography and Geographic Information Science, University of Illinois at Urbana-Champaign, Urbana, IL, USA
2. Civil and Environmental Engineering, University of Illinois at Urbana-Champaign, Urbana, IL, USA
3. Hydrology Technical Group, Pacific Northwest National Laboratory, Richland, WA, USA
4. Scienze dell'Ingegneria Civile, Universita di Roma Tre, Rome, Italy

Subsurface stormflow is an important component of the rainfall-runoff response in mountainous regions, and is strongly affected by soil hydraulic properties. However, its contribution is poorly represented in current generation of land surface hydrological (i.e. rainfall-runoff) models. We conducted work aimed at deriving universally applicable parameterizations of the storage-discharge relationship relating to subsurface flow from a combination of top-down (Darwinian) empirical data analysis and physically based (Newtonian) model simulations. Empirical analysis involved derivation of storage-discharge relationships from streamflow recession curves extracted from 50 eastern United States catchments. Detailed regression analyses were then performed between parameters of these empirical storage-discharge relationships and the controlling climate, soil and topographic characteristics. Parameterizations of storage-discharge relationships were then independently derived through simulations with a physically based (Darcian) subsurface flow model for idealized three dimensional rectangular hillslopes, accounting for within-hillslope heterogeneity of soil hydraulic properties, which were subsequently up-scaled to the catchment scale by accounting for within-catchment heterogeneity of topographic slopes. In both cases, i.e., the theoretical simulations as well as empirical analyses of recession curves, the regression analyses with respect to landscape properties showed the significant influence of soil hydraulic properties on the storage-discharge relationship. One key property is the vertical profile of the saturated hydraulic conductivity. However, the regression relations in the two cases were substantially different, and the divergence between the model prediction and observed recession coefficients highlight the importance of accurate estimation of the effective saturated hydraulic conductivity at catchment scale in subsurface flow generation. This calls for improved understanding of natural heterogeneity of soil hydraulic properties in real catchments, their relationship to climate and vegetation, and their long-term co-evolution. Indeed, empirical analyses of recession curves indicates a strong climate (aridity) dependence of the recession curve

parameters, which needs to be explained and quantified in terms of possible co-evolutionary processes.

Yeshaneh, Eleni

Temporal Variation of Suspended Sediment Transport in the Koga Catchment, North Western Ethiopia and Environmental Implications

Yeshaneh, Eleni[1]; Eder, Alexander[1, 2]; Blöschl, Günter[1]

1. Civil Engineering, Center for Water Resources Systems, Vienna University of Technology, Vienna, Austria
2. Institute for Land and Water Management Research, Federal Agency for Water Management, Petzenkirchen, Austria

Event sediment transport and yield were studied for 45 events in the upstream part of the 260 km2 agricultural Koga catchment that drains to an irrigation reservoir. Discharge and turbidity data were collected over a period of more than a year, accompanied by grab sampling. Turbidity was very well correlated with the sediment concentrations from the samples (r=0.99) which allowed us to estimate the temporal patterns of sediment concentrations within events. The hysteresis patterns between discharge and sediment concentrations were analyzed to provide insight into the different sediment sources. Anticlockwise patterns are the dominant hysteresis patterns in the area, suggesting smaller contributions of suspended sediment from the river channels than from the hill slopes and agricultural areas. Complicated types of hysteresis patterns were mostly observed for long events with multiple peaks. For a given discharge, sediment yields in August and September, when the catchment was almost completely covered with vegetation, were much smaller than during the rest of the rainy season. The hysteresis patterns and timing suggest that the sediment availability from the agricultural areas and hill slopes affects sediment yields more strongly than does peak discharge. Two distinct types of sediment rating curves were observed for the season when the agricultural land was covered with vegetation and when it was not, indicating the dominating contribution of land use/cover to sediment yields in the catchment. The rate of suspended sediment transport in the area was estimated as 25.6 t year-1 ha-1.

Young, Michael

Soil development, time, and ecosystem function in water-limited systems

Caldwell, Todd[1]; Young, Michael[1]

1. Bureau of Economic Geology, University of Texas at Austin, Austin, TX, USA

The evolution of alluvial deposits to soil is a complex system driven by the intrinsic property of time. Soil formation and development result from coupling between biotic and abiotic factors which ultimately influence canopy structure and vigor and they are part of a complex interplay between climate and water movement. Soil development is based on the rate systematic changes in soil properties in relation to those of the parent material. Unlike all other fluxes within the soil system, time flows uniformly and irreversibly, and attaining an equilibrium state of a mature or fully-developed soil is thermodynamically improbable. In practice, we generally maintain that the larger the number of horizons and the greater their thickness, the more mature or developed the soil. Young soils formed on arid alluvium deposited during the Holocene (deposited within the last 10^4 year) are weakly developed with minimal horizonation and high disorder. By comparison, old soils residing on Pleistocene alluvium (sediments deposited between about 10^4 to 10^7 year) are more strongly developed and have subsoil B-horizons dominated by the pedologic accumulation of silt, clay, calcium carbonate, and other soluble constituents. These two soils are commonly mosaicked across the bajada resulting in heterogeneity of the soil system we observe today. These systems are not isolated from their environment and therefore are continuously exchanging energy and matter with their surroundings. It is such energy and mass flow across various gradients and boundaries (and associated transformations) that have driven the evolution and functioning of soils and ecosystems. Time, in a truly long-term sense, cannot be explicitly removed from our experimental design in critical zone studies. Ecology, hydrology, pedology, and geomorphology imply time yet a profound understanding across disciplines is required to fully understand both the heterogeneity and dynamics of the critical zone. The synthesis presented will illustrate the complex biotic-abiotic feedback that results through time dependent processes of soil pedogenesis in arid regions of the desert southwest; at least as we see them today.

Yunjia, Liu

Arsenic Speciation in the Copper Tailings with the Effects of Magnetite Removal

Yunjia, Liu[1]; Lu, Zhao[1]; Longbin, Huang[1]

1. Sustainable Minerals Institute, University of Queensland, Brisbane, QLD, Australia

Arsenic is considered as one of severe metalloid pollutants in the copper tailings, which may pose risks to the environment and human health. It is known that iron oxides are one of the most important adsorbents of minor elements due to their reactivity and large specific surface area, which can coprecipitate and adsorb arsenic. Magnetite (Fe3O4), counting for up to 30% of in copper tailings, may act as a sink mineral to prevent arsenic mobilization. However, the ore processing has recently changed to remove magnetite as a by-product for economic benefit, which reduce magnetite concentration from 20 – 30% to 5%. Thus may affect arsenic speciation and consequently mobilize arsenic in tailings. In this study, we compared the sequential leaching results from the old copper tailings (total arsenic concentration 330 mg/kg) with magnetite and new copper tailing without magnetite. There was 34% arsenic adsorbed with iron in old tailing, comparing to 7% arsenic in new tailings. Organic matter (biochar and mulch) were added in those tailings and two types of Australian native plants were planted in the pot experiment. The leachate was collected

which may display the different adsorption effects of organic matter on arsenic due to the reduction of the arsenic adsorption caused by magnetite removal. The results will allow us to understand the changes of arsenic speciation under the effects of magnetite removal in copper tailings and show the effects of organic matter addition to the tailings. The results will be interpreted in terms of the influence of magnetite and organic matter, which will provide essential information for further phytoremediation practice.

Zaharescu, Dragos G.

Role of Ecosystem Development in Rare Elements Cycling in an Ultra-oligotrophic System at Biosphere-2

Zaharescu, Dragos G.[1, 2]; Burghelea, Carmen I.[1]; Dontsova, Katerina[1, 2]; Presler, Jennifer C.[1]; Chorover, Jon[2]; Maier, Raina[2]; Huxman, Travis[3]

1. Biosphere-2, University of Arizona, Tucson, AZ, USA
2. Soil Water and Environmental Science, University of Arizona, Tucson, AZ, USA
3. School of Biological Sciences, University of California Irvine, Irvine, CA, USA

Rare elements (RE) are a group of 17 metals highly dispersed in the Earth's crust whose economic and scientific importance has become critical in recent years, with applications ranging from computing, clean energies, to studying the origin of sediments and magmas. While there is a relatively significant body of literature on their physical properties, the role and fate of RE in the biosphere is still poorly understood. For example, few studies from China have suggested that low values of these elements may promote plant growth. However, there are conflicting evidence and opinions regarding the importance of REs in biology, particularly because of limitations in their quantitative analysis. This study originated from a need to finely test the role of plant-bacteria-mycorrhizae associations in RE mobilization and uptake particularly at the initial stage of bedrock colonization. For this we setup an ultra-oligotrophic experiment at Biosphere-2 (Tucson, Arizona). A total of 4 granular bedrocks were used: basalt, rhyolite, granite and schist. The ecological treatments were a combination of rock extracted bacteria, mycorrhizal fungi and two types of plants: Buffalo grass (Bouteloua dactyloides) -a highland species and Ponderosa pine (Pinus ponderosa), as well as an un-inoculated control. An ectomycorrhiza (Rhizopogon evadens) and a vesicular arbuscular mycorrhiza (VAM; Glomus intraradices) were used to inoculate the pines and the grasses, respectively. Infected and non-infected plants were seeded on the preinoculated mineral media and watered biweekly with nano-pure water. Samples of pore water were collected for the initial 4 months of ecosystem development (biweekly for first 2 months, and monthly thereafter) and analyzed for a range of chemical parameters including RE by ICP-MS. Results of principal component analysis revealed that for all studied rocks REs clustered together and represented a major portion in the total variability in pore water element content. Their leaching was higher on rhyolite followed by schist, granite and basalt, most likely being related with differences in their mineral contents. The cluster also displayed significant differences between control and ecological treatments with incremental values for the ecosystem growing on basalt, rhyolite and granite and a decrease on schist. Pine treatment had a significant effect on rhyolite as compared to grass in terms of increased element release. Moreover, VAM significantly increased leaching on basalt and rhyolite. Regarding element uptake by plants, data analysis revealed that roots had generally higher content than shoots/leaves. VAM treatment clearly enhanced the accumulation of certain elements including Y, La, Ce, Pr, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu on basalt and rhyolite, as compared to un-inoculated plants. The findings provide clear quantitative evidence of an important effect of ecosystem settlement on the initiation on RE cycling, specifically on the effect of arbuscular mycorrhizae.

Zapata-Rios, Xavier

PEDON SCALE SOIL MOISTURE AND WATER FLUXES DYNAMICS DURING EXTREMELY DRY YEARS IN A HIGH ELEVATION SNOW DOMINATED LANDSCAPE

Zapata-Rios, Xavier[1]; Troch, Peter A.[1]; McIntosh, Jennifer[1]

1. Hydrology and Water Resources, University of Arizona, Tucson, AZ, USA

High elevation semi-arid ecosystems are water limited environments where the timing and amount of water availability is a fundamental factor that controls processes such as weathering, organic matter decomposition, soil respiration, nutrient uptake, and biomass production among others. In turn, water fluxes at higher elevations are controlled by interactions between climate, vegetation and soils. Understanding of these interactions has been hindered by a lack of integrated measurements of governing fluxes and states. In the southwestern US, high elevation catchments are snowmelt dominated and recent research has shown a reduction in snowpack accumulation. The possible alterations in hydrologic pathways such as evaporation, runoff, infiltration, water residence time due to these reductions remain poorly understood. The main goal of this research is to improve our understanding of soil moisture dynamics and soil water fluxes at the pedon scale during extremely dry conditions in the southwestern United States. There are high confidence predictions that snowpacks will continue to decline in northern New Mexico through the year 2100 and projections of snowpack accumulation for mid-century (2041-2070) show a marked reduction for snow water equivalent (SWE) of about 40%. During 2011, 2012 and 2013 total winter precipitation in the Jemez Mountains was reduced by 42%, 9% and 46%, respectively, compared to average conditions (353mm). Reductions of SWE during these years compared to average conditions (256mm) were 56%, 26% and 54%, respectively. The years 2011 and 2013 were the driest winters in terms of snow accumulation measured during the last 30 years on record. Similarly, the summer seasons 2011 and 2012 were dry and the total rainfall during the summer monsoons were 15% and 27% below average conditions (357mm). This study integrates co-located direct observations of snow depth, rainfall, radiation, air temperature, eddie covariance measurements, and soil moisture at four soil pits into a one dimensional pedon scale moisture dynamics and soil water balance model. Evaporation, throughfall, vegetation water use, water storage and infiltration are modeled at soil pits located under different tree canopy coverage and terrain aspect at a similar elevation of about 3000 meters on a landscape dominated by densely welded Bandelier Tuff (Tshrige Member) and associated rhyolite/rhyodacite rocks. Model results are validated by comparing soil moisture measurements and soil solution water stable isotopes at three different depths in each soil pit. The study site and climatic conditions during the time period of analysis provide a unique setting and opportunity to study water partitioning, vegetation water use, deep infiltration and water residence time at the soil pedon scale under extremely dry conditions.