Integrating soil and subsurface processes in OLAM-SOIL:

A global soil and Earth systems modeling platform

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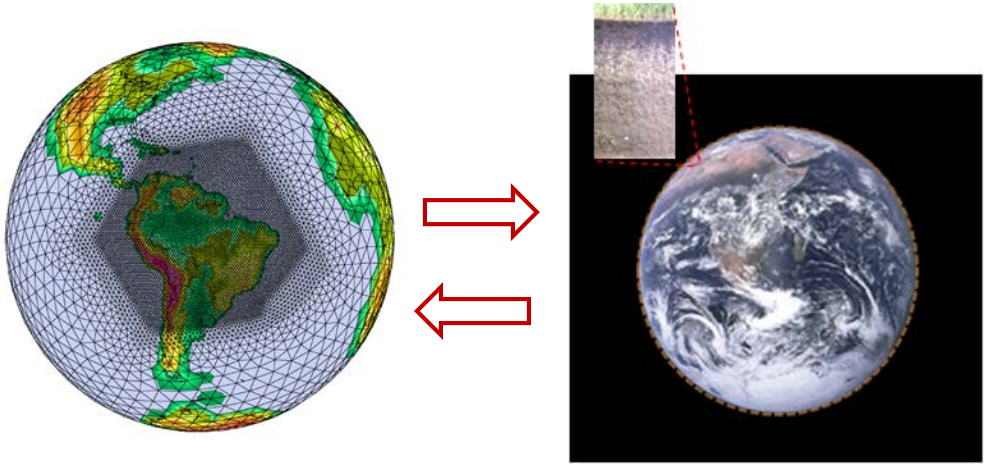
Michael Young **-** *Bureau of Economic Geology, U. Texas at Austin*
Kris van Looy – *ISMC and Agrosphere, Forschungszentrum Jülich*

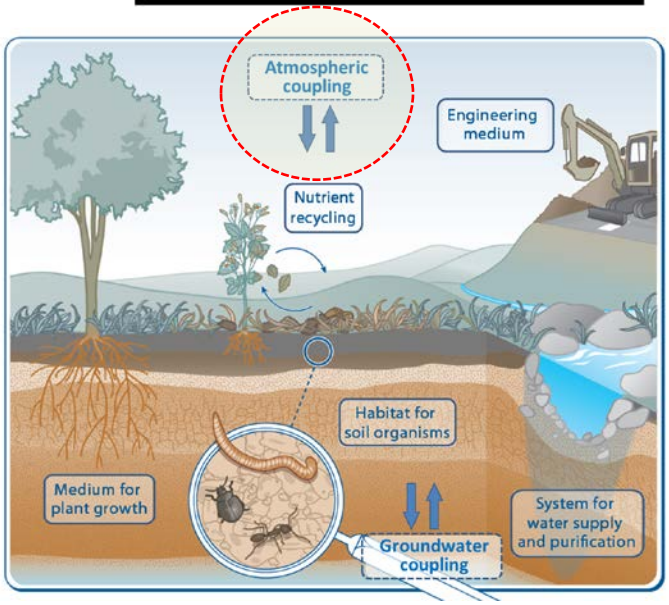


OLAM-SOIL Workshop AGU Fall meeting
New Orleans, December 2017

Soil – *Earth's life support system → going global*

- Soil is arguably the most biologically active compartment of the biosphere hosting largest pool of biodiversity
- Soil is a giant recycling system providing human needs for food and supports global biomass stocks
- Soil functions as Earths' life support body, a thin film of life covering terrestrial surfaces
- Nearly all contemporary societal challenges (from climate change to food security) involve a significant "***soil***" component

- In the past few years the soil and critical zone community is reaching out to other disciplines and scientific platforms (e.g., ***GEWEX-SoilWat***) to improve integration and provide better context for broader consideration of key soil processes
- The newly established ***International Soil Modeling Consortium (ISMC)*** provides an opportunity for considering soil systems modeling in a global context → OLAM-SOIL an ideal platform for going global



Why we need to study soil processes in a global context?

1. **Soil is important** – all key societal challenges (climate change, food security, water resources, environmental protection) contain an important soil component, but require a large scale view
2. **Society does not care about pore or column scale processes** – Earth system modes (ESM) and decision makers need to know how processes work at large scales
3. **No global soil model (*yet*)** – problems are addressed a profile at a time with limited spatial context and no systematic process integration as routinely done in climate models and ESM
4. **Climate and ESM need informed soil science** – as climate models mature they recognize that many critical land-atmosphere processes must be revised to represent soil processes
5. **Discipline survivability** - a global context of soil sciences is critical for the future of the discipline
6. **New opportunities in large scale soil science** - many new satellite and spatial information are available and waiting for scientific interpretation and integration
7. **How do we expand the scale of our activities?**
   a) Link with other disciplines – climate, ESM
   b) Train students to think of large scales
   c) Frame problems and publish on large scale issues
   d) Other ideas ???

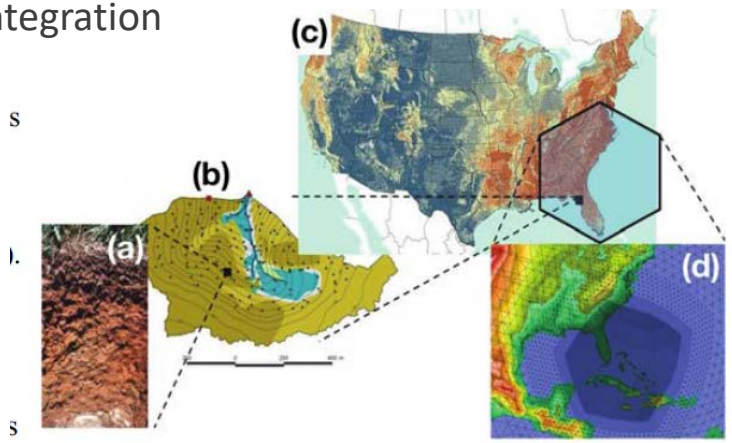


Fig. 2. *An illustration of OLAM's zooming capabilities and the range of soil process scales (continental to pedon).*

Potential *GEWEX-SoilWat* synergism - *examples*

- **Integration of *Critical Zone Observatories*** (CZO) and similar eco-hydrological observatories within GEWEX (eLTER-H2020 - European Long-Term Ecosystem Research Infrastructure; TERENO; ICOS; CUAHSI) – design; sensors; monitoring protocols; data repository [in coordination with GHP]
- **Formation of a global lysimeter network** – to inventory, standardize, and expand coverage of lysimeter observations; links with CZO's (lead – FZ Julich and Wageningen) [in coordination with GHP]
- **Integration of the *International Soil Modelling Consortium*** – coherence and better links between climate and soil modelers with respect to models, data sets for model testing, etc. (lead – FZ Julich) [in coordination with GLASS]
- **Development of linkages with the *Global Soil Map* initiative** [all panels]
- **Simple and low-cost soil moisture monitoring networks** (e.g., TxSON) for highly resolved soil moisture information [GHP and GDAP]
- **Integrating human interactions affecting soil-water processes** [GLASS, others]
- **Incorporation of near surface and small-scale soil processes** (evaporation physics; plants-soil interactions; biogeochemical processes) [GLASS]

Who is interested in *GEWEX-SoilWat* activities?

- ***Core group of highly motivated professionals:*** a wide range of people from all over the world were contacted and expressed keen interest and enthusiastic support
- ***Professional and scientific societies:*** the Soil Science Society of America (SSSA) – the primary dedicated professional society for soil science. Interest groups formed at AGU (Soil systems and critical zone processes Technical committee); The Geological Society of America - Soils and Soil Processes Interdisciplinary Interest Group); EGU-Soil Systems Section; others
- ***National agencies and projects:*** USDA/ARS; existing and future US-NSF, China and European CZO networks; eLTER H2020; Global soil map initiative
- ***Academic centers and industry:*** for example - *Water for Food* – NE; *World Food Centers* – ETH and UC Davis); Soil water sensor manufacturers (*Decagon*; *RainBird*; *Campbell Scientific; Delta-T*)

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

LTER europe

World Food Center

GlobalSoilMap.net

DECAGON DEVICES

Soil Science Society of America

Planning workshop: *GEWEX-SoilWat UFZ Leipzig June 2016*

- To provide a scientific basis, scope and integration of *SoilWat initiative* with existing GEWEX structures and activities, we plan a dedicated planning workshop hosted by UFZ in Leipzig-Halle (*June 28-30, 2016*) - the objective is to engage the GEWEX and Soil community members in the planning and in the workshop
- **Discussion areas/potential topics and core group** (tentative):
  1. Integrating (sub-) surface modeling in hydrological and climate models (*Conveners:* ***Dani Or, Harry Vereecken, Eleanor Blyth, Matthias Cuntz, Bill Kustas***)
  2. Model complexity and utility (simple vs complex models) (*Conveners:* ***Martin Best, Gab Abramovitz, Aaron Boone, Jan Vanderborght, Jasper Vrugt, Alex Mcbratney***)
  3. Groundwater-surface-atmosphere interactions (*Conveners:* ***Marc Bierkens, Remko Uijlenhoet, Gerrit de Rooij, Stephan Kollet***)
  4. Human interactions affecting soil-water processes (*Conveners:* ***Taikan Oki, Howard Wheater, Katja Frieler, Jacob Schewe, Shmuel Assouline, John Crawford, Michael Young***)
  5. Soil observations for hydro-climate research (*Conveners:* ***Jan Hopmans, Sonia Seneviratne, Steffen Zacharias , Hendricks-Franssen Harrie-Jan, Colin Campbell, Todd Caldwell***)

JÜLICH
FORSCHUNGSZENTRUM

On the Need to Establish an International Soil Modeling Consortium, ISMC

The ISMC Team: H. Vereecken, A. Schnepf, J. Vanderborght, M. Young, D. Or, J.W. Hopmans, M. Javaux, R. Kunkel

The International Inaugural Conference on Soil Modeling, Austin, 29 March-1 April

Motivation for community-based ISMC

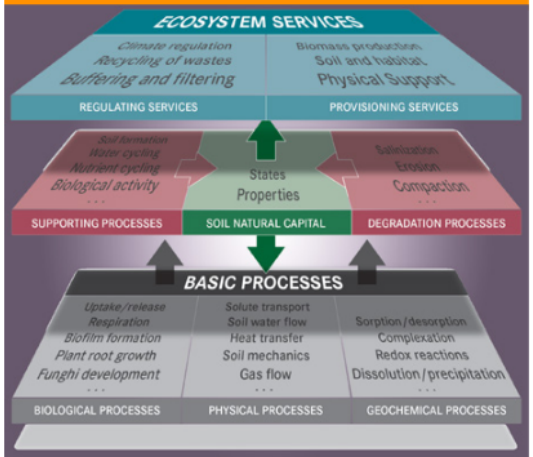
- Modelling soil processes is fragmented and dispersed
- Exchange between different soil disciplines is lacking
- An improved “position“ and visibility of soil research and modelling in the Earth Sciences Community is needed. We need to reach out to other modelling communities in the field of terrestrial systems, climate systems, ecology, …
- The scientific community lacks easy-to-access and available standardized and high quality data and protocols for calibration and validation
- A better exchange of ideas, expertise and need for development of joint activities through cross-cutting topical areas
- **→ ISMC as a community effort**

The primary objectives of the ISMC

- To address scientific gaps and promote soil science research
- To develop a platform for soil model development/intercomparisons
- To identify interactions with other relevant platforms
- To establish data platforms for model development and validation
- To promote integration of soil modelling expertise in neighbouring disciplines (climate, land surface, ecological, crop and contaminant models)
- To develop cross-topical areas as hubs for innovation and exchange of ideas, models, data and expertise

Published May 13, 2016

Review and Analysis



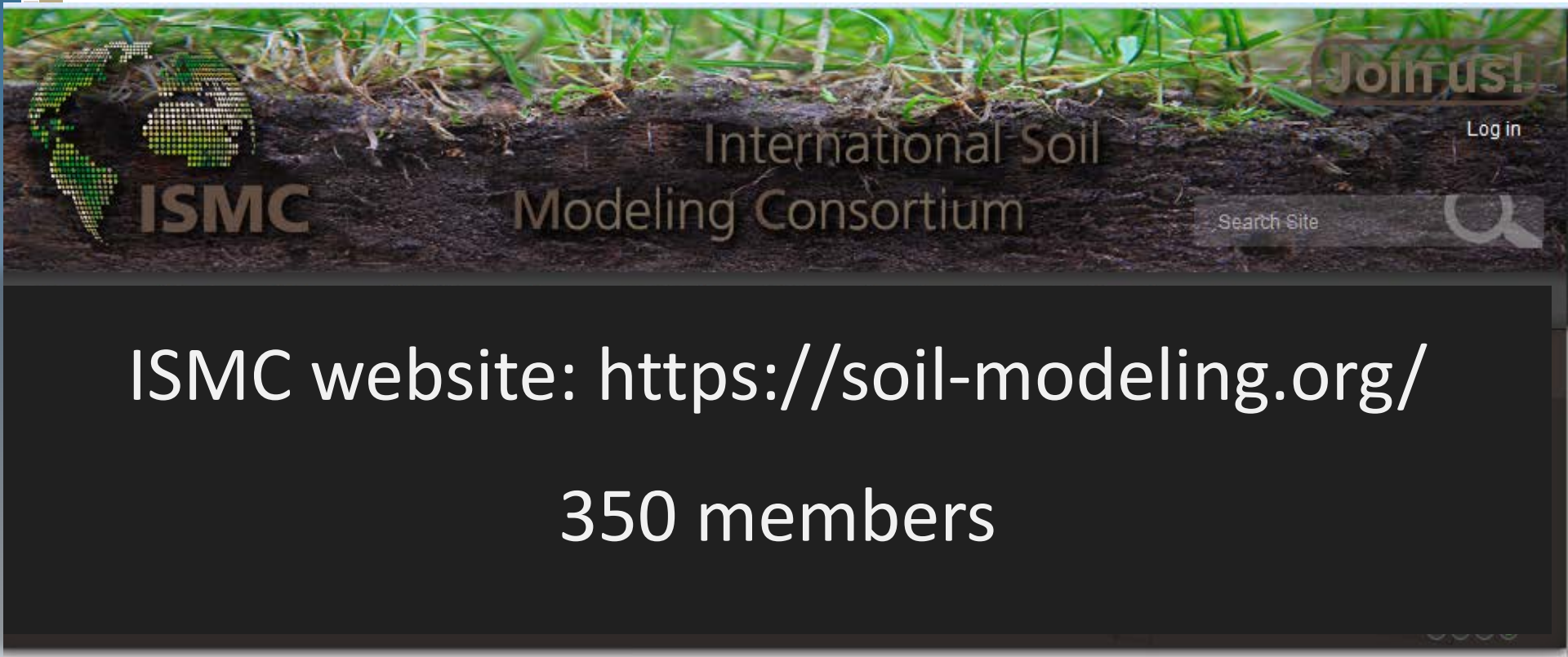
Core Ideas

- A community effort is needed to move soil modeling forward.
- Establishing an international soil modeling consortium is key in this respect.
- There is a need to better integrate existing knowledge in soil models.
- Integration of data and models is a key challenge in soil modeling.

Modeling Soil Processes: Review, Key Challenges, and New Perspectives

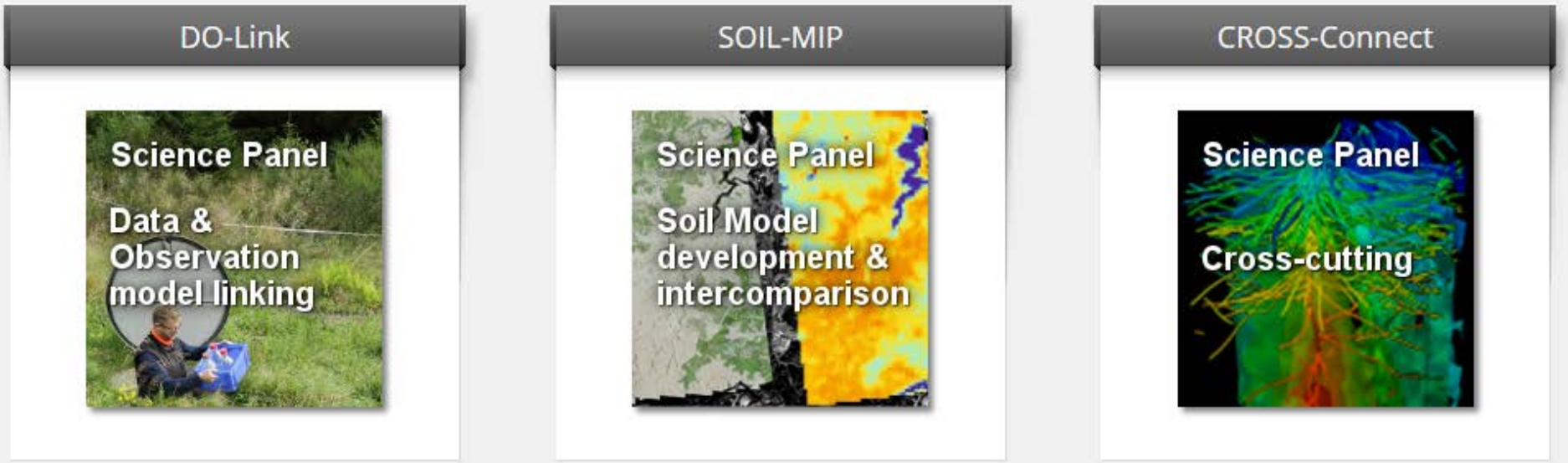
H. Vereecken,* A. Schnepf, J.W. Hopmans, M. Javaux, D. Or, T. Roose, J. Vanderborght, M.H. Young, W. Amelung, M. Aitkenhead, S.D. Allison, S. Assouline, P. Baveye, M. Berli, N. Brüggemann, P. Finke, M. Flury, T. Gaiser, G. Govers, T. Ghezzehei, P. Hallett, H.J. Hendricks Franssen, J. Heppell, R. Horn, J.A. Huisman, D. Jacques, F. Jonard, S. Kollet, F. Lafolie, K. Lamorski, D. Leitner, A. McBratney, B. Minasny, C. Montzka, W. Nowak, Y. Pachepsky, J. Padarian, N. Romano, K. Roth, Y. Rothfuss, E.C. Rowe, A. Schwen, J. Šimůnek, A. Tiktak, J. Van Dam, S.E.A.T.M. van der Zee, H.J. Vogel, J.A. Vrugt, T. Wöhling, and I.M. Young

The remarkable complexity of soil and its importance to a wide range of ecosystem services presents major challenges to the modeling of soil processes. Although major progress in soil models has occurred in the last decades, models of soil processes remain disjointed between disciplines or ecosystem services, with considerable uncertainty remaining in the quality of predictions and several challenges that remain yet to be addressed.



ISMC website: https://soil-modeling.org/

350 members



Integrating soil and subsurface processes in OLAM-SOIL:

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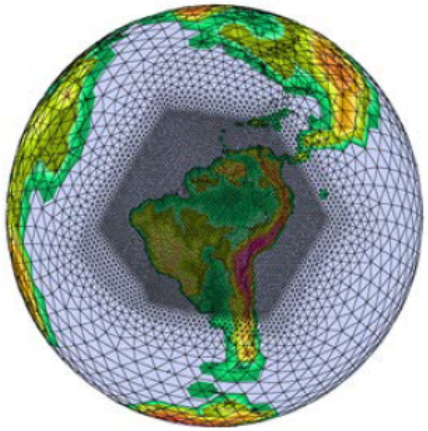
- **Schedule:**
  - OLAM presentation – 9:00-10:00
  - Key databases and formats – 10:00-11:00
  - OLAM-SOIL expansion and future 11:00-12:00
  - Lunch break (*catered in the room*)
  - Generic OLAM-SOIL model run 13:00-14:30
  - OLAM-Soil – the role of soil structure case study 15:00-16:30
  - Summary and follow up 16:30-17:00



OLAM-SOIL Workshop AGU Fall meeting

New Orleans, December 2017

OLAM-SOIL training workshop: introduction and hands-on experiences using a state-of- the art global model with focus on soil and subsurface processes (*an AGU fall meeting ancillary activity sponsored by ISMC and GEWEX SOILWAT)*

- **Location and time**: Hilton New Orleans Riverside (***Newberry/Ascot 3rd floor***) - Saturday December 9 from 9:00-17:00
- **Schedule:**
  - OLAM presentation – 9:00-10:00
  - Key databases and formats – 10:00-11:00
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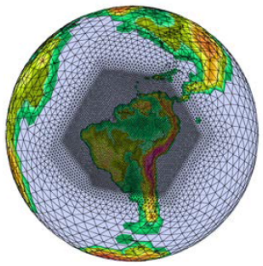


- **Model installation and requirements**: the main requirements to run the model are:
  - Linux (or equivalent) operating system
  - Fortran compiler (Intel Fortran is strongly recommended as others will likely have issues)
  - HDF5 library - https://support.hdfgroup.org/downloads/index.html
  - C compiler (gcc is fine - https://gcc.gnu.org/)
  - Optional: NCAR Graphics (aka NCL - http://www.ncl.ucar.edu/Download/) This graphics package is not required to run the model, but is convenient to produce visual output (MATLAB could also produce plots of OLAM output)
  - We will post and distribute model pre-uploading instructions for all participants

- **OLAM-SOIL website** - http://olam-soil.org/workshop-agu-2017/ (under development)
- **Instructors and format:** Drs. Robert Walko and Simone Fatichi – will conduct the demonstrations and hands-on examples (model pre-uploading will be provided to the registered participants)

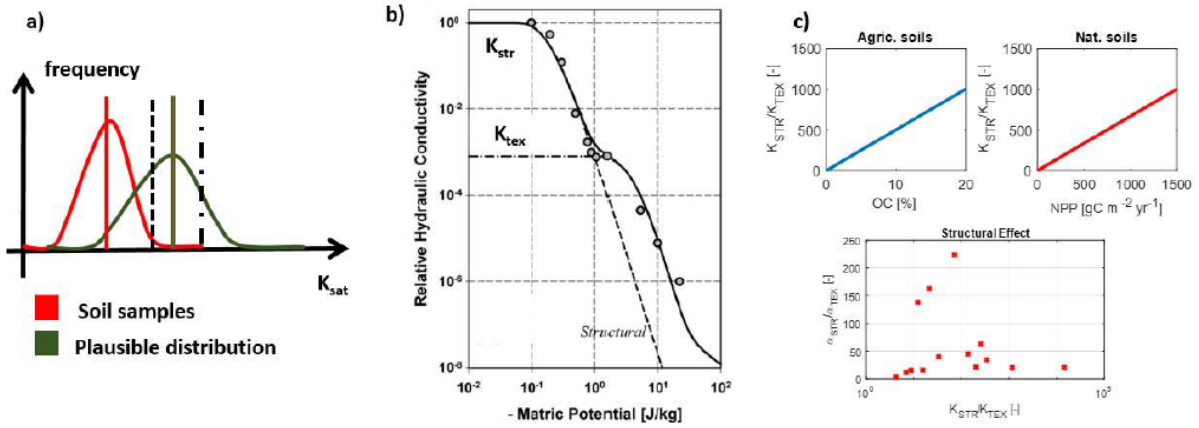
The OLAM-SOIL Team

Dani Or, Robert Walko, Simone Fatichi, Harry Vereecken, Stefan Kollet, Roni Avissar, Tom Hengl, Teamrat Ghezzehei, Michael Young and Kris van Looy (ISMC)

GEWEX

ISMC

The influence of soil structure on global climate…



- A simple addition of soil structure information by adjusting Ks for structured soils (correlated with vegetation cover) – changes the energy balance of surfaces globally!

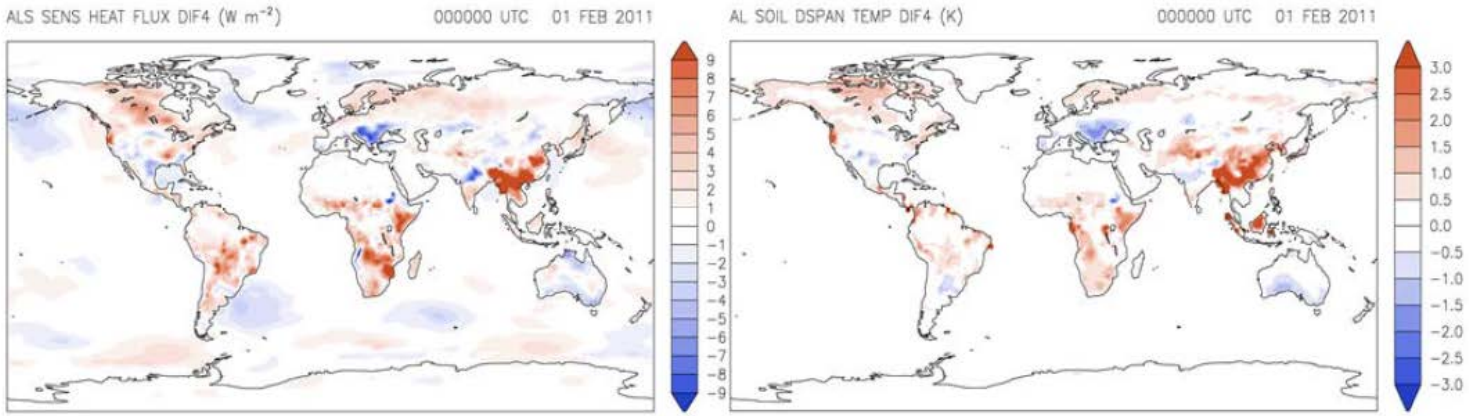


Fig. 6. *Global changes in sensible heat flux (left, W/m^2) and diurnal surface temperature range (right, K) when soil structure effects on loamy soils are considered (results are averages over 10 years).*