ISMC
International Soil Modeling Consortium

**ISMC Annual Report of Activities in 2020**

Chairs: Martine van der Ploeg, Teamrat Ghezzehei, Coordinator: Roland Baatz

The **IUSS Working Group International Soil Modeling Consortium (WG ISMC)** was established in 2016 with the aim to integrate and advance soil systems modeling, data collection, and observational capabilities. The underlying principles and scientific basis were outlined in a recent white paper on "Modeling soil processes: review, challenges and new perspectives" published in Vadose Zone Journal in 2016. Its activities are organized into three science panels: data and observation model linking, soil modeling development and intercomparison, and cross cutting and outreach activities. WG ISMC has an executive board and a scientific advisory board that guides WG ISMC in pursuing its objectives. WG ISMC is a community effort based on voluntary contributions. Everyone can sign up freely under http://eepurl.com/hjZvnX .

First quarter 2020, the ISMC Executive Board elected **Martine van der Ploeg as new Co-Chair** effective from 1st July 2020. Together with Teamrat, Martine will lead ISMC for the coming three years. Martine succeeds Harry Vereecken as European Co-Chair.

The **3rd ISMC Conference - Advances in Modeling Soil Systems** (Figure 1) was postponed, and will now be a virtual event to take place from May 18-22, 2021. The conference programme addresses recent research in the soil-vegetation-atmosphere continuum centred around soils over all spatial scales, time scales, and elements - from processes to prediction. Conference goals of 1) Engagement during scientific sessions 2) Active interaction and discussions and 3) Excellent oral talks and poster presentations will be achieved within ten scientific sessions from soil processes in Earth system models, soil formation, soil and plant interaction, transport processes, scaling of biogeochemical models, runoff and erosion, landscape heterogeneity, soil functions, biogeochemical fluxes and soil organic carbon dynamics, and a big data session.


*Figure 1: Banner ISMC Conference May 2021 ©ISMC ©freeimages.com Flavio Takemoto and ©imaggeo.egu.eu Shailendra Pratap*

**ISMC Award Winners 2021**

The biennial Rien van Genuchten Award is issued for outstanding contributions to the understanding of flow and transport processes in soils. It is dedicated to recognizing outstanding scientific achievements made by well-established researchers in the field of soil and vadose zone sciences. The ISMC Executive Board thanks the four anonymous reviewers for carrying out the review process on this year's nominations.

**This year's Rien van Genuchten Award goes to Prof. Tiina Roose (Figure 2 a),** University of Southampton. The award was made on the basis of Prof. Roose's significant contributions to advancing understanding of plant-soil interactions by combining theory, computational modeling, and experimentation. In particular, her work on plant-soil systems extends from fundamental theory to practical application. A further reason for her receiving the award was the fact that her scientific contributions are broad and innovative. The broad application here is the extension of her work to the field of biophysics, modeling such phenomena as the growth of tumours. The innovative technique being applying her mathematical skills and insights to advance a fundamental understanding of the plant-soil-microbiome continuum.

*Figure 2: a) Prof. T. Roose, winner of the Rien van Genuchten Award 2021, b) Dr. M. Sadeghi and c) Dr. R. Stewart, winners of the ISMC Early Career Award 2021. ©Prof. Tiina Roose ©Dr. Morteza Sadeghi ©Dr. Ryan Stewart*

The **ISMC Early Career Award** recognizes outstanding scientific achievements made by early career researchers in the field of soil and vadose zone sciences. This year's ISMC Early Career Award goes to two candidates who received equal scores during review: Morteza Sadeghi, California Environmental Protection Agency, and Ryan Stewart, Virginia Tech.

**Dr. Morteza Sadeghi (Figure 2b) receives the ISMC Early Career Award** on the basis of his work on bridging the gap between traditional soil physics and terrestrial remote sensing. His work has been particularly interdisciplinary and bridging across scales to better capture and understand hydro-terrestrial processes. This is exactly what is needed from the next generation hydro-terrestrial scientists to advance the field.

**Dr. Ryan Stewart (Figure 2c) receives the ISMC Early Career Award** on the basis of his work in the area of environmental quality and "soil health" with emphasis on water, solute and gas transport in soils. In particular, Dr. Stewart has helped the concept of soil health and made it "a quantitative sub-discipline of soil science". This is significant as it requires a holistic systems perspective in which the complexities of physical, chemical, biological, ecological processes have to be treated as a whole. In our opinion, this set Ryan apart as a leader in this important sub-field.

The **ISMC General Assembly** (Figure 3) took place during the virtual European Geoscience Union (EGU) Assembly 2020. At EGU2020, ISMC co-sponsored two sessions namely "HS8.3.2 Modeling Soil and Vadose Processes: Status and Challenges" and "SSS10.7. Scaling soil processes across space and time: leveraging models and data syntheses". The first session aimed to bring together scientists advancing the current status in modelling soil processes from the pore to the catchment and continental scale. The Modeling soil and vadose zone processes is vital for estimating physical states, parameters and fluxes from the bedrock to the atmosphere. Because the solid, liquid, and gaseous phases in the soil physically affect biogeochemical processes, transport of nutrients and pollutants, and infiltration-runoff generation, the implications on ecosystem functions and services and terrestrial storage capacities are vital to the understanding of global, land use and climate change. Advanced measurement techniques, increased availability of high-resolution data, and the need for terrestrial system understanding challenge vadose zone modeling concepts. The second session aimed at soil organic matter (SOM) as an ecosystem property that emerges from a suite of complex biological, geochemical, and physical interactions across scales. As the largest pool of actively-cycling terrestrial carbon, understanding how SOM persistence and vulnerability will respond to global change is critical. However, Earth System Models (ESMs) are often unable to capture emergent SOM patterns and feedbacks across smaller spatial and temporal scales. Identifying, prioritizing, and scaling key driving

mechanisms from detailed process models to advance ESMs is crucial, and better empirical constraints on SOM pools and fluxes are urgently needed to advance understanding and provide model benchmarks. Interdisciplinary research and observation networks collecting long-term, geographically-distributed data can help elucidate key mechanisms, and international efforts that synthesize and harmonize these data are needed to inform data-model comparisons.

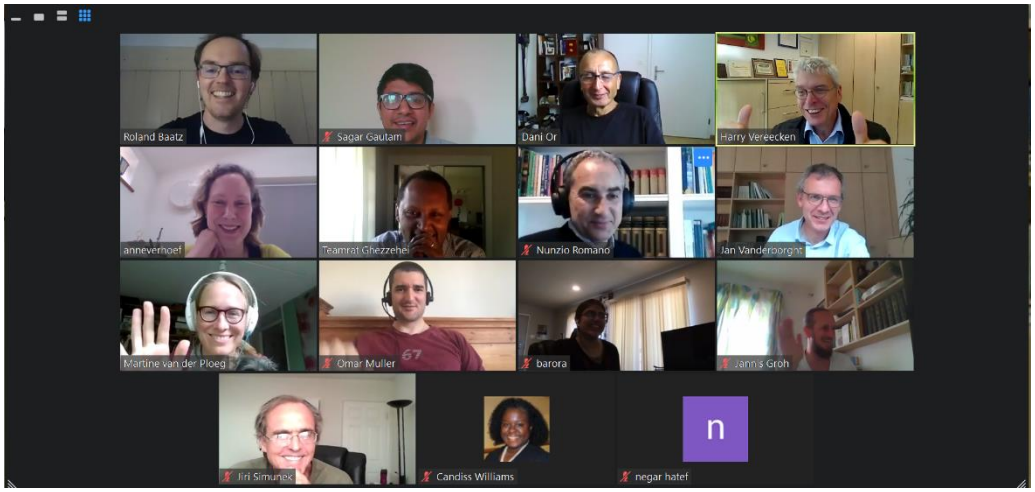


*Figure 3: Screenshot of virtual ISMC General Assembly 2020 ©ISMC*

Under the ISMC umbrella, three main international task forces were established. The **task force on soil carbon modeling** started a new ISMC project focusing on comparing global soil carbon maps generated with machine learning products to soil carbon maps generated using a reduced complexity process model. This may be one way to address global soil storage potential, and/or a way to highlight shortcomings in our understanding of the global biogeochemical cycle. We are also aware of the latest effort in monitoring top layer soil organic carbon globally using the state-of-the-art Earth Observation models/algorithms, which will be taken into account for the comparison when available. The task force is led by Kathe Todd-Brown and Jan Vanderborght together with Sagar Gautam, Umakant Mishra and Martine van der Ploeg.

The **task force on Soil Thermal Properties** aims towards improved descriptions of thermal soil properties, and related global parameter sets, for land surface models. The overarching aims of this ISMC task force project are i) to collate and generate global datasets of measured thermal property data (laboratory and field), conditions during the experiments (including soil moisture content and temperature, and ideally matric potential), and sample/field soil properties (texture, OM, mineralogy (if available), stoniness); ii) to collate and test (using measured thermal property data, as mentioned above) existing, and design and test improved equations of thermal soil properties, that can be used


in land surface models, at field to global scales; and iii) to link thermal theories with hydraulic theories, and to move away from empirical approaches where possible; iv) to generate global datasets of parameters required in existing and proposed equations, based on soil texture, OM, as well as mineralogy and rock content, or proxies thereof ; v) to generate datasets of field-site driving data and thermal regime verification variables (soil temperature, soil moisture/matric potential, soil heat flux) for testing of the equations at the field-scale (this includes FLUXNET-style sites, where these data are available). This task force serves to support development and verification of models simulating thermal properties, by both existing and novel approaches. The task force is led by Anne Verhoef and Yijian Zeng. https://soil-modeling.org/science-panels/working-groups/soil-thermal-properties

The **task force on Pedotransfer functions and land surface parameterization** aims to bring together international experts working on pedotransfer functions and land surface parametrization in different disciplines such as soil sciences, climate, and crop modelling. Hereby, the focus will be in a first step on pedotransfer functions (PTF) to estimate soil hydraulic parameters. In addition, also thermal and biogeochemical pedotransfer functions will be tackled. Within the task force urgent needs in pedotransfer and land surface parameterization development and validation will be identified covering the following topics: i) Establishing a database of hydraulic properties, soil properties that not only contain data on texture, bulk density, organic carbon, and other basic properties but that also include information on soil structural features. Hereby, discussions are needed which structural information can be routinely measured to improve PTFs. Current knowledge shows that taxonomic information such as granular, blocky, subangular, did not prove to be valuable. Imaging techniques are most likely the way forward. Measuring and including such information can be a community effort in a way that defined groups measure soil hydraulic properties on undisturbed samples, and others use their imaging capabilities such as CT or MRI. If possible, such an effort will be financially co-supported by ISMC in terms of shipping costs. ii) Integration of soil structure in pedotransfer functions iii) Development of harmonized and physically constrained pedotransfer functions iv) Functional sensitivity studies of developed pedotransfer functions v) Pore-scale modeling of the effects of soil structure on soil hydraulic properties vi) Validation of pedotransfer functions in land surface modelling. The task force is led by Lutz Weihermüller and Yonggen Zhang.
https://soil-modeling.org/science-panels/working-groups

**ISMC responded to the new EU Soil Strategy, Healthy Soil for a Healthy Life**, highlighting the need to account for long term processes and the key role of modeling in prediction.
The International Soil Modeling Consortium (ISMC) strongly supports the new EU Soil Strategy to develop knowledge-based management options to support the formulated objectives. The

consortium's Executive Board envisions European scale soil databases providing concrete evidence for high-resolution soil process models synergized with Copernicus Earth Observation Programmes. These will be some key components of a soil strategy implementation. The 2017 Report of the EU Soil Thematic Strategy identified a gap between science, policymakers, and society. The strategy to overcome this gap requires measures for exchange, integration, and dissemination of knowledge on maintaining soil ecosystem functioning. It urges for a concept to promote, integrate, and strengthen soil-related data availability and model capacity so that stakeholders and the broader public can better understand soil and soil processes' status and importance. To this end, developing knowledge and research is instrumental in guiding the gap between the goals of the new EU Soil Strategy and how to get there. Beyond the challenges addressed in the New Soil Strategy, we suggest consideration of three further challenges:

i) Integrate soil, crop, and socio-economic models to assess economic impacts on soil functions and services across different scales. Such modeling efforts inform long term monitoring campaigns on which processes need careful observation. These models integrate data, processes, and transdisciplinary knowledge in a machine-readable format.

ii) Assess the implications of proposed policies through pilots. We point out increasing carbon stocks by conservation tillage takes 3-5 decades to be detected (Angers and Eriksen-Hamel 2008 SSSAJ, Haddaway et al. 2017 Enviro. Evidence). We highlight the challenge for the New Soil Strategy to consider massive calibration of expectations.

iii) Assess the costs and benefits of land management on soil degradation, thereby informing policy in a meaningful way on medium and long-term costs and gains of soil management scenarios. Land degradation (in terms of SOC) due to land-use conversion is rapid (a decade or two) in adverse to soil carbon sequestration processes and chronic compaction effects. Restoration considers a policy-planning period of half a century.

Further information can be found under here.

ISMC also **promoted several movies (Figure 4)** to promote further ways to disseminate knowledge. The video abstract were made on highlighted publications of the vadose zone journal, supported by the journal editor Markus Flury. Magazine 1 features 'Research and tools to achieve a more productive and sustainable agriculture, combining geophysics-based soil mapping and crop growth modelling' by Naftali Lazarovitch, Cosimo Brogi and Nimrod Schwartz https://www.youtube.com/watch?v=oRnD8HbgKpc. Further, the @ISMC_News Twitter channel was visited frequently and serves as outlet for short news items https://twitter.com/ISMC_News for its 665 followers.

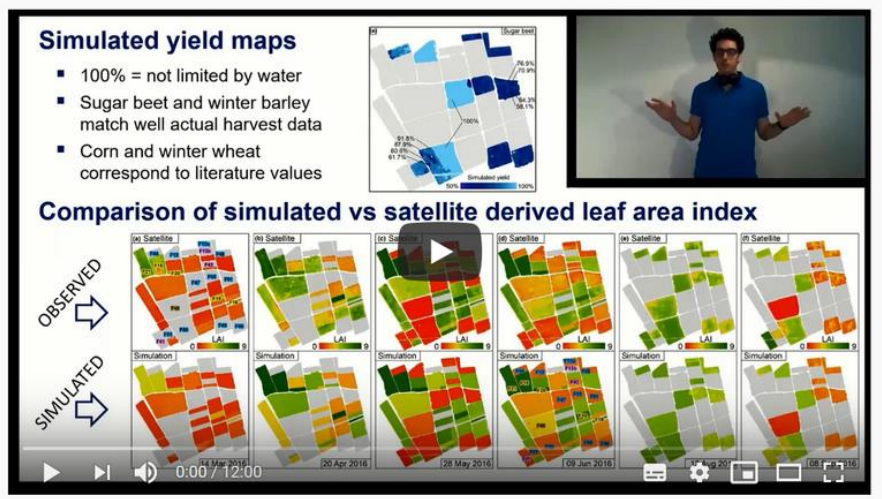


*Figure 4: Magazin 1 Video on Youtube. Screenshot of Youtube ©ISMC.*

The existing **Soil Meta Data Repository** (Figure 5a) links to databases relevant for international soil modeling experts. The 18 data sets cover root and biological data, soil hydraulic data, soil sample analyses, and many more. The Soil Model Portal (Figure 5b) has grown to 41 numerical models focusing on one or more of the soil-vegetation-atmosphere compartments. With tens of thousands of visits a year, these portals guide researchers and practitioners through the dungeon of available simulation tools. Most frequently visited were the models DNDC and RothC in the model portal with 864 and 1411 visits a month.


*Figure 5:a) ISMC Meta Data Portal and b) ISMC Soil Model Portal ©ISMC*

# ISMC

International Soil Modeling Consortium


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**Recent publications relevant and published by partners are:**

Baartman JEM, Melsen LA, Moore D, Van der Ploeg MJ, 2020. On the complexity of model complexity: Viewpoints across the geosciences. Catena 186: 104261 https://doi.org/10.1016/j.catena.2019.104261 Pre-print: ResearchGate https://www.researchgate.net/publication/339596386_On_the_complexity_of_model_complexity_Viewpoints_across_the_geosciences

Fatichi, S., Or, D., Walko, R. et al. Soil structure is an important omission in Earth System Models. Nat Commun 11, 522 (2020). https://doi.org/10.1038/s41467-020-14411-z

Hailong He, Dong He, Jiming Jin, Kathleen M. Smits, Miles Dyck, Qingbai Wu, Bingcheng Si, Jialong Lv, Room for improvement: A review and evaluation of 24 soil thermal conductivity parameterization schemes commonly used in land-surface, hydrological, and soil-vegetation-atmosphere transfer models, Earth-Science Reviews, Volume 211, 2020, 103419,ISSN 0012-8252,https://doi.org/10.1016/j.earscirev.2020.103419.

Lehmann, P., S. Bickel, Z. Wei, and D. Or. (2020). Physical constraints for improved soil hydraulic parameter estimation by pedotransfer functions. Water Resources Research. 56. e2019WR025963: https://doi.org/10.1029/2019WR025963.

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Wang, Y., Zeng, Y., Yu, L., Yang, P., Van der Tol, C., Yu, Q., Lü, X., Cai, H., and Su, Z.: Integrated modeling of canopy photosynthesis, fluorescence, and the transfer of energy, mass, and momentum in the soil–plant–atmosphere continuum (STEMMUS–SCOPE v1.0.0), Geosci. Model Dev., 14, 1379–1407, https://doi.org/10.5194/gmd-14-1379-2021, 2021