天津大学 地球系统科学学院
Tianjin University School of Earth System Science

Program for the 4th ISMC Conference 2024

Advances in Modeling Soil System Science, Earth System Science, and Beyond

Pan Pacific Hotel, Tianjin, China

May 7 to 10, 2024

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Introduction of the 4th ISMC Conference 2024

"Advances in Modelling Soil System Science, Earth System Science, and Beyond"

Soil is one of the most critical life-supporting resources, providing the foundation for food and fibre production, ecosystem services, biodiversity, water, nutrients, energy, among others. Nevertheless, soil resources are pressured by increasing food demand and climate change, which call for sustainable management practices and innovative research. Soil are essential resources to be protected and managed to meet UN Sustainable Development Goals (SDGs).

The International Soil Modelling Consortium (ISMC) aims to bring together modelers and experimental soil scientists at the forefront of new technologies and approaches to characterize soils. By addressing these aims, ISMC will contribute to improve the role of soil modelling as a knowledge dissemination instrument in addressing key global issues and stimulate the development of translational research activities.

The 1st ISMC Conference was held in Austin, Texas, USA, from March 29th to April 1st, 2016. The conference attracted around 200 participants from around the world. The 2nd ISMC Conference was held at Wageningen University and Research, Netherlands, from November 5th to November 7th, 2018, with the conference theme "Advances in Soil System Simulation Research". The 3rd ISMC Conference was held from May 18th to May 22nd, 2021, as a virtual meeting. Approximately 200 participants from around the world attended the conference.

The 4th ISMC Conference, to be held in Tianjin from May 7th to 10th, 2024, is a science symposium that aims to integrate and advance soil system modelling, Earth system science, and beyond, through:

- bringing together leading experts in modelling soil processes within all major soil disciplines;
- addressing major scientific gaps in describing key processes and their long term impacts with respect to the different functions and ecosystem services provided by soil;
- promoting integration of soil modelling expertise in neighbouring disciplines (climate, land surface, eco, hydro, and other models);
- performing soil model intercomparison studies at local to global scales;
- consolidating soil and other data platforms for modelling purposes;
- integrating societal and environmental considerations into soil and ecosystem functioning.

We welcome all colleagues gathering in beautiful Tianjin for the "4th ISMC Conference". Let's come together to discuss the path of innovation in soil science, strengthen exchanges, foster cooperation, and work hand in hand to create a beautiful and liveable Earth.

Organization of the 4th ISMC conference

- **Host:**

The International Soil Modelling Consortium

- **Organizer:**

School of Earth System Science, Tianjin University, Tianjin, China

- **Co-organizers:**

Tianjin Bohai Rim Coastal Earth Critical Zone National Observation and Research Station, Tianjin, China

Tianjin Key Laboratory of Earth Critical Zone Science and Sustainable Development in Bohai Rim, Tianjin, China

State Key Laboratory of Hydraulic Engineering Simulation and Safety, Tianjin University, Tianjin, China

State Key Laboratory of Water Resources Engineering and Management, Wuhan University, Wuhan, China

Institute of Soil Science, Chinese Academy of Sciences, Nanjing, China

College of Land Science and Technology, China Agricultural University, Beijing, China

School of Atmospheric Sciences, Sun Yat-sen University, Guangzhou, China

School of Geography, Nanjing Normal University, Nanjing, China

• Conference Organizing Committee

Conference Chairs:

Congqiang Liu (Tianjin University)

Harry Vereecken (Forschungszentrum Jülich)

Executive Chairs:

Yonggen Zhang (Tianjin University)

Lutz Weihermüller (Forschungszentrum Jülich)

Yijian Zeng (University of Twente)

Conference Organizing Committee Members:

Yonggen Zhang (Tianjin University)

Lutz Weihermüller (Forschungszentrum Jülich)

Yijian Zeng (University of Twente)

Martine van der Ploeg (Wageningen University & Research)

Yanping Xu (Tianjin University)

Xi Chen (Tianjin University)

Jianzhi Dong (Tianjin University)

Lichun Wang (Tianjin University)

Gang Wang (China Agricultural University)

Zhongwang Wei (Sun Yat-sen University)

Nan Wei (Sun Yat-sen University)

Zhifeng Yan (Tianjin University)

Renmin Yang (Tianjin University)

Yuanyuan Zha (Wuhan University)

Jianchao Zhang (Tianjin University)

Man Gao (Tianjin University)

Yifei Zhang (Tianjin University)

Wenchao Ma (Nanjing Normal University)

Wenhao Shi (Tianjin University)

Shiao Feng (Tianjin University)

Wenjuan Chen (Tianjin University)

Wenhong Wang (Tianjin University)

Conference Overview and Notice

• Basic Information

Conference Time: May 8 to 10, 2024

Conference Venue: Pan Pacific Hotel, Tianjin, China

Registration Times: **Hotel Lobby**: May 7, 2024, 10:00 - 20:00

Third Floor, Pacific Ballroom Entrance: May 8 to 9, 2024, 8:30 - 17:00

• Opening /Oral /Poster Sessions

Opening Session

Time: May 8, 2024, 8:30 - 9:15

Venue: Pacific Ballroom, Pan Pacific Hotel, Tianjin, China

Oral Session

Time: May 8, 2024, 8:30 - 12:30, 14:00 - 17:00

May 9, 2024, 8:30 - 12:30, 14:00 - 18:10

May 10, 2024, 8:15 - 12:30, 14:00 - 17:45

Venue: Pacific Ballroom, Pan Pacific Hotel, Tianjin, China

Poster Session

Time: May 8, 2024, 17:00 - 18:30

May 9, 2024, 18:10 - 19:30

Venue: Poster Area (please see the floorplan of the 3rd floor of Pan-Pacific Tianjin Hotel)

Note:

1. The conference screen scale is 16:9, and please adjust your slide size accordingly if you would like. Please arrive at the venue half an hour before the conference start in the morning to copy your PowerPoint slides (16:9 aspect ratio) to the conference computer or send them in advance to the venue coordinator via email: sess_workshop@tju.edu.cn. After the deadline, it may not be available for copying.

2. For the poster session 1 (on Wednesday, May 8th, 2024), you may attach your poster to the stand anytime on May 7th or latest in the morning May 8th. Please remove your poster after the poster session concludes, no later than 19:00 on May 8th. For the poster session 2 (on Thursday, May 9th, 2024), please affix your poster to the stand before the morning coffee break on Thursday, May 9th, 2024, and remove the posters before the conference concludes.

• Conference Meals

The conference will provide lunches (Buffet) on May 8, 9, and 10, and conference dinner on May 9 during the award time. The restaurant is located at the 1st floor of the Pan-Pacific Hotel, i.e., Pacific Restaurant. Please bring your meal vouchers and proceed to the designated dining area accordingly. For specific dining locations, please refer to on-site information.

• Conference Invoice

1. Registration fees will be collected and electronic invoices will be issued by Tianjin Zhongnuo Conference Service Co., Ltd., authorized by the conference. Electronic invoices will be sent to the email address provided during registration within seven working days after the conference.
2. If you have not received the invoice seven working days after the conference, please contact the staff of Tianjin Zhongnuo Conference Service Co., Ltd. Contact: Huanzhao Liu (刘焕钊), Phone: +86-13820583024.

• Notices

1. Please wear your name badge when entering the conference venue.
2. Distributing or disseminating materials and remarks not related to the conference is strictly prohibited both inside and outside the venue.
3. When leaving the venue, please take all beverages, food containers, and conference materials with you to keep the area clean.

• Conference Organizers and Contact Information

For conference inquiries, please contact:

Yonggen Zhang	+86-17695926877	ygzhang@tju.edu.cn
Wenhao Shi	+86-13932381680	shiwenhao@tju.edu.cn
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For invoice inquiries, please contact:

Huanzhao Liu	+86-13820583024	13820583024@126.com

Simple Program for the 4th ISMC Conference 2024

"Advances in Modelling Soil System Science, Earth System Science, and Beyond"

Pan-Pacific Hotel, Tianjin, China

May 7 to 10, 2024

Tuesday May 7, 2024		
Time	**Program**	**Location**
10:00-20:00	Registration	Hotel Lobby (1st floor)
Afternoon	Early Career Workshop	Shanghai Hall (3rd floor)
Evening	Icebreaker	

Wednesday May 8, 2024		
Time	**Program**	**Location**
08:30-09:15	Opening	Pacific Ballroom (3rd floor)
09:15-09:45	Group Photo & Coffee Break	
09:45-10:30	Plenary Keynote	
10:30-12:30	Session: Modelling soil processes in land surface modelling	
12:30-14:00	Lunch Break	Pacific Restaurant (1st floor)
14:00-15:00	Plenary Keynote	Pacific Ballroom (3rd floor)
15:00-16:00	Session: On representing memory effects, hysteresis and feedbacks in the Critical Zone	
16:00-16:30	Coffee Break	
16:30-17:00	Lightning Talks	
17:00–18:30	Poster Session	

Thursday May 9, 2024

Time	Program	Location
08:30-09:15	Plenary Keynote	Pacific Ballroom (3rd floor)
09:15-10:30	Session: How to include root hydraulic architecture in soil models to simulate root water uptake	
10:30-10:45	Coffee Break	
10:45-11:00	Session: How to include root hydraulic architecture in soil models to simulate root water uptake (continued)	
11:00-12:30	Session: General Session of any model related research	
12:30-14:00	Lunch Break	Pacific Restaurant (1st floor)
14:00-15:00	Session: General Session of any model related research (continued)	Pacific Ballroom (3rd floor)
15:00-15:30	Session: Toward characterising and modelling the temporal variability of effective soil properties	
15:30-16:00	Coffee and Posters	
16:00-16:45	Session: Toward characterising and modelling the temporal variability of effective soil properties (continued)	
16:45-17:30	Plenary Keynote	
17:30-18:10	World Café "Transformative Soil Modeling through Inclusive Collaboration and Disseminated Education"	
18:10-19:30	Poster Session	
19:30	Conference Dinner ISMC Award Ceremony	Pacific Restaurant (1st floor)

*Opening Ramarks by Rien van Genuchten (online)

Friday May 10, 2024		
Time	**Program**	**Location**
08:15-9:00	Plenary Keynote	Pacific Ballroom (3rd floor)
09:00-10:30	Session: Saturation kinetics in soils: stochiometric limits, mineral-organic interactions, and microbial explicit models	
10:30-11:00	Coffee Break	
11:00-12:30	Session: Constraining soil hydrologic processes using in-situ & remote sensing observations	
12:30-14:00	Lunch Break	Pacific Restaurant (1st floor)
14:00-15:30	Session: Data fusion for characterization of soil states and heterogeneity	Pacific Ballroom (3rd floor)
15:30-15:45	Coffee Break	
15:45-16:15	Session: Data fusion for characterization of soil states and heterogeneity (continued)	
16:15-17:45	Session: Application of machine learning and non-linear methods for spatial data analysis	
17:45-18:30	Summary by ISMC chairs and convenors Handout of young scientist poster /presentation award*	

*Convenors: ISMC board and all convenors

Friday May 10, night & Saturday May 11, full day, 2024
Excursion*

***Registration on-site**; please visit https://ismc-conference.tju.edu.cn/Excursion for excursion itinerary

天津大學 地球系统科学学院
Tianjin University School of Earth System Science

4th ISMC Conference 2024

Detailed Program

Pan Pacific Hotel, Tianjin, China

May 7 to 10, 2024

May 8 (Wednesday), 2024

Opening

Time	Program
08:30-09:00	1) Vice President of Tianjin University 2) Dean of Earth System Science, Tianjin University by Congqiang Liu 3) ISMC representatives by Lutz Weihermüller
09:00-09:15	Presentation by ISMC co-chairs Martine van der Ploeg & Yijian Zeng

9:15-9:45
Group Photo & Coffee Break

Plenary Keynote

Time	Title	Speaker	Institution
09:45-10:30	On the hydrology of soils in the Earth System	Harry Vereecken (invited)	Forschungszentrum Jülich, Germany

Session: Modelling soil processes in land surface modelling

Conveners: Zhongwang Wei, Nan Wei, Yongjiu Dai, Tobias KD Weber, Jingyi Huang

Time	Title	Speaker	Institution

10:30-11:00	How to derive soil property information from satellite data	Kun Yang (invited)	Tsinghua University, Beijing, China
11:00-11:15	Choice of soil thermal property parameterization schemes matters in earth system modelling of water, heat and carbon transport	Hailong He	Northwest A&F University, China
11:15-11:30	A soil albedo parameterisation scheme for land surface model	Wenye Sun	Sun Yat-sen University, China
11:30-11:45	Improved soil water retention curve and relative hydraulic conductivity models	Xingxing Kuang	Southern University of Science and Technology, China
11:45-12:00	Dimensionality and scales of preferential flow in soils of Shale Hills hillslope simulated using HYDRUS	Ying Zhao	Ludong University, China
12:00-12:15	Modelling Soil Phosphorus Dynamics in Biomass Buffer Zone to Predict Phosphorus Concentration in Agricultural Runoff	Tianying Li	University of Guelph, Canada
12:15-12:30	CNMM-DNDC: a catchment-scale hydro-biogeochemical simulation model for managing water quality and greenhouse gas emissions	Yong Li	Institute of Atmospheric Physics, CAS, China
12:30-14:00 **Lunch Break**			

Plenary Keynote

Time	Title	Speaker	Institution
14:00-14:45	The need for a soil digital twin and how it can look like	Johan Alexander Huisman (invited)	Forschungszentrum Jülich, Germany

Introduction of the 4th ISMC Conference Special Collection & Call for papers from JAMES, GRL, and JGR: Biogeosciences

Time	Title	Speaker	Institution
14:45 -15:00	Seeking to publish your research? Consider Special Collection - Advances in Modeling Soil System Science, Earth System Science, and Beyond	Wenbai Yang, Yuling Tan	AGU & Wiley

Session: On representing memory effects, hysteresis and feedbacks in the Critical Zone

Conveners: Mehdi Rahmati, Harry Vereecken, Dani Or

Time	Title	Speaker	Institution
15:00-15:15	Identifying time lags between precipitation and spring discharge by their phase differences and casual information flow	Yonghong Hao	Tianjin Normal University, China
15:15-15:30	Using fractional calculus theory to implement soil moisture memory in its evolution	Mehdi Rahmati	Forschungszentrum Jülich, Germany
15:30-15:45	Improved modelling of subsurface stormflow based on source-responsive method for simulation of rapid hillslope runoff response	Xuhui Shen	Hohai University, China
15:45-16:00	Responses of deep soil moisture to direct rainfall and groundwater in the red soil critical zone: A four-stage pattern	Yaji Wang	Nanjing Soil Research Institute, Chinese Academy of Sciences, China

16:00-16:30

Coffee Break

Lightning Talks				
Time	**Title**	**Speaker**	**Institution**	**Poster ID**
16:30	Seismic vulnerability of crossed river RC bridge structure under soil scour and corrosion attack	Mohammed Al-Haaj	Tianjin University, China	Poster P4
16:33	County-level evaluation of large-scale gridded datasets of irrigated area over China	Xin Tian	Tianjin University, China	Poster P22
16:36	Exploring the relationship between soil basic properties and shape parameters in soil water retention curves within dual porosity in soil hydraulic properties	Wenhao Shi	Tianjin University, China	Poster P26
16:39	Nonlinear mapping of physicochemical soil properties to land use/cover histories in China	Hao Chen	Tianjin Normal University, China	Poster P28
16:42	Source Apportionment of Heavy Metal and Ecological and Health Risk Assessment of Typical Non-Ferrous Metal Smelting Plant	Wangcai Shuai	Tianjin University, China	Poster P29
16:45	The effectiveness of data merging in estimating extreme precipitation events	Xiaoqi Kang	Tianjin University, China	Poster P32
16:48	The streamline-based approach for delineating porous and fractured bedform-induced hyporheic zone	Di Gao	Tianjin University, China	Poster P34
16:51	Improved Soil Moisture Simulation and Production of Maps Using Automatic Machine Learning: A Case Study of a Watershed in the United States	Shiao Feng	Tianjin University, China	Poster P35
16:54	Simulation of the Evolution Process of Variable-Density Groundwater Induced by Seawater Intrusion in the Coastal Areas of the Bohai Bay	Wenhong Wang	Jilin University, China	Poster P38
16:57	Similarity-based classification of groundwater hydrographs and insights for groundwater modelling	Xiangbo Meng	Tianjin University, China	Poster P39
17:00	Spatiotemporal Dynamics in Baseflow Index Using Machine Learning Techniques in the Contiguous United States	Ali R. AL_Aizari	Tianjin University, China	Poster P53

17:00-18:30
Poster Session

May 9 (Thursday), 2024

Plenary Keynote

Time	Title	Speaker	Institution
08:30-09:15	Priority of soil research and soil management in China in the future decade	Gan-Lin Zhang (invited)	Chinese Academy of Sciences, China

Session: How to include root hydraulic architecture in soil models to simulate root water uptake

Conveners: Gaochao Cai, Yilin Fang, Daniel Leitner, Andrea Schnepf

Time	Title	Speaker	Institution
09:15 – 09:45	From 3D root hydraulic architecture models to 2,1 or 0 D root water uptake functions: opportunities, challenges, and solutions	Jan Vanderborght (invited)	Forschungszentrum Jülich GmbH
09:45 – 10:00	A new water isotope-based mixing model for root water uptake scouring	Bingcheng Si	University of Saskatchewan, Canada
10:00 – 10:15	Interactions of Soil-plant Hydraulic Resistances under Drought Stress	Guoqing Lei	Wuhan University, China
10:15 – 10:30	Root hydraulic phenotypes impacting water uptake in drying soils	Gaochao Cai	Sun Yat-sen University, China
10:30-10:45			

Coffee Break			
10:45-11:00	Evaporation-driven internal hydraulic redistribution alleviates root drought stress: Mechanisms and modeling	Yang Liu	Beijing Forestry University, China

Session: General Session of any model related research			
Conveners: Yonggen Zhang, Yijian Zeng, Lutz Weihermueller, Martine van der Ploeg, Gang Wang, Hailong He			
Time	**Title**	**Speaker**	**Institution**
11:00-11:30	Soil water potential and its impact on soil properties	Ning Lu (invited)	Colorado School of Mines, USA
11:30-11:45	What really controls pedotransfer function performance	Attila Nemes	Norwegian Institute of Bioeconomy Research, Norway
11:45-12:00	Constraint-based model conditioning for robust simulation of crop rotations	Holger Pagel	Forschungszentrum Jülich, Germany
12:00-12:15	The transit time of world's rivers and the widespread effects of damming	Lichun Wang	Tianjin University, China
12:15-12:30	The ProCarbon-Soil model: a carbon farming approach for improved model-data compatibility	Luis Gustavo Barioni	Embrapa Digital Agriculture, Brazil

12:30-14:00 Lunch Break			
14:00-14:15	Bridging a gap in our understanding and modelling of soil organic carbon	Xiaoxian Zhang	Rothamsted Research, UK
14:15-14:30	Reactive transport modeling of carbon capture in soil amended with fast weathering silicate minerals	Yi Wai Chiang	University of Guelph, Canada
14:30-14:45	Estimation of evapotranspiration in a double-row maize field: A new method based on an analytical water flux model	Yili Lu	China Agricultural University, China
14:45-15:00	Mechanisms and modelling of coupled soil cycles of carbon and silicon	Zhaoliang Song	Tianjin University, China

Session: Toward characterising and modelling the temporal variability of effective soil properties

Conveners: Attila Nemes, Anne Verhoef, Kathe Todd-Brown, Martine van der Ploeg

Time	Title	Speaker	Institution
15:00–15:15	Predicting Soil Organic Carbon of China in the Future and Role of Carbon Flux	Wei Shangguan	Sun Yat-sen University, China
15:15–15:30	To capture the effects of soil structure on soil hydraulic properties using deep learning and physical model	Yunquan Wang	China University of Geosciences, Wuhan, China
15:30-16:00 Coffee and Posters			
16:00–16:15	Elucidating the Dynamics of Grazing-Induced Soil Hydraulic Properties Variability: A Meta-Analysis and Modelling Approach	Yong Wang	University of Reading, Reading, United Kingdom

16:15–16:45	Toward characterizing and modelling the temporal variability of effective soil properties	Katharina Meurer (invited)	Swedish University of Agricultural Sciences, Sweden

Plenary Keynote

Time	Title	Speaker	Institution
16:45-17:30	EU Priorities in soil research within the Green Deal	Panos Panagos (invited)	Joint Research Centre of the European Commission

World Café "Transformative Soil Modeling through Inclusive Collaboration and Disseminated Education"

Conveners: Mahyar Naseri, Rafaella Chiarella, Ali Mehmandoostkotlar, Bárbara Costa da Silva,Elisa Bruni, Mojtaba Zeraatpisheh

Time	Title	Speaker	Institution
17:30-17:40	Introduction to the World Café	Mahyar Naseri	Thünen-Institut, Germany
17:40-18:10	Advancing Science, Serving Society: Our Responsibility to Address Global Challenges and Foster Inclusive Excellence	Teamrat Ghezzehei (invited)	University of California, Merced, USA
18:10 – 19:30 Poster Session			

19:30
Conference Dinner and ISMC Award Ceremony
Comments and summaries made by
Rien van Genuchten
(Location: the 1st Floor of Pan Pacific Hotel, Pacific Restaurant)

May 10 (Friday), 2024

Plenary Keynote

Time	Title	Speaker	Institution
08:15-09:00	Soil and Water conservation through conservation agriculture	Ranjan Bhattacharyya (invited)	Intergovernmental Technical Panel on Soils, Food and Agriculture Organization, the United

10:15-10:30	Soil aggregate turnover: methodology and modeling	Xinhua Peng	Institute of Agricultural Resources and Regional Planning, CAAS, China
			Nations

Session: Saturation kinetics in soils: stochiometric limits, mineral-organic interactions, and microbial explicit models

Conveners: Zhifeng Yan, Katherine Todd-Brown, Gangsheng Wang, Wenping Yuan, Gang Wang

Time	Title	Speaker	Institution
09:00-09:30	Enhanced response of soil respiration to experimental warming upon thermokarst formation	Yuanhe Yang (invited)	Chinese Academy of Sciences, China
09:30-09:45	Small scale water dynamics drives microbial biophysical interactions and ecology	Gang Wang	China Agricultural University, China
09:45-10:00	Incorporating Explicit Microbial Kinetics Enhances Methane Modelling Under Oxygen Fluctuation	Gangsheng Wang	Wuhan University, China
10:00-10:15	Quantify gaseous nitrogen production from agricultural soils using a microbial-explicit model	Zhifeng Yan	Tianjin University, China

10:30-11:00 **Coffee Break**			
Session: Constraining soil hydrologic processes using in-situ and remote sensing observations			
Conveners: Jianzhi Dong, Tianjie Zhao, Long Zhao, Chunyu Dong			
Time	**Title**	**Speaker**	**Institution**
11:00-11:30	Retrieval of permafrost related datasets on the Tibetan Plateau	Lin Zhao (invited)	Nanjing University of Information Science and Technology, China
11:30-11:45	A high-resolution integrated hydrologic model for simulating groundwater-land surface process in the Heihe River Basin	Xiaofan Yang	Beijing Normal University, China
11:45-12:00	Combined measurement of surface soil moisture and salinity by an UAV-based ground penetrating radar	Qinbo Cheng	Hohai University, China
12:00-12:15	Improving Land Surface Modelling through Multi-sensor Observations	Long Zhao	Southwest University, China
12:15-12:30	Extending Historical Soil Moisture Records Using a Diagnostic Approach for the Validation of Satellite Retrievals	Qing Zhang	Henan Polytechnic University, China
12:30-14:00 **Lunch Break**			

Session: Data fusion for characterization of soil states and heterogeneity

Conveners: Yuanyuan Zha, Tian-Chyi Jim Yeh, Deqiang Mao, Lingzao Zeng, Michael Tso, Xiaoqing Shi

Time	Title	Speaker	Institution
14:00-14:30	Evaluation of Hydraulic Conductivity Estimates from Various Approaches with Subsurface Flow Models	Walter A. Illman (invited)	University of Waterloo, Canada
14:30-14:45	Assessment and digital management simulation of soil degradation from water erosion based on combined field survey data and erosion modelling on East European Plane	Andrey Zhidkin	V.V. Dokuchaev Soil Science Institute, Russia
14:45-15:00	Developing an integrated soil information system to support resource management in British Columbia, Canada	Jin Zhang	Dalhousie University, Canada
15:00-15:15	Bayesian estimation of spatially distributed soil hydraulic properties from geometric scaling and KL expansion	Na Li	China University of Geosciences, China
15:15-15:30	Exploiting laboratory and field hyperspectral measurements to estimate the soil hydraulic properties	Paolo Nasta	University of Napoli, Italy
15:30-15:45 Coffee Break			
15:45-16:00	Evaluation and development of pedotransfer functions of saturated hydraulic conductivity for subtropical soils	Zhengchao Tian	Huazhong Agricultural University, China
16:00-16:15	Micro-Raman imaging in soil-related analysis	Di Yan	Bruker Optics German Headquarters

Session: Application of machine learning and non-linear methods for spatial data analysis			
Conveners: Ruhollah Taghizadeh-Mehrjardi, Brandon Heung, Ana M. Tarquis			
Time	**Title**	**Speaker**	**Institution**
16:15-16:45	Reimagining the Application of Machine Learning and AI in Soil Science	Budiman Minasny (invited)	University of Sydney, Australia
16:45-17:00	Segmentation of plant residues on soil X-ray CT images using neural network	Anna Yudina	V.V. Dokuchaev Soil Science Institute, Russia
17:00-17:15	Comparing soil-atmosphere-vegetation dynamics through multifractal cross-correlated analyses	Ernesto Sanz	Universidad Politécnica de Madrid, Spain
17:15-17:30	Making Machine Learning More Transparent Using Explainable AI for soil modeling	Wei Shangguan	Sun Yat-sen University, China
17:30-17:45	Unraveling threshold and interaction effects of environmental variables in soil organic carbon mapping in plateau watershed	Chi Zhang	Wuhan University, China
17:45 – 18:30 **Plenary** **Summary by ISMC chairs convenors** **Handout of young scientist poster & oral award**			

天津大學 地球系统科学学院
Tianjin University School of Earth System Science

4th ISMC Conference 2024

Poster

Pan Pacific Hotel, Tianjin, China

May 7 to 10, 2024

Poster

- All poster stands will be set up by Wednesday morning, May 7th.
- For the **poster session 1** (on Wednesday, May 8th, 2024), you may attach your poster to the stand anytime on May 7th or latest in the morning May 8th. Please remove your poster after the poster session concludes, no later than 19:00 on May 8th
- For the **poster session 2** (on Thursday, May 9th, 2024), please affix your poster to the stand before the morning coffee break on Thursday, May 9th, 2024, and remove the posters before the conference concludes.
- Although there are two dedicated poster sessions with scheduled attendance times, attendees are welcome to visit the posters during any of the breaks.
- Refreshments will be served during the poster sessions.

Poster Session 1

Wednesday May, 8, 2024

Attendance time 17:00 – 18:30

Session: Modelling soil processes in land surface modelling

Conveners: Zhongwang Wei, Nan Wei, Yongjiu Dai, Tobias KD Weber, Jingyi Huang

Poster P1: **Ce Zheng (Chang'an University, China)** *Exploration of Soil Water and Vapor Transport Mechanism and Isotope Ecological Effects in Cold and Arid Regions*

Poster P2: **Danila Bardashov (V.V. Dokuchaev Soil Science Institute, Russia)**, *Continuous representation and modelling of soil organic matter as a tool for assessing long-term carbon dynamics in forest-steppe uncultivated black-soils*

Poster P3: **Elizaveta Malyshkina (Perm State University, Russia)** *Automation of soil salinization assessment.*

Poster P4: **Mohammed Al-Haaj (Tianjin University, China)** *Seismic vulnerability of crossed river RC bridge structure under soil scour and corrosion attack*

Poster P5: **Natalya Mitrakova (Perm State University, Russia)** *Modelling of sulfate contamination of soils in mining areas using information logical analysis*

Poster P6: **Polina Sairanova (Perm State University, Russia)** *Information-logical analysis in modelling technogenic salinization in soils*

Poster P7: **Wande Gao (Chang'an University, China)** *Identification and Quantification of Lateral Soil Moisture Flow in Sand Dune Slopes of the Maowusu Area*

Poster P8: **Xuebin Xu (Ningbo University, China)** *A hybrid model based on microbial-explicit model and machine learning for improving prediction and mapping accuracy of soil organic carbon*

Poster P9: **Nan Wei (Sun Yat-sen University, China)** *Upscaling Techniques of Soil Hydraulic and Thermal Parameters for use in Land Surface Models*

Poster P10: **Rafaella Chiarella (Forschungzentrum Juelich, Germany)** *Nutrient cycling in forest ecosystems – a new modelling approach*

Poster P11: **Nikita Kriuchkov (Shenzhen MSU-BIT University, China)** *Adaptation RUSLE2 model for different regions (on example of southeast of the East European Plain and northern part of the North China Plain))*

Poster P12: **Xiaoyu Zhang (China Agricultural University, China)** *Influence of Freeze-Thaw Cycles on Soil Water and Heat under Global Climate Warming*

Poster P13: **Yiwen Han (China Agricultural University, China)** *The Response of Non-Point Source Pollution to Climate Change in an Orchard-Dominant Coastal Watershed*

Session: On representing memory effects, hysteresis and feedbacks in the Critical Zone

Conveners: Mehdi Rahmati, Harry Vereecken, Dani Or

Poster P14: **Liantao Niu (Chinese Academy of Sciences, China)** *Water and Nitrate Transport Through the Vadose Zone Under Orchard Expansion in A Cultivated Loess Critical Zone*

Poster P15: **Qahtan Mugahed Ghaleb Alshami (Tianjin University, China)** *Exploring Elastic Wave Reduction through Forest Phononic Crystals: An Application of Periodic Theory in Seismic Engineering*

Poster P16: **Shunhua Yang (Chinese Academy of Sciences, China)** *Deep nitrate accumulation in relation to surface soil management versus regolith interactions in a highly weathered subtropical Critical Zone*

Poster P17: **Alla Yurova (Chinese Academy of Sciences, China)** *Modelling the dependence of climate regulating functions of Eurasian steppe soils on soil moisture*

Poster P18: **Shaojie Hu (Hunan University, China)** *Quantifying Coupling Effects between Soil Matric Potential and Osmotic Potential*

Poster P19: **Guangrong Hu (Beijing Normal University, China)** *Identifying Spatiotemporal Patterns of Hillslope Subsurface Flow in an Alpine Critical Zone on the Qinghai-Tibetan Plateau Based on Three-Year, High-Resolution Field Observations*

Session: Constraining soil hydrologic processes using in-situ and remote sensing observations

Conveners: Jianzhi Dong, Tianjie Zhao, Long Zhao, Chunyu Dong

Poster P20: **Dongyang Ren (China Agricultural University, China)** *Quantifying soil water and nutrient balances for a tile-drained agricultural watershed using improved SWAT model*

Poster P21: **Qiong Han (Tianjin University, China)** *Actual evapotranspiration differences between measurements of lysimeters and eddy covariance along climate and ecosystem gradients*

Poster P22: **Xin Tian (Tianjin University, China)** *County-level evaluation of large-scale gridded datasets of irrigated area over China*

Poster P23: **Jie Tian (Lanzhou University, China)** *Soil moisture response pattern based on soil moisture observations in mountainous areas*

Poster P24: **Chaoyang Du (Chinese Academy of Sciences, China)** *The experiment and simulation of Water-Vapor-Heat coupled transport in desert vadose zone*

Poster P25: **Yuan Guo (Tianjin University, China)** *Distribution, migration and transformation of phosphorus in mangrove wetland of Dongzhai Harbor*

Session: Toward characterising and modelling the temporal variability of effective soil properties

Conveners: Attila Nemes, Anne Verhoef, Kathe Todd-Brown, Martine van der Ploeg

Poster P26: **Wenhao Shi (Tianjin University, China)** *Exploring the relationship between soil basic properties and shape parameters in soil water retention curves within dual porosity in soil hydraulic properties*

Poster P27: **Yingqi Zhang (China Agricultural University, China)** *Assessing the response mechanisms of elevated CO_2 concentration on various forms of nitrogen losses in the Golden Corn Belt*

Session: General Session of any model related research

Conveners: Yonggen Zhang, Yijian Zeng, Lutz Weihermueller,
Martine van der Ploeg, Gang Wang, Hailong He

Poster P28: **Hao Chen (Tianjin Normal University, China)** *Nonlinear mapping of physicochemical soil properties to land use/cover histories in China*

Poster P29: **Wangcai Shuai (Tianjin University, China)** *Source Apportionment of Heavy Metal and Ecological and Health Risk Assessment of Typical Non-Ferrous Metal Smelting Plant*

Poster P30: **Wentai Zhang (Xinjiang Agricultural University, China)** *Modelling effective soil depth at regional scale in Xinjiang, China*

Poster P31: **Xiaodong Song (Chinese Academy of Sciences, China)** *Pervasive soil phosphorus losses in terrestrial ecosystems in China*

Poster P32: **Xiaoqi Kang (Tianjin University, China)** *The effectiveness of data merging in estimating extreme precipitation events*

Poster P33: **Cuiting Qi (Tianjin Normal University, China)** *Analysis of heat transfer in an ATES system: on the role of two-dimensional thermal conduction*

***Poster P34*:** **Di Gao (Tianjin University, China)** *The streamline-based approach for delineating porous and fractured bedform-induced hyporheic zone*

Poster P35: **Shiao Feng (Tianjin University, China)** *Improved Soil Moisture Simulation and Production of Maps Using Automatic Machine Learning: A Case Study of a Watershed in the United States*

Poster P36: **Tiago Ramos (University of Lisbon, Portugal)** *Field-scale assessment of soil water dynamics using distributed modelling and electromagnetic conductivity imaging*

Poster P37: **Wei Shangguan (Sun Yat-Sen University, China)** *Our recent advances in soil modelling and data products using machine learning and explainable AI*

Poster P38: **Wenhong Wang (Jilin University, China)** *Simulation of the Evolution Process of Variable-Density Groundwater Induced by Seawater Intrusion in the Coastal Areas of the Bohai Bay*

Poster P39: **Xiangbo Meng (Tianjin University, China)** *Similarity-based classification of groundwater hydrographs and insights for groundwater modelling*

Poster Session 2

Thursday May, 9, 2024

Attendance time 18:10 – 19:30

Session: How to include root hydraulic architecture in soil models to simulate root water uptake

Conveners: Gaochao Cai, Yilin Fang, Daniel Leitner, Andrea Schnepf

Poster P40: **Jiayun Wang (China Agricultural University, China)** *Characteristics of Soil Pore Structure and Permeability Simulation under Conservation Tillage*

Poster P41: **Jie Zhang (China Agricultural University, China)** *Modelling the effect of real soil macropore structure on water infiltration using COMSOL*

Poster P42: **Scott Jones (Utah State University, USA)** *Modelling Dryland Evapotranspiration and Biomass Yield using Water Content Measurements and Machine Learning*

Poster P43: **Xiaoya Shao (Chinese Academy of Sciences, China)** *Simulation Research of the Interaction Mechanisms Among Deep Soil Water, Typical Afforestation and Climate in the Loess Plateau*

Session: Saturation kinetics in soils: stochiometric limits, mineral-organic interactions, and microbial explicit models

Conveners: Zhifeng Yan, Katherine Todd-Brown, Gangsheng Wang, Wenping Yuan, Gang Wang

Poster P44: **Zhi Qu (Xi'an University of Technology, China)** *Effects of phosphorus addition on one-dimensional vertical infiltration characteristics of soil water*

Poster P45: **Liang Dong (South China University of Technology, China)** *Quantifying the worth of ecological data in developing soil carbon models*

Session: Data fusion for characterization of soil states and heterogeneity

Conveners: Yuanyuan Zha, Tian-Chyi Jim Yeh, Deqiang Mao, Lingzao Zeng, Michael Tso, Xiaoqing Shi

Poster P46: **Gaosong Shi (Sun Yat-Sen University, China)** *A 1 km daily soil moisture dataset over China using in situ measurement and machine learning*

Poster P47: **Na Li (China University of Geosciences, China)** *Bayesian estimation of spatially distributed soil hydraulic properties from geometric scaling and KL expansion*

Poster P48: **Xuezi Gong (Wuhan University, China)** *Geostatistical-Incorporated Physics-Informed Generative Adversarial Networks for Modelling of Heterogeneous Unsaturated Flows*

Poster P49: **Yuanyuan Zha (Wuhan University, China)** *Deep learning integrating scale conversion and pedotransfer function to avoid potential errors in cross-scale parameter transfer*

Poster P50: **Enqing Hou (South China Botanical Garden, CAS, China)** *A data assimilation approach to quantify soil phosphorus dynamics*

Poster P51: **Jiong Zhu (Wuhan University, China)** *Forward and Inverse Modelling of Soil Water Flow in Layered Soil: A Perspective from Frequency Domain*

Poster P52: **Hyun-Jin Park (National Institute of Crop Science, Rural Development Administration, Korea)** *Changes in methane emissions form paddy soils under non-puddling condition*

Session: Application of machine learning and non-linear methods for spatial data analysis

Conveners: Ruhollah Taghizadeh-Mehrjardi, Brandon Heung, Ana M. Tarquis

Poster P53: **Ali R. AL_Aizari (Tianjin University, China)** *Spatiotemporal Dynamics in Baseflow Index Using Machine Learning Techniques in the Contiguous United States*

Poster P54: **Ana Maria Tarquis (Universidad Politécnica de Madrid, Spain)** *Using Remote Sensing for Precision Irrigation Management Zone Identification*

Poster P55: **Andrés Almeida-Ñauñay (Universidad Politécnica de Madrid, Spain)** *Recurrence based on methods for detecting regime transitions in soil-vegetation-atmosphere dynamics*

Poster P56: **Gaosong Shi (Sun Yat-Sen University, China)** *Reducing Location Error of Legacy Soil Profiles Leads to Improvement in Digital Soil Mapping*

Poster P57: **Qiyun Xiao (Changchun Normal University, China)** *LandBench 1.0: A benchmark dataset and evaluation metrics for data-driven land surface variables prediction*

Poster P58: **Pu Shi (Jilin University, China)** *Spatial assessment of soil degradation via multitemporal spectral imaging of exposed croplands*

Poster P59: **Wenye Sun (Sun Yat-Sen University, China)** *Using Hierarchical Random Forest Classification Model to Produce China's Soil Classification Map*

Poster P60: **Jiankang Dong (Tianjin Normal University, China)** *A deep learning model with time delay to predict soil water content with the profile in forest and grassland transition zone*

Session: General Session of any model related research

Conveners: Yonggen Zhang, Yijian Zeng, Lutz Weihermueller,
Martine van der Ploeg, Gang Wang, Hailong He

Poster P61: **Jianglong Liu (Xinjiang Agricultural University, China)** *Modelling of saturated soil hydraulic conductivity of farmland in Xinjiang, China*

Poster P62: **Wenjing Qin (Taiyuan University Of Technology, China)** *Study on pedo-transfer function of soil hydraulic parameters in loess area*

Poster P63: **Yanqiao Li (China Agricultural University, China)** *Assessing the Impact of Long-Term Climate Change on Hydrology and Crop Diversity Yield in the Texas High Plains*

Poster P64: **Teligeer Bao (Tianjin Normal University, China)** *What can we learn from the centuries-long development of Longzici Springs, China*

Poster P65: **Bihan Yang (Tianjin Normal University, China)** *Spatiotemporal Variation of Groundwater Reserves in the Tarim River Basin Based on GRACE Gravity Satellite Data*

Poster P66: **Darrell Tang (Wageningen University, Netherlands)** *Managed Phreatic Zone Recharge for Irrigation and Wastewater Treatment*

Poster P67: **Gihan Mohammed (Forschungszentrum Juelich, Germany)** *Modelling the phosphorus dynamics in arable soil under long-term fertilization*

Poster P68: **Jinrong Yao (Zhejiang University, China)** *Numerical simulation of hydrothermal circulation in Tianxiu hydrothermal zone*

Poster P69: **Qingliang Li (Changchun Normal University, China)** *A Novel Methodology for Unveiling Insights in Evapotranspiration Modelling through Knowledge-Guided Deep Symbolic Regression Model*

Poster P70: **Mahyar Naseri Moghaddam (Thünen Institute of Agricultural Technology, Germany)** *Recent Advancements in the Hydraulic Properties of Stony Soils: A Critical Review*

Poster P71: **Jingwen Deng (Beijing Forestry University, China)** *Modelling the Influence of Rock Thermal Properties on Soil Thermal and Hydrological Dynamics*

Poster P72: **Yong Chen (China Agricultural University, China)** *Enhancement and Application of the SWAT Model in Mechanism of Watershed Processes*

Poster P73: **Javad Safarhamidi (Technical University of Braunschweig, Germany)** *Impact of Root Distribution on Soil Hydraulic Properties Under Different Water Quality Stressors*

Poster P74: **Jieliang Zhou (China University of Geosciences, China)** *Development of a pedotransfer function that considers soil structure*

Poster P75: **Júnior Melo Damian (Embrapa Digital Agriculture, Brazil)** *Modelling the economic and environmental impacts of the inclusion of the soil organic carbon model in the sugarcane-livestock integrated systems*

Poster P76: **Lianyi Hao (Changan University, China)** *Transport and numerical evaluation of CO_2 concentration and flux in Salix cheilophila site at different profile depths during the growing season*

Poster P77: **Mohammadhossein Khanipour Raad (Technical University of Braunschweig, Germany)** *Characterizing effective hydraulic properties of highly stony soils using inverse modelling*

Poster P78: **Na Wen (China Agricultural University, China)** *Enhancing Hydrological Models to Narrow the Gap between Elevated Carbon Dioxide Concentrations and Crop Responses: Implications for Water Resources*

Poster P79: **Pengfei Qi (University of Geosciences Wuhan, China)** *Simulation of soil water, heat and salt transport in considering of capillary flow, film flow and vapor diffusion*

Poster P80: **Chunmei Ma (Tianjin Normal University, China)** *Simulation of Spring Discharge Using Deep Learning, Considering the Spatiotemporal Variability of Precipitation*

Poster P81: **Kakha Nadiradze (DesertNET International, France)** *Soils Microbiota - biodiversity footprint and ESRI Products*

Poster P82: **Olga Sukhoveeva (Institute of Physicochemical and Biological Problems in Soil Science RAS, Russia)** *Modelling the influence of no till technology on the main indicators of carbon cycle in agroecosystems*

Poster P83: **Dongdong Wu (China Fire and Rescue Institute, China)** *Spatiotemporal dynamics of soil moisture and matric potential under different land covers at an agricultural site*

Poster P84: **Jan De Pue (Royal Meteorological Institute Belgium)** *Impact of groundwater dynamics on drought response and soil moisture memory in ISBA-CTRIP*

Poster P85: **Yinying Jiao (Northwest normal university)** *Estimating non-productive water loss in irrigated farmland in arid oasis regions: Based on stable isotope data*

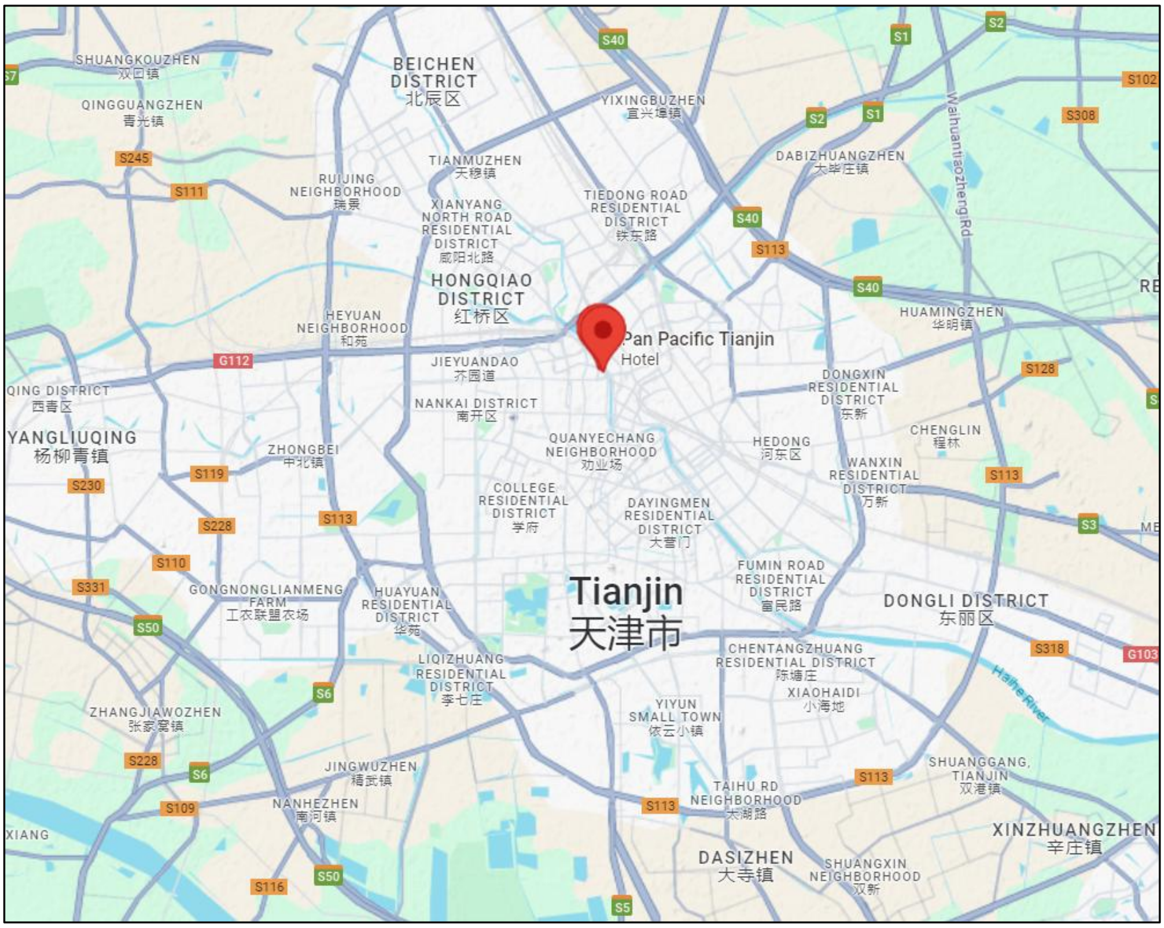
Poster P86: **Dantong Lin (Lanzhou University)** *Prediction of colloid transport in soil using pore-network model*

Poster P87: **Jun Gu (Institute of Soil Science, Chinese Academy of Sciences)** *Edaphic regulation of soil organic carbon fractions in the mattic layer across the Qinghai-Tibetan Plateau*

Poster P88: **Jie Zhang (Aarhus University)** *Modeling coupled nitrification-denitrification in soil with an organic hotspot*

Poster P89: **Adeel Ahmad Nadeem (Wuhan University)** *SAFER-ET based assessment of irrigation patterns and impacts on groundwater use in the central Punjab, Pakistan*

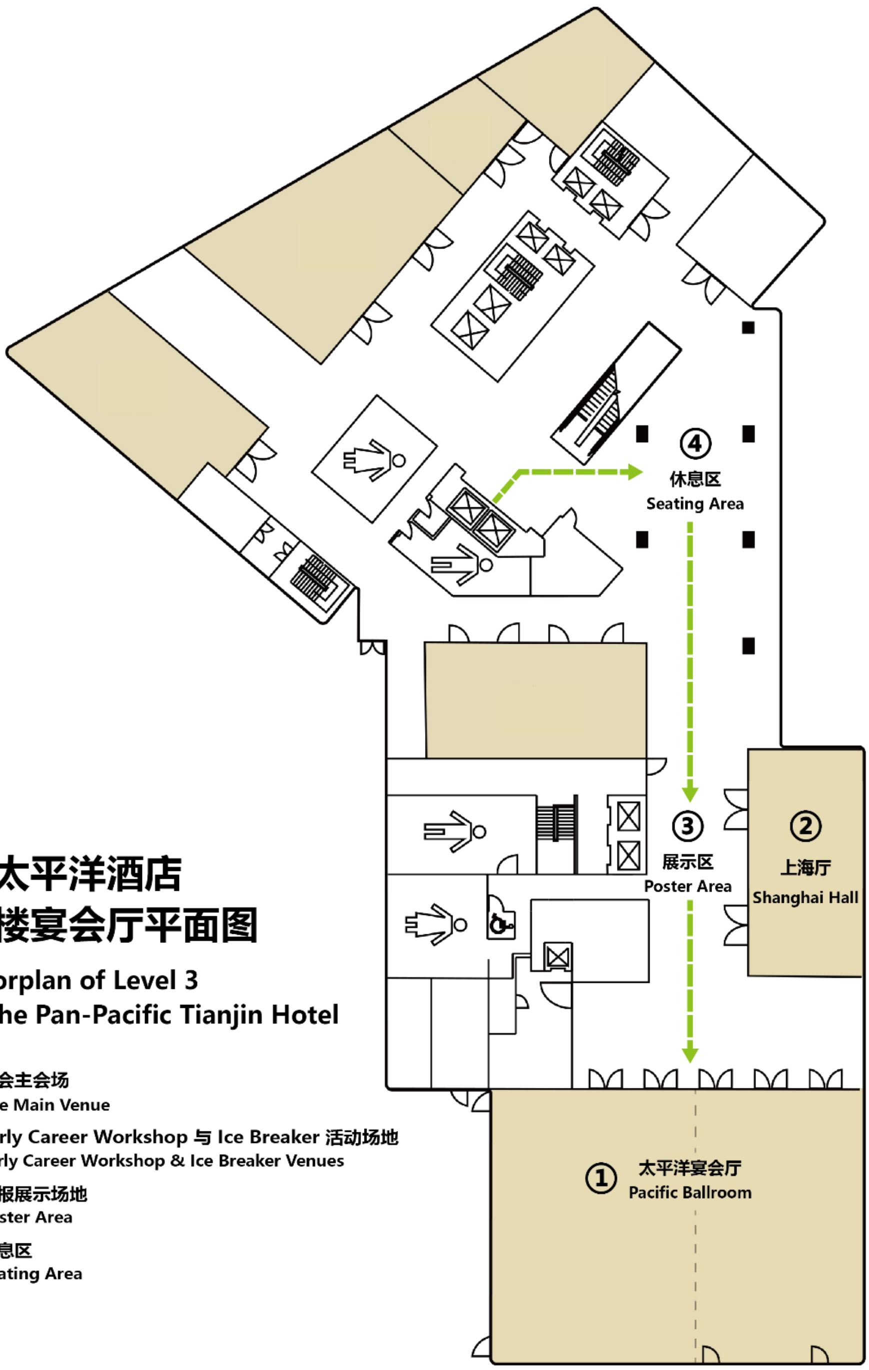
Location of the Hotel



Pan Pacific Tianjin

No. 1 Zhang Zi Zhong Road, Hong Qiao District, Tianjin, China.

Floorplan of Venue



泛太平洋酒店
三楼宴会厅平面图

Floorplan of Level 3
of the Pan-Pacific Tianjin Hotel

① 大会主会场
The Main Venue

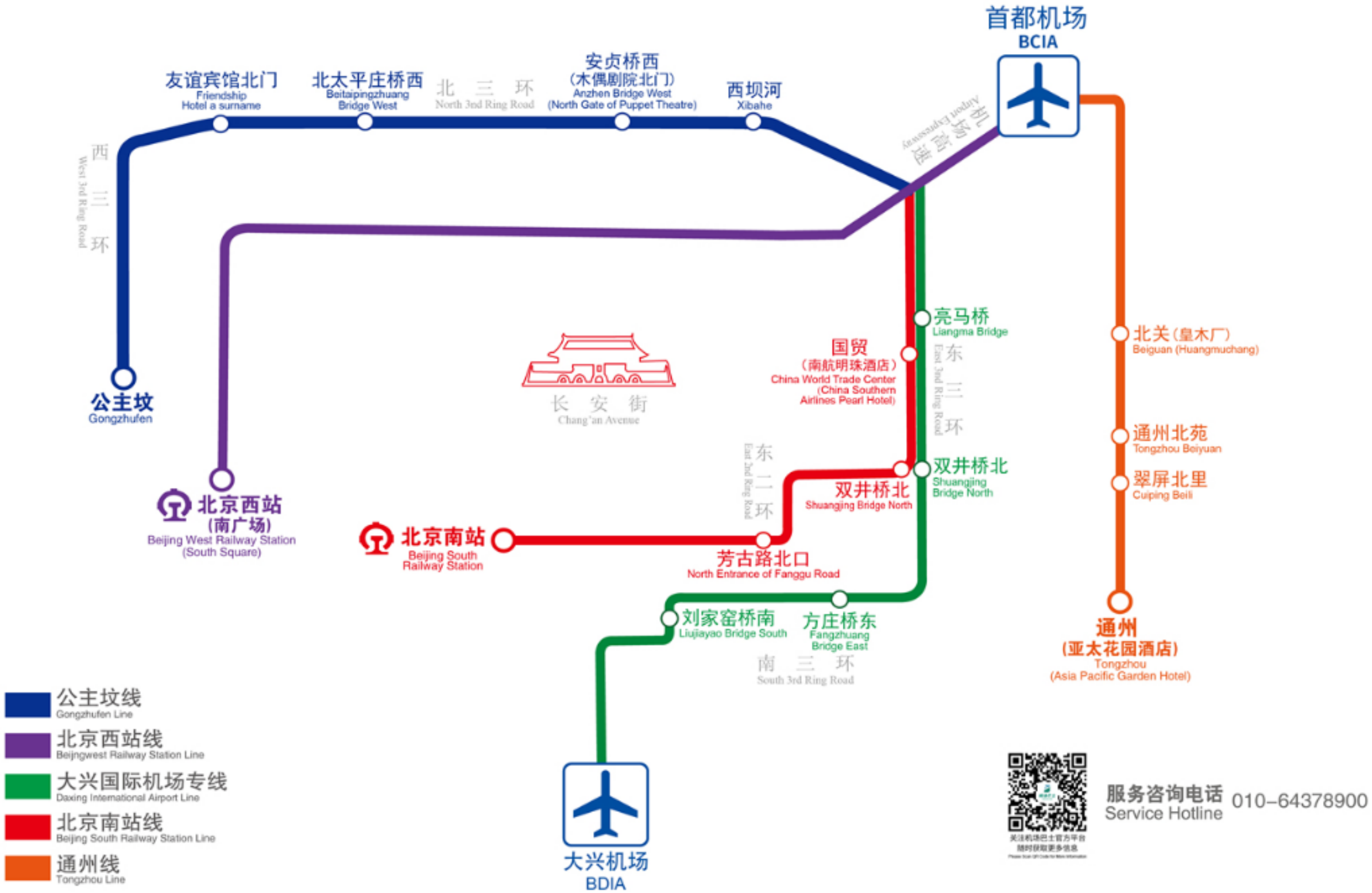
② Early Career Workshop 与 Ice Breaker 活动场地
Early Career Workshop & Ice Breaker Venues

③ 海报展示场地
Poster Area

③ 休息区
Seating Area

Transportation Tips

	TAXI	SUBWAY
Tianjin Binhai International Airport (天津滨海国际机场)	• nearly 21 km • cost 75 CNY • nearly 50 minutes	Take Tianjin Subway Line 2 (towards Caozhuang) to Dongnanjiao Station (Exit C), then walk 1.3 kilometers or take a taxi to the hotel.
Tianjin Railway Station (天津站)	• nearly 3.5 km • cost 25 CNY • nearly 30 minutes	Take Tianjin Subway Line 2 (towards Caozhuang), get off at to Dongnanjiao Station (Exit C), then walk 1.3 kilometers or take a taxi to the hotel.
Tianjin West Railway Station (天津西站)	• nearly 8 km • cost 30 CNY • nearly 30 minutes	Take Tianjin Subway Line 1 (towards Shuangheqiao), get off at to Xibeijiao Station (Exit D), then walk 1.3 kilometers or take a taxi to the hotel.
Tianjin South Railway Station (天津南站)	• nearly 25 km • cost 100 CNY • nearly 50 minutes	Take Tianjin Subway Line 3 (towards Xiaodian) to Tianjin Station and transfer to Subway Line 2 (towards Caozhuang). Get off at Southeast Corner Station (Exit C), then walk 1.3 kilometers or take a taxi to the hotel.
Beijing Daxing International Airport (北京大兴国际机场)	• nearly 136 km	Take high-speed train from Daxing International Airport Station to Tianjin Station or Tianjin West Station. The subsequent guidance from each station to the hotel please refer to the guide line from Tianjin/Tianjin West railway station to the hotel.
Beijing Capital International Airport (北京首都国际机场)	• nearly 165 km	Take the Airport Bus (toward Beijing South Railway Station). After the bus arrives at the station, you have the option to take the high-speed train from Beijing South Station to Tianjin Station, Tianjin West Station, or Tianjin South Station. Then, please refer to the above to learn from each station to the hotel.



Tips:

(1) For international attendees, please note that you will need to present your passport at the train station ticket window to purchase high-speed train tickets.

(2) If you are unable to use Google Maps, please consider using Apple Maps or Baidu Maps as alternatives.

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AGU ADVANCING EARTH AND SPACE SCIENCE

CSSA Crop Science Society of America

SSSA Soil Science Society of America

Abstract: Oral presentation

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Session: Modelling soil processes in land surface modelling

Session: Modelling soil processes in land surface modelling
Wednesday May 8, 2024
Attendance time 11:00 -11:15

Choice of soil thermal property parameterization schemes matters in earth system modelling of water, heat and carbon transport

Hailong He, Heng Liu, Anne Verhoef, Yijian Zeng, Yang Liu

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Abstract

The gap between earth system or climate model simulations and observations is still a topic of scientific and political concern. The latest phase of the Coupled Model Intercomparison Project (CMIP) is still showing overestimations in near-surface air temperature among other parameters, despite various model structural improvements and numerical advances. Great efforts have been made to increase model skill, yet few studies considered the heat transfer within soil and at the land-atmosphere interface, which are dominated by soil thermal conductivity (STC) parameterization schemes. By incorporating the commonly used STC parameterization schemes of various mainstream land surface models (LSMs) of earth system and climate models into the Community Earth System Model (CESM) and comparing with European Center Reanalysis version 5 (ERA5) and FLUXNET data, we found that the role of STC parameterization schemes in earth system model has been underestimated. The results unveil that STC parameterization schemes alone can lead to errors in global mean absolute bias (MAB) of shallow soil temperature of 2.1 °C with a 5~95% range of 1.75~3.26 °C. These errors propagate via the land-atmosphere interactions and feedbacks in earth system models, leading to MAB for near-surface air temperature of 1.67 °C with a 5~95% range of 1.53~2.07, and for sensible and latent heat flux of 9.8 $W \cdot m^{-2}$ with a 5~95% range of 7.8~12.4 $W \cdot m^{-2}$. Therefore, uncertainties arisen from STC parameterization schemes to a considerable extent explain the overestimated global mean temperatures, and affect the decision-making processes concerning the global temperature rise targets. In addition, the STC associated errors would propagate to affect the carbon cycle and lead to large bias in net primary production estimates. Hence, there is an urgent need to improve the neglected STC parametrization schemes to better understand our earth system, how it is affected by climate change and to guide our decisions on the best climate change mitigation strategies.

Session: Modelling soil processes in land surface modelling
Wednesday May 8, 2024
Attendance time 11:15 -11:30

A soil albedo parameterisation scheme for land surface model

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Affiliation: Sun Yat-sen University

Abstract

Surface albedo, the ratio of reflected to incident solar radiation at the Earth's surface, is a crucial parameter for characterizing the energy balance. Within land surface models, the significance of surface albedo is paramount as it greatly impacts energy partitioning and climate simulations. Consequently, access to accurate albedo data can dramatically enhance the precision of simulating various land surface processes, thereby contributing to more reliable climate modeling outcomes. Despite substantial advancements, contemporary parameterization methods still grapple with accurately discerning the albedo of bare soil from that of vegetation at a high level of precision. Several schemes rely on statistical techniques to derive albedo parameterizations for both bare soil and vegetation using soil color information and satellite-derived datasets. Other approaches employ straightforward vegetation index relationships to separate the albedo contributions of bare soil and vegetation. Yet these methodologies are currently fraught with substantial uncertainties. In this study, we present a novel and more sophisticated bare soil albedo parameterization model that meticulously distinguishes the albedo of bare soil from vegetation. This is achieved by investigating the intricate dependence of surface albedo on several key variables, including but not limited to soil moisture content, solar zenith angle, and soil roughness. Building upon the MODIS albedo products spanning from 2000 to 2020, we further develop a comprehensive global map of bare soil albedo. Our primary objective is to meticulously document and understand the variations in soil albedo resulting from fluctuating soil moisture levels and solar zenith angles. By doing so, our study provides essential, high-resolution data that can significantly enhance and refine land surface process models, ensuring their accuracy and reliability.

Session: Modelling soil processes in land surface modelling
Wednesday May 8, 2024
Attendance time 11:30-11:45

Improved soil water retention curve and relaltive hydraulic conductivity models

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Abstract

Modeling water flow in unsaturated soils requires accurate characterization of soil water retention curve and relative hydraulic conductivity. The objectives of this study are to propose new soil water retention curve models and improve the prediction ability of relative hydraulic conductivity model. A new soil water retention curve equation considering the air-entry value is proposed and its performance is contrasted with a well-supported equation by comparing measured and calculated data. A modification of the van Genuchten (1980) soil water retention model is also proposed to improve the agreement between measured and predicted relative hydraulic conductivity, with the Brooks and Corey-Burdine model is used to predict relative hydraulic conductivity. Furthermore, the performances of seven Weibull distribution models for predicting relative hydraulic conductivity using the Assouline et al. (1998) soil water retention curve model were evaluated.

Session: Modelling soil processes in land surface modelling
Wednesday May 8, 2024
Attendance time 11:45 -12:00

Dimensionality and scales of preferential flow in soils of Shale Hills hillslope simulated using HYDRUS

Ying Zhao

Email: yzhaosoils@gmail.com
Affiliation: Ludong University

Abstract

Complex subsurface soil structures across different scales influence preferential flow (PF). While model validation faces data constraints, it's unclear if accounting for more complexity improves accuracy. Using data from Shale Hills, we provide a comprehensive understanding of model ability based on Richards equations by comparing PF simulations in 2D hillslopes, 1D-vertical profiles, and 3D spatially-distributed domains. Results showed limited alignment between 1D simulations and soil moisture data, mainly affected by vertical changes in porosity, permeability, and precipitation features. Sub-daily fluctuations due to PF were not well captured. However, 2D and 3D simulations, considering hillslope features and factors like slope and fractured bedrock, outperformed 1D models. During 2D simulations, the models that captured the dual-porosity and anisotropy of soils provided more accurate predictions. Our findings underscore the significance of multi-dimensional modeling and accurate representation of bedrock and soil structures for PF simulations. Specifically, the 3D model results indicate a more effective depiction of PF pathways under current hillslope soil conditions, owing to the enhanced representation of hydraulic connectivity. Considering the complexity and refinement of 2D and 3D 'bottom-up' physically-based models (like the Darcy–Richards equations) in illustrating variations in soil profiles at a larger (hillslope) scale, the outcomes of this research have the potential to significantly contribute to creating a comprehensive modeling framework, applicable across diverse sectors in water resources and environmental sciences.

Session: Modelling soil processes in land surface modelling
Wednesday May 8, 2024
Attendance time 12:00 -12:15

Modelling Soil Phosphorus Dynamics in Biomass Buffer Zone to Predict Phosphorus Concentration in Agricultural Runoff

Tianying Li, Fatima Haque, Ogochukwu Udume, Yi Wai Chaing

Email: tianying@uoguelph.ca
Affiliation: University of Guelph

Abstract

Abstract: The primary objective of this study is to aid the design of cultivable biomass buffer strips in agricultural fields to effectively mitigate excess nutrients, particularly phosphorus, in surface runoff and groundwater seepage. The study will also improve the understanding of phosphorus movement mechanisms within the soil, while simultaneously reducing soil erosion into the surrounding environment, thereby preventing eutrophication of water bodies. To achieve these goals, the study will follow a two-pronged approach: the uptake rate of nutrients by biomass crops, specifically Miscanthus sinensis and Panicum virgatum, will be quantitatively evaluated through laboratory lysimeter experiments based on analysis of soil properties, including soil composition, pH, alkalinity, electrical conductivity, organic matter content, and phosphorus concentration; the dynamics of major components of phosphorus cycle in soil, including their movement through biomass buffer zones by surface runoff and subsurface flow, will be modeled based on soil-water balance using the Soil and Water Assessment Tool (SWAT), which will be combined with ArcGIS for landscape analysis to facilitate extensive area simulations. The integrated approach of laboratory experiments and modelling work seeks to provide theoretical frameworks for field trials, thereby supporting the effective design and implementation of biomass buffer strategies. The presented study closely aligns with the conference theme of "Modelling soil processes in land surface modelling." Based on the soil-water mass balance, this study considers the input of various substances into the soil, with a specific emphasis on understanding and modelling phosphorus dynamics. This encompasses the transformation processes within the soil and the uptake process by biomass vegetation in biomass buffer zone, as well as their subsequent outputs via surface runoff and groundwater seepage.

Keywords: Biomass buffer strips; phosphorus; biomass crops; soil; SWAT

Session: Modelling soil processes in land surface modelling
Wednesday May 8, 2024
Attendance time 12:15 -12:30

CNMM-DNDC: a catchment-scale hydro-biogeochemical simulation model for managing water quality and greenhouse gas emissions

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Abstract

Mitigating agricultural diffuse pollution and greenhouse gas emissions is a complicated task due to tempo-spatial lags between the field practices and the watershed responses. Spatially-distributed modeling is essential to the implementation of cost-effective and best management practices (BMPs) to optimize land uses and nutrient applications as well as to project the impact of climate change on the watershed service functions. CNMM (the Catchment Nutrients Management Model, Li et al., 2017) – DNDC is a 3D spatially-distributed, grid-based and process-oriented biophysical model comprehensively developed to simulate energy balance, hydrology, plant/crop growth (C3, C4 & CAM), biogeochemistry of biogenic elements (e.g., C, N and P), waste treatment, waterway vegetation/purification, stream water quality and land management in agricultural watersheds as affected by land utilization strategies such as BMPs and by climate change (Zhang et al., 2018). The CNMM-DNDC is driven by a number of spatially-distributed data such as weather, topography (including DEM and shading), stream network, stream water, soil, vegetation and land management (including waste treatments), and runs at hourly time step. It represents a catchment as a matrix of square uniformly-sized cells, where each cell is defined as a homogeneous hydrological response unit with all the hydrologically-significant parameters the same but varied at soil depths in fine intervals. Therefore, spatial variability is represented by allowing parameters to vary horizontally and vertically in space. A four-direction flux routing algorithm is applied to route water and nutrients across soils of cells governed by the gradients of either water head or elevation. A linear channel reservoir scheme is deployed to route water and nutrients in stream networks; and the stream and lake water quality is governed by the QUALKW6 algorithms. The model is capable of computing plant biomass and yield, soil C-N-P dynamics, surface water quality, and C-N gases (such as CO_2, CH_4, NH_3, NO, HONO, N_2O, and N_2) emissions from soils and stream waters. The CNMM-DNDC model has been verified and validated in a number of agricultural catchments along the eastern coastlines in China over various climatic zone. Currently, the model is being implemented in the CAS-ESM on EarthLab® to simulate the terrestrial ecosystems of China at very fine spatial-temporal scales. The CNMM-DNDC can serve as an idea modelling tool to investigate the overwhelming critical zone research at various catchment scales.

References Li et al., 2017. CNMM: a grid-based spatially-distributed catchment hydroAttendance time -biogeochemical simulation model. 202p. China Science Press, Beijing. Zhang et al., 2018. A process-oriented hydro-biogeochemical model enabling simulation of gaseous carbon and nitrogen emissions and hydrologic nitrogen losses from a subtropical catchment. Science of the Total Environment 616, 305–317.

Session: On representing memory effects, hysteresis and feedbacks in the Critical Zone

Session: On representing memory effects, hysteresis and feedbacks in the Critical Zone
Wednesday May 8, 2024
Attendance time 15:00-15:15

Identifying time lags between precipitation and spring discharge by their phase differences and casual information flow

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Abstract

The groundwater system is mainly replenished by atmospheric precipitation infiltration, and then controlled by karst fissures to form runoff, which is finally discharged centrally in the form of karst springs. Spring discharge responds to precipitation with different cycles and frequencies. The heterogeneity and anisotropy of karst aquifers make it difficult to investigate hydrodynamic response of karst water systems. Thus, it is crucial to determine how precipitation affect spring discharge. Taking Niangziguan, the largest karst spring in northern China, as an example, we collected precipitation from seven precipitation recharge areas to determine 1) What types of resonance periods and frequencies are exposed to when precipitation drives spring discharge and 2) with the change of climate and human activities, how does the lag law of spring water response to precipitation change. The result show that spring discharge in karst area is mainly driven by elastic wave and infiltration recharge. The significant periods of pressure wave propagation and infiltration recharge are 1- year and 6-8 years respectively. In terms of time, the precipitation driven spring water during the study period can be divided into three stages, which are 1959-1980, 1980-2000, and 2001-2019. On the periodic-scale of 1-year, the wavelet phase difference (WPD) in the three stages rises in a stepped way, with a time-lag of 1-3.5 years. On the time scale of 6-8 years, the WPD in the three stages is the change law of decreasing-increasing-decreasing. Spatially, the time of discharge lagging precipitation is mainly related to the distance from spring and the development degree of karst aquifer. The precipitation in Yuxian County is located in the groundwater fast flow zone, while Zuoquan is located in the groundwater stagnation zone. Other areas are located in convergence zones. Understanding spring-flow characteristics in karst areas is very important for efficient utilization of water resources.

Session: On representing memory effects, hysteresis and feedbacks in the Critical Zone
Wednesday May 8, 2024
Attendance time 15:15-15:30

Using fractional calculus theory to implement soil moisture memory in its evolution

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Abstract

The approximate time that soil column needs to forget an anomaly caused by, for example, a heavy rainfall event or lack thereof is known as Soil moisture memory (SMM). Several studies have shown that SMM can impact several land surface processes including drought. This has been investigated mainly through ad hoc adjustments to initial conditions, and no mathematical solutions have yet been proposed to account for the effects of SMM on its evolution and therefrom on its effects on disturbances. Therefore, in this paper, we accounted for the past conditions and trajectories of soil water evolution by solving a simple hydrological model using fractional differential equations instead of ordinary differential equations where a memory term varying between zero and two is injected into model. The solution of the presented model with the lysimeter data of the experimental sites of Rollesbroich (energy-limited) and Selhausen (water-limited) in Germany showed that the inclusion of the soil moisture memory at both sites leads to a more accurate estimation of the evolution of soil moisture. The memory at the energy-limited site (with an average memory parameter of 0.71) is insignificantly stronger than at the water-limited site (with an average memory parameter of 0.74). The time scale of memory is shorter in Selhausen than in Rollesbroich (2 months compared to 9 months).

Session: On representing memory effects, hysteresis and feedbacks in the Critical Zone
Wednesday May 8, 2024
Attendance time 15:30-15:45

Improved modelling of subsurface stormflow based on source-responsive method for simulation of rapid hillslope runoff response

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Abstract

In humid hilly regions, macropore preferential flow in soils dominates the distribution of event water, thereby influencing runoff generation and development. However, the mechanism of how soil functions on macropore drainage and matrix absorption remains poorly understood due to the complex soil water dynamics in a dual-porosity subsurface networks. In this study, based on the source-responsive method (SRM) that divides the soil into source-responsive and diffusive domains, the allocation ratio of infiltrated water in macropores were derived and a newly hydrologic model, namely PIHM-SRM (PS), was developed. By simulating the soil moisture process at profile scale and the runoff process at catchment scale, it was found that the PS overcame the difficulty of replenishing moisture in dry soil, compared to the original PIHM models. This leads to more satisfactory performance for flood peaks at the outlet (CCC > 0.84) and soil moisture peaks at three profiles (CCC = 0.97). Moreover, the separate channel of film flow in the PS further improves the simulation accuracy of peak response speed in subsurface floods under rainstorms (TP > 40 mm). In addition, sensitivity analysis shows that the storage-discharge capacity of soil profiles dominates torrential flood forecasting in humid headwater when considering the influence of macropores. And improving the parameterization scheme in the PS is vital for distributed catchment modeling and further understanding the subsurface stormflow.

Session: On representing memory effects, hysteresis and feedbacks in the Critical Zone
Wednesday May 8, 2024
Attendance time 15:45-16:00

Responses of deep soil moisture to direct rainfall and groundwater in the red soil critical zone: A four-stage pattern

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Abstract

Deep soil moisture (DSM) plays a critical role in vadose zone hydrological processes. However, the recharge processes and their underlying mechanisms remain unclear due to the scarcity of comprehensive deep hydrological data, especially in regions characterized by active interactions between surface and subsurface hydrological processes. To address this knowledge gap, we performed an event-based study using a four-year hydrological monitoring dataset, encompassing rainfall, profile soil moisture, and groundwater along a hillslope at the Red Soil Critical Zone Observatory (CZO) in China. A total of 226 rainfall events were classified into four distinct types (I-IV) using a k-means clustering algorithm. The changes in DSM and groundwater table (GWT) were dependent on the rainfall type. The GWT (0.57–0.97) played a greater role in contributing to the DSM than the direct rainfall (0.48–0.64) based on a structural equation model, which was more pronounced from upper slope to foot slope. DSM recharge pattern can be described by a four-stage conceptual model, as indicated by the relationship between DSM and GWT: a slow and linear increase (stage 1), a small plateau (stage 2), a rapid linear rise (stage 3), and finally a great plateau (stage 4). DSM at the small and great plateau were closely related with the field capacity and saturation, respectively. Rainfall type, vadose zone features, and soil physical properties jointly shaped DSM recharge patterns. These findings can offer valuable insights into understanding the deep hydrological processes of the red soil region as well as regions with similar hydroclimatic conditions.

Session: How to include root hydraulic architecture in soil models to simulate root water uptake

Session: How to include root hydraulic architecture in soil models to simulate root water uptake
Thursday May 9, 2024
Attendance time 9:45 – 10:00

A new water isotope-based mixing model for root water uptake scouring

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Abstract

The recently introduced continuous root water uptake model has notably improved accuracy and diminished uncertainty in plant water partitioning in contrast to the discrete root water uptake model, MixSIAR. However, constrained by the inherent shape, the parametric probability density function might prove unsuitable, potentially biasing the root water uptake profile. To address this limitation, this study introduced a nonparametric B-spline to approximate the root water uptake pattern. To evaluate the performance of the new mixing model, we conducted virtual and field-based tests under various prior information. In the virtual tests, our model demonstrated RMSE ranges of 10.7%-38.7% and 10.1%-20.8%, respectively, across diverse prior settings, both showing smaller values than RMSE of MixSIAR (17.8%-43.1%). Additionally, our model consistently showed the lowest uncertainties among the three models. Further assessments through posterior predictive checking revealed accurate reconstructions of plant water isotopic distributions by our model. The absolute errors in mean plant water δ^2H and $\delta^{18}O$ were at 0.4‰ and 0.7‰, respectively, with absolute errors in standard deviations at 0.02‰ and 0.04‰, respectively. By contrast, MixSIAR exhibited higher absolute errors in mean δ2H and δ18O of plant water at 1.9‰ and 0.8‰, respectively, and larger absolute errors in standard deviations at 3.3‰ and 0.6‰, respectively. In the field test, soil and leavesf water potential gradients and fine root distribution were used as prior information. Our model exhibited the least uncertainty among the models. Furthermore, leave-one-out cross-validation demonstrated that our model exhibited the highest expected log pointwise predictive density (-3.3) compared to MixSIAR (-4.5), indicating a superior accuracy of our model. Moreover, compared to MixSIAR, the continuous nature of our model enables a more detailed and accurate depiction of root water uptake profile at higher spatial resolutions. Therefore, our model emerged as a robust tool for plant water partitioning.

Session: How to include root hydraulic architecture in soil models to simulate root water uptake
Thursday May 9, 2024
Attendance time 10:00 – 10:15

Interactions of Soil-plant Hydraulic Resistances under Drought Stress

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Abstract

Plant transpiration is a critical hydrological process that regulates the water, carbon, and energy fluxes in the terrestrial system. However, there is significant uncertainty in the transpiration estimation due to a limited understanding of the hydro-physiological responses of plants to drought stress. In recent years, there has been increasing attention to exploring the primary component of hydraulic resistance that restricts soil-water water transport under drought stress. The impact of specific soil-plant hydraulic resistances on water transport is the preferred focus over their interactive way. We utilized a soil-plant water transport model to illustrate the interactions of stomatal sensitivity, plant hydraulic resistance, and soil planting conditions under drought stress. Results show soil drought almost simultaneously triggers hydraulic resistance variations in multiple components, including stomata, stem xylem, roots, and soil. These variations have distinct influences on water transport and interact with each other. Stomata-sensitive plants can slow down the increase in plant hydraulic resistance and water potential gradient between soil and leaf by promptly closing their stomata. Soil texture and its distribution in the rhizosphere are critical factors affecting transpiration, root water uptake distribution, and plant hydraulic conductance. Stomatal behavior, plant hydraulic resistance, and soil planting conditions all contribute to iso/anisohydric behaviors. Thus, we advocate adopting a systematic view to examine the process of soil-plant water transport.

Session: How to include root hydraulic architecture in soil models to simulate root water uptake
Thursday May 9, 2024
Attendance time 10:15 – 10:30

Root hydraulic phenotypes impacting water uptake in drying soils

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Abstract

Soil drying is a limiting factor for crop production worldwide. Yet, it is not clear how soil drying impacts water uptake across different soils, species, and root phenotypes. Here we ask (1) what root phenotypes improve the water use from drying soils? and (2) what root hydraulic properties impact water flow across the soil–plant continuum? The main objective is to propose a hydraulic framework to investigate the interplay between soil and root hydraulic properties on water uptake. We collected highly resolved data on transpiration, leaf and soil water potential across 11 crops and 10 contrasting soil textures. In drying soils, the drop in water potential at the soil–root interface resulted in a rapid decrease in soil hydraulic conductance, especially at higher transpiration rates. The analysis reveals that water uptake was limited by soil within a wide range of soil water potential (−6 to −1000 kPa), depending on both soil textures and root hydraulic phenotypes. We propose that a root phenotype with low root hydraulic conductance, long roots and/or long and dense root hairs postpones soil limitation in drying soils.

Session: How to include root hydraulic architecture in soil models to simulate root water uptake
Thursday May 9, 2024
Attendance time 10:45-11:00

Evaporation-driven internal hydraulic redistribution alleviates root drought stress: Mechanisms and modeling

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Abstract

Many tree species have developed extensive root systems that allow them to survive in arid environments by obtaining water from a large soil volume. These root systems can transport and redistribute soil water during drought by hydraulic redistribution (HR). A recent study revealed the phenomenon of evaporation-driven hydraulic redistribution (EDHR), which is driven by evaporative demand (transpiration). In this study, we utilized microcomputed tomography technology to reconstruct the xylem network of poplar's woody lateral root and proposed new root water uptake models based on the lateral root hydraulic architectures. Our results indicated that EDHR is driven by the internal water potential gradient within the plant xylem network, which requires three conditions: high evaporative demand, soil water potential gradient, and special xylem structure of the root junction. The simulations demonstrated that during periods of extreme drought, EDHR could replenish water to dry roots and improve root water potential up to 38.9% to 41.6%. This highlights the crucial eco-physiological importance of EDHR in drought tolerance. Our proposed models provide insights into the complex structure of root junctions and their impact on water movement, thus enhancing our understanding of the relationship between xylem structure and plant hydraulics.

Session: General Session of any model related research

Session: General Session of any model related research
Thursday May 9, 2024
Attendance time 11:30-11:45

What really controls pedotransfer function performance

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Abstract

Soil hydraulic properties are essential for modeling and evaluating several soil–water processes. Pedotransfer functions (PTFs) have been used for decades to estimate soil hydraulic properties. It is often generically argued that PTFs have to be developed from data that come from the same area or geoclimatic region to be reliable, and that they have to cover the same data range. These are reasonable, common-sense statements that, however, typically rely only on superficial empirical studies and conservative judgment. We examined input-input and input-output relationships in the data underlying several internationally known PTFs from different geoclimatic areas and that of the area of application, the Pelotas River Watershed in Southern Brazil, to help gain understanding why some PTFs are more successful than others for a given study area. The performance of PTFs from different climate zones was mixed, and similarity in the data correlation structure between PTF development and application data sets appeared to be a good predictor of their general predictive power. There was no clear grouping in such correlation structures within climate-zones, and we conclude that the often claimed geoclimatic difference or similarity between an empirical PTF's origin and its application site is not, or at least not the sole driver of a PTF's expected performance.

Session: General Session of any model related research
Thursday May 9, 2024
Attendance time 11:45-12:00

Constraint-based model conditioning for robust simulation of crop rotations

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Abstract

Simulating the coupled soil and plant dynamics in crop rotations is challenging because of the very large multi-dimensional parameter spaces with high parameter uncertainty due to limited data availability. We tested the applicability of constraint-based sampling of parameters using a Markov Chain Monte Carlo method (CBS-MCMC) for robust forecasting with the process-based crop growth model GECROS as implemented in the modular agro-ecosystem modeling framework Expert-N. We constrained a set of high-impact model parameters related to plant phenology and growth and simulated a crop rotation at three field sites located on the Swabian Alb in Southwestern Germany. Parameter constraints were formulated based on regional data and expert knowledge. Model conditioning with CBS-MCMC led to a slightly lower model performance than the hand-calibration with site-specific calibration data. The model validation with an independent site-specific validation data set, however, revealed slightly better prediction performance if conditioned with CBS-MCMC compared to hand-calibration. Thus, although no site-specific observation data was used to constrain parameters, CBS-MCMC enabled a robust prediction performance of crop rotation modeling. The analysis of model predictions conditioned with CBS-MCMC further revealed severe limitations of the GECROS model to achieve realistic yield responses to different nitrogen fertilization regimes. These limitations might be overcome by improved variety-specific model parametrizations of the main crop and better representations of cover crop effects. The CBS-MCMC method can be applied to leverage expert knowledge systematically in the parameterization of soil-plant models. The method proves to be a useful diagnostic tool in analyzing and improving models to predict plant development and growth in crop rotations, particularly if the availability of long-term observation data is limited.

Session: General Session of any model related research
Thursday May 9, 2024
Attendance time 12:00-12:15

The transit time of world's rivers and the widespread effects of damming

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Abstract

The transit time of river water (T) or its derived residence time dictates the time-dependent biogeochemical reactions and material transport from land to the ocean. Yet little is known about the magnitude of T for river corridors at the global scale, despite the transit time of groundwater systems has been well established for decades. Here, we develop an analytical framework to model and route T along ~2.94 million global river reaches by including the previously overlooked dispersion and mixing effects. We find that the median T increases with Strahler stream order, ending up with a median value of 28.1 days for the largest portion of rivers under a naturalized condition that accounts for lakes' retardation effects. Global damming severely elongates T by including water turnover time, and the aging effect is far less pronounced at low stream orders than these of high stream orders. Prominently, ~12% of the world's large rivers have at least doubled their T with dams, and this percentage is alarming for highly-regulated basins, e.g., ~49% for the Mississippi River basin. Overall, the topology and hydraulic properties of river networks, the storage capacities of lakes/reservoirs, and the basin's hydroclimate conditions jointly determine the spatial variability of T. The geographical distribution of river aging in a dammed world should offer a better physical constraint on the reactive solute transport and other time-dependent transport processes.

Session: General Session of any model related research
Thursday May 9, 2024
Attendance time 12:15-12:30

The ProCarbon-Soil model: a carbon farming approach for improved model-data compatibility

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Abstract

Deterministic dynamic systems models (DDSM) have been widely applied to simulate soil organic carbon (SOC) stocks. But the accuracy of DDSMs is limited by data availability, the model's structure complexity and error propagation, and spatial and temporal variability. In addition, DDSMs need to account for the effects of land management practices, such as tillage, crop rotation, irrigation, and pasture restoration. Most of the existing DDSMs represent the trajectory of SOC stocks based on a multi-compartmental system, leading to structural complexities that are lead to difficulties for calibration and data-fusion with available SOC data in developing countries experiments and carbon farming data. In this paper, we apply mathematical analytical solving techniques adapting the first-order kinetics equation for variable carbon turnover rates to reduce the generic structure of multicompartmental DDSMs to a single compartment without reducing the model's generality and predictive accuracy. As a result, we've obtained the ProCarbon-Soil (ProCS) model. In contrast to existing DDSMs, the ProCS focus only on the measurable dynamics of SOC trajectories and C decomposability. The ProCS has a model structure with measurable states while holding the fundamental assumptions of the previous multicompartmental models. Apart from the environmental effects, our simplified model needs only one parameter that aggregates the necessary information for generating robust carbon predictions. This parameter can be empirically calibrated with incubation or field data and easily corrected for individual plots of land by using data assimilation algorithms. Our proposed simplified DDSM remarkably benefits model-data compatibility in calibration and model-data fusion with only total carbon data, reducing overfitting and increasing assertiveness in data assimilation, data learning and other novel data science methods. L.G.B. thanks the Royal Society Wolfson Visiting Fellowships for the research grant (RSWVF\R2\222008).

Session: General Session of any model related research
Thursday May 9, 2024
Attendance time 14:00-14:15

Bridging a gap in our understanding and modelling of soil organic carbon

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Abstract

Climate warming substantially influences soil organic carbon (SOC) dynamics, yet the mechanisms underlying the temperature-SOC feedback remain elusive, with field experiments showing mixed responses of soil CO_2 efflux to warming. The prolonged and inconclusive debate over the contribution of microbial processes and substrate supply to these variations suggests the presence of as-yet-unidentified mechanisms. In situ soil CO_2 emission in natural environments is a complicated multiscale process, intricately influenced by oxygen (O_2) reduction in hydrated pore space and temperature-dependent physical processes operating across various scales. These physical processes interact with biotic processes and vary spatially between different soil depths at macroscopic scale and across different pores at microscopic scale. They are crucial for microbial decomposition of SOC but have been overlooked in SOC modelling. To address this gap, we develop a process-based multiscale model by incorporating physical processes in both pore space and across soil profile to simulate whole-profile soil respiration. Our model adequately reproduces the thermal sensitivity of CO_2 efflux measured in various biomes across continents 1, as well as the attenuated and enhanced thermal sensitivity of CO_2 efflux observed from warming experiments conducted in different ecosystems2,3. These findings demonstrate physical processes are important in regulating the response of CO_2 emission to warming and, along with biological processes, they should be measured in experiments and represented in models. This is essential to accurately predicting the response of SOC to global warming.

Session: General Session of any model related research
Thursday May 9, 2024
Attendance time 14:15-14:30

Reactive transport modeling of carbon capture in soil amended with fast weathering silicate minerals

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Abstract

Reactive transport modeling of carbon capture in soil amended with fast weathering silicate minerals Reza Khalidy, Yi Wai Chiang*, Rafael M. Santos School of Engineering, University of Guelph, Guelph, Ontario, Canada, N1G 2W1 *Corresponding author: chiange@uoguelph.ca Abstract There is an urgent need to develop large-scale carbon dioxide removal technologies. Enhanced Rock Weathering (ERW), mineralization of powder form of fast-weathering silicate minerals, is reckoned as a stable and relatively low-cost method for sequestrating atmospheric CO_2 in agricultural and urban soils. While the capacity of carbon drawdown of the ERW process has been demonstrated in lab and field scale studies, the long-term evolution of formation/redissolution of weathering product is less discussed in the literature. This study assesses long-term carbonate formation and migration over the soil profile with a reactive transport model using the Geochemist Workbench software. The model is built on the basis of experimental design/ procedure conditions and accounts for intermittent irrigation regimes and kinetic dissolution/precipitation of minerals as well as calcite formation. Simulation results show that short-term mineral dissolution rates were higher at the beginning, as the pH elevates, the dissolution of reactive minerals decelerates, and less cations (Ca^{2+} and Mg^{2+}) leave the system as efflux. The long-term results indicate that the minerals continuous to weather in soil for a long period and are dissolved in the soil-water system. The carbonate formation and migration were found to be a function of the irrigation regime. Higher inflow rates ease movement of dissolved cations and carbonates through efflux, while lower inflow leads to higher carbonate formation (in form of solid) and less mobilization of weathering products in the system. Investigating the vertical distribution of newly formed carbonate over the soil profile denoted that carbonate accumulates in the top layer (e.g., 0-15 cm) at the initial stage of simulation (first and second year). From a longer perspective, carbonate migrates to deeper layers through the dissolution/recrystallization process, while a small portion of dissolved carbonates leaves the column through the effluent.

KEYWORDS: reactive transport modeling; enhanced rock weathering; soil inorganic carbon; pedogenic carbonate formation.

Session: General Session of any model related research
Thursday May 9, 2024
Attendance time 14:30-14:45

Estimation of evapotranspiration in a double-row maize field: A new method based on an analytical water flux model

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Abstract

Quantifying evapotranspiration (ET) in rainfed cropping systems can be challenging due to complicated interactions among site-specific soil, plant, and management factors. In Northeast China, ET and soil water status in maize field often display strong spatial and temporal variations due to the changes in tillage practice, planting pattern, and maize plant density. Previous studies have shown that near-surface soil water content observations at multiple scales provide the potential to estimate surface soil water fluxes. In this study, we introduced a new method to estimate daily field ET by using a soil water flux model based on mainly the time-series of water content in near-surface soils. The new method required a calibration of soil water diffusivity with maximum net water flux in the near-surface soil layer, which related to precipitation redistribution below the canopy. Finally, the new method was evaluated using observed 2-year ET values in a maize field, where independent measurements of soil water evaporation and transpiration were made with heat-pulse sensors and sap-flow gauges, respectively. The results showed that E dominated water loss during the early stage of maize growth, and exhibited great spatio-temporal variabilities at various positions between maize rows. The proposed method to estimate ET performed well on rain-free days, and provided an effective way to quantify maize ET in a double-row maize field.

Session: General Session of any model related research
Thursday May 9, 2024
Attendance time 14:45-15:00

Mechanisms and modelling of coupled soil cycles of carbon and silicon

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Abstract

The coupled soil cycles of carbon (C) and silicon (Si) driven by biological action play an important role in the regulation of atmospheric carbon dioxide (CO_2). Generally, the soil processes in the coupled cycles of C and Si include CO_2 consumption from plant-enhanced silicate weathering, turnover of phytolith-occluded carbon (PhytOC), silicon-enhanced plant biomass carbon input, mineral stabilization of soil organic carbon (SOC), and silicon regulation of greenhouse gases (GHGs) emission etc. However, complex feedbacks exist amongst the processes within the coupled soil cycles of C and Si. Recent advances in the mechanism of coupled soil cycles of C and Si offer promising new possibilities for developing models of coupled soil cycles of C and Si, which would increase our understanding, modeling and predicting soil carbon cycle, and offer references for enhancing atmospheric CO_2 sequestration.

Session: Toward characterising and modelling the temporal variability of effective soil properties

Session: Toward characterising and modelling the temporal variability of effective soil
Thursday May 9, 2024
Attendance time 15:00–15:15

Predicting Soil Organic Carbon of China in the Future and Role of Carbon Flux

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Abstract

The impact of carbon fluxes on soil organic carbon (SOC) remains underexplored. We employed machine learning to model SOC dynamics, leveraging a space-for-time substitution approach. Our findings project an increase in China's SOC through to the year 2100 across various Shared Socioeconomic Pathways. Sensitivity analyses have identified carbon fluxes as the main drivers for this projected rise, followed by climate change and land use change. Further examination using Explainable Artificial Intelligence has uncovered both spatial and temporal variations in how gross primary production (GPP) influences SOC levels. Notably, GPP's influence on SOC is initially negative at low levels, turning positive once a threshold of approximately 3 gC $m^{-2}d^{-1}$ is surpassed. Beyond a GPP of about 7 gC $m^{-2}d^{-1}$, its positive contribution to SOC plateaus. Critical zones for soil carbon sequestration are located around 400 mm annual precipitation line. Papers at https://atmos.sysu.edu.cn/teacher/372.

Session: Toward characterising and modelling the temporal variability of effective soil properties
Thursday May 9, 2024
Attendance time 15:15–15:30

To capture the effects of soil structure on soil hydraulic properties using deep learning and physical model

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Abstract

The profound impact of soil structure on soil hydraulic characteristics and soil water movement has long been recognized in hydrology. However, due to the lack of appropriate characterization indicators and measurement data for hydraulic characteristics in near-saturation conditions, delineating the influence of soil structure and establishing corresponding transformation functions remains a formidable challenge. In this study, by developing a hydraulic characteristic model capable of representing the effects of soil structure and leveraging deep learning frameworks, we quantitatively characterized the influence of soil structure on soil hydraulic properties at a global scale, utilizing multisource remote sensing information and site data.

Session: Toward characterising and modelling the temporal variability of effective soil properties
Thursday May 9, 2024
Attendance time 16:00–16:15

Elucidating the Dynamics of Grazing-Induced Soil Hydraulic Properties Variability: A Meta-Analysis and Modelling Approach

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Abstract

This study investigates the impact of grazing on pore size distribution and related soil hydraulic properties and, as these are crucial factors influencing soil hydrology, ecosystem services, and agricultural productivity. Despite extensive research, findings on the effect of grazing on soil physical status are heterogeneous, due to varying grazing intensities, grazing duration, grassland management practices, soil type, climate, and their interactions. Grazing-induced soil compaction, as well as bioturbation, and organic matter alterations affect soil physical properties, influencing pore size distribution and infiltration rates. Moderate grazing can enhance soil structure and porosity through improved root growth and soil biota development, improving infiltration, and subsequent redistribution and storage of water throughout the soil profile. Conversely, heavy grazing may cause compaction, especially in wet conditions, reducing porosity, adversely affecting pore-size distribution, and increasing surface runoff. This study adopts a meta-analysis approach to systematically collate and analyze global field data on the impact of grazing on soil properties, offering a nuanced understanding of its effects under various conditions. To further quantify these impacts, the Van Genuchten (VG) model and Kosugi model were utilized to assess the effects of soil compaction on hydraulic properties and infiltration capacities. The VG model predicts variations in soil-water retention (SWR) and hydraulic conductivity (HC) via parameters that describe the shape of the SWR and HC curves, while the Kosugi model makes direct use of information on the pore-size distribution to derive parameters in these curves. Together with the Kosugi model, the Fokker-Planck Equation (FPE) was employed to model the temporal evolution in pore size distribution and hydraulic properties in grassland soils, for example following the collapse of larger pores post-grazing. Using drift, dispersion, and degradation coefficients, alongside Kosugi's lognormal pore-size distribution function, the FPE predicts dynamic changes in soil pore space across seasons. This integrated approach can help inform optimal grazing intensities for maintaining soil health, water conservation, and ecological functioning, contributing significantly to land management and ecological research.

World Café "Transformative Soil Modeling through Inclusive Collaboration and Disseminated Education"

Session: General Session of any model related research
Thursday May 9, 2024
Attendance time 17:30-17:40

Recent Advancements in the Hydraulic Properties of Stony Soils: A Critical Review

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Abstract

Stony soils are soils that contain a substantial volume of rock fragments and are widespread around the world. When modeling variably-saturated water flow in these soils, it is crucial to consider the impact of rock fragments. Since the mid-20th century, there have been theoretical and experimental efforts to characterize the soil hydraulic properties (SHP) of stony soils. We review the advancements in measurement, simulation and modeling techniques used to identify SHP of stony soils. We further emphasize the necessity of developing more sophisticated measurement and modeling approaches that incorporate the distinct characteristics of rock fragments and background soils. Presenting recent evidence from measurement and modeling attempts to characterize SHP of stony soils, we highlight the drawbacks of ignoring the influence of rock fragments in soil modeling.

Session: General Session of any model related research
Thursday May 9, 2024
Attendance time 17:30-17:40

Advancing Science, Serving Society: Our Responsibility to Address Global Challenges and Foster Inclusive

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Abstract

As scientists, we have the privilege and responsibility to investigate and address the complex issues that affect populations worldwide. Through our research, we can contribute to finding solutions to pressing global challenges and improving the lives of people from all walks of life. Moreover, we must recognize the importance of creating an inclusive and equitable scientific community, ensuring that everyone with the drive and potential to contribute to science has the opportunity to do so. In this talk, we will explore how we can leverage our unique position as scientists to make a meaningful impact on society while fostering an environment that enables all individuals to thrive in their scientific endeavors.

Session: Saturation kinetics in soils: stochiometric limits, mineral-organic interactions, and microbial explicit models

Session: Saturation kinetics in soils: stochiometric limits, mineral-organic interactions, and microbial explicit models
Friday May 10, 2024
Attendance time 9:30-9:45

Small scale water dynamics drives microbial biophysical interactions and ecology

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Abstract

Small water configuration and its dynamics shape numerous environmental gradients that are key determining microbial activity and ecology. Yet little is known about the underlying functioning mechanisms. Employing microscale experiments and/or agent-based simulation models, we illustrate how small-scale water dynamics and biological (populations) configuration shape microbial interactions and ecology, and impacts on soil nitrogen (N) cycling. We firstly show how bacterial flagellar motility drives bacterial dispersal along a hyphal network, which counteracts the purifying effects of ecological drift at the expansion frontier and thereby increases the spatial intermixing and extent of range expansion of the bacterial strains. We further demonstrate that fungal hyphae-associating small water networks have important functions promoting plasmid-mediated functional novelty during range expansion in an interaction-independent manner, and thereby contributes to regulate microbial diversity. In addition, we employed a soil microcosm experiment and illustrate that sufficient labile carbon from plant residues such as straw induced fast O_2 consumption with microoxic development in the straw-soil interfaces. In the meantime, the porous structure of straw materials could enhance O_2 diffusive inputs in the core area, and subsequently formed a concentric ring-like microoxic area around the straw patch. Such enriched oxic-microoxic transient zones would induce nitrification coupled denitrification, leading to high-level N_2O emission. Additionally, the microbial degradation of straw resulted in a pulse decline of soil pH, which possibly inhibited the N_2O reductases, yielding enhanced N_2O emission. These results contribute to a better understanding of the driving factors for microbial interactions and possible impacts of soil biogeochemical processes.

Session: Saturation kinetics in soils: stochiometric limits, mineral-organic interactions, and microbial explicit models
Friday May 10, 2024
Attendance time 9:45-10:00

Incorporating Explicit Microbial Kinetics Enhances Methane Modeling Under Oxygen Fluctuation

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Abstract

The climate impact of methane (CH_4) emissions and their link to the soil carbon (C) cycle have garnered increasing attention. However, the role of CH_4 in soil organic carbon (SOC) modeling has been relatively underexplored compared to carbon dioxide (CO_2), and the omission of microbial processes and kinetics may prevent us from accurately modeling CH_4 dynamics under environmental changes. Here, we developed a microbially-explicit CH_4 module within the Microbial-ENzyme Decomposition (MEND) model, namely MENDmm6 with six microbial functional groups characterized by the Michaelis-Menten kinetics. Two sub-versions of the new model, one with first-order kinetics (MENDfo6) and the other without syntrophic acetate oxidation (MENDmm5), alongside MENDmm6 were compared with the previous MEND model with only one microbial function group (MENDmm1). We conducted rigorous model calibration and validation using high-temporal-resolution CO_2 and CH_4 efflux observations across two soils under five oxygen (O_2) fluctuation treatments. MENDmm6 (average coefficient of determination $R^2 = 0.66$) improved the modeling performance for CH_4 efflux by 47% over MENDmm1 ($R^2 = 0.45$), while there was a 15% improvement for CO_2 efflux. We further revealed that the inclusion of microbial processes did not necessarily enhance model performance if microbial kinetics were not explicitly represented (MENDfo6). Additionally, the lack of syntrophic acetate oxidation (MENDmm5) could not explain the observed dominance of hydrogenotrophic methanogenesis. Our results demonstrated that adopting microbial functional groups and explicit microbial kinetics could provide a basis for testing hypotheses on microbially mediated CH_4 processes and their responses to environmental changes. With the wealth of diverse data now available and the development of molecular measurements of CH_4-cycling microbes, our modeling framework presented here will empower us to predict impacts of management interventions on CH4 production, a key element of climate mitigation in the Paris Accord.

Session: Saturation kinetics in soils: stochiometric limits, mineral-organic interactions, and microbial Friday May 10, 2024
Attendance time 10:00-10:15

Quantify gaseous nitrogen production from agricultural soils using a microbial-explicit model

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Abstract

Agricultural soils are a major source of anthropogenic N_2O, but their N_2O emission estimates are highly uncertain, mainly due to the complexity of nitrogen (N) processes. Most soil N models include only primary N processes such as nitrification and denitrification, which limits their ability to realistically simulate N transformations in soils and accurately estimate N_2O emissions from soils. This study introduces a Microbial-Explicit Model incorporating Comprehensive Nitrogen processes (MEMCN) to evaluate and quantify the influences of various N processes on the production of N_2O as well as NO and N_2, including nitrification, denitrification, anaerobic ammonium oxidation (ANAMMOX), dissimilatory nitrate reduction to ammonium (DNRA), mineralization, and microbial assimilation (i.e., growth) and death. The MEMCN was evaluated in laboratory experiments using agricultural soils with different levels of N additions under anaerobic and aerobic conditions, and reproduced well the dynamics of NH^{4+}, NO^{3-}, NO^{2-}, NO, N_2O, and N_2. After nitrification and denitrification, ANAMMOX and assimilation were found to be most important in controlling N transformations in agricultural soils. ANAMMOX directly increased N_2 emissions by 139% at the beginning of the simulations (i.e., 48 h) under anaerobic conditions, while microbial assimilation indirectly reduced NO, N_2O, and N_2 emissions by 88%, 54%, and 58%, respectively, at the end of the simulations (i.e., 336 h) under aerobic conditions. Correspondingly, the biomass of ANAMMOX bacteria increased significantly at the beginning of the simulations under anaerobic conditions, while the biomass of nitrite oxidizing bacteria increased substantially under aerobic conditions. In contrast, DNRA, mineralization and microbial death had minor effect on soil N transformations, and the biomass of DNRA bacteria and heterotrophs did not change significantly during the simulations. Our study shows that it is necessary to include ANAMMOX and microbial assimilation in soil N models, while explicit simulation of microbial biomass dynamics may only be necessary if microbial biomass pools change significantly.

Session: General Session of any model related research
Friday May 10, 2024
Attendance time 10:15-10:30

Extracellular polymeric substances exhibit concentration-dependent effects on bacterial transport in saturated porous media

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Abstract

The transport and retention of bacteria in porous media is governed by the interface characteristics and bacterial motility. The secretion of extracellular polymeric substances (EPS) modifies the surface property of bacteria, and thereby has effects on their adhesion. Uncertainties of the role of EPS played to bacteria were reported either facilitated or inhibited bacterial mobility in saturated quartz sand media, and the mechanisms is not clear by now. In this study, an artificial EPS solution at 4concentrations (0 $mg{\cdot}L^{-1}$, 50 $mg{\cdot}L^{-1}$, 200 $mg{\cdot}L^{-1}$ and 1000 $mg{\cdot}L^{-1}$) was used to simulate EPS secretion. The effects of EPS concentration on bacterial transport behavior are investigated and possible underlying mechanism is identified using laboratory experiments in conjunction with Extend Derjaguin-Landau-Verweu-Overbeek (XDLVO) modeling. The results showed that EPS facilitated bacterial mobility at all tested concentrations, where bacterial transport increased with increasing concentration (0-200 $mg{\cdot}L^{-1}$). It could be partially explained by the increased energy barrier between bacterial cells and quartz sand surface; the XDLVO sphere-plate model predicts that EPS induced a higher electrostatic double layer (EDL) repulsive force, Lewis acid-base (AB) and steric stabilization (ST), as well as a lower Lifshitz-van der Waals (LW) attractive force. However, the promotion of EPS on bacterial mobility weakened at high EPS concentration (1000 $mg{\cdot}L^{-1}$). The XDLVO sphere-sphere model revealed lower repulsive interactions between cells, which is supported by observed enhanced bacterial aggregation. Consequently, the increased aggregation led to greater bio-colloidal straining and ripening in the sand column, weakening the positive impact of EPS on bacterial transport. These findings suggested that EPS exhibits concentration-dependent effects on bacterial surface properties and transport behavior and reveals non-intuitive dual effects of EPS on those processes.

Session: Constraining soil hydrologic processes using in-situ and remote sensing observations

Session: Constraining soil hydrologic processes using in-situ and remote sensing observations
Friday May 10, 2024
Attendance time 11:30-11:45

A high-resolution integrated hydrologic model for simulating groundwater-land surface process in the Heihe River Basin

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Abstract

The Heihe River Basin (HRB) is a typical inland river basin in arid/semi-arid areas in China, with complex groundwater-surface water (GW-SW) interactions. In this study, we developed a high-resolution integrated hydrologic model of simulating groundwater-land surface process in the (HRB) using ParFlow-CLM. First, a handful of observation data, such as river runoff, groundwater levels, evapotranspiration, and surface temperature, were used for model validation. The results show that the simulated data are highly consistent with the observation data, proving that the proposed model has high accuracy and efficiency. Secondly, a series of numerical simulation experiments were then conducted, taking full account of joint irrigation of groundwater and surface water. The accuracy of ten remote sensing soil moisture products, fused soil moisture products and assimilated soil moisture products in the agricultural irrigation area in the middle reaches of the HRB were evaluated against the simulated data. The results show that the accuracy of fusion and assimilation soil moisture products is higher than that of single-source remote sensing soil moisture products, and permeability coefficient and leaf area index are the dominant factors of spatial variability of soil moisture. Finally, according to the spatial heterogeneity scenarios of different permeability coefficients, the differences in spatial distribution characteristics of groundwater levels, surface water heat flux, evapotranspiration and surface temperature were simulated and analyzed, and the heterogeneity of permeability coefficients between the vadose zone and the saturated zone was clarified. The ParFlow-CLM based model in the HRB could serve as a numerical testbed for simulating hydrologic cycles in the area.

Session: Constraining soil hydrologic processes using in-situ and remote sensing observations
Friday May 10, 2024
Attendance time 11:45-12:00

Combined measurement of surface soil moisture and salinity by an UAV-based ground penetrating radar

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Abstract

The measurement of soil moisture and salinity information is important to understand their distribution and migration characters and implications on plant health and fertility, and then to implement scientific means e.g., effective irrigation and fertilization management of cultivated farmland. However, most traditional measurement methods are unsuitable for simultaneously mapping the field scale variability of soil moisture and salinity. In this study, we proposed a method that uses an unmanned aerial vehicle (UAV) to separately support the ground penetrating radars (GPR) with different frequencies for spatial scanning investigation of surface reflectivity, and then employed the optimization algorithm to combinedly estimate the soil permittivity and electric conductivity (EC), next calculated the soil moisture and salinity using the empirical pedotransfer functions. The new UAV-GPR method improved the original method proposed by Cheng et al. [2023] by taking into account the effect of EC. The field tests at the riparian zone adjacent to the Yangtze River and the salinized land close to the Yellow Sea illustrated that in the low EC area, the results of UAV-GPR are close to these measured by HydraProbe meter, of which root mean square error (RMSE) are 8 and 0.03 S/m for permittivity and EC, respectively. By contrast, in the high EC area, the measured permittivity values are severe fluctuation, but comparing with the specialized EC sensor, the EC values measured by UAV-GPR are more reliable than these measured by HydraProbe. These findings are confirmed by the accuracy analysis using the Monte Carlo simulation under the assumption of 2% measurement errors, which is shown that the measurement error of permittivity increased with the EC in the test area, and the relative errors of EC were clearly less than those of permittivity except in the high permittivity and low EC area.

Session: Constraining soil hydrologic processes using in-situ and remote sensing observations
Friday May 10, 2024
Attendance time 12:00-12:15

Improving Land Surface Modeling through Multi-sensor Observations

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Abstract

Land surface model is commonly used to obtain grided land state variables, e.g., soil moisture and snow. However, when implemented at global and regional scales, the model estimates are usually subject to large uncertainties due to various error sources like biased forcing and/or unknown thermal-hydraulic parameters. Satellite-based multi-sensor observations, especially those launched or released in recent years, have provided extraordinary opportunities to monitor the land surface, yet the retrievals are often with limited spatiotemporal coverage and/or resolutions. The use of satellite data to effectively constrain land model has been recognized as a key issue within the committee. For years, we have been trying to make use of multi-sensor data in improving land surface modeling, mainly through two solutions. Firstly, a prototype of multi-sensor land data assimilation system was established by linking the Community Land Model (CLM) and the Ensemble Adjustment Kalman Filter (EAKF), which is capable of ameliorating global soil moisture and snow depth estimation through the joint assimilate of MODIS snow cover fraction, AMSR-E brightness temperature, and GRACE terrestrial water storage anomaly. Secondly, the SMAP soil moisture and MODIS albedo products are used to reasonably map global and regional key land surface parameters like soil texture type and soil colors in the Noah land model with multi-parameterizations (Noah-MP). Note that this is achieved without referring to any soil samples, further indicating the feasibility of improving land surface modeling through satellite remote sensing. This presentation will report major findings in the abovementioned studies.

Session: Constraining soil hydrologic processes using in-situ and remote sensing observations
Friday May 10, 2024
Attendance time 12:15-12:30

Extending Historical Soil Moisture Records Using a Diagnostic Approach for the Validation of Satellite Retrievals

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Abstract

A long-term in situ measurement of soil moisture has wide applications in water resources management and is crucial for the reliable validation of satellite-derived soil moisture products, since the measurement periods for in situ soil moisture often do not align with the operational lifetimes of satellites. The availability of long-term records of in situ soil moisture is limited and often leads to insufficient validation and an inability to assess the interannual variations in soil moisture products. To address these challenges, this study utilized a daily diagnostic soil moisture equation to extend the data record of a Soil Moisture Network in the ShanDian River basin (SMN-SDR) of China to a preceding period covering the years 2015 to 2017, prior to the SMN-SDR's establishment in 2018. The results indicate that during the period of 2015-2017, the extended soil moisture showed correlations (R) of 0.746, 0.474, and 0.741, with corresponding root mean square errors (RMSE) of 0.041 m^3/m^3, 0.054 m^3/m^3, and 0.04 m^3/m^3, respectively, in comparison to soil moisture derived from SMAP observations. The case was similar that the R between SMAP soil moisture and the original in situ measurements from 2019 to 2021 was 0.801, 0.76, and 0.889, with RMSE values of 0.036 m^3/m^3, 0.033 m^3/m^3, and 0.046 m^3/m^3, respectively. These results imply that the extended soil moisture data demonstrated validation metrics closely resembling actual in situ soil moisture, indicating that the practical feasibility of the diagnostic model within the SMN-SDR. Furthermore, our findings underscore the necessity of ample temporal data for robust soil moisture product validation, revealing that a minimum of about 300 days (up to 5 years in the SMN-SDR) of data pairs is required. These insights enhanced knowledge in the validation of remote sensing soil moisture products.

Session: Data fusion for characterization of soil states and heterogeneity

Session: Data fusion for characterization of soil states and heterogeneity
Friday May 10, 2024
Attendance time 14:30-14:45

Assessment and digital management simulation of soil degradation from water erosion based on combined field survey data and erosion modelling on East European Plane

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Abstract

Soil erosion is the most dangerous process of soil degradation on a global scale. Currently, erosion modeling is widely used to create digital maps of the rates of erosion-accumulation processes. These maps can be produced in high quality if the input parameters are properly calibrated; and can be used for soil conservation measures. However, unfortunately, forecast estimates often do not take into account the current degree of soil degradation, which can vary very significantly in areas with different durations of plowing, as well as in conditions of contrasting soil cover. This work, using the example of 5 key sites located on the East European Plain, shows the possibilities of sharing information on current soil degradation and modeling predicted risks of soil degradation from erosion in the medium term. In addition, erosion modeling makes it possible to predict changes in soil erosion rates depending on climate change, land use, crop rotation, tillage practice, erosion control measures, etc. We have developed a web service that allows us to simulate changes in the predicted risks of land degradation from water soil erosion depending on the use of various agricultural technologies and anti-erosion measures. This service currently works for the Belgorod region of Russia, and will expand. The service is available free of charge to farmers, government employees and all scientists. Acknowledgments This research was supported by the Russian Science Foundation within scientific project 22-17-00071 (assessment of soil erosion rates, field survey data) and the Ministry of Science and Higher Education of the Russian Federation (Agreement No. 075-15-2020-805 dated October 2, 2020) (web service development).

Session: Data fusion for characterization of soil states and heterogeneity
Friday May 10, 2024
Attendance time 14:45-15:00

Developing an integrated soil information system to support resource management in British Columbia, Canada

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Abstract

Legacy soil data provide critical information for facilitating soil-related research initiatives, testing pedological theories, and developing models. Often, soil scientists find it challenging to access well-established soil datasets that are both integrated and enhanced with environmental information from different data sources, especially as soil research has been adapted to machine learning and Big Data techniques, which commonly utilize environmental variables as predictors. This project develops a workflow and tests the potential of including environmental data to create an integrated soil database of British Columbia, Canada to support current and future digital soil mapping projects. Here, we use multi-source environmental variables to represent the soil-forming environment and the SCORPAN model factors. For this purpose, we first explored the possibility of collecting and combining data from different sources, such as remote sensing, newly collected data, and historical survey records. We highlighted that using integrated data improves the spatial coverage and scalability of soil information. We then identified gaps in data coverage and put forth a prospective plan for future sampling. Lastly, we identified the future challenges in developing a soil information system, including the need for data standardization across different sectors, and privacy concerns. This initiative accomplished three objectives. Firstly, we established a standardized system and workflow to construct a standardized data framework, capable of hosting accessible datasets and seamlessly integrating with other soil data sources through automated processes. Lastly, our third objective was to provide supporting data infrastructure for ongoing and future soil mapping and monitoring initiatives in BC, encompassing a wide range of scales, ecosystems, and landscapes. This adaptable and replicable data management framework serves as a solid basis for developing a nationwide soil database.

Session: Data fusion for characterization of soil states and heterogeneity
Friday May 10, 2024
Attendance time 15:00-15:15

Bayesian estimation of spatially distributed soil hydraulic properties from geometric scaling and KL expansion

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Abstract

The water retention characteristic and unsaturated soil hydraulic conductivity function exert a large control on soil water dynamics in the unsaturated zone. During the past decades, much progress has been made in estimating these soil hydraulic properties from in situ measurements using inverse modeling techniques. Most of these contributions have focused attention on the characterization of the hydraulic properties of homogeneous or layered soil profiles. In this paper, we use Bayesian inference coupled with geometric scaling and KL expansion to inversely estimate high-resolution spatially distributed hydraulic properties in a multi-dimensional soil water model. The combined use of the scaling method and KL expansion reduces with orders of magnitude the dimensionality of the soil hydraulic parameter estimation problem. We illustrate our method by application to spatiotemporal simulated soil water pressure heads. Our numerical experiments explicitly evaluate the effect of soil type, soil heterogeneity, spatial organization and data amount/quality on the accuracy of the inferred hydraulic properties.

Session: Data fusion for characterization of soil states and heterogeneity
Friday May 10, 2024
Attendance time 15:15-15:30

Exploiting laboratory and field hyperspectral measurements to estimate the soil hydraulic properties

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Abstract

Assessing the spatial variability of soil hydraulic properties (SHPs) across extensive regions is important for optimal management of water resources. However, direct methods for measuring SHPs face challenges due to the time and cost associated with field sampling surveys and laboratory experiments. Pedotransfer functions (PTFs) offer an indirect approach to estimate SHPs by using easily obtainable soil physical properties (SPPs) such as sand and clay contents, soil bulk density, pH, and soil organic carbon content. Nonetheless, even the measurements of SSPs are time-consuming, labor-demanding and expensive. Therefore, the use of soil spectroscopy in the visible, near-infrared, and shortwave infrared (vis-NIR-SWIR 350-2500nm) range is rapidly increasing as a cost-effective and non-destructive method for predicting SPPs which serve as primary input variables in PTFs. In this study, the spectral reflectance of 184 soil samples was measured across the vis-NIR-SWIR ranges together with the co-located SPPs and SHPs (water retention and hydraulic conductivity functions) in the Monteforte Cilento sub-catchment (MFC2), located in the Upper Alento River Catchment (southern Italy). We tested two existing PTFs (ROSETTA and Weynants 2009) based on the van Genuchten (VG) soil hydraulic model, employing either measured or estimated SSPs derived from field or laboratory spectral measurements. The 10-fold cross validation partial-least squares regression (PLSR) was used to estimate the SPPs. The prediction performance was evaluated in terms of root mean squared error (RMSE) and coefficient of determination (R2). Preliminary findings indicate that PTFs relying on spectral measurements can preserve a good prediction performance of the SPPs and, consequently, of SHPs. This is promising for large-scale studies since spectral measurements significantly reduce the need for experimental efforts.

Session: General Session of any model related research
Friday May 10, 2024
Attendance time 15:45-16:00

Evaluation and development of pedotransfer functions of saturated hydraulic conductivity for subtropical soils

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Abstract

The determination of soil saturated hydraulic conductivity (Ks) is crucial in environmental and engineering fields. However, the current direct measurement methods of Ks are time-consuming and labor-intensive. As an alternative method, many researchers have developed a series of pedotransfer functions (PTFs) that estimate Ks based on easily accessible soil properties. Unfortunately, most existing PTFs of Ks focus on temperate and tropical regions. There is a lack of research discussing the applicability of Ks models in subtropical areas. To resolve this issue, we conduct a study using 515 subtropical soil samples to test the performance of existing PTFs of Ks. The Ks values of tested soils range from 1.4×10-4 to 290 $cm \cdot h^{-1}$ for investigated soils. Among the affecting factors, soil bulk density (ρb) and effective porosity (φe) are found to be the most important variables. Current PTFs considering soil pore structural property (i.e., φe) or soil texture solely are not effective in assessing Ks of subtropical soils. To address this limitation, we integrate soil pore structural and textural properties and develop a new PTF based on the Kozeny-Carman equation. The performance and reliability of the new PTF are evaluated using independent Ks datasets from various regions. The results show a significant positive correlation between the measured Ks and the modeled Ks from the new PTF for subtropical soils with an R^2 of 0.69, an average RMSE in log10 (Ks, $cm \cdot h^{-1}$) of 0.496, and a mean bias value of 0.070. Besides, the new PTF is found to perform as well as widely used machine learning tools.

Session: General Session of any model related research
Friday May 10, 2024
Attendance time 15:45-16:00

Micro-Raman imaging in soil-related analysis

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Abstract

Raman spectroscopy can be used to detect the vibrational characteristics of molecules. Due to its non-invasive nature, minimal sample preparation, and low interference from water, it is widely used in the analysis of various chemical components. Micro-Raman techniques combined with optical microscopy further provide spatial resolution at the diffraction limit. For instance, in soil-related research, micro-Raman technology can be used to analyze organic matter, inorganic salts, mineral components, microbes, plant roots, and soil contamination. Novel micro-Raman techniques such as Structured line illumination (SLI), Surface-Enhanced Raman (SERS), and data processing methods based on machine learning, make micro-Raman technology have the potential to a flexible routine analysis tool.

Session: Application of machine learning and non-linear methods for spatial data analysis

Session: Application of Machine Learning and Non-Linear Methods for Spatial Data Analysis
Friday May 10, 2024
Attendance time 16:45-17:00

Segmentation of plant residues on soil X-ray CT images using neural network

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Abstract

In soil, plant residues have low contrast making them difficult to detect using X-ray computed tomography (CT). In this work, we tested a convolutional neural network (U-Net) for its ability to improve the identification of crop residues in soil samples assembled from aggregates of different size fractions (small, large, water-stable aggregates, and average aggregate composition). Soil CT images were obtained using a 244 µm resolution. About 2500 soil images were annotated to train the neural network, of which only 631 images were selected for the training data set. Intersection over Union (IoU) was used as a measure of success of segmentation by neural network, which takes values from 0 to 1. In the validation data set, IoU of background was 0.93, IoU of solid phase was 0.95, IoU of pore space was 0.77, and IoU of plant residues was 0.40. However, IoU of plant residues in the total data set increased to 0.7. Soil structure influences the quality of multiphase segmentation of soil CT images. The poorest segmentation of plant residues was in the soil samples composed of average aggregate size composition. The quality of pore space segmentation increased with increasing porosity of the soil sample . The model tends to generalize the large areas occupied by plant residues and overlooks the smaller ones. The low values of the IoU metric for plant residues in the training data set can also be related to insufficient quality of annotation of the original images.

Session: Application of Machine Learning and Non-Linear Methods for Spatial Data Analysis
Friday May 10, 2024
Attendance time 17:00-17:15

Comparing soil-atmosphere-vegetation dynamics through multifractal cross-correlated analyses

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Abstract

Rangelands, covering nearly 33% of ice-free land, face severe degradation at an alarming rate. Predicting their responses to changing grazing regimes is challenging due to complex interactions among grazers, soil, atmosphere, and vegetation. Understanding the interactions of the different components of the soil-atmosphere-vegetation system at various scales is crucial for effective grazing and vegetation management in semiarid areas Two rangeland plots (250×250m) in central and southeastern Spain (Madrid and Almeria) were chosen to study their dynamics. Selection criteria included proximity to a weather station and maximum rangeland coverage, with Madrid featuring mesoxeric grassland and Almeria showcasing xeric grassland. Over 20 years, time series data for precipitation (PCP), water availability (WA), and Normalized Difference Vegetation Index (NDVI) were collected from weather station (PCP), remote sensing (NDVI) and modelled data (WA). Multifractal cross-correlated detrended fluctuation analysis (MFCCA), involving two time series at a time, was performed in each area. The generalized Hurst exponent (closely related to the roughness of the time series) obtained from the MFCCA was compared to the average of the multifractal detrended fluctuation analyses (MFDFA) of the respective univariate series. The most significant difference between the two areas is seen when comparing the cross-correlated and averaged generalized Hurst exponent of PCP with WA and NDVI respectively (PCP-WA and PCP-NDVI). Madrid exhibited a markedly lower cross-correlated generalized Hurst exponent (more antipersistent). Therefore, precipitation scaling behavior differs largely compared to WA and NDVI in Madrid. When looking at the relationship of WA and NDVI in Madrid and all the variables in Almeria, we observe similarities or only differences when the scaling exponent q is less than 0, showing a disparity in scaling behavior only at small scales. PCP and WA univariate series were less multifractal in Madrid, while NDVI was more multifractal in this region. PCP-NDVI and WA-NDVI were more multifractal in Madrid than in Almeria, suggesting PCP and WA had a more complex interaction with NDVI in Madrid. Overall, MFCCA is proposed as a powerful tool to help understand complex dynamics and how the studied variables interact with each other within rangeland ecosystems. Acknowledgements The authors acknowledge the support of the Project "Fusión de modelos de base física y basados en datos para la modelización de fenómenos precipitación-flujo HYDER", from Universidad Politécnica de Madrid (project number: TED2021-131520B-C21). Bibliography: Oświęcimka, P., Drożdż, S., Forczek, M., Jadach, S., & Kwapień, J. (2014). Detrended cross-correlation analysis consistently extended to multifractality. Physical Review E, 89(2), 023305.

Session: Application of Machine Learning and Non-Linear Methods for Spatial Data Analysis
Friday May 10, 2024
Attendance time 17:15-17:30

Making Machine Learning More Transparent Using Explainable AI for soil modeling

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Abstract

With the rapid development of artificial intelligence (AI) in the field of soil science, the lack of interpretability in AI restricts its further commercialization in hydrology and meteorology. To address this issue, we conducted interpretability analysis for soil moisture prediction. We adopted the explainable artificial intelligence (XAI) method of global and local interpretability to interpret the model and developed a post-hoc interpretation system suitable for hydrological and meteorological forecasting. We found that at the station scale, the hysteresis of soil moisture itself and the cumulant of precipitation are more important for its prediction. At the same time, the Random Forest model can also find the impact of snow melting process on soil moisture. In addition, we also explored the prediction of global soil moisture drought. The prediction of grassland drought shows that soil temperature, atmospheric water deficit and latent heat flux are important variables, while the prediction of forest drought is more dependent on interannual time changes and time series. From the perspective of spatiotemporal prediction, we have established the Conv-LSTM model to predict soil moisture in China, using permutation importance and smooth gradient to explain the model globally and locally. The results showed that precipitation and soil properties have a significant impact on soil moisture, and the gradient spatiotemporal distribution of precipitation, net heat radiation, and temperature is consistent with basic physical cognition. This indicates that permutation importance and smooth gradient can better reflect the internal understanding of physical relationships within the model, enhancing its interpretability and trustworthiness. Overall, XAI has certain potential in soil modeling using artificial intelligence, providing support for the development of AI in this field and improving the reliability of AI forecasting. We provided a XAI toolbox named ExplainAI, available at https://pypi.org/project/ExplainAI/. Papers at https://atmos.sysu.edu.cn/teacher/372.

Session: Application of Machine Learning and Non-Linear Methods for Spatial Data Analysis
Friday May 10, 2024
Attendance time 17:30-17:45

Unraveling threshold and interaction effects of environmental variables in soil organic carbon mapping in plateau watershed

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Abstract

Understanding the spatial distribution and influence mechanism of soil organic carbon (SOC) under complex surface conditions is vital for evaluating soil carbon stocks and realizing carbon sequestration in agricultural fields. The linear and nonlinear relationships between environmental variables and SOC have been widely studied, while the threshold and interaction effects are less known. Farmland in the Qilu Lake watershed, Yunnan Province, China, which has complex surface conditions due to both climate change and human activities, was selected as the study area. With 216 samples collected from the Qilu Lake watershed, this study aimed to explore the threshold and interaction effects of environmental variables on SOC. Specifically, gradient-enhanced decision trees (GBDT) combined with partial dependence analysis were employed to derive knowledge on the spatial distribution of SOC and the intricate relationships between environmental factors and SOC. The results indicated that GBDT outperformed RF, achieving higher accuracy (47% vs. 38%) and lower uncertainty, supported by a narrower 90% prediction interval (PI). SOC distribution was mainly impacted by soil moisture, elevation and contagion index (CONTAG). Threshold effect was observed in that SOC peaked at higher soil moisture (>50%), CONTAG (>85%) and lower elevation (<1812 m). The nonlinear relationship between one environmental variable and SOC could be influenced by another environmental variable. This indicated an interaction effect of environmental variables with SOC rather than a simple superposition. Our findings suggest that combining GBDT modeling with partial dependence analysis provides an efficient and interpretable approach for SOC mapping. Knowledge on the threshold and interaction effects is critical to understand the complex relationship between environmental variables and SOC, which has important implications for soil carbon management.

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Session: Modelling soil processes in land surface modelling

Convenors: Zhongwang Wei, Nan Wei, Yongjiu Dai, Tobias KD Weber, Jingyi Huang

Session: Modelling soil processes in land surface modelling
Wednesday May, 8, 2024
Attendance time 17:00 – 18:30

Exploration of Soil Water and Vapor Transport Mechanism and Isotope Ecological Effects in Cold and Arid Regions

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Abstract

In cold and arid regions, freeze-thaw cycles play a critical role in many engineering and agricultural applications and cause soil water flow and heat transport studies to be much more complicated due to phase changes involved. A fully coupled numerical module for simulating the simultaneous movement of water, vapor, and heat during freezing-thawing periods was developed and incorporated in the Hydrus-1D software in this study. The proposed freezing module's performance was then validated using experimental data collected at the Mu Us Sandy Land in northwestern China with typical seasonal freezing/thawing processes of 2017-2018 winter and 2018-2019 winter. Results showed that the model could efficiently obtain a convergent solution and that simulated soil moisture and temperature variations captured the observed data well. Driven by soil matric potential and temperature gradients, both liquid water and water vapor flowed towards the freezing front. The isothermal liquid flux was the most significant component of overall flow in most soil depths except in the frozen layer, where it decreased by 1-5 orders of magnitude from values before freezing. Instead, the thermal vapor flux was the dominant moisture transfer mechanism in the frozen layer and contributed about 10% to the ice formation, indicating the significance of considering vapor flow. To further elucidate the hydrological process affected by typical vegetation in these regions, the isotope module considering the evaporation fractionation effect, as well as the root water uptake function, were incorporated into the proposed model, and the results also fitted well with the measured isotope data. Since the condensation and accumulation of water vapor can greatly contribute to the vegetation under soil drought and freezing stress, it is of great significance to maintain the desert vegetation ecosystem, where the soil water is critical to the vegetation growth in the fragile ecological areas.

Session: Modelling soil processes in land surface modelling
Wednesday May, 8, 2024
Attendance time 17:00 – 18:30

Continuous representation and modeling of soil organic matter as a tool for assessing long-term carbon dynamics in forest-steppe uncultivated black-soils

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Abstract

Conventional compartment soil organic carbon (SOC) dynamics models allow for a detailed description of the processes occurring in soil using a pool-based approach. However, the more complex the system, the greater the number of parameters and the higher the uncertainty, rendering long-term prediction ineffective. The compartmental approach, with separate pools described by first-order kinetic equations, hinders obtaining analytical solutions and significantly raises computational costs for numerical ones. The dramatic change in SOC turnover rate required by compartment models becomes even more pronounced when the difference between SOC stocks and turnover rates in slow and fast pools becomes too large. To this end, models based on continuous decomposability of SOC, referred to as "quality", are used. Developed for forest litter dynamics modelling, continuous Q-model provides insight into the equilibrium between depletion and accumulation of SOC in virgin forest-steppe chernozems known for richness in organic carbon. Paired with lateral water redistribution modeling, the Q-model allows to represent how soil water affects organic matter decomposition across a microtopographic moisture gradient from flat and sloping interfluves to closed depressions. Long-term model experiments show that topographic conditions leading to difference in moisture availability and temperature is a key factor controlling the stabilization of organic carbon in chernozems. Aerobic soils developing in wetter and cooler conditions of depressions showed earlier SOC stabilization and stored more carbon than the upslope ones while there is little variation in net primary production and litter input between them, which shows that soils of closed depressions have a higher capacity for carbon sequestration. Sensitivity analysis showed that all parameters that were considered generic prior to current study, namely quality shift rate towards stabilization with each decomposition cycle $\eta 11$ and basal decomposer metabolic rate $u0$ turned out to be influenced by local conditions at each particular position within microtopographic gradient. Therefore, parameters controlling SOC stabilization need to be considered as local, site-specific and land-use-specific. Reducing sampling depth to the upper 30 cm, as per FAO guidelines, can lead to data misinterpretation since the most stable carbon stock in chernozems is stored below that level. Differences in hydrothermal conditions in the early stages of stabilization directly affects the functioning of the decomposer

community in the early stages of litter decomposition, which may change the mechanisms and pathways of active pool stabilization. This implies the need to further guide the Q-model parameterization by the explicit consideration of various mechanisms of soil organic matter decomposition which will aid in developing detailed, knowledge-driven policies for SOC sequestration in managed and unmanaged grasslands.

Session: Modelling soil processes in land surface modelling
Wednesday May, 8, 2024
Attendance time 17:00 – 18:30

Automation of soil salinization assessment.

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Abstract

Soil salinization is a global environmental issue. According to the United Nations Food and Agriculture Organization (FAO), in 2021, saline soils occupied approximately 8.7% of the land surface (1). Industrial development and urban growth lead to an increase of areas with technogenically salinized soils. The presence of easily soluble salts within the soil profile impairs soils properties and fertility, has a toxic effect on plants. Soil salinization is assessed by the sum of toxic salts (2). One of the approaches involves calculating the levels of toxic and non-toxic salts through the analysis of the water extract from the soil. This method is highly effective but can be challenging to execute. It is based on the binding of ions into hypothetical salts, with carbonates being bound first, followed by sulfates and chlorides. The method also considers the cross-impact of salts and their solubility. To develop the soil salinization model, automating the calculations for assessing salinization is necessary. We implemented a software that performs hypothetical salt calculations using the Python programming language. By using the automated calculation method, we are able to solve the tasks that involve the formation of hypothetical salts, determining the number of ions in mg *eq /100 g of soil, and converting them into percentages (percentage ratio). The program takes into account the sequence of ions binding in salt based on their solubility, as well as the pattern of association and dissociation of carbonates under alkaline conditions. An automated calculation is carried out during the environmental assessment of soils in areas of technogenic salinization. This particular program is used to calculate soil salinization at the Verkhnekamskoe Potash Deposit and assess the salinization of urban soils in the northern regions. References 1. https://www.fao.org/newsroom/detail/salt-affected-soils-map-symposium/en 2. Bazilevich N.I., Pankova E.I., 1968, A tentative of classifying soils according to salinization: Pochvovedenie, Vol. 11., P. 3-16. Acknowledgements This research was funded by the Ministry of Science and Higher Education of the Russian Federation, project FSNF-2020-0021. The research was endorsed by a Doctor of Geographical Sciences, E.A. Khayrulina.

Session: Modelling soil processes in land surface modelling
Wednesday May 8, 2024
Attendance time 17:00 – 18:30

Seismic vulnerability of crossed river RC bridge structure under soil scour and corrosion attack

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Abstract

Bridge infrastructure is critically important for transportation networks, yet seismic events often cause damage through complex soil-structure interactions. Crossed river bridges are especially vulnerable due to scour-induced foundation weakening and corrosion deterioration over time in harsh submerged environments. This study conducts a vulnerability analysis to evaluate the seismic response of a prototype multi-span continuous bridge incorporating realistic scour and corrosion effects. Three-dimensional finite element models are developed to simulate the bridge superstructure, piers, piles, and surrounding soil conditions. Scour is simulated by removing sediments within a defined scour depth calculated using HEC-RAS for various levels of discharges. Corrosion effects is modeled by reducing steel reinforcement cross-sections and material properties according to experimental data for the local environmental conditions. Nonlinear time-history analyses are performed under a suite of natural ground motions scaled to reflect hazard levels from frequent to rare events. Engineering demand parameters including pier curvatures and piles curvatures are extracted. Fragility curves are generated relating structural responses to intensity measures to probabilistically assess damage states. Results provide insights into the influence of transient and long-term deterioration on seismic vulnerability, and strategies to enhance resilience through design modifications or mitigation measures. The methodology developed could aid transportation agencies in performance-based assessment and cost-effective management of critical river crossing assets.

Session: Modelling soil processes in land surface modelling
Wednesday May, 8, 2024
Attendance time 17:00 – 18:30

Modeling of sulfate contamination of soils in mining areas using information logical analysis

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Abstract

Mining activities, particularly coal mining, are widespread throughout the world. One of the most important environmental problems of coal mining is acid mine drainage, which persists even after the mines' closure [1, 2]. Acid sulfate soils affected by mine waters were studied on the territory of the liquidated Kizel Coal Basin (KCB) in Perm Krai, Russia. A total of 75 soil samples, including 13 background samples, were analyzed. In order to examine the specific soil states resulting from the impact of acid mine water, information-logic analysis (ILA) was used via the ALI program. The ILA method makes it possible to identify the correlation between a phenomenon and factors (indicators of the condition) of soils. For acid sulfate soils of the KCB, the pH value with hydrogen peroxide (pH-H2O2) served as the phenomenon, i.e., the dependent variable. Soil acidity in hydrogen peroxide was determined in order to oxidize sulfide minerals present in dumps, drains, and outflows of acid mine water. Thus, according to Brinkman R. and Pons L.J. [3], the tentative pH-H2O2 limit for hazardous acid sulfate soils after peroxide treatment is 2.5. Several factors were considered, including the content of sulfate ions in soil water extract, the content of total and mobile sulfur, mobile forms of iron (II, III), and hydrolytic acidity. The results of the information-logical analysis showed that the contents of mobile sulfur and iron have the biggest impact on soil pollution, whereas hydrolytic acidity and total sulfur contribute the least. The model developed from calculations revealed that soils can be classified as acid sulfate soils if the mobile sulfur content is more than 500 mg/kg, the mobile iron content exceeds 0.3 g/kg, the gross sulfur content exceeds 5 g/kg, the sulfate ion content exceeds 2 cmol/kg, and the hydrolytic acidity is over 20 mmol/kg. The findings suggested that the model can be used to forecast the state of soils under technogenic impact. «The study was supported by a grant from the Russian Science Foundation № 24-27-00324, https://rscf.ru/project/24-27-00324/». 1. Jiao Y., Zhang C., Tang P.Su, Y., Huang Z., Ma T. A review of acid mine drainage: Formation mechanism, treatment technology, typical engineering cases and resource utilization // Process Safety and Environmental Protection. 2023. 170, 1240-1260. https://doi.org/10.1016/j.psep.2022.12.083 2. Mitrakova N.V., Khayrulina E.A., Poroshina N.V., Perevoshchikova A.A., Malyshkina E. E. Formation of Acid Sulfate Soils under the Influence of Acid Mine Waste in the Taiga Zone. Eurasian Soil Science, 2023, Vol. 56, Suppl. 2, pp. S183–S193.

https://doi.org/10.1134/S106422932360152X 3. Brinkman R., Pons L.J. Recognition and prediction of acid sulphate soil conditions. In Dost, H. (ed). Acid sulphate soils. Proceedings of an International Symposium. (Wageningen, International Institute for Land Reclamation and Improvment, Publication 18, 1973). pp. 169–203.

Session: Modelling soil processes in land surface modelling
Wednesday May, 8, 2024
Attendance time 17:00 – 18:30

Information-logical analysis in modeling technogenic salinization in soils

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Abstract

The assessment of technogenic soil salinization appears to lack a standard permissible limit for Na^+, Cl^-, and SO_4^{2-} (MPC, APC). The process of soil salinization is usually examined together with an analysis of the vegetation cover state, but this estimate is not always effective. Mathematical modeling of soil processes is a relatively new and reliable method. There has been a growing use of universal information-logical analysis. It allows for logical statements to be made between any properties without the requirement of linearity. This method can be used to predict different states. Information-logical analysis, similar to correlation analysis, examines the correlation between factors. It also determines the correlation form, in addition to its strength of the correlation. Soils were researched in the salt-affected area in the vicinity of potash mining. The relationship was studied between various soil parameters, including pH of the salt extract, calcium ion content, sulfate ion content in the water extract of the soil, the difference in pH between water and salt extracts (ΔpH), sodium adsorption ratio (SAR), and the degree of soil salinity (sum of toxic salts, ∑ts) which was included in our model as a main factor. Soil samples (167) were collected from various types of landscapes, including alluvial, transit, and eluvial areas. The studied soils consist of Cambisols, Podzols, Fluvisols, and Technosols (WRB). The resulting model can be expressed as a formula: $\sum ts = SAR \times Ca^{2+} \times SO_4^{2-} \times \Delta pH \times pH_{KCl}$ where ∑ts is soil salinity, which refers to the degree of the main factor, the sum of toxic salts; SAR, Ca^{2+}, SO_4^{2-}, ΔpH, and pH_{KCl} represent the factors involved; and $\times$ represents the sign of the logical operation of the nonlinear function. Information-logical analysis indicated that the sodium adsorption ratio had the greatest influence on salinity. This is followed (in descending order) by the content of calcium ions, sulfate ions in the soil water extract, the calculated indicator ΔpH, and the pH of the salt extract. Based on the model, the highest concentration of toxic salts (where ∑ts is greater than 1.40%) was observed at pH_{KCl} 5.3–7.4, with a sulfate ion content exceeding 500 mg/kg, a Ca^{2+} content exceeding 1000 mg/kg, a SAR greater than 10, and a ΔpH less than 0.5. These indicator values are characteristic of Fluvisols found in small river valleys, which are particularly susceptible to soil transformation. By using the information-logical model and soil indicators, it becomes possible to predict soil transformation caused by technogenic salinization. This research was funded by the Ministry of Science and Higher Education of the Russian Federation, project FSNF-2020-0021.

Session: Modelling soil processes in land surface modelling
Wednesday May, 8, 2024
Attendance time 17:00 – 18:30

Identification and Quantification of Lateral Soil Moisture Flow in Sand Dune Slopes of the Maowusu Area

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Abstract

土壤水分控制着不同规模的径流、入渗和蒸散过程，影响着陆地浅表层的水文循环。在区域尺度上，地形在土壤水分的空间再分配中有着重要作用，是影响土壤水分区域异质性的关键因素。降雨过程中，坡面控制着水分的重新分配，地形起伏不仅影响超过地表入渗能力的多余降雨量在地表沿地形梯度向低洼处汇聚，同时，会驱使进入土壤内部的水分在降雨结束后沿下坡方向侧向运移，地上和地下的水分沿地形梯度朝下坡方向的流动形成坡底土壤水分的空间湿润组织区域，导致土壤水分在不同空间尺度上的高度空间异质性，支撑和影响不同单元植被的可用水量。地表和土壤内部补给到坡底位置的这部分水量对植被的生长是非常重要的，特别是在干旱半干旱地区的毛乌素沙地。然而，鲜有对土壤水分通过坡面渗流补给到坡底的过程和水量进行系统深入的试验分析研究。基于此，为提高地形对土壤水分过程异质性及其水文循环影响的理解，此研究以毛乌素沙地沙丘坡面为研究对象，以沙丘-丘间低地为单元，对迎风坡和背风坡的坡顶、坡中和坡底，利用沙丘坡面高空间分辨率、高时间分辨率的土壤水分全季节监测数据，结合室内外试验、统计学方法以及数值模拟方法，分析了沙丘坡面不同位置、不同深度土壤水分的时空变化特征以及坡面的水文过程。在此基础上，从动力学角度量化了不同降雨条件下、不同水文年坡底土壤水分通过侧向流动补给到坡底的横向补给量。

Session: Modelling soil processes in land surface modelling
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A hybrid model based on microbial-explicit model and machine learning for improving prediction and mapping accuracy of soil organic carbon

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Abstract

Modeling soil organic carbon (SOC) is helpful for understanding its distribution and turnover processes. This can guide the implementation of effective measures for carbon (C) sequestration and improve land productivity. Process-based simulation with high interpretability and extrapolation and machine learning modeling with high flexibility are two common methods for investigating SOC distribution and turnover. In this study, we developed a hybrid model based on the fusion of a two-carbon pool process model and machine learning and investigated its accuracy for predicting and mapping SOC in Ningbo. The results indicate that the process model with density-dependence ($\beta = 2$) and microbial biomass carbon simulation performed better in modeling the parameters of the microbial-based C cycle, including microbial carbon use efficiency (CUE), microbial mortality rate, and assimilation rate. Combining the optimal process model and random forest (RF) model, the hybrid model improved the prediction accuracy of SOC, with an increased R2 from 0.74 to 0.84, residual prediction deviation from 1.97 to 2.50, and decreased root-mean-square error from 4.65 to 3.67 g kg−1 compared to the conventional RF model. As a result, the predicted SOC distribution exhibited high spatial variation and abundant details. Microbial CUE and potential C input, that is, net primary productivity, were the main direct factors driving SOC distribution in Ningbo. The projection of SOC under the CMIP6 SSP2-4.5 scenario showed that regional C loss in high SOC areas was mainly caused by decreased microbial CUE and C input induced by climate change. These findings have demonstrated the potential of combining the microbial-explicit model and machine learning to improve the accuracy of SOC prediction and understand SOC feedback in a changing climate. Keywords: soil organic carbon, model fusion, microbial-explicit model, machine learning, microbial carbon use efficiency, Bayesian parameter estimation.

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Wednesday May, 8, 2024
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Upscaling Techniques of Soil Hydraulic and Thermal Parameters for use in Land Surface Models

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Abstract

With the intensification of human activities and advancements in observation technology/computational capabilities, land surface models (LSMs) have gradually evolved to applications with kilometer-scale resolutions, while the resolution of weather and climate models remains in the range of 10 to 100 km in practical applications. Therefore, upscaling techniques play a crucial role in coupling LSMs with weather and climate models. The soil water and heat transfer processes are core components in LSMs, and their accurate representation depends largely on the data quality of soil thermal and hydraulic parameters. In recent years, the release of multiple datasets of high-resolution (kilometer-scale) soil thermal and hydraulic parameter has laid the foundation for fine-scale simulation of soil water and heat transfer processes. However, effectively utilizing these data to obtain medium-resolution soil thermal and hydraulic parameters, thereby improving the simulation accuracy of soil water and heat transfer processes at medium resolutions, is a vital issue, so that more accurate underlying boundary conditions can be provided for weather and climate models. This study, based on the Common Land Model (CoLM), aims to develop and evaluate upscaling techniques for soil thermal and hydraulic parameters in LSMs. For soil hydraulic parameters (used in Campbell (1974) and van Genuchten (1980) – Mualem (1976) soil hydraulic models which are commonly adopted in LSMs), we propose a method in which soil hydraulic characteristic curves and soil hydraulic conductivity curves corresponding to all fine-resolution grid cells within a coarse-resolution grid are fit to obtain equivalent parameters for that coarse-resolution grid (referred to as FIT hereafter), and we compare the simulation results in CoLM using parameters obtained by this method with those obtained using traditional statistical methods. For soil thermal parameters, we also compare the simulation results in CoLM using different parameters obtained through traditional statistical methods. This work focus on three regions with strong soil heterogeneity: Central North America, Central Eurasia, and Northeast China. The simulation results which are run at the original high resolution (1 km) are used as reference results, and the simulation results with medium resolutions (e.g., 0.25 degrees) of soil parameters obtained through different upscaling methods are assessed. The results indicate

that, from a regional mean perspective, the FIT method outperforms other methods in simulating soil moisture during summer and winter (RMSE between 0.01-0.02, and correlation coefficient above 0.98). This result holds for all the three regions and at various soil depths, with the most significant superiority of FIT shown in the root zone area (0.1-1 m). Combining FIT with the geometric mean of soil thermal parameters provide the most acceptable summer soil temperature across all soil layers. However, the simulation results.

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Nutrient cycling in forest ecosystems – a new modelling approach

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Abstract

Rafaella Chiarella, Michael Herbst, Lutz Weihermüller, and Harry Vereecken Agrosphere Institute IBG-3, Forschungszentrum Jülich GmbH 52425 Jülich, Germany Contact: r.chiarella@fz-juelich.de Current forest ecosystem models typically do not account for all key nutrients (N and P) and especially colloid facilitated transport of phosphorus is not considered but it plays an important role in understanding the impact of P on forest growth. We propose a new model that aims to simulate not only forest growth but also CO2 dynamics, water and solute fluxes, and colloidal transport of nutrients in forest ecosystems. The new forest module in our model is heavily inspired by the TREEDYN model by Bossel (1996) and is built into the already established agroecosystem model AgroC. The extension is able to simulate homogeneous forest of different tree species of tropical, deciduous or boreal trees. The forest interacts and exchanges matter with the atmosphere and soil. For the general tree geometry, allocation of resources, and tree growth the structure of the TREEDYN model were followed with some minor modifications. The soil hydraulics, heat, gas and solute transport is calculated by AgroC based on Herbs et al. (2008). The carbon, nitrogen, and phosphorus turnover in the soil is also simulated by AgroC. Photosynthesis is calculated by the Farquhar approach. Additional routines were included to account for the decomposition and nutrient cycling within the litter layer due to the complex feeding of the litter layer by leaf, fruit, and wood fall. To allow for simulations with future climate scenarios, a varying photosynthesis rate driven by changing CO2 concentrations in the atmosphere has been recently embedded. Next, nutrient cycling and availability of N and P for growth has been integrated as already done for crops in AgroC. The option of simulating fruiting bodies based on seasons, the possibility of periodic partial thinning of the forest, and damages due to pollution, pests or severe weather events will be implemented in the future as well. Afterwards, a simplified approach of colloid genesis and transport, especially colloid facilitated P-transport, has to be integrated. The data needed for the implementation of the routine will be provided by two PhDs in the project who will quantify and parametrize the natural soil colloid concentration, composition and transport.

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Adaptation RUSLE2 model for different regions (on example of southeast of the East European Plain and nothern part of the North China Plain))

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Abstract

Water erosion of soils is one of the most potent degradation processes in soils and land, leading to a deterioration in the quality of ecosystem services. Thus, understanding the mechanisms and consequences of water-based soil erosion is crucial for developing effective strategies to mitigate its effects and protect our environment. The first problem is the practical assessment of water erosion of soils over large areas since field measurements can be expensive for large areas. Modeling and subsequent verification using field measurements offer a cost-effective and practical approach. The second problem is the limitations of existing models, often designed for specific regions and data conditions. Our research aims to solve these problems by adapting the widely used RUSLE2 model to our data and local conditions. In that current work, we adopt the RUSLE2 model for the southeast of the East European Plain (Volgograd region, Russia) and the northern part of The North China Plain (Beijing, China). The modified model has shown promising results: the difference between our model and other results is various, between <1% (for Beijing) and 12 % (for the Volgograd region).

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Influence of Freeze-Thaw Cycles on Soil Water and Heat under Global Climate Warming

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Abstract

全球变暖导致环境温度升高，降雪量和积雪深度减少。与此相对应，土壤温度对环境温度的升高表现出非线性反应。这种非线性模式不仅表现在土壤温度上，还表现在区域范围内的空间分布上。这种影响在对气候变化敏感的地区尤为重要，例如密西西比河流域上游地区（UMRB），会对水资源和土壤侵蚀造成影响。本研究采用了增强型生态水文模型 SWAT-FT，以研究全球气候变暖背景下冻融循环变化对 UMRB 土壤水热的影响。研究结果表明，在单纯升温情景下，如果气温从 2° C 上升到 8° C，土壤温度会先下降后上升，临界阈值出现在 6° C。这主要是由于在低升温情景下（2° C 和 4° C），冻结期土壤含冰量较高导致水分渗透受限，阻碍传热过程，土壤温度在气温上升 4° C 时达到最低值，而当土壤温度升高 6° C 时，土壤含冰量降低，土壤温度也随之升高 。我们进一步用 GCM 未来气候模型，以测试未来复杂气候变化背景下冻融循环对土壤水热的影响。 结果显示 SSP1-2.6 和 SSP2-4.5 情景土壤温度变化不显著，而在高排放 SSP5-8.5 情景下，土壤温度随环境温度的升高而大幅度提高。总体而言，全球气候模型的结果与理论预期一致，观察到的任何变化都可能归因于降水量的增加，这增加了未来全球气候变化效应的复杂性。我们的研究揭示了之前未曾考虑过的气温上升对土壤水热条件的非线性影响。

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The Response of Non-Point Source Pollution to Climate Change in an Orchard-Dominant Coastal Watershed

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Abstract

China is the largest global orchard distribution area, where high fertilization rates, complex terrain, and uncertainties associated with future climate change present chal-lenges in managing non-point source pollution (NPSP) in orchard-dominant growing areas (ODGA). Given the complex processes of climate, hydrology, and soil nutrient loss, this study utilized an enhanced Soil and Water Assessment Tool model (SWAT-CO2) to investigate the impact of future climate on NPSP in ODGA in the coastal basins of North China. Our investigation focused on climate-induced variations in hydrology, nitrogen (N), and phosphorus (P) losses in soil, considering three CMIP6 climate sce-narios: SSP1-2.6, SSP2-4.5, and SSP5-8.5. Continuous changes in CO2 levels signifi-cantly influenced evapotranspiration and water yield in ODGA. Percolation and surface runoff emerged as primary pathways for N and P losses in ODGA. Future climate sce-narios led to substantial increases in precipitation, percolation, surface runoff, N loss, and P loss in ODGA, ranging from 15% to 28%, 25% to 85%, 120% to 250%, 10% to 58%, and 145% to 550%, respectively, compared to the reference period (1971-2000). Orchards in the northwest basin proved susceptible to nitrate leaching, while others were more sensitive to N and P losses via surface runoff. Implementing targeted strate-gies, such as augmenting organic fertilizer usage and constructing terraced fields, based on ODGA's response characteristics to future climate, could effectively improve the basin's environment.

Session: On representing memory effects, hysteresis and feedbacks in the Critical Zone

Convenors: Mehdi Rahmati, Harry Vereecken, Dani Or

Session: On representing memory effects, hysteresis and feedbacks in the Critical Zone
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Water and Nitrate Transport Through the Vadose Zone Under Orchard Expansion in A Cultivated Loess Critical Zone

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Abstract

Extensive cropland-to-orchard transition alters water flow and nitrate transport in the vadose zone (VZ) of the Earth's Critical Zone (CZ), which may impact groundwater recharge and threaten future water quality from intensive nitrogen fertilizer application. Understanding the regional unsaturated water and nitrate fluxes and travel times in the deep VZ is crucial for the sustainable management of the groundwater system. Here, a regional-scale model was developed to estimate the recharge and nitrate transport in the cultivated loess CZ of China's Guanzhong Plain (CGP), where cropland-to-orchard transition has been extensively promoted in the past few decades. A comparison between model simulations and observations at 12 sites exhibits good simulation performance. Application over the CGP based on measured SHPs indicates that the central and eastern CGP were the hotspots for groundwater nitrate contamination. By comparing traditional cropland and orchard scenarios, simulations reveal that cropland-to-orchard transition results in a 39.3-fold increase in nitrate leaching fluxes and a 9.8% decrease in groundwater recharge fluxes. Modeled nitrate travel times through the deep VZ range between decades and centuries under both land use scenarios; however, the cropland-to-orchard transition would extend the time (~22.4 years) it takes for nitrate to reach the aquifer. Although cropland-to-orchard transition delays nitrate transport to the aquifer, the increased nitrate leaching flux will increase the risk of nitrate groundwater pollution, especially in areas with shallow VZs and coarse soil texture. This study provides valuable information for assessing the future vulnerability of groundwater resources under agricultural land use and management changes in the cultivated loess CZ.

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Exploring Elastic Wave Reduction through Forest Phononic Crystals: An Application of Periodic Theory in Seismic Engineering

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Abstract

This study delves into the innovative application of forest phononic crystals (FPCs) in mitigating elastic waves, particularly in the context of seismic wave attenuation. Building upon the concept of forest metamaterials as explored in previous research, this paper introduces the use of periodic theory to enhance the effectiveness of FPCs. The research employs advanced numerical simulations to model the interaction between elastic waves and FPCs, structured in periodic arrangements. By systematically altering the geometric and material properties of these FPCs, the study aims to identify configurations that exhibit optimal wave attenuation characteristics. The finite element method (FEM), facilitated by COMSOL Multiphysics and ANSYS software, serves as the primary tool for this analysis. The results aim to provide insightful data on the impact of FPCs on elastic wave propagation and offer practical guidelines for integrating these natural structures into urban planning and construction, particularly in seismically active zones. The study not only contributes to the field of seismic engineering but also promotes the sustainable use of natural resources in civil engineering applications.

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Deep nitrate accumulation in relation to surface soil management versus regolith interactions in a highly weathered subtropical Critical Zone

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Abstract

Nitrate accumulated deep (>100 cm) in the regolith threatens groundwater quality, but most studies focus only on nitrate nearer the surface (<100 cm). Surface soil management versus regolith interactions affect deep nitrate leaching, but their combined impact remains unclear. This study investigated how deep nitrate accumulation was affected by land use type, landscape position, crop planting years, regolith structure, and soil properties in highly weathered subtropical red soils. Deep nitrate storage varied from 43.6 to 1116.3 kg ha–1. Nitrate concentrations in the deep horizons of cropland and orchard regoliths were significantly larger than those in the paddy fields or woodland ($p < 0.05$). When compared to the regoliths from the upper slope of the cropland, those from the middle slope stored significantly more nitrate in the deep regolith layer ($p < 0.05$). Nitrate accumulation generally increased with the planting years. The difference in peak nitrate concentration (9.0–20.0 mg kg–1) with planting year gradient (3–58 years) varied by 2.2 times, and the difference in nitrate storage (43.6–425.7 kg ha–1) varied by 9.8 times. Regolith thickness was positively correlated with nitrate storage (R2 = 0.43, $p < 0.05$). Reticulated red clay (110–838 cm) had 81% of the accumulated nitrate and overlapped with 79% of the nitrate accumulation layer. Texture and pH explain 41.6% of the variation in nitrate concentration. As surface soil management practices interact with deeper regolith to control the spatial pattern of nitrate accumulation, vulnerable regions could be identified to avoid high accumulation. This study shows that internal hydropedological conditions determine fundamentally solute transportation and consequently environmental functions.

Session: On representing memory effects, hysteresis and feedbacks in the Critical Zone

Wednesday May, 8, 2024
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Modelling the dependance of climate regulating functions of Eurasian steppe soils on soil moisture

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Abstract

The Eurasian steppes form one of the largest continuous terrestrial natural biomes of the world and the Phaeozems, Chernozems and Kastanozems with a unique thick organic topsoil are soils formed along the gradient of decreasing soil moisture on the plains of Eurasia. Most of the inferred impacts of soil moisture for the climate system are induced by its role for evapotranspiration in soil moisture-limited regimes in transitional zone between dry and wet climates which is within the steppe biome. Due to its position the most important climate regulating function of steppe soils is biogeophysical in nature and is related to downshifting of summer high temperature extremes due to soil moisture – evapotranspiration coupling. Secondary, through biogeochemical mechanism soil water content strongly regulates carbon sequestration in soils. Here we compared these two main climate regulating functions of Eurasian steppe soils testing the role of soil water content in defining the climate mitigation potential by model simulations. Canadian land surface model CLASSIC was used. The model was calibrated using in situ observation of the slowly changing variables (carbon pools, permafrost temperature) and further constrained by the dynamic remote-sensing data, namely global reanalysis data based on assimilating passive microwave SMOS measurements as well as CO2 fluxes retrieved from GOSAT for the period 2010-2022. The test ensemble model experiments with artificially prescribed moisture initialization were mimicking the variability in soil water content in each e 1◦ × 1 ◦ grid cell belonging to Eurasian steppe biome by applying 1) distribution function of precipitation and evapotranspiration 2) binned frequency distribution of local correction factor due to land use type such as high-yield farming, land sparing and rangelands. In addition, the results of the Global Land-Atmosphere Coupling Experiment (GLACE-2) were quantified in terms of soil water effect on air temperature specifically for each ecoregion within the Eurasian steppe biome. Mapped climate sensitivity indices showed that strong soil moisture–climate coupling is seen where there is a dependency of evapotranspiration on soil moisture and relatively large mean evapotranspiration. East European forest-steppe and North-East Asia forest-steppe are the key regions for the soil moisture impact on climate. They are at the higher end of the soil water content

gradient among the Eurasian plains' steppe ecoregions and do pose a potential for increasing soil moisture and reducing climate extremes due to land use change. For the same two regions additional soil moisture leads to strong soil carbon stabilization rather than respirational loss in non-steady state conditions. Therefore, these two steppe ecoregions have comparably higher potential to regulate the climate through sustainable land-use change primarily by biogeophysical and secondly biogeochemical mechanism.

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Quantifying Coupling Effects between Soil Matric Potential and Osmotic Potential

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Abstract

Soil matric potential and osmotic potential are widely accepted as two independent components of total soil water potential. However, laboratory observations repeatedly demonstrated that matric potential can vary with salt concentration, implying a potential coupling between matric potential and osmotic potential. To date, it remains elusive whether matric potential and osmotic potential are independent or not and why so, and a theoretical theory for quantifying the coupling between them is still missing. Herein, a theoretical model is developed to quantitatively explain this problem via a lens provided by a recent concept of soil sorptive potential (SSP). The proposed model substantiates that matric potential and osmotic potential are not independent. The increasing salt concentration can notably depress two variables underpinning soil sorptive potential, namely relative permittivity and electrical double layer thickness, leading to non-negligible decreasing (more negative) of matric potential in the high suction range, and increasing (less negative) of it in the low suction range. In turn, the soil-water interactions redistribute ions in soil water, raising osmotic potential especially for clay with high cation exchange capacity. The proposed model shows excellent performance in capturing experimental data, validating its accuracy. A parametric study implies that the neglection of coupling effects can lead to a significant underestimation of soil hydraulic conductivity in the film flow regime.

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Identifying Spatiotemporal Patterns of Hillslope Subsurface Flow in an Alpine Critical Zone on the Qinghai-Tibetan Plateau Based on Three-Year, High-Resolution Field Observations

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Abstract

The spatial heterogeneity and temporal variability of hillslope subsurface flow (SSF) generation are poorly understood in the alpine critical zone (CZ). Owing to the limitations of observation technology bottlenecks and harsh environments, existing studies lack a holistic and process-based understanding of SSF generation, particularly for the deep CZ and annual freeze–thaw cycle. This study improves the conventional trenching observation scheme and is the first to have successfully monitored SSF processes from the soil to the bedrock layer with high-resolution from 2017 to 2020 in a headwater catchment of the Qinghai–Tibetan Plateau. The results show that hillslope runoff generation exhibited similar trends over the years while exhibiting distinct patterns across seasons. Spatially, slope aspects significantly affect the runoff amount and ratio. The south-facing slope is dominated by overland flow (OF, 84.2–97.0%), while the north-facing slope is dominated by SSF (88.9–97.3%). The runoff depth of the north-facing slope is 11.0 times that of the south-facing slope. The SSF in the deep CZ accounts for 20.8–37.8% of the total runoff along the north-facing slope. Temporally, runoff generation exhibits distinct patterns across seasons. OF exhibits two different patterns, while SSF exhibits five across seasons. Our results indicate that runoff generation in different freeze–thaw stages should be studied by the time phase. Therefore, we propose seasonal or freeze–thaw period-based classification criteria and divide OF and SSF into two and three consecutive periods throughout the calendar year. We suggest that these inferences and observations should be considered in the framework of hydrological models in cold regions.

Session: Constraining soil hydrologic processes using in-situ and remote sensing observations

Convenors: Jianzhi Dong, Tianjie Zhao, Long Zhao, Chunyu Dong

Session: Constraining soil hydrologic processes using in-situ and remote sensing observations
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Quantifying soil water and nutrient balances for a tile-drained agricultural watershed using improved SWAT model

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Abstract

Quantifying soil water and nutrient balances is essential for water quantity and quality management in agricultural watersheds. This is especially true in the U.S. Corn Belt, where subsurface tile drainage is widely applied and excessive nutrient loads (e.g., nitrogen and phosphorus) discharge to stream networks, causing serious water quality and ecological issues in downstream rivers and estuaries. A SWAT (Soil and Water Assessment Tool) model simulation was set up in an agricultural watershed with about 50% tile drainage area in the U.S. Corn Belt to study the water and nutrient balance components for the whole watershed and the crop system. The SWAT model was improved to consider additional forms of nitrogen and phosphorus lost through lateral soil flow, tile drainage and percolation. The model was comprehensively calibrated and validated for simulating monthly stream flow, total suspended solids (TSS), nutrient loads (including total Kjeldahl nitrogen (TKN), nitrate and nitrite nitrogen (NOx-N), total phosphorus (TP) and orthophosphate phosphorus (orthoP)), actual evapotranspiration (ETa), leaf area index (LAI) and annual crop yields in the watershed from 2011 to 2019. Results showed that the model performance was very good for simulating stream flow, ETa and TSS, and acceptable for nutrient loads, LAI and crop yields. For the entire watershed, ETa and surface runoff were the main water outputs, respectively accounting for 66% and 15% of the precipitation. For the nutrients lost to the water system, nitrogen loss was mainly through surface runoff, tile drainage and percolation, each contributing about 30%; phosphorus loss was mainly through surface runoff, which represented 66% of the total losses. Nitrogen forms lost with surface runoff were dominated by organic-N, while losses with tile drainage and percolation were mainly NO3-N. Organic-P and soluble-P almost contributed equally to losses in surface runoff, lateral flow, tile drainage and percolation. Representing about 49% of the watershed area, the crop system contributed 83% and 88% of the total nitrogen and phosphorus inputs, respectively, to the watershed, as well as 64% and 46% of the nitrogen and phosphorus losses to the water system, respectively. The non-growing season (October to the next April) was recognized as the critical period resulting in water and nutrient losses due to low evapotranspiration and plant uptake. Based on these, targeted management strategies for reducing nutrient loads to the water system were suggested.

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Actual evapotranspiration differences between measurements of lysimeters and eddy covariance along climate and ecosystem gradients

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Abstract

Accurate measurements of actual evapotranspiration (ET) play an important role in understanding land surface processes and agricultural management. Two of the most commonly used and established methods for quantifying ET are eddy covariance (EC) and weighable lysimeters measurements. Previous studies on hourly or daily basis indicated sometimes large differences between the ET of the two methods (ΔET). It is still unclear which environmental factors influence these differences. Here, we examine and compare half-hourly ET measurements from EC and weighable lysimeters during clear and cloudy days at five different sites. The five sites span an ecosystem and climatic gradient from humid conditions at two grasslands (Rollesbroich and Graswang, DE) and a cropland (Elora, CA) to semi-arid conditions at two sites with a natural grass and shrub (Els Plans, ES) and a tree-grass ecosystem (Majadas, ES). Our results revealed that substantial differences were found with a mean annual ΔET of 0.018 mm/30min on clear days and 0.011mm/30min on cloudy days, and ΔET displayed obvious spatiotemporal variabilities across the sites. Energy balance non-closure of EC was found to be the most important factor contributing to the large annual ΔET, especially during cloudy days. Monthly ΔET showed clear seasonal variations with peaking values occurring in summer, except at Majadas, where ΔET peaked earlier due to the Mediterranean climate in Spain. Daily ΔET also had the consistent variation trend with plant heights, but plant heights differences between lysimeters and EC field seemed to have no significant impacts on daily ΔET due to the influences of interactions of ΔET with surrounding environment conditions. The boosted regression tree method quantitively showed that daytime ΔET was energy-controlled at humid sites to moisture-controlled at semi-arid sites, which was also constrained by the vegetation types. There were no significant differences in the controlling factors under clear and cloudy conditions, except at Els Plans, where ΔET was strongly controlled by wind speed on cloudy days. These findings provide a critical evaluation for the roles of climatic and land surface conditions on turbulent flux dynamics from different measurements, which has important implications for ecosystem water and energy balance.

Session: Constraining soil hydrologic processes using in-situ and remote sensing observations
Wednesday May, 8, 2024
Attendance time 17:00 – 18:30

County-level evaluation of large-scale gridded datasets of irrigated area over China

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Abstract

The reliability of irrigated area (IA) information dominates the performance of irrigation water use and crop modeling accuracy. IA is typically mapped using Food and Agriculture Organization (FAO) agricultural census and remote sensing indices. Recent advances in machine learning and sampling techniques further improve IA mapping. However, the relative performances of different IA mapping approaches and their capability in capturing long-term IA temporal variability remain unknown. Here, 1861 county-level IA information from Government Censored Data (GCD) during 2000 to 2021 are collected, cross-validated, and employed to evaluate commonly used gridded IA datasets. Results show that IA datasets based on the direct interpolation of FAO agricultural census can accurately capture the spatial distribution of IA. However, FAO statistics are only available in a particular year, which cannot capture inter-annual irrigation variations. In contrast, IA products solely based on vegetation indices are prone to positive biases over humid regions due to the lack of contrast in vegetation dynamics. Overall, the latest GCD-based machine learning IA datasets are relatively more accurate, but they are also problematic in presenting IA trends due to the use of temporal static training samples. Such biases are tightly related to agricultural suitability (AS calculated using precipitation and potential evapotranspiration). This suggests that AS should be employed as an endogenous variable in future machine learning based IA mapping algorithms.

Session: Constraining soil hydrologic processes using in-situ and remote sensing observations
Wednesday May, 8, 2024
Attendance time 17:00 – 18:30

Soil moisture response pattern based on soil moisture observations in mountainous areas

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Abstract

we constructed a soil moisture (SM) observation network since 2012 in Qilian Mountains. It consists of 32 SM monitoring stations at depths of 5 cm, 15 cm, 25 cm, 40 cm, and 60 cm. Based on the observations and soil wetting events, we investigated the dynamic response processes of profile soil moisture under different land covers (scrubland, meadow, high coverage grassland (HCG), medium coverage grassland (MCG) and barren land). In addition, HYDRUS-1D simulations were used to further analyze the effect of land cover on soil moisture dynamics. Results showed the different responses patterns of SM under different land covers and preferential flow occurred mostly in soils covered by scrubland. Furthermore, sensitivity analysis indicated that soil hydraulic properties are key factors in regulating profile soil wetting events. We further explore the occurrence patterns of preferential flow based on the SM observations and machine learning (Random Forest, RF).

Session: Constraining soil hydrologic processes using in-situ and remote sensing observations
Wednesday May, 8, 2024
Attendance time 17:00 – 18:30

The experiment and simulation of Water-Vapor-Heat coupled transport in desert vadose zone

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Abstract

The transport of water and vapour in the desert vadose zone plays a critical role in the overall water and energy balances of near-surface environments in arid regions. However, field measurements in extremely dry environments face many difficulties and challenges, so few studies have examined water and vapour transport processes in the desert vadose zone. The main objective of this study is to analyse the mechanisms of soil water and vapour transport in the desert vadose zone (depth of similar to 350 cm) by using measured and modelled data in an extremely arid environment. The field experiments are implemented in an area of the Gobi desert in northwestern China to measure the soil properties, daily soil moisture and temperature, daily water-table depth and temperature, and daily meteorological records from DOYs (Days of Year) 114-212 in 2014 (growing season). The Hydrus-1D model, which simulates the coupled transport of water, vapour and heat in the vadose zone, is employed to simulate the layered soil moisture and temperature regimes and analyse the transport processes of soil water and vapour. The measured results show that the soil water and temperatures near the land surface have visible daily fluctuations across the entire soil profile. Thermal vapour movement is the most important component of the total water flux and the soil temperature gradient is the major driving factor that affects vapour transport in the desert vadose zone. The most active water and heat exchange occurs in the upper soil layer (depths of 0-25 cm). The matric potential change from the precipitation mainly re-draws the spatio-temporal distribution of the isothermal liquid water in the soil near the land surface. The matric potential has little effect on the isothermal vapour and thermal liquid water flux. These findings offer new insights into the liquid water and vapour movement processes in the extremely arid environment.

Session: Constraining soil hydrologic processes using in-situ and remote sensing observations
Wednesday May, 8, 2024
Attendance time 17:00 – 18:30

Distribution, migration and transformation of phosphorus in mangrove wetland of Dongzhai Harbor

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Abstract

Phosphorus (P), as one of the important biogenic elements providing primary productivity, plays an important role in the biogeochemical cycling process of offshore biogenic elements. In this study, we used the mangrove wetland of Dongzhai Harbor as the research object, and explored the molecular composition of organic phosphorus and the migration and transformation process at the molecular level by means of three-dimensional fluorescence spectroscopy of dissolved organic matter (DOM) and Fourier Transform Ion Cyclotron Resonance Mass Spectrometry (FT-ICR MS), and at the same time we used phosphorus and iron fractions combined with three-dimensional fluorescence spectroscopy to explore the control of phosphorus by the organic matter and iron minerals in the sediment, revealing the migration and transformation process of phosphorus in the sediment. The control of phosphorus by organic matter and iron minerals in sediments was also investigated by using phosphorus and iron fractions in combination with three-dimensional fluorescence spectroscopy to reveal the transport and transformation of phosphorus in sediments.

Session: Toward characterising and modelling the temporal variability of effective soil properties

Convenors: Attila Nemes, Anne Verhoef, Kathe Todd-Brown, Martine van der Ploeg

Session: Toward characterising and modelling the temporal variability of effective soil properties
Wednesday May 8, 2024
Attendance time 16:36

Exploring the relationship between soil basic properties and shape parameters in soil water retention curves within dual porosity in soil hydraulic properties

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Abstract

Currently, most models have typically been used to describe the soil water retention curve often rely on an ideal assumption of unimodal pore-size distribution. In reality, natural soils often exhibit a bimodal or even multimodal pore-size distribution. Here, we used three published global soil database to analyze the feature of soil samples with bimodal pore-size distribution in terms of basic properties and the shape parameters of the curve. We selected nearly 500 samples with bimodal soil characteristics by distinguishing the soil moisture characteristic curves. Results indicate that soil texture plays an important role in influencing the pore-size distribution in soil, with predominantly unimodal characteristics observed in soils with lower sand content. As bulk density increases, it naturally diminishes larger pore spaces within the soil, reducing the disparity in pore size and promoting a predominant unimodal pore-size distribution. Higher organic matter content can promote the soil aggregation process, leading to a pore-size distribution that opposes that of bulk density. For bimodal samples, the correlation between basic soil properties and structural pores in the dual-vG model is weak, whereas the correlation between basic soil properties and matrix pores is strong. The shape parameters of the soil water retention curve also have a close relationship with model parameters. We expect that the results will contribute to the understanding of soil structure, clarify the applicable conditions for bimodal pore-size distribution, and boost the derivation of the PTF for structural soils.

Session: Toward characterising and modelling the temporal variability of effective soil properties
Wednesday May 8, 2024
Attendance time 17:00 – 18:30

Assessing the response mechanisms of elevated CO2 concentration on various forms of nitrogen losses in the Golden Corn Belt

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Abstract

Nitrogen (N) loss is a significant source of water quality pollution in alluvial watersheds. However, the mechanisms linking N loss and elevated CO2 concentration (eCO2) are not well recognized. In this study, we comprehensively calibrated the SWAT model equipped with a dynamic CO2 input and response module to investigate the response mechanisms between multiform N losses and eCO2 in a representative large-scale watershed. Results revealed nitrate loss under eCO2 exceeding 100% in some upstream zones under the SSP5-8.5 scenario ($P < 0.05$) compared to the constant CO2 concentration. This was directly related to the great increase in hydrological variables, which were the carriers of N losses, and the intensive inputs of N fertilizer. Results also found that nitrate leaching was greater than the other two processes for future periods, peaking at 309.3%, as compared to the baseline period. The findings suggested reducing fertilizer inputs by 10%-20% was promising, especially for reducing nitrate loss through runoff and leaching by up to 17.7% and 12.2%. This study explored the mechanisms of increased N loss in response to eCO2 and provided scientific evidence for early warning and making decisions to improve water quality at a large watershed scale.

vSession: General Session of any model related research

Convenors: Yonggen Zhang, Yijian Zeng, Lutz Weihermueller,
Martine van der Ploeg, Gang Wang, Hailong He

Session: General Session of any model related research
Wednesday May, 8, 2024
Attendance time 17:00 – 18:30

Nonlinear mapping of physicochemical soil properties to land use/cover histories in China

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Abstract

To enhance our comprehension of soil processes and their impact on Earth system processes, it is necessary to accurately quantify human-induced soil changes, especially those related to land use/cover (LUC) histories. Although it is crucial to conduct further investigations to understand the widespread effects of LUC changes on soils, it is equally important to address significant knowledge gaps regarding the explanatory power of soil properties on LUC histories. To achieve this goal, we utilized validated LUC and soil databases that are specific to China. By using an explainable machine-learning approach, we were able to determine how soil physicochemical properties, either individually or in combination, explain LUC histories. Our historical validations demonstrated that the machine-learning models we proposed can accurately simulate the pattern of LUC histories. The nonlinear relationships of different soil properties in explaining LUC histories were demonstrated, and critical thresholds for directional changes in the explanatory capacity of each soil property for specific LUC histories were identified. The predicted LUC changes suggest more intensive dynamics, characterized by expansions in forest and pasture/rangeland areas, coupled with a reduction in cropland areas. Overall, a better understanding of the bidirectional links between soil and LUC, especially in terms of filling the knowledge gap as demonstrated in this study, is a critical and necessary step towards improving the representation of soils in Earth system models.

Session: General Session of any model related research
Wednesday May 8, 2024
Attendance time 16:42

Source Apportionment of Heavy Metal and Ecological and Health Risk Assessment of Typical Non-Ferrous Metal Smelting Plant

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Abstract

Clarified the concentration and sources of heavy metals in soil at defunct metals smelting plant sites is important for future soil utilization and ecological function restoration. This study examines typical metals (As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn) in soils from the defunct Shenyang Non-Ferrous Metal Processing Factory site. Spatial distribution characteristics of metals were identified through inverse distance weighting interpolation and mathematical statistics. Sources of soil heavy metals were also quantified using Principal Component Analysis (PCA) and Positive Matrix Factorization (PMF) receptor models. The Potential Ecological Risk Index method and Health Risk Assessment model was employed to assess ecological and health risks these metals. Results indicated that the mean concentrations of As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn were much higher than the background soil values of the Liaoning Province. Notably, Cd and Cu levels were 44.57 and 34.97 times of the provincial background values, signaling severe ecological contamination. Relative to GB36600-2018 standard, except Hg, Cr, As, Pb, Zn, Cu, Ni, and Cd have exceeding areas. As, Pb and Zn would derive from a common source, while Cu, Hg and Ni likely originated from another consistent source. In addition, Cd was related to the aforementioned metals, whereas Cr's originated differently from the other metals. Based on the results of principal component analysis, quantitative analysis by PMF model suggested that the heavy metals primarily derived from zinc and copper smelting activities, fuel auxiliary material emissions and natural sources. The results of the ecological risk assessment show that among the eight heavy metals at the research site, Cd from fuel auxiliary materials posed a markedly elevated ecological risk and needed to be prioritised for prevention, control and remediation in the subsequent ecological restoration of the site. The results of the health risk assessment showed that metals such as Pb and Cr emitted from fuel auxiliaries posed an unacceptable carcinogenic risk to the receptor population, and therefore heavy metal pollution control is required prior to the subsequent development of the site.

Session: General Session of any model related research
Wednesday May 8, 2024
Attendance time 17:00 – 18:30

Modeling effective soil depth at regional scale in Xinjiang, China

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Abstract

Soil depth reflects the quantity and ecosystem service functions of soil resources. However, there is no universal standard to measure soil depth at present, and digital soil mapping approaches for predicting soil depth at the regional scale remain immature. Using observation of soil profile morphology, we compared the soil depth nomenclatures from the World Reference Base for Soil Resources, Chinese Soil Taxonomy, and Soil Taxonomy. For this study, shallow soils were defined as those with an effective soil depth < 100 cm. Based on legacy data and field soil survey, the spatial distribution of shallow soils in Xinjiang, China, and the main controlling environmental factors were explored. Results showed that shallow soils in Xinjiang are mainly distributed in high altitude regions such as the Tian Mountains. At the regional scale, significant correlations were observed between soil depth and climate factors, as well as between soil depth and vegetation fractional coverage. Contrary to previous conclusions at small spatial scales, terrain attributes could not explain soil depth variation at the regional scale. This study addressed knowledge gaps on soil depth prediction at regional scales while elucidating climate-vegetation-soil coevolution.

Session: General Session of any model related research
Wednesday May 8, 2024
Attendance time 17:00 – 18:30

Pervasive soil phosphorus losses in terrestrial ecosystems in China

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Abstract

Future phosphorus (P) shortages could seriously affect terrestrial productivity and food security. We investigated the changes in topsoil available P (AP) and total P (TP) in China's forests, grasslands, paddy fields and upland croplands during the 1980s-2010s based on substantial repeated soil P measurements (63,220 samples, in the 1980s, 2000s and 2010s) and machine learning techniques. Between the 1980s and 2010s, total soil AP stock increased with a small but significant rate of 0.13 kg P ha-1 yr-1, but total soil TP stock declined substantially (4.5 kg P ha-1 yr-1) in the four ecosystems. We quantified the P budgets of soil–plant systems by harmonizing P fluxes from various sources for this period. Matching trends of soil contents over the decades with P budgets and fluxes, we found that the P-surplus in cultivated soils (especially in upland croplands) might be overestimated due to the great soil TP pool compared to fertilization and the substantial soil P losses through plant uptake and water erosion that offset the P additions. Our findings of P-deficit in China raise the alarm on the sustainability of future biomass production (especially in forest), highlight the urgency of P re-cycling in croplands and emphasize the critical role of country-level basic data in guiding sound policies to tackle the global P crises.

Session: General Session of any model related research
Wednesday May 8, 2024
Attendance time 17:00 – 18:30

The effectiveness of data merging in estimating extreme precipitation events

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Abstract

Data merging frameworks can effectively improve precipitation estimation accuracy. However, they may contain significant conditional errors in extreme precipitation (EP), due to the inappropriate use of merging algorithms and remote sensing (RS)/reanalyzed products. Here, we compare three merged, six RS and two reanalyzed precipitation datasets to investigate the impacts of merging strategies on EP. Based on 1050 meteorological or hydrological gauges in China, we find that all merged datasets are negatively biased during extreme events. Although commonly used least-square merging can attenuate precipitation intensity, it only has minor impacts on EP biases. Instead, such EP biases are mainly attributable to the pre-processing and the selection of input RS/reanalyzed precipitation products. Specifically, RS/reanalyzed precipitation biases are typically corrected linearly using monthly precipitation totals. Such pre-processing procedure cannot effectively address EP biases, which will eventually propagate into the merged results. Therefore, increasing the number of merged products always lead to higher risks in EP underestimation. To better address EP biases, more sophisticated bias correction procedures should be applied, e.g., cumulative distribution function (CDF) matching. However, obtaining accurate CDF matching parameters over ungauged areas appears to be a key challenge. Nonetheless, we find that these parameters are tightly related to local topography and climate and machine learning techniques might be useful to map large-scale CDF matching parameters.

Session: General Session of any model related research
Wednesday May 8, 2024
Attendance time 17:00 – 18:30

Analysis of heat transfer in an ATES system: on the role of two-dimensional thermal conduction

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Abstract

含水层储热(ATES)系统在可再生能源的应用、能源的高效利用、减少 CO2 排放等方面发挥着重要作用。为了实现 ATES 系统的成功运行，必须充分了解回灌过程中的热行为。解析模型是模拟 ATES 系统中热行为的一种有力工具，而现有的解析模型通常通过忽略含水层横向热传导过程和围岩纵向热传导过程来简化 ATES 系统，这种简化可能会给模拟结果带来误差。本研究建立了一种新型 ATES 系统解析模型，模型中考虑了含水层中热对流、热弥散、纵向和横向热传导过程以及围岩纵向和横向热传导过程。所得耦合模型采用格林函数法求得温度的半解析解，并进行了全局敏感性分析，分析各参数的相对重要性。

Session: General Session of any model related research
Wednesday May 8, 2024
Attendance time 16:48

The streamline-based approach for delineating porous and fractured bedform-induced hyporheic zone

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Abstract

河床形态导致的河床上的压力变化能够引起垂向潜流交换。潜流交换在支撑河流生态系统中的作用取决于潜流带的空间范围以及其中的物质和能量交换率的大小。然而，对由河床形态引起的潜流带空间范围的量化仍然缺少一定的规范性，特别是在非均质的地下环境中。因此，本研究开发了一种基于对流场的分析来识别潜流带范围的方法。在模拟地表和地下流体流动的基础上，通过分析流场的流线来完成识别过程。基于潜流带与底流（Underflow）界面上没有通量交换的特性，可以通过在水平方向上寻找一系列垂直位置来识别界面，该位置由整个区域垂直积分通量的全局最小值确定。研究结果表明，该方法适用于瞬态流动条件下二维和三维的非均质多孔介质、裂缝性河床中的潜流带识别，可以直接计算出潜流带的体积、平均停留时间和最大深度。最终，本研究通过与数值模拟的粒子跟踪和溶质运移进行对比验证了该方法的鲁棒性。

Session: General Session of any model related research
Wednesday May 8, 2024
Attendance time 17:00 – 18:30

Improved Soil Moisture Simulation and Production of Maps Using Automatic Machine Learning: A Case Study of a Watershed in the United States

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Abstract

Soil moisture plays a crucial role in the circulation of water and energy among the spheres of the Earth System. Access to large-scale, high-resolution soil moisture data is essential for various applications including agricultural irrigation, drought monitoring, and flood forecasting. However, previous studies on produced soil moisture maps by ML (machine learning) methodologies have been limited by factors such as reliance on single-model approaches that underutilize available data, lack of spatial extrapolation capabilities in model verification, the inability of low-resolution data products to capture small-scale variations in soil moisture, etc. To this end, we carried out a soil moisture simulation model based on Auto-ML (automatic machine learning) in conjunction with ERA5land data, high-resolution soil property data, and in-situ soil moisture data sourced from the ISMN (International Soil Moisture Network). we selected a watershed in the United States and considered not only for the influence of fundamental high resolution soil properties on soil moisture but also incorporated the lagged effects of meteorological factors. To evaluate the performance of our model, both temporal and spatial testing methodologies were employed. Temporal test divides the data into training set (calibration & validation) and test set by chronological order to confirm its continuous prediction ability for changes in soil moisture. Spatial test randomly divided in-situ sites within our study area into training set (calibration & validation) and test set to verify our model's spatial extrapolation ability. The results demonstrate that our produced Auto-ML soil moisture simulation model, outperformed existing datasets and methodologies at capturing spatio-temporal variations of soil moisture.

Session: General Session of any model related research
Wednesday May 8, 2024
Attendance time 17:00 – 18:30

Field-scale assessment of soil water dynamics using distributed modeling and electromagnetic conductivity imaging

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Abstract

Knowledge of the soil water balance is fundamental for improving crop water use in agricultural fields. Estimates are normally for representative and homogeneous areas where the variability of soil properties is neglected. However, this variability significantly impacts soil water dynamics at the field scale. In this study, the MOHID-Land distributed process-based model was used to compute the spatially explicit soil water dynamics in a 22.6-ha almond field located in southern Portugal. An electromagnetic induction survey was first performed to obtain electromagnetic images of the real soil conductivity in depth, which were related to soil texture. Then, pedotransfer functions were used to convert soil texture into soil hydraulic data. MOHID-Land results included maps of the spatial distribution of soil water contents, actual crop transpiration, actual soil evaporation, percolation below the rootzone, and surface runoff. These allowed identifying preferential flow pathways as well as the main control factors influencing soil water dynamics at the field scale. Some development needs were identified, and overcoming them would enhance the significance of contributions such as this study to the field of precision agriculture.

Session: General Session of any model related research
Wednesday May 8, 2024
Attendance time 17:00 – 18:30

Our recent advances in soil modeling and data products using machine learning and explainable AI

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Abstract

Our recent advances on this topic include the following three aspects: 1. Products and downscaling method 1.1 LandBench 1.0: A benchmark dataset and evaluation metrics for data-driven land surface variables prediction. —Presentation at session 8 1.2 A 1-km daily soil moisture dataset over China using in-situ measurement and machine learning.—Presentation at session 7 1.3 Using Hierarchical Random Forest Classification Model to Produce China's Soil Classification Map — Presentation at session 8 1.4 A 1-km Global Carbon Flux Dataset using in situ measurements and deep learning 1.5 A spatial downscaling method for soil moisture based on random forest considering soil moisture memory and mass conservation 2. Prediction using machine learning and deep learning 2.1 A Novel Methodology for Unveiling Insights in Evapotranspiration Modeling through Knowledge-Guided Deep Symbolic Regression Model — Presentation at session 9 2.2 Reducing location error of legacy soil profiles leads to improvement in digital soil mapping — Presentation at session 8 2.3 Predicting Soil Organic Carbon of China in the Future and the Role of Carbon Flux— Presentation at session 3 2.4 A soil albedo parameterisation scheme for land surface model— Presentation at session 1 2.5 An attention-aware LSTM model for soil moisture and soil temperature prediction 2.5 Improved daily SMAP satellite soil moisture prediction over China using deep learning model with transfer learning 2.6 Enhancing Deep Learning Soil Moisture Forecasting Models with integrating Physical-based Models 3. Making machine learning model more transparent using Explainable AI (XAI)—Presentation at session 8 3.1 Beyond prediction: An integrated post-hoc approach to interpret complex model in hydrometeorology 3.2 Interpreting Conv-LSTM for Spatio-Temporal Soil Moisture Prediction in China 3.3 Towards interpreting machine learning models for predicting soil moisture droughts Each of the above items corresponds to a paper published or in preparation. Find details at https://atmos.sysu.edu.cn/teacher/372.

Session: General Session of any model related research
Wednesday May 8, 2024
Attendance time 17:00 – 18:30

Simulation of the Evolution Process of Variable-Density Groundwater Induced by Seawater Intrusion in the Coastal Areas of the Bohai Bay

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Abstract

Seawater intrusion (SWI) is a significant threat to freshwater resources in coastal aquifers around the world. Furthermore, anthropic activities and climate change (e.g., ongoing sea-level rise) have exacerbated salinization in coastal areas. Here, we utilize numerical simulation of seawater intrusion and analysis of its evolutionary process to advance the scientific management of groundwater in the Bohai Bay in Tianjin, China. A three-dimensional finite element model, the SUTRA (Saturated-Unsaturated Transport) model, is employed to simulate density-dependent flow and transport in coastal groundwater aquifers. A sensitivity analysis is used to explore how the model output varies with the boundary conditions and hydraulic parameters, e.g., permeability and porosity. Results highlight the vulnerability of terrestrial freshwater aquifers to anthropic activities and climate change. These findings also suggest the importance of the investigation and management of groundwater to alleviate coastal seawater intrusion.

Session: General Session of any model related research
Wednesday May 8, 2024
Attendance time 17:00 – 18:30

Similarity-based classification of groundwater hydrographs and insights for groundwater modeling

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Abstract

Understanding groundwater dynamics driven by climate variations and human activities is vital for sustainable groundwater utilization and agriculture development. However, it is difficult to explore behaviors of groundwater dynamics in agricultural areas as they are affected by climate variations and human activities both spatially and temporally, and varies according to subsurface hydrological conditions. Here, similarity-based classification of groundwater table (GWT) series is developed by using the discrete wavelet transformation with hierarchical clustering (DWT-HC) and applied in the study area. The driving factors of classified GWT are then identified by Random Forest (RF).

Session: How to include root hydraulic architecture in soil models to simulate root water uptake

Convenors: Gaochao Cai, Yilin Fang, Daniel Leitner, Andrea Schnepf

Session: How to include root hydraulic architecture in soil models to simulate root water uptake
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Characteristics of Soil Pore Structure and Permeability Simulation under Conservation Tillage

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Abstract

Long-term tillage has a profound impact on the physical properties of both the tilled layer and even the deep soil. However, Traditional empirical formula models can not reflect the real soil pore structure and flow characteristics at the pore scale. In this study, undisturbed soil samples from two different cultivation practices were collected and scanned to obtain the three-dimensional soil structure. Two XCT-based methods, i.e. the Lattice Boltzmann Method (LBM) and the Pore Network Model (PNM) were used to model the pore-scale behaviour of saturated hydraulic conductivity under different cultivation practices. The accuracy of the two models were evaluated by comparing their simulated values with the measured values in an indoor infiltration experiment. The computational efficiency of them was also analyzed in the study. The main findings are as follows: 1. Changes in total soil porosity did not necessarily lead to significant changes in soil saturated hydraulic conductivity. Soil permeability does not strongly depend on porosity but on the specific porous media structure. 2. Cultivation is beneficial for loosening the topsoil, reducing its permeation resistance. A decrease in tillage intensity may lead to the decreased soil permeability by at least 1 order of magnitude of the surface soil, but it is not conducive to the formation of large pores in the soil below the tilled layer. This study emphasizes the uncertainty in reflecting hydraulic properties through macroscopic parameters and highlights the importance of pore-scale flow simulations in capturing the spatial and temporal distribution characteristics and transport processes of soil moisture, which is crucial for understanding the mechanisms of soil moisture movement.

Session: How to include root hydraulic architecture in soil models to simulate root water uptake
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Modeling the effect of real soil macropore structure on water infiltration using COMSOL

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Abstract

Soil macropores play a significant role in soil hydrology and solute transport as important preferential flow channels. Due to the complexity of macropore structures, most soil hydrodynamic simulations use simplifying assumptions (such as cylindrical) that do not represent fluid flow in actual macropores well. In this study, we obtained the real 3D structure of soil macropores (earthworm burrows) by using a tin casting method and a 3D scanner, and then simulated the effects of diameter, length, tortuosity, and number of soil macropores on water infiltration with the help of COMSOL. In addition, we quantified the effect of different sizes of macropores in the soil column on water infiltration with the help of X-ray computed tomography and COMSOL. The results showed that the connectivity (length) of soil macropores was the most important factor influencing soil water infiltration, followed by diameter and number, with the effect of tortuosity being relatively low. This study may provide a contribution to the understanding of soil moisture movement at the pore scale.

Session: How to include root hydraulic architecture in soil models to simulate root water uptake
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Modeling Dryland Evapotranspiration and Biomass Yield using Water Content Measurements and Machine Learning

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Abstract

Plant available soil water plays a vital role in the sustainability of dryland and rangeland agriculture, especially in regions facing episodic drought such as in the Western US. We are developing an approach for both understanding mechanisms of root water extraction as well as modeling that uptake through the integration of water content sensor depth and measured data coupled with machine learning algorithms. We estimate crop root density profiles and correlate with soil moisture sensor depth(s) within the root zone to approximate water uptake functions. Machine learning algorithms are used to analyze these interactive data patterns and to learn relationships between seasonality and plant root uptake exhibited within the historical sensor data. By leveraging historical sensor data, we can derive soil-specific hydraulic functions facilitating simulation of root zone soil profile hydrodynamics. The integration of water content sensor depth, historical sensor data, and machine learning algorithms holds promise for improved modeling of water use by plants. By accurately estimating soil hydraulic properties and predicting soil profile water uptake, we hope to improve estimation of crop and rangeland biomass production for improved management of land resources in water-limited regions.

Session: How to include root hydraulic architecture in soil models to simulate root water uptake
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Simulation Research of the Interaction Mechanisms Among Deep Soil Water, Typical Afforestation and Climate in the Loess Plateau

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Abstract

Analysis of the response of deep soil water use (DSWU) to precipitation change and its relationship with tree physiology is necessary to disentangle mechanisms underlying tree mortality. However, in drylands, the contribution of DSWU to the total water consumption of planted trees across different precipitation years is still unclear, and science-based evidence remains limited on whether DSWU can alleviate water stress on tree photosynthesis. In this study, a process-based model parameterized with in-situ measured fine root distribution data for 0-2000 cm was used to explore variations in DSWU strategy and its relation to tree photosynthetic traits in mature apple tree (Malus pumila Mill) and black locust (Robinia pseudoacacia L.) plantations in both a wetter (Changwu, 583 mm) and a drier (Yan'an, 507 mm) sites on China's Loess Plateau. DSWU at 200-2000 cm depth in different precipitation years of both species mainly occurred during the early growing seasons (blossom and young fruit period). Black locust trees relied more on deep soil water than apple trees during this period. On average, DSWU contributed 22.9% and 25.1% to the total water consumption of apple and black locust trees, respectively, and its contribution increased to 26.0% and 36.7% in extremely dry years. Interestingly, there was a significant ($p<0.05$) negative relationship between DSWU and stomatal conductance and photosynthesis for both tree species, suggesting that significant DSWU does not compensate drought stress effects on tree photosynthetic traits.

Session: Saturation kinetics in soils: stochiometric limits, mineral-organic interactions, and microbial explicit models

Convenors: Zhifeng Yan, Katherine Todd-Brown, Gangsheng Wang, Wenping Yuan, Gang Wang

Session: Saturation kinetics in soils: stochiometric limits, mineral-organic interactions, and microbial explicit models
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Effects of phosphorus addition on one-dimensional vertical infiltration characteristics of soil water

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Abstract

Phosphorus (P) is one of the macroelements necessary for the plant growth, second only to nitrogen (N) in importance. Excessive application of phosphorus fertilizer has posed a great threat to the physical and chemical properties of soil structure. This study aims to reveal the effect of phosphorus addition on the one-dimensional vertical infiltration characteristics of soil water. A series of soil infiltration experiments were carried out, where the phosphorus was added with water. Each experiment was set the five P gradients, namely CK/ICK (0 g/kg), P1/IP1 (0.075 g/kg), P2/IP2 (0.15 g/kg), P3/IP3 (0.225 g/kg), and P4/IP4 (0.3 g/kg). The results showed that: (1) Phosphorus application with water presented no significant effect on the soil infiltration during the infiltration process; 2) The water infiltration capacity was significantly enhanced, after the soil was incubated with the phosphorus addition for 90 days. Compared with the control ICK, the cumulative infiltration amount of IP1, IP2, IP3, and IP4 increased by 7.82%, 8.85%, 9.82%, and 11.21%, respectively, whereas, the corresponding infiltration time decreased by 7.77%, 14.56%, 22.33%, and 27.18%, respectively. The cumulative infiltration amount and the migration speed of the wetting front increased significantly, with the increase of the phosphorus concentration. There was an excellent linear relationship between the infiltration parameters and phosphorus concentration in the fitted Kostiakov and migration distance-time formula of the wetting front; 3) The IP3, and IP4 treatments presented a significantly larger amount of 0.25-2 mm particle size aggregates, compared with the control ICK without phosphorus. The amount increased by 35.9%, and 51.28%, respectively, indicating the addition of phosphorus significantly increased the proportion of large aggregates of 0.25-2 mm in the soil, thus changing the one-dimensional vertical infiltration characteristics of soil water. In summary, the duration of phosphorus addition in the soil was closely related to the change of soil structure. Phosphorus addition also increased the proportion of large aggregates of 0.25-2 mm in the soil, thereby to enhance the infiltration capacity of the soil. It is very necessary to consider the effect of phosphorus fertilizer on soil structure, especially in the case of excessive application of phosphorus fertilizer. Therefore, the phosphorus application can be combined with the soil infiltration capacity, in order to reveal the effect of

phosphorus addition on the soil moisture and infiltration capacity. The finding can provide a theoretical basis for the rational and standardized phosphorus application.

Session: General Session of any model related research
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Quantifying the worth of ecological data in developing soil carbon models

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Abstract

Ecologists and earth system scientists are collecting a large amount of data related to the soil carbon (C) cycle, primarily out of concern for climate change and soil health. The data assimilation-based framework can utilize these observations to reasonably predict soil carbon dynamics. However, these measurements are often time-consuming and expensive. Therefore, the important questions are: "Which data streams provide the most valuable information for the model?" and "What frequency and precision data do we need?". Therefore, based on the Bayesian framework, we compared the modelling worth of the traditional measurements (soil organic carbon (SOC) and soil respiration (SR)), less frequently measured variables (microbial biomass carbon (MBC)), and functional gene abundances (G) under different observation noises and frequencies. Our results show that low-frequency sampling of soil data has been enough to effectively improve the predictability of soil C dynamics and reduce uncertainty. Some data (e.g., G) are relatively redundant when other data are available and do not significantly improve the effectiveness of soil carbon prediction. However, incorporating functional gene abundance data into the model can better describe changes in enzyme concentration, thereby improving the accuracy and reliability of overall soil health prediction. The modelling worth of observation data is influenced by observation noise and frequency. High measurement error increases prediction uncertainty and reduces estimation accuracy. However, by increasing the measurement frequency or using other calibration datasets, we can alleviate the decline in data worth caused by high errors in expensive measurements. Our findings should promote further collaboration between modelers and measurement teams and may help determine measurement priorities and resource allocation.

Session: Data fusion for characterization of soil states and heterogeneity

Convenors: Yuanyuan Zha, Tian-Chyi Jim Yeh, Deqiang Mao, Lingzao Zeng,
Michael Tso, Xiaoqing Shi

Session: Data fusion for characterization of soil states and heterogeneity
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

A 1 km daily soil moisture dataset over China using in situ measurement and machine learning

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Abstract

High-quality gridded soil moisture products are essential for many Earth system science applications, while the recent reanalysis and remote sensing soil moisture data are often available at coarse resolution and remote sensing data are only for the surface soil. Here, we present a 1 km resolution long-term dataset of soil moisture derived through machine learning trained by the in situ measurements of 1789 stations over China, named SMCI1.0 (Soil Moisture of China by in situ data, version 1.0). Random forest is used as a robust machine learning approach to predict soil moisture using ERA5-Land time series, leaf area index, land cover type, topography and soil properties as predictors. SMCI1.0 provides 10-layer soil moisture with 10 cm intervals up to 100 cm deep at daily resolution over the period 2000-2020.Using in situ soil moisture as the benchmark, two independent experiments were conducted to evaluate the estimation accuracy of SMCI1.0: year-to-year (ubRMSE ranges from 0.041 to 0.052 and R ranges from 0.883 to 0.919) and station-to-station experiments (ubRMSE ranges from 0.045 to 0.051 and R ranges from 0.866 to 0.893). SMCI1.0 generally has advantages over other gridded soil moisture products,including ERA5-Land, SMAP-L4, and SoMo.ml.However, the high errors of soil moisture are often located in the North China Monsoon Region.Overall,the highly accurate estimations of both the year-to-year and station-to-station experiments ensure the applicability of SMCI1.0 to study the spatialtemporal patterns. As SMCI1.0 is based on in situ data, it can be a useful complement to existing model-based and satellite-based soil moisture datasets for various hydrological, meteorological, and ecological analyses and models. The DOI link for the dataset is http://dx.doi.org/10.11888/Terre.tpdc.272415 (Shangguan et al.,2022).

Session: Data fusion for characterization of soil states and heterogeneity
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Bayesian estimation of spatially distributed soil hydraulic properties from geometric scaling and KL expansion

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Abstract

The water retention characteristic and unsaturated soil hydraulic conductivity function exert a large control on soil water dynamics in the unsaturated zone. During the past decades, much progress has been made in estimating these soil hydraulic properties from in situ measurements using inverse modeling techniques. Most of these contributions have focused attention on the characterization of the hydraulic properties of homogeneous or layered soil profiles. In this paper, we use Bayesian inference coupled with geometric scaling and KL expansion to inversely estimate high-resolution spatially distributed hydraulic properties in a multi-dimensional soil water model. The combined use of the scaling method and KL expansion reduces with orders of magnitude the dimensionality of the soil hydraulic parameter estimation problem. We illustrate our method by application to spatiotemporal simulated soil water pressure heads. Our numerical experiments explicitly evaluate the effect of soil type, soil heterogeneity, spatial organization and data amount/quality on the accuracy of the inferred hydraulic properties.

Session: Data fusion for characterization of soil states and heterogeneity
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Geostatistical-Incorporated Physics-Informed Deep Learning for Modeling of Heterogeneous Unsaturated Flows

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Abstract

The Richardson-Richards equation (RRE) plays a pivotal role in soil hydrodynamics modeling, particularly within the unsaturated zone that serves as a vital link between groundwater and surface water. However, the equation's nonlinearity and the complexity of its constitutive relationships present significant challenges, rendering it among the most formidable equations to address in the field of hydrology. Traditional methodologies, despite their advancements, continue to grapple with limitations when confronting soil heterogeneity and uncertainties in boundary conditions. In response, the advent of deep learning (DL) has ushered in a novel paradigm for hydrological modeling. Yet, the reliance on purely data-driven models is hampered by a lack of physical interpretability, which in turn curtails their applicability across a broader spectrum. This research introduces an innovative approach that leverages physics-informed generative adversarial networks (PI-GAN) in conjunction with geostatistical insights to effectively solve the RRE under completely heterogeneous conditions. By integrating geostatistical data with Karhunen-Loève expansions (KLE), we achieve a nuanced parameterization of soil's random fields. This preparatory step is followed by the amalgamation of a pre-trained PI-GAN with a neural network specifically engineered to delineate the relationship between spatiotemporal coordinates and matric potential, culminating in an augmented physics-informed neural network (PINN). This concerted methodology is designed to concurrently honor geostatistical inputs and impose physical constraints throughout both the preliminary learning and subsequent estimation phases. Initial findings suggest that this model exhibits considerable promise in accurately simulating flows within heterogeneous, unsaturated soils. The PI-GAN-geo model, by synthesizing physical laws with geostatistical data, not only enhances prediction accuracy in the face of complex soil properties but also adeptly quantifies uncertainties associated with upper boundary conditions. Although this model awaits validation from field experiments, we anticipate it will offer insightful perspectives on the modeling and understanding of soil water dynamics in heterogeneous environments.

Session: Data fusion for characterization of soil states and heterogeneity

Thursday May, 9, 2024
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Deep learning integrating scale conversion and pedo-transfer function to avoid potential errors in cross-scale parameter transfer

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Abstract

Pedo-transfer functions (PTFs) relate soil/landscape basic properties to a wide range of model input (e.g., soil hydraulic parameters) that are essential to soil hydrological modeling. Combining PTFs and hydrological models is a powerful strategy allowing the use of soil basic properties for the generalization of large-scale modeling. However, since the spatial scales of soil hydraulic parameters required for model input and soil basic properties are often not identical, cross-scale parameter transfer is required, which can be a significant source of errors. Here, we investigate potential errors in cross-scale parameter transfer and develop an approach that avoids them. We propose the use of the convolutional neural network (CNN) as a cross-scale parameter transfer approach to directly map soil basic properties to soil hydraulic parameters across different spatial scales. To evaluate the proposed CNN approach, it is applied under two different estimation frameworks to invert the hydraulic parameters of a soil-water balance model and subsequently the quality of the parameters are assessed. Both synthetical and real-world results around the conterminous United States (CONUS) indicate that in general the proposed end-to-end framework is superior to the two-step framework. The CNN-based integrated model successfully reduces potential errors in cross-scale parameter transfer and can be applied to other areas lacking information on hydraulic parameters or observations. The proposed method can be extended to improve parameter estimation in earth system models and enhance our understanding of key hydrological processes.

Session: Data fusion for characterization of soil states and heterogeneity
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

A data assimilation approach to quantify soil phosphorus dynamics

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Abstract

The dynamics of soil phosphorus (P) control its bioavailability. Yet it remains a challenge to quantify soil P dynamics. Here we developed a soil P dynamics (SPD) model. We then assimilated eight data sets of 426-day changes in Hedley P fractions into the SPD model, to quantify the dynamics of six major P pools in eight soil samples that are representative of a wide type of soils. The performance of our SPD model was better for labile P, secondary mineral P, and occluded P than for nonoccluded organic P (Po) and primary mineral P. All parameters describing soil P dynamics were approximately constrained by the data sets. The average turnover rates were labile P 0.040 g g−1 day−1, nonoccluded Po 0.051 g g−1 day−1, secondary mineral P 0.023 g g−1 day−1, primary mineral P 0.00088 g g−1 day−1, occluded Po 0.0066 g g−1 day−1, and occluded inorganic P 0.0065 g g−1 day−1, in the greenhouse environment studied. Labile P was transferred on average more to nonoccluded Po (transfer coefficient of 0.42) and secondary mineral P (0.38) than to plants (0.20). Soil pH and organic C concentration were the key soil properties regulating the competition for P between plants and soil secondary minerals. The turnover rate of labile P was positively correlated with that of nonoccluded Po and secondary mineral P. The pool size of labile P was most sensitive to its turnover rate. Overall, we suggest data assimilation can contribute significantly to an improved understanding of soil P dynamics.

Session: Data fusion for characterization of soil states and heterogeneity
Thursday May, 9, 2024
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Forward and Inverse Modeling of Soil Water Flow in Layered Soil: A Perspective from Frequency Domain

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Abstract

Scientists generally rely on the Richardson-Richards equation (RRE) to simulate soil moisture dynamics. Because the nonlinear relationship between the hydraulic responses of soil and soil characteristics is nonlinear, solving RRE generally requires iterative approaches and demands significant computational resources. The modeling of soil water flux based on RRE relies heavily on accurate estimates of soil saturated hydraulic conductivity (Ks), while direct measurements for Ks are time- and labor-consuming. Soil moisture and periodic flux in the vadose zone are mainly driven by weather periodic variability, and we could estimate the soil moisture periodic variation from the periodic boundary flux conditions at different frequencies. This study develops a frequency-domain inverse model to estimate Ks. In addition, it derives a semi-analytical solution to vertical, one-dimensional RRE based on the Gardner-Kozeny (GK) model in a heterogeneous soil with sinusoidally varying flux, avoiding the high computational cost in the conventional time-domain model. Guided by the cross-correlation maps, several inverse experiments demonstrate that soil moisture fluctuations have the information content of different observations at different frequencies, facilitating accurate estimation of Ks. Monte Carlo simulations suggest that multi-frequency data can provide non-redundant and useful information about the estimation of heterogeneous Ks. Synthetic data based on a commonly-applied nonlinear van Genuchten-Mualem (VG) model is then tested in our inversion algorithm. The results indicate that the spatial pattern of the inverted GK Ks is very similar to that of the VG Ks, although these two parameters are inherently not identical since they are used in two different models. In addition, the inverted GK Ks can successfully predict the soil moisture fluctuation of frequencies that were not used in the inversion. Despite having no field experiments to validate this model, we believe this is the first attempt to conduct frequency-domain inverse modeling in vadose zone hydrology using soil moisture fluctuation.

Session: Data fusion for characterization of soil states and heterogeneity
Thursday May, 9, 2024
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Changes in methane emissions form paddy soils under non-puddling condition

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Abstract

Puddling, which is a common process for preparing submerged paddy field conditions, is time- consuming and labor-intensive. Recently, with the development of modern agricultural machinery and the expansion of laser leveling machines, it has become easier to prepare paddy fields without puddling process. Non-puddling technology not only reduces labor and production costs but also preserves water quality, so it is being applied in many countries that cultivate rice (i.e., Japan, India, and the United States). In particular, recently, in line with carbon neutrality, some studies reported that non-puddling reduces the methane (CH4) emissions from rice fields by improving soil aeration and thus suppressing soil reduction. Therefore, in this study, the effects of non-puddling technology on CH4 emissions from paddy fields in the Republic of Korea. Rice (Oryza sativa L.) seedlings were transplanted on June 8. During the cultivation period, the gas samples were collected once a week by using closed chambers fixed to the paddy fields and soil Eh was monitored. The gas concentrations were analyzed using gas chromatography. During the cultivation period, the soil Eh average was higher in the paddy with non-puddling (-305.1 mV) than that with puddling (-382.5 mV), suggesting that soil reduction conditions were suppressed. The soil Eh had a negative correlation (r2=0.58, P<0.001) with CH4 flux, and thus, the cumulative CH4 emissions from paddy with non-puddling (4,778.9 mg CH4 m-2) were lower by 8.1% than that with puddling. This is because by omitting puddling, the large pores were not destroyed and oxygen was sufficiently supplied to the soil. Therefore, our study suggests that there is a need to review the application of non-puddling technology when preparing paddy fields to reduce CH4 emissions.

Session: Application of machine learning and non-linear methods for spatial data analysis

Convenors: Ruhollah Taghizadeh-Mehrjardi, Brandon Heung, Ana M. Tarquis

Session: Application of Machine Learning and Non-Linear Methods for Spatial Data Analysis
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Spatiotemporal Dynamics in Baseflow Index Using Machine Learning Techniques in the Contiguous United States

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Abstract

The Baseflow Index (BFI) serves as an essential hydrological indicator, delineating the proportion of streamflow sustained by groundwater discharge, and thus reflecting the intricate coupling between aquifers and surface water flows. Fluctuations in the BFI signal changes in response to groundwater recharge, land use practices, and climatic factors that collectively shape hydrological processes. An increase in the BFI suggests enhanced groundwater recharge, potentially arising from land use modifications conducive to infiltration or from climatic alterations favoring baseflow augmentation. In contrast, a decrease in BFI may indicate a depletion of groundwater reservoirs, possibly due to prolonged droughts, increased rates of water extraction, or urban development that limits ground infiltration. This study leverages a comprehensive dataset comprising daily mean streamflow records from 9,230 monitoring stations across the contiguous United States, covering the period from 1979 to 2020. A recursive digital filter method was employed to compute the BFI, establishing the ratio of base flow to total streamflow. We implement advanced machine learning algorithms to analyze the spatiotemporal patterns of BFI, offering insights into the dynamics of groundwater-stream interactions over time. Our analysis reveals distinct regional patterns, with some areas exhibiting significant increases in baseflow contribution, while others face notable declines. The outcomes of this research underscore the heterogeneous response of hydrological systems to anthropogenic and natural influences. The findings are instrumental for water resource managers and policymakers in strategizing sustainable groundwater utilization and in adapting to the hydrological impacts of land-use changes and climate variability. By leveraging machine learning techniques, we provide a better understanding of baseflow variability, setting the stage for predictive modeling and risk assessment in the realm of water resource management.

Session: Application of Machine Learning and Non-Linear Methods for Spatial Data Analysis
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Using Remote Sensing for Precision Irrigation Management Zone Identification

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Abstract

The composition of soil holds a paramount influence over a spectrum of its attributes, encompassing its physical, chemical, and biological facets. Among these, soil texture stands as a pivotal determinant, governing crucial factors such as aeration, nutrient availability, water retention, and thermal properties. These fundamental characteristics collectively shape the environment for plant growth, dictating their development, productivity, and, ultimately, the quality of agricultural output. In recent times, there has been a burgeoning interest in leveraging machine learning (ML) techniques to deepen our understanding of soil behaviour. Yet, the practical application of ML models encounters a challenge posed by inherent imbalances within real-world datasets. Such imbalances often lead to a skewed emphasis on majority classes at the expense of minority ones, impacting the model's performance. To address this issue, this study sets out to explore the ramifications of data imbalance on the efficacy of a random forest (RF) model. The primary dataset employed in this study originates from the La Chimenea farm station in close proximity to Aranjuez, Madrid, Spain. It encompasses variables derived from Sentinel-2 imagery and soil texture derived from proximal sensing. A descriptive statistics analysis was conducted to gain insights into the dataset's characteristics, complemented by Pearson's coefficient (r) calculation to ascertain potential interrelations among variables. Then, the Synthetic Minority Oversampling Technique (SMOTE) was employed to rectify the data imbalance, thereby creating a balanced dataset from the original. Comparative analysis between the classification results of imbalanced and balanced datasets sheds light on the efficacy of SMOTE in enhancing the classification of soil texture. Through this investigation, the study aims to contribute to a deeper understanding of the interplay between data imbalance and model performance. Acknowledgements This work has received support from projects PID2021-124041OB-C22 and PID2021-122711NB-C21, funded by the Ministerio de Ciencia e Innovación (Ministry of Science and Innovation).

Session: Application of Machine Learning and Non-Linear Methods for Spatial Data Analysis
Thursday May, 9, 2024
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Recurrence based on methods for detecting regime transitions in soil-vegetation-atmosphere dynamics

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Abstract

Multispectral and satellite imagery has been employed to develop and analyse vegetation time series. However, soil-atmosphere-vegetation time series tend to present non-linear dynamics which hinder the understanding of the dynamical system. Recurrence techniques allow us to characterize the dynamics of the system and quantify its structure through complexity measures. The goal of this work is to compute recurrence plots and lacunarity to visualize and quantify regime transitions to further comprehend semiarid grassland dynamics. In this study, we chose a semiarid grassland area in the centre of Spain (Madrid, Soto del Real, 958 m.a.s). We employed the MODIS TERRA (MOD09Q1.006) product collecting a total of 920 images from 2002 to 2020, each one of them composed every 8-days and with a spatial resolution of 250 x 250 m2. Furthermore, temperature and precipitation time-series were obtained from a neighbouring meteorological station and transformed into an 8-day time step. Recurrence plots (RPs) and cross-recurrence plots (CRPs) were employed to visualize the system states. This was done through the phase space concept and the temporal evolution of dynamical systems trajectories in complex systems. RP is a square matrix where recurrence is represented as a black dot and the structures in the matrix are visually analysed and then quantified through recurrence quantification analysis (RQA). Furthermore, we introduce lacunarity as a measure of the heterogeneity of spatial patterns in the RPs matrix and CRPs matrix. Therefore, lacunarity could be employed as a detector of dynamical regime shifts in the analysed time series. Our results demonstrated that RPs depicted the seasonality of the normalized difference vegetation index (NDVI) and temperature time series. Whereas, precipitation (PCP) time series showed stochastic behaviour. These results were further demonstrated in the RQA, where DET, an indicator of determinism, was higher in NDVI and TEMP in comparison to PCP. A mixed pattern was found in the CRPs when the time series were crossed among them, where NDVI and TEMP patterns were more evident in comparison to PCP structure. Furthermore, lacunarity was able to distinguish dynamical regime shifts in different periods between 2002-2020. Specially, when NDVI and PCP were employed as an input to compute lacunarity. Overall, our results suggest that recurrence techniques can unravel the dynamics in soil-

atmosphere-vegetation systems, and the lacunarity measure further improves the recurrence plots approach and our understanding of the complexity of biological systems. Acknowledgements The authors acknowledge the support of the Project “Fusión de modelos de base física y basados en datos para la modelización de fenómenos precipitación-flujo HYDER”, from Universidad Politécnica de Madrid (project number: TED2021-131520B-C21).

Session: Application of Machine Learning and Non-Linear Methods for Spatial Data Analysis
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Reducing Location Error of Legacy Soil Profiles Leads to Improvement in Digital Soil Mapping

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Abstract

Abstract. Digital soil mapping relies on statistical relationships between soil profile observations and environmental covariates at the sample locations. However, inherent limitations of legacy soil profiles, such as inaccurate georeferencing and inconsistent sampling techniques, frequently introduce location errors into these soil profiles that greatly affect the quality of digital soil mapping. To address this challenge, this study focuses on reducing the location error of legacy soil profiles and evaluating the resulting impact on digital soil mapping. We enhanced the consistency between environmental covariates (i.e., elevation, slope and land use) with relative high accuracy and detailed descriptive information of legacy soil profiles to reduce the location error of legacy soil profiles. We constructed quantile regression forest models to predict soil properties and their uncertainty at different depths using soil profiles before and after location error correction. Our results demonstrate that for the majority of soil variables, correcting positional errors in legacy soil profiles significantly enhances the accuracy of the digital soil mapping. The largest improvement was found for soil organic carbon at 5cm depth, with 21% increase of R^2. The impact of reduced location error is particularly noteworthy in regions characterized by complex terrain or sparse sampling. In addition, the accuracy and details of the predicted maps are significantly improved, which better represent the spatial variation of soil attributes across China. Besides, we also found that elevation was the primary controlling factor for correcting location error of legacy soil profiles. This research presents a significant step towards producing high-resolution and high-quality spatial soil datasets, which can provide essential support for soil management and ensure future soil security.

Session: Application of Machine Learning and Non-Linear Methods for Spatial Data Analysis
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

A benchmark dataset and evaluation metrics for data-driven land surface variables prediction

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Abstract

The advancements in deep learning methods have presented new opportunities and challenges for predicting land surface variables (LSVs) due to their similarity with computer sciences tasks. However, few researchers focus on the benchmark datasets for LSVs predictions that hampers fair comparisons of different data-driven deep learning models. Hence, we propose a LSVs benchmark dataset and prediction toolbox to boost research in data-driven LSVs modeling and improve the consistency of data-driven deep learning models for LSVs. LSVs benchmark dataset contains a large number of hydrology-related variables, such as global soil moisture, runoff, etc., which can verify the simulation of hydrological processes. Various global data from European Centre for Medium-Range Weather Forecasts reanalysis 5 (ERA5), ERA5-land, global gridded soil information (SoilGrid), soil moisture storage capacity (SMSC), and moderate-resolution imaging spectroradiometer (MODIS) datasets have been pre-processed into daily data at 0.5-, 1-, 2-, and 4-degree resolutions to facilitate their use in data-driven models. Simple statistical metrics, i.e., the root mean squared error and correlation coefficient, are chosen to evaluate the performance of different deep learning (DL) models, including convolutional neural network, long short-term memory and convolution long short-term memory models, with lead times of 1 and 5 days. A processed-based model serves as a physic baseline, soil moisture and surface sensible heat fluxes are taken as the target variables. The developed benchmark dataset and evaluation metrics for predicting LSVs using data-driven approaches, named as the LandBench toolbox, were implemented using Pytorch. This toolbox facilitates the reimplementation of existing methods, the development of novel predictive models, and the utilization of unified evaluation metrics. Additionally, the toolbox incorporates address mapping technology to enable high-resolution global predictions with constrained computing resources. We hope LandBench will not only serves as a standardized framework, fostering equitable model comparisons, but also provides indispensable data and a robust scientific foundation essential for advancing climate change research, disaster management, and sustainable development initiatives.

Session: Application of Machine Learning and Non-Linear Methods for Spatial Data Analysis
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Spatial assessment of soil degradation via multitemporal spectral imaging of exposed croplands

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Abstract

Cropland degradation assessment requires effective mapping tools to capture the spatial variability of soil properties, especially at scales relevant for implementing targeted conservation measures. Soil imaging spectroscopy, based on the distinctive spectral features in the visible to short-wave infrared region (400-2500 nm), is a proven method for the prediction of key soil properties. This points to the potential of multispectral remote sensing approaches to quantify degradation-induced spatiotemporal changes in soil composition, thus enabling the detection of soil degradation hotspots. In this context, we will present a multitemporal Sentinel-2 remote sensing approach to achieving high-resolution soil organic carbon (SOC) and soil erosion mapping in a typical agricultural region (11,500 km2) of northeast China. Bare soil pixels were extracted via spectral index thresholding to ensure that the pixels represented true spectral signatures of surface soils. Multitemporal soil composites were then obtained by synthesizing over multiple single-date bare soil images to achieve spatially continuous coverage. Based on the bare soil composites, predictive models for SOC and soil erosion demonstrated the capability of spectral imaging to accurately detect the hotspots that experienced severe SOC loss and soil erosion. Specifically for soil erosion mapping, the accuracy of the predicted map was validated by independent Caesium-137 (137Cs) observations. The spatial accordance of crop growth to soil erosion intensity especially in localized settings further highlighted the potential of bare soil imaging to map the spatiotemporal development of soil degradation.

Session: Application of Machine Learning and Non-Linear Methods for Spatial Data Analysis
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Using Hierarchical Random Forest Classification Model to Produce China's Soil Classification Map

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Abstract

Soil class map serves as a pivotal source of information for soil modeling at global and regional scales. It furnishes the foundational knowledge for understanding soil, and plays an integral role in land assessment, land use planning, and agricultural technology. However, China's most detailed soil classification map from its second national survey was created several decades ago through traditional hand-drawn methods, which has resulted in a low-resolution product that inadequately addresses contemporary needs in soil modeling. This research leverages digital soil mapping techniques and statistical learning algorithms to generate a high-resolution spatial representation of soil classes, capitalizing on the existing data resources The study develops a robust empirical model to quantitatively describe the relationship between soil classes and multi-source environmental covariates including soil, vegetation, climate, topography, and parent material. We construct a hierarchical Random Forest classification model, thereby reducing model complexity while enhancing both accuracy and interpretability. To ensure enhanced mapping precision, we compare two sampling strategies for selecting the most representative sampling points. Ultimately, our study delivers a high-resolution soil class map of China with a spatial resolution of 90 meters. This innovative map boasts an impressive overall accuracy rate of 46.3%, surpassing the precision of existing datasets and effectively capturing the intricate distribution patterns of Chinese soils.This study's outcomes aspire to furnish more accurate soil data for a range of applications such as land surface models, as well as for informed soil planning and management decisions.

Session: Application of Machine Learning and Non-Linear Methods for Spatial Data Analysis
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

A deep learning model with time delay to predict soil water content in forest and grassland transition zone

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Abstract

The soil moisture distribution and dynamics are crucial for understanding ecosystem function and water resource resilience. However, predictions of deep soil moisture, especially under mixed land use and vegetation types, are challenging. This study developed an LSTM model with a time delay to predict soil water content (SWC) within the soil profile to depict the response of deep and shallow SWC and meteorological factors. This model was then applied to predict deeper SWC based on the SWC observation data at shallow layers and mereological data at the Oklahoma State University Research Range, USA, from August 16, 2010, to October 30, 2016. Results showed that the time delays of the LSTM models range from 6 to 8 days, depending on the soil depth and vegetation types. The models' performances have a mean Nash-Sutcliffe Efficiency (NSE) of 0.90 in the training period and 0.65 in the testing period of the three types of vegetation zones. This analysis allows us to explore the dynamics of SWC with the soil profile in forest and grassland transition zone. It can be readily generalized to SWC of other regions as well.

Session: General Session of any model related research

Convenors: Yonggen Zhang, Yijian Zeng, Lutz Weihermueller,
Martine van der Ploeg, Gang Wang, Hailong He

Session: General Session of any model related research
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Modeling of saturated soil hydraulic conductivity of farmland in Xinjiang, China

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Abstract

Saturated soil hydraulic conductivity (Ks) is a crucial parameter for quantifying the soil water pool function. We measured Ks of 30 soil samples from 5 farmland soil profiles with different elevations in Yumin County, Xinjiang. Soil profiles were sampled at 0-10cm, 10-20cm, 20-30cm, 30-50cm, 50-70cm, and 70-100cm depths. Ks was determined using the variable head infiltrometer method. Results showed that the maximum Ks occurred in the 70-100cm soil layer, with a value of 0.49 mm/min. The Ks decreased with decreasing altitude, i.e., 1000 m and more(0.382mm/min), 700-1000m(0.316mm/min), and 400-700m(0.19mm/min). This trend may be due to the coevolution of topography and climate. Correlation analysis showed a significant linear relationship between Ks of the 0-10cm soil layer and altitude: Ks=0.0007At-0.1273 (R2=0.708). Using multiple linear regression, we established a pedotransfer function with bulk density (BD), fine fraction, and sand fraction as the independent variables: Ks=0.01Si+0.426BD+0.001Sa-0.723 (R2=0.953). This study provides the fundamental data and methodological insights for simulating soil saturated hydraulic conductivity in arid regions of northwest China.

Session: General Session of any model related research
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Study on Pedo-transfer function of soil hydraulic parameters in loess area

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Abstract

Loess is a special kind of Quaternary continental loose accumulation formed through sedimentation and consolidation in a special natural environment, which is mainly distributed in arid and semi-arid zones of the northern hemisphere of the world's continents in the mid-latitude and covers about 10% of the earth's land surface. Determination of soil hydraulic parameters of loess is crucial for characterizing, evaluating and predicting soil water, groundwater and solute transport processes. Due to the problems of time-consuming, laborious and difficult to realize on a large scale in the direct acquisition of soil hydraulic parameters, the Pedo-transfer function has become the main method to obtain hydraulic parameters at present. In this paper, based on a series of experiments in loess area, a soil hydraulic parameter dataset considering spatial variability was established, and linear, nonlinear and machine learning algorithms were used to construct the relationship between the basic physical and chemical parameters and the soil water characteristic curve, unsaturated hydraulic conductivity, and diffusivity, and systematically evaluate the prediction effect of the transfer function, which overcame the difficulty of upgrading the scales of the hydraulic parameters of the loess area. The research results can provide more accurate parameterization schemes for soil water, groundwater movement and solute transport models, land surface models and climate models in loess areas.

Session: General Session of any model related research
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Attendance time 18:10 – 19:30

Assessing the Impact of Long-Term Climate Change on Hydrology and Crop Diversity Yield in the Texas High Plains

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Abstract

得克萨斯高原（THP）是美国一个重要的农业地区，面临着气候变化风险和奥加拉拉含水层地下水供应枯竭的巨大挑战。本研究利用改进的水土评估工具（SWAT）模型，量化了气候变化对灌溉耕作和旱地耕作下主要农作物的需水量和产量的影响。该模型结合了管理允许耗竭 (MAD) 灌溉调度和动态二氧化碳输入法（SWAT-MAD-CO2），采用了第六次国际耦合模式比较计划（CMIP6）中最新的 22 个一般环流模式（GCMs）在三种共享社会经济路径（SSP）排放情景（SSP1-2.6、SSP2-4.5 和 SSP5-8.5）下经过偏差校正后预测的未来气候数据。模拟结果表明，与基线期（1986-2015 年）相比，不同灌溉作物的实际蒸散量（ETa）变化不一，而在未来气候变化情景下，旱地作物和连作休耕的 ETa 普遍增加（2.4%-11.5%）。灌溉用水量（除灌溉棉花外）预计将减少，在三种 SSP 情景下，未来灌溉冬小麦（16.1%-85.5%）和灌溉高粱（18.1%-78.0%）的灌溉用水量与两个 30 年期间的其他灌溉作物相比将减少更多。在作物产量方面，与基准期相比，未来灌溉棉花、灌溉向日葵和旱地棉花的年产量预计将分别增加 109.3%-142.7%、1.1%-9.4% 和 93.9%-150.2%。相反，在气候变化情景下，灌溉高粱和旱地大豆的模拟产量与基线期相比降幅最大，分别为 6.4%-27.3% 和 5.9%-51.3% 。

Session: General Session of any model related research
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What can we learn from the centuries-long development of Longzici Springs, China

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Abstract

Springwater has been a key factor in the scale development of ancient agricultural societies, and the varying water management patterns in different periods reflect the primary contradictions in the contemporary society. Taking the Longzici Spring in northern China as an example, this paper utilizes a combination of qualitative description and semi-quantitative analysis methods to review historical records of springwater utilization from the Tang Dynasty to the Qing Dynasty (618 AD to 1911 AD). The study analyzes the development process of ancient springwater societies from three perspectives: engineering construction, water management, and water culture. The research reveals that over 600 years of water conservancy and flood control engineering ensured stable water use in the region for more than 800 years afterward. The continuous evolution of grassroots management organizations achieved meticulous water resource management. Throughout this process, the proportion of local elites increased from 17% to 42%, gradually strengthening their control over water rights. Collective water deity worship became the cultural foundation for water resource management, forming a community consensus centered around springwater resources. This study, from a historical perspective, provides new insights for future water resource management and offers a practical case for regional-scale sociohydrology research.

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Spatiotemporal Variation of Groundwater Reserves in the Tarim River Basin Based on GRACE Gravity Satellite Data

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Abstract

The Tarim River Basin, situated in the arid northwest region of China, faces challenges with scarce precipitation, fragile ecology, and a critical dependence on water resources for local social, economic, and ecological well-being. To enhance groundwater development, implement effective utilization measures, and formulate comprehensive groundwater resource management plans, this study employs GRACE and GLDAS data to assess changes in groundwater reserves in the Tarim River Basin from 1980 to 2019, analyzing their spatial-temporal distribution. The findings indicate a declining trend in groundwater reserves throughout the Tarim River Basin from 1980 to 2019. Spatially, the reduction in groundwater reserves gradually intensified from north to south. The most significant groundwater loss occurred in the central part of the southern slope of the Tianshan Mountain, while groundwater reserves in the lower reaches of the Tarim River demonstrated a steady increase, attributed to emergency ecological water transport in the past two decades. Remarkably, the vegetation area in the lower reaches of the Tarim River witnessed substantial growth, suggesting an improvement in vegetation conditions. This outcome implies an augmented coverage of natural vegetation and enhanced vegetation growth following ecological water transfer. The exploration of temporal and spatial variations in groundwater reserves in the Tarim River Basin holds valuable insights for optimizing water resource allocation and promoting the sustainable development of the ecological environment, not only in China but also globally.

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Managed Phreatic Zone Recharge for Irrigation and Wastewater Treatment

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Abstract

Managed phreatic zone recharge with marginal water, using (existing) drainage systems, raises the water table and increases water availability for crops. This nature-based solution uses the soil, groundwater, and rainwater between the drains and root zone as a buffer zone for biodegradation and adsorption; due to biodegradation and adsorption, the soil functions as a bioreactor. This is a newly developed method of freshwater conservation and marginal water treatment and disposal, but risks crop and environmental contamination. The fate of contaminants of emerging concern (CECs) within the irrigated water is addressed. We introduce numerical and analytical models, inspired loosely by a field site where treated domestic wastewater is used for subsurface irrigation. The treated wastewater would otherwise have been discharged into rivers, thereby spreading downstream. Model results show that minimal amounts of CECs are transported to deeper aquifers. Crops are not contaminated, except during dry years where small amounts of mobile CECs rise to the root zone, but then only directly above each irrigation drain. Under an annual precipitation surplus, less-mobile solutes are thus unlikely to ever enter the root zone. The primary mechanism of solute transport is lateral advection within the phreatic aquifer. Despite spatio-temporal heterogeneity in water flux magnitudes and directions, contaminant retardation does not significantly alter mass balance outcomes, only how fast it gets there. Therefore, persistent CECs pose the greatest risks, though overall environmental and crop contamination risks appear low. To maximize complementarity with subsurface irrigation systems, future advances in water treatment technologies should focus on removing persistent CECs. However, the system may be unsuitable for climates with annual precipitation shortages, as CECs may accumulate in the root zone and crops.

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Modeling the phosphorus dynamics in arable soil under long-term fertilization

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Abstract

The current economic and climate situation requires an increase in agricultural productivity while simultaneously minimizing mineral fertilizer input, leading to a growing demand for improved fertilization management. Among fertilizers, phosphorus (P) has received a growing concern due to the limited availability of its high-quality resources. Thus, a better understanding and prediction of the P cycling in arable soil-system is crucial due to its significant impact on crop yield and environmental sustainability. In this study, we present a new P module that was developed as a supplemental module of the AgroC model to simulate the coupled cycling of carbon, nitrogen, and P in arable soils. The observations of a long-term field experiment in Bad-Lauchstädt, Germany, were used first to evaluate the model performance to determine the effect of regular application of three types of fertilizers (mineral, organic, and a combination of both) on P dynamics in the soil and P availability for crops and to compare them with a control soil that receives no amendment. Subsequently, we employed the validated model to simulate a range of environmental scenarios, aiming to optimize the quantity and quality of P application while minimizing losses and degradation of water quality. Initial results suggest that our model can adequately predict the performance of different types of P fertilizers at increasing P availability for crops and can provide complimentary data to soil survey field studies. A comparison of simulated and observed P field data showed that the model predicted the different P-pools measured at the field scale satisfactorily. Our study shows the treatment based on the combined applications of organic and inorganic fertilizers resulted in the highest P availability and highest crop yields with no significant difference in P leaching from the control treatment. Organic treatment was found to behave similarly to the combined treatment when the amount of applied manure was increased and this eliminate the need for additional mineral inputs, resulting in economic and environmental profits.

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Numerical simulation of hydrothermal circulation in Tianxiu hydrothermal zone

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Abstract

Seafloor hydrothermal circulation is an important process of mass transport and energy conversion within the oceanic crust. When the high temperature seafloor fluids released from vents and low temperature seawater mix, the metallogenic elements produce chemical reactions, form hydrothermal mineral precipitation and settle near the vents, that causing the change of the seabed morphology. However, the understanding of how metallogenic elements enter the hydrothermal circulation in the ocean crust and reach the hydrothermal vents is far from sufficient. Our research takes the structurally controlled Tianxiu hydrothermal zone as a typical example to explore the concentration distribution of metallogenic elements in the process of hydrothermal circulation within the oceanic crust. The Tianxiu hydrothermal zone is the first hydrothermal system with ultramafic rock as the surrounding rock found on the Karlsberg Ridge, with an average water depth of about 3450m. Based on the percolation theory, we study the laws of migration and transformation of metallogenic elements during the transport of hydrothermal fluids in oceanic crust that considered as porous medium. By means of numerical simulation, the finite volume method was used to discretize the governing equations. Given appropriate initial and boundary conditions, and retrieve the thermodynamic parameters of fluids, such as specific heat capacity by referring to the look-up tables, the flow rate field, temperature field, pressure field and elements concentration field of the seafloor hydrothermal circulation in the Tianxiu hydrothermal zone were calculated and solved. Based on this, the mechanism of seafloor hydrothermal circulation and the transport path of metallogenic elements in the Tianxiu hydrothermal zone are discussed and the possible influence on the seabed geomorphology is discussed.

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A Novel Methodology for Unveiling Insights in Evapotranspiration Modeling through Knowledge-Guided Deep Symbolic Regression Model

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Abstract

Artificial Intelligence (AI) assumes a pivotal role in Earth science, leveraging the robust fitting capabilities of deep learning in dedicated black-box designs for prediction. Despite its prevalence, the impact of AI on scientific discovery remains uncertain. In Earth sciences, the emphasis extends beyond mere accuracy, striving for groundbreaking discoveries with distinct physical properties essential for driving advancements through thorough analysis. This study introduces a novel knowledge-guided deep symbolic regression model (KG-DSR) that incorporates prior knowledge of physical process interactions into the network. As an example, We successfully estimate evapotranspiration using the KG-DSR-based Penman-Monteith (PM) scheme, yielding a novel parameterization aligned with fundamental cognitive principles for surface resistance associated with this process. Results demonstrate that KG-DSR surpasses the currently accepted conventional theory in surface resistance parameterization, emphasizing the role of AI in unraveling process intricacies and ushering in a new paradigm in tasks related to "AI for Land Surface Modeling."

Session: General Session of any model related research
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Recent Advancements in the Hydraulic Properties of Stony Soils: A Critical Review

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Abstract

Stony soils are soils that contain a substantial volume of rock fragments and are widespread around the world. When modeling variably-saturated water flow in these soils, it is crucial to consider the impact of rock fragments. Since the mid-20th century, there have been theoretical and experimental efforts to characterize the soil hydraulic properties (SHP) of stony soils. We review the advancements in measurement, simulation and modeling techniques used to identify SHP of stony soils. We further emphasize the necessity of developing more sophisticated measurement and modeling approaches that incorporate the distinct characteristics of rock fragments and background soils. Presenting recent evidence from measurement and modeling attempts to characterize SHP of stony soils, we highlight the drawbacks of ignoring the influence of rock fragments in soil modeling.

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Modelling the Influence of Rock Thermal Properties on Soil Thermal and Hydrological Dynamics

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Abstract

在中国经济大力发展的背景下，工程上对建筑材料需求的急剧上升，加大了对矿产资源的开发利用。但在矿产资源的开采和道路建设过程中，严重的生态环境问题持续发生，如岩质边坡裸露、滑坡崩塌、固体废物污染等。岩质边坡由于立地条件特殊，它的出现逐渐破坏了坡面原有的植被覆盖面层及生物群落，由此在自然状态下极易形成次生裸地，并诱发水土流失、土地沙漠化等一系列生态恶果。在生态修复过程中，由于岩石吸水性差且不具备植物所需养分，覆土成为了常见的修复手段。考虑到不同岩性岩石的热物理性不同，基岩对其上覆土温度与湿度的影响也有所不同，且作为植物赖以生存的主要环境因子，土壤为其生长发育提供了所需的养分和水分。因此探究不同种类岩石表面覆土的水热特性，在已有土壤水热耦合理论的基础上，通过引入岩石热能，建立和完善考虑岩石热作用对其上覆盖土壤能量平衡和活动层水热过程影响的模型具有重要的理论价值和现实意义。

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Enhancement and Application of the SWAT Model in Mechanism of Watershed Processes

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Abstract

基于物理意义的定量刻画和描述流域水文过程和作物生长十分有必要，本研究系统改进了 SWAT 模型的二氧化碳投入与响应模块、自动灌溉和地下水模块、以及土壤冻融循环模块，从而更具代表性的模拟了相应的水文和作物生长过程。本研究在多个流域开展改进模型的比较验证，研究结果发现改进的模型显著的提高了模型的模拟精度。进一步利用改进的模型研究了未来气候变化对流域水文循环和作物生长的影响并识别影响相关指标的主要因素。本研究对流域过程机理模型的改进以及未来气候变化的适应具有一定的参考价值。

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Impact of Root Distribution on Soil Hydraulic Properties Under Different Water Quality Stressors

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Abstract

Environmental stresses, such as the application of low-quality water for irrigation, can affect plant root systems and evapotranspiration (ET). Changes in root morphology can alter soil hydraulic properties (SHP). In this study, we investigated the impact of root distribution on SHP and ET in laboratory soil lysimeters planted with grass. To do so, we used different water qualities as stressors to limit grass root growth. Soil matric potential was measured at two depths in soil columns, and soil moisture content and grass ET were monitored using scales with a precision of 0.1 g in a three-month experiment. The data were used as input for Hydrus 1D to identify the SHP of planted laboratory lysimeters with different root intensities. The lysimeter treated with higher salinity showed approximately 40% less ET due to lower root development in the soil in addition to the impact on the hydraulic gradient. However, it had a lower impact on SHP induced by root development in the soil.

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Development of a Pedotransfer Function that considers soil structure

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Abstract

The existing widely used soil pedotransfer functions (PTFs) often ignore the influence of soil structure. In this study, we developing a new PTF that considers the effects of soil structure near saturation in prediction of hydraulic conductivity.

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Modeling the economic and environmental impacts of the inclusion of the soil organic carbon model in the sugarcane-livestock integrated systems

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Abstract

One of the main challenges of the 21st century is to meet the increasing food demand while ensuring environmentally, economically and socially sustainable agricultural production. Integrated sugarcane-livestock production systems (ISLS) offer promising contributions to overcome this challenge in Brazil, including improved resource use efficiency, economies of scope, reduced environmental impacts, increased soil carbon stocks, and mitigation of weather and price risks. Furthermore, it has also great potential to generate co-benefits with the livestock sector as co-products of the sugarcane industry (e.g., bagasse, molasses, yeast, and filter muds) can be used as supplements or ingredients to cattle diets, potentially increasing stocking rates and, thus, sparing land besides reducing feeding costs and increasing economic efficiency of the livestock activity. Adoption of more intensive and diversified systems (i.e., ISLS) can help farmers and other stakeholders of food, agriculture and bioenergy sectors to activate different purposes synergically such as: i) food security, ii) mitigation of indirect land use change, iii) increased farm incomes and rural development, and iv) climate change mitigation and adaptation. Cattle production, on the other hand, is usually associated with high carbon (C) footprints particularly due to high methane (CH4) emissions from enteric fermentation. Therefore, reducing CH4 emissions through improved diet formulations using sugarcane co-products while increasing C sinks in soils are of utmost importance for the integrated system's environmental efficiency. Soil is considered the main C sink among the terrestrial ecosystems, as it can sequester, store, and stabilize atmospheric CO2 as soil organic carbon (SOC). Tropical pastures are known as having one of the greatest potentials of sequestering C among all other agricultural activities. Hence, economic and environmental tradeoffs of integrated systems can get quite intricate and demand decision support tools to optimize management. In this study, we propose a new optimization modeling approach to evaluate the economic and environmental impacts of ISLS. The modeling approach integrates livestock diet optimization and SOC models. We hypothesize that the inclusion of a SOC model can i) enable a more comprehensive and accurate C footprint analysis, identifying and potentially reducing previously unobserved environmental impacts due to an enhanced decision-making process, and ii) promote additional income sources due to possible C trading

in emergent carbon farming trading schemes. Fig. 1 shows the general conceptual model structure, indicating how this new modeling approach can be suitable and useful to evaluate the economic and environmental outcomes of ISLS in Brazil, where the SOC acts as a coupling component of this integration for a sustainable production system. Keywords: carbon credits, on-farm carbon, sustainability, economic-environmental security.

Session: General Session of any model related research
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Transport and numerical evaluation of CO2 concentration and flux in Salix cheilophila site at different profile depths during the growing season

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Abstract

In this paper, we selected typical sand-fixing vegetation (grassland, Salix cheilophila, and Pinus sylvestris var. mongholica Litv.) and bare ground (control) monitored for a long period of time in Yulin, Shaanxi Province, and attempted to reveal the seasonal changes and profile changes of CO2 in the root zone of the plant based on in situ monitoring, and then estimated CO2 production and fluxes in different depths of soil during the growing season and freeze-thaw period, respectively, based on convection-diffusion and conservation of mass by using the SOILCO2 module of the Hydrus software. The CO2 production and fluxes in the soil at different depths during the growing season and freeze-thaw period were estimated by the SOILCO2 module in Hydrus software on the basis of convective diffusion and mass conservation. In each vegetation sample plot, meteorological data, soil moisture and temperature were monitored at three different depths, 0cm, 20cm, 50cm and 100cm, respectively. The results showed that soil temperature was the most important influencing factor affecting soil carbon concentration and carbon flux, which was very similar to the changes in carbon concentration, while soil moisture content and rainfall were the main factors affecting carbon concentration and flux. It was also found that the direction of carbon fluxes in the top (20 cm), 50 cm, and bottom (100 cm) layers of the soil were upward, downward, and upward, respectively. This will provide an important basis for the accurate evaluation of carbon sources and sinks in different vegetation sites in the Mu Us Desert.

Session: General Session of any model related research
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Characterizing effective hydraulic properties of highly stony soils using inverse modeling

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Abstract

To model variably-saturated water flow using Richard's equation in stony soils, it is necessary to consider the change in soil hydraulic properties (SHP) due to rock fragments. However, the effective SHP of stony soils, particularly under unsaturated conditions, is still being researched. In this study, we utilized inverse modeling with HYDRUS 1D to identify the SHP of stony soils with two soil textures and varying volumetric rock fragments up to 50% (v/v). The study utilized time series data of local soil pressure heads at two depths, mean water contents, and fluxes across the upper boundary to estimate SHP through inverse modeling. The identified SHP was then compared with the SHP of the samples identified through evaporation experiments. This research demonstrates the effectiveness of inverse modeling in identifying SHP of highly stony soils.

Session: General Session of any model related research
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Enhancing Hydrological Models to Narrow the Gap between Elevated Carbon Dioxide Concentrations and Crop Responses: Implications for Water Resources

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Abstract

大气中的二氧化碳浓度上升通过作物生理作用影响作物生长及相关水文循环，主要是通过减少气孔导度和增加叶面积指数来实现。然而，减少的气孔导度和增加的叶面积指数可能会影响作物对水分的消耗，因此需要在升高二氧化碳浓度的条件下对整体影响进行量化。在这项研究中，我们开发了一个 SWAT-gs-LAI 模型，该模型结合了非线性的 gs-CO2 方程和缺失的 LAI-CO2 关系，以研究玉米在美国密西西比河流域中对升高二氧化碳浓度的水消耗、玉米产量以及水土流失的响应。结果显示，历史时期（1985-2014 年）二氧化碳浓度从 495 ppm 增加到 825 ppm 时，玉米产量增加，同时水消耗减少。升高二氧化碳浓度促进了地表径流，但抑制了沉积物损失，这是由于 LAI-CO2 引起的增强地表覆盖的主要影响。对未来气候变化的全面分析显示，与历史时期相比，玉米的水消耗有所增加，这主要是由于整体气候变化的更加显著的影响，而不仅仅是升高二氧化碳浓度的效应。总体而言，未来气候变化在美国密西西比河流域的大多数地区促进了玉米产量，适用于三种共享社会经济途径（SSP）情景。未来地表径流普遍增加，沉积物损失分别为 SSP1-2.6、SSP2-4.5 和 SSP5-8.5 平均增加 0.39、0.42 和 0.66 吨/公顷。这是由于负面气候变化效应在很大程度上超过了升高二氧化碳浓度的正面效应，特别是在中下游附近的区域。我们的结果强调了在升高二氧化碳浓度条件下采用基于物理的模型来表示作物生理过程的关键作用，从而提高了与作物生长和水文循环相关的预测的可靠性。

Session: General Session of any model related research
Thursday May, 9, 2024
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Simulation of soil water, heat and salt transport in considering of capillary flow, film flow and vapor diffusion

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Abstract

At present, although numerous studies have conducted detailed theoretical analyses on soil water-vapor movement processes there is still great uncertainty about how to quantify the influence characteristics of various factors from the mechanism. The introduction of film flow will inevitably re-examine the contribution of vapor diffusion and liquid flow to soil water and salt transport under low water content conditions and provide new insights into the effectiveness and necessity of the vapor enhancement factor. Therefore, the aim of this study is to introduce the impact of film flow in soil water, heat, and salt transport simulation, and to develop a comprehensive soil water, heat and salt coupled model that considers capillary flow, adsorption, and vapor transport. Three results of numerical simulation sets indicate that the considering film flow can better represent soil moisture movement at dry condition and the vapor enhancement factor model is not always accurate for vapor diffusion. By altering the vapor enhancement factor, the third set of numerical models can perfectly better predict the results than previous research, this shows that the validation of vapor diffusion needs to rely on the results of solute transport.

Session: Application of Machine Learning and Non-Linear Methods for Spatial Data Analysis
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Simulation of Spring Discharge Using Deep Learning, Considering the Spatiotemporal Variability of Precipitation

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Abstract

Precipitation data collected from sparse monitoring stations in numerous karst basins pose a challenge for hydrologic models to accurately capture spatial and temporal correlation between precipitation and karst spring discharge, hindering the development of robust simulation models. To address this data scarcity issue, this study employes a coupled deep learning model that integrates a variation autoencoder (VAE) for augmenting precipitation data and a long short-term memory (LSTM) network for karst spring discharge prediction. The VAE contributes by generating synthetic precipitation data through an encoding-decoding process. This process generalizes the observed precipitation data by deriving joint latent distributions with improved preservation of temporal and spatial correlations in the data. The combined VAE-generated precipitation and observation data are used to train and test the LSTM for predicting the spring discharge. Applied to Niangziguan spring catchment in northern China, our coupled VAE/LSTM model demonstrated significantly higher predictive accuracy compared to a LSTM model using only field observations. We also explored temporal and spatial correlations in the observed data and the impact of different ratios of VAE-generated precipitation data to actual data on model performances. Additionally, our study evaluated the effectiveness of VAE-augmented data on various deep learning models and compared VAE with other data augmentation techniques. Our study demonstrates that the VAE offers a novel approach to address data scarcity and uncertainty, improving learning generalization and predictive capability of various hydrological models.

Session: General Session of any model related research
Thursday May, 9, 2024
Attendance time 18:10 – 19:30

Soils Microbiota - biodiversity footprint and ESRI Products

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Abstract

The collapse of Soils Micro biodiversity jeopardizes our entire Quality and Quantity of Soil Fertility and well-being, as our Food Systems are completely dependent on the quality of Soil Fertility. Climate Change, Flooding, Overgrazing and almost all human activity affects Soils and the Soils Microbiota - biodiversity footprint measures this impact. Our Presentation could describe well how much damage a product, company, municipality or consumer cause to biodiversity. Our study provides an estimate of the spatial patterns of cropland susceptibility to erosion and report the co-occurrence of these processes using a multi-model approaches by using the ESRI Products ArcGIS GEO Software and in addition, to give a global overview of potential future changes, we identify the locations where these multiple concurrent soil erosion and desertification processes may be expected to intersect with projected dry/wet climate changes. The generated insight on multiple erosion processes can be a useful starting point for decision-makers working with ex-post and ex-ante policy evaluation of the UN Sustainable Development Goal 15 (Life on Land) activities. Scientifically, this work provides the hitherto most comprehensive assessment of soil erosion risks at the global scale, based on state-of-the-art models.

Session: General Session of any model related research
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Modeling the influence of no till technology on the main indicators of carbon cycle in agroecosystems

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Abstract

In Russia, no till technology is applied only on 1-2% of agricultural lands. Therefore, assessment of its impact on the accumulation of organic carbon in the soil and other indicators of the carbon cycle is of definite interest for expanding its use. One of the farms using no till technology is "Orlovka - Agro-Innovation Center", located in the Samara region, which became the basis for the study. The objectives of the work included the calculation of the main carbon fluxes in agroecosystems with no till and their comparison with conventional plowing. The dynamics of soil organic carbon stocks (SOC), soil CO2 emission and net ecosystem exchange were selected as target indicators. The DNDC (DeNitrification-DeComposition) simulation model developed specifically for arable soils was used. Based on the results of soil sampling in the 2022 field season, the input data for this model were calculated. The information was prepared separately for fields with no till technology and for fields with moldboard plowing. Six crops were selected as objects, the area of cultivation and representation in crop rotations of which in the farm is maximum: winter wheat, spring wheat, barley, corn, sunflower, soybean. Accordingly, the same number (six) of years for calculations was chosen: from 2017 to 2022. Verification was performed by comparing model data with soil CO2 emission measurements conducted in September-November 2021 on fields with three tillage options: (i) spring wheat, no till 8 years, (ii) sunflower, no till 5 years, (iii) sunflower, moldboard plowing. The success of model parametrization was confirmed by the corresponding values of Nash-Sutcliffe efficiency, Theil inequality and Pearson correlation coefficients. According to the results of calculations, it was obtained that no till technology allows preventing SOC losses from soil, and even promotes its accumulation. Thus, at moldboard plowing soils lose 259-871 kg C ha-1 yr-1, possible accumulation under winter wheat is 218 kg C ha-1 yr-1. Exclusion of plowing changes the soil carbon balance to positive (24-232 kg C ha-1 yr-1), and accumulation under winter wheat increases to 316 kg C ha-1 yr-1. Soil respiration at no till (1391-3473 kg C ha-1 yr-1) is significantly lower than at moldboard plowing (2114-3830 kg C ha-1 yr-1). This is due to the fact that microbial respiration rate decreases (by 15-44%), although root respiration remains at the same level. Negative values of net ecosystem exchange

(difference between total ecosystem respiration and net primary production) indicate carbon uptake by agrocoenoses during crop growth. It is small under traditional tillage system (-69...-1731 kg C ha-1 yr-1), while under no till technology it is much more intensive (-724...-3382 kg C ha-1 yr-1). Thus, the positive effect of no till on organic carbon accumulation in arable soils and its uptake by crop phytomass is confirmed. The study was carried out according to the state assignment No. 122111000095-8.

Session: Toward characterising and modelling the temporal variability of effective soil properties
Thursday May, 9, 2024
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Spatiotemporal dynamics of soil moisture and matric potential under different land covers at an agricultural site

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Abstract

Knowledge of the spatiotemporal patterns of soil moisture (SM) and soil matric potential (SMP) is important for understanding landscape hydrological processes and agricultural management. Previous studies mostly focused on the spatiotemporal characteristics of SM, while relevant studies on SMP are still limited. In this study, the spatiotemporal patterns of SM and SMP were jointly investigated based on one year SM and SMP data, which were collected at 30 and 60 cm along a 100-m transect under cropped conditions and an 18-m transect under bare surface conditions in the North China Plain. The results showed similar spatiotemporal patterns of SM and SMP, based on the analysis of the spatial mean-variance relationship and the temporal stability analysis. However, the field data also indicated that the impact of vegetation on the spatiotemporal variability in SM and SMP differed noticeably. In particular, vegetation tended to reduce the spatial variability in SMP at deeper soil depths, although SMP showed wider range compared with SM. Moreover, the data in our study provided strong field evidence that the spatial variability in SM and SMP at field scales depended on both moisture and land cover conditions. What's more, the WTC analysis was employed to examine the spatial interactions between SM and SMP under cropped conditions, demonstrating the intra-seasonal temporal stability dependent on scale and location between SM and SMP was more significant at 30 cm in spring and at 60 cm in summer. Those results of this study had implications of the necessity to jointly investigate the interactions of SM and SMP with surrounding environments, and could provide some insights and helped for spatiotemporal variation of SM and SMP at field scales.

Session: General Session of any model related research
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Impact of groundwater dynamics on drought response and soil moisture memory in ISBA-CTRIP

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Abstract

Soil moisture dynamics in land surface models are typically simulated using a free drainage boundary condition and a homogeneous soil profile. This approximation can result in a misrepresentation of the response to dry events, due to the absence of the dampening influence of groundwater, and the missing long-term legacy effect after severe droughts. In this study, we evaluate the impact of 1) introducing of a "poor man's groundwater table" by means of a depth-decaying hydraulic conductivity to restrict deep drainage, and 2) coupling of the vadose zone with a groundwater hydrologic model. Offline simulations are performed using ISBA-CTRIP. The analysis is centered around the Belgian domain, where the simulations are evaluated using observations of soil moisture, phreatic ground water level and surface fluxes from eddy covariance stations. To characterize the response to drought at longer timescales, the soil moisture memory was evaluated. Coupling the land surface model with groundwater hydrology adds complexity and computational cost. The aim of this study is to evaluate its added value, in particular in response to droughts.

Session: Toward characterising and modelling the temporal variability of effective soil properties
Thursday May, 9, 2024
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Estimating non-productive water loss in irrigated farmland in arid oasis regions: Based on stable isotope data

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Abstract

In arid oasis regions, water resources are severely scarce, with agricultural water usage far exceeding that of more humid areas. As a result, assessing non-productive water losses in farmland becomes crucial for estimating the water requirements reliant on irrigation for oasis cultivation. From April 2018 to October 2021, we established an observation system in the Minqin Oasis farmland. By utilizing hydrogen and oxygen isotopes in precipitation, soil water, and maize stem xylem water, we quantified the non-productive water loss (FE) and soil water infiltration rate (fe) in maize fields. Our findings indicate: (1) The average non-productive losses from rainfall and irrigation in arid maize fields were 39 %, with peak losses reaching 58 %; (2) Non-productive losses due to evapotranspiration were mainly observed in June and July, while losses from infiltration predominantly occurred in April-May and August-September; (3) Crop evapotranspiration capacity emerged as a significant factor influencing evaporation losses, while individual irrigation amounts and rainfall determined soil infiltration losses. We believe that judiciously managing irrigation volume and adjusting irrigation strategies in arid farmlands could unlock substantial potential for conserving water resources.

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Prediction of colloid transport in soil using pore-network model

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Abstract

Colloid transport and retention in porous media is a common phenomenon in nature. However, retention mechanisms are not fully revealed based on macroscale experimental observations. The pore-network model (PNM) is an effective method to account for the pore structure of a porous medium and provides a direct connection between pore-scale retention mechanisms and macroscale phenomenon. In this study, PNMs with cylindrical pore throats and spherical pore bodies are used to upscale water flow and colloid transport from pore- to macro-scales, taking into consideration surface deposition, hydrodynamic bridging, and straining. Numerical experiments were conducted to investigate the effect of colloid size, initial concentration, and flow velocity of pore water on colloid transport and retention behavior. Results show that hydrodynamic bridging and straining produce hyper-exponential retention profiles, whereas surface deposition due to nanoscale roughness and charge heterogeneity yields exponential or uniform retention profiles.

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Edaphic regulation of soil organic carbon fractions in the mattic layer across the Qinghai-Tibetan Plateau

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Abstract

The mattic layer is a main ecological function bearer of alpine meadow soils in the Qinghai-Tibet Plateau. It has high soil organic carbon (SOC) content with a variety of SOC fractions, which are thought to have different sensitivities to climate change. The effects of soil properties and climate on the SOC fractions in the mattic layer have been poorly understood. To address this, we analyzed the effects of environmental factors on two SOC fractions: particulate organic carbon (POC) and mineral-associated organic carbon (MAOC). A random forest model (RFM), partial correlation analysis, and structural equation model (SEM) were used to quantify the relative effects of soil and climatic factors on SOC fractions. We found that SOC and its fractions are primarily regulated by soil properties rather than climate. Partial correlation analysis and SEM revealed that climate indirectly affects SOC by influencing soil properties. Silt+Clay and exchangeable calcium (Caex) were found to be the strongest contributing factors of MAOC and POC, respectively. A distinct shift occurs in the mechanism underlying SOC stabilization with varying soil pH. In acidic and neutral environments, amorphous Al/Fe-(hydr) oxides contribute to the stability of MAOC, whereas free Al/Fe-(hydr) oxides promote SOC mineralization. Conversely, Caex positively influences the stabilization of both POC and MAOC throughout the pH range. These results may be extrapolated to SOC dynamics in future soil conditions affected by environmental change, especially for use in Earth system models.

Session: General Session of any model related research
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Modeling coupled nitrification-denitrification in soil with an organic hotspot

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Abstract

Application of manures to land is a widely used practice to recycle nitrogen (N) and other nutrients for crop production, and meanwhile it is a large and highly variable source of agricultural nitrous oxide (N2O) emissions. Liquid manure (slurry) containing degradable organic C (DOC) and water is prone to create local anaerobiosis, which may have implications for N transformations. Models often fail in capturing high N2O fluxes in croplands upon manure application, and there is a lack of studies in investigating the N transformations around such hotspots for N2O emissions using mechanistic models. In this study, we aimed to examine the biochemical processes and mass transfer around the manure hotspot by proposing a mechanistic model to provide new insights on this topic.

Session: General Session of any model related research
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SAFER-ET based assessment of irrigation patterns and impacts on groundwater use in the central Punjab, Pakistan

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Abstract

The excessive pumping of groundwater during the dry season in Pakistan is identified as a significant concern for groundwater sustainability. Farmers encounter difficulties in efficiently managing irrigation, and adopting the outputs of Irrigation Advisory System (IAS) to improve irrigation practices. Upgrading the existing IAS can help to identify the regions with over-irrigation issues and optimize outreach efforts. To solve these issues, we define the new concept of integrating Gravity Recovery and Climate Experiment (GRACE) total water storage anomalies (TWSA) and Landsat 8 imageries, which can enhance the IAS efficiency by accurately identifying regions facing groundwater depletion by estimating actual crop water consumption through application of the Simple Algorithm For Evapotranspiration Retrieving (SAFER) on Landsat 8 data and Penman-Monteith (PM) method was used to calculate crop water demand using meteorological forcing data from Global Land Data Assimilation System (GLDAS) over the five selected districts of Punjab during the dry seasons of year 2013–2020. Comparing actual water consumption (SAFER evapotranspiration (ET)) with in-situ groundwater depth, strong correlations were found between them that are supporting the use of Landsat 8 data for irrigation monitoring. Further, compared SAFER ET was with PM ET to calculate the percentage of over/under irrigated regions, and the results revealed that most of the selected districts were over-irrigated, indicating the potential for excessive irrigation water savings. Our results show that the integration of GRACE TWSA and Landsat 8 data enhance the efficiency of operational IAS and can lead to potential savings of 81% (equivalent to 155 million m 3) of groundwater during the dry season in the Central Punjab, Pakistan. Satellite data integration globally enhances IAS implementation, aiding regions with unsustainable dry season irrigation. This empowers farmers to optimize agriculture through precise IAS outputs

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