Soil structure – a neglected component of land-surface models

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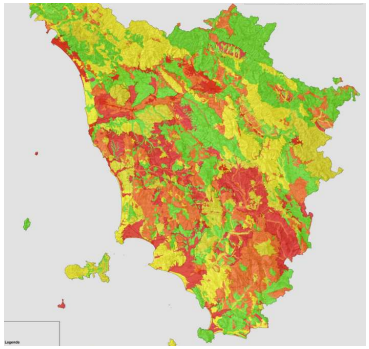
SOIL HYDRAULIC PROPERTIES

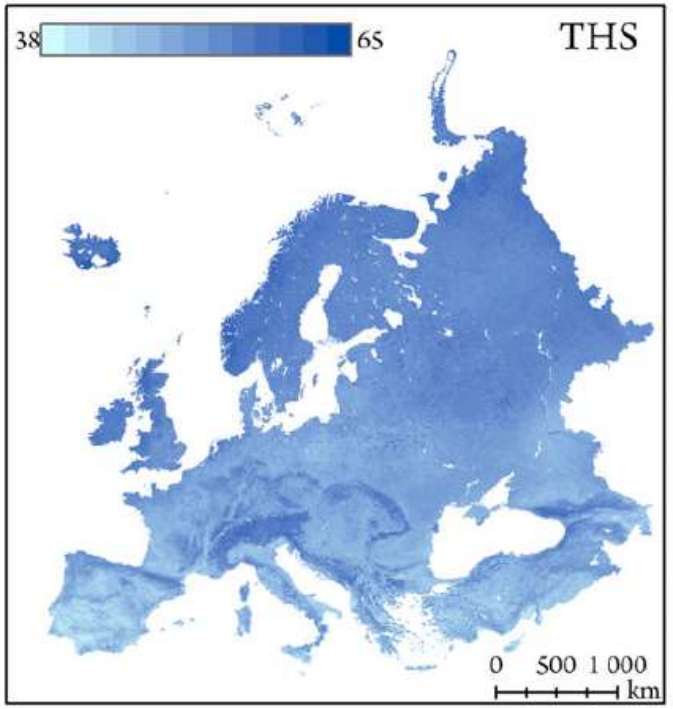
Sand Content [%]
Soil map Tuscany regions (IT)



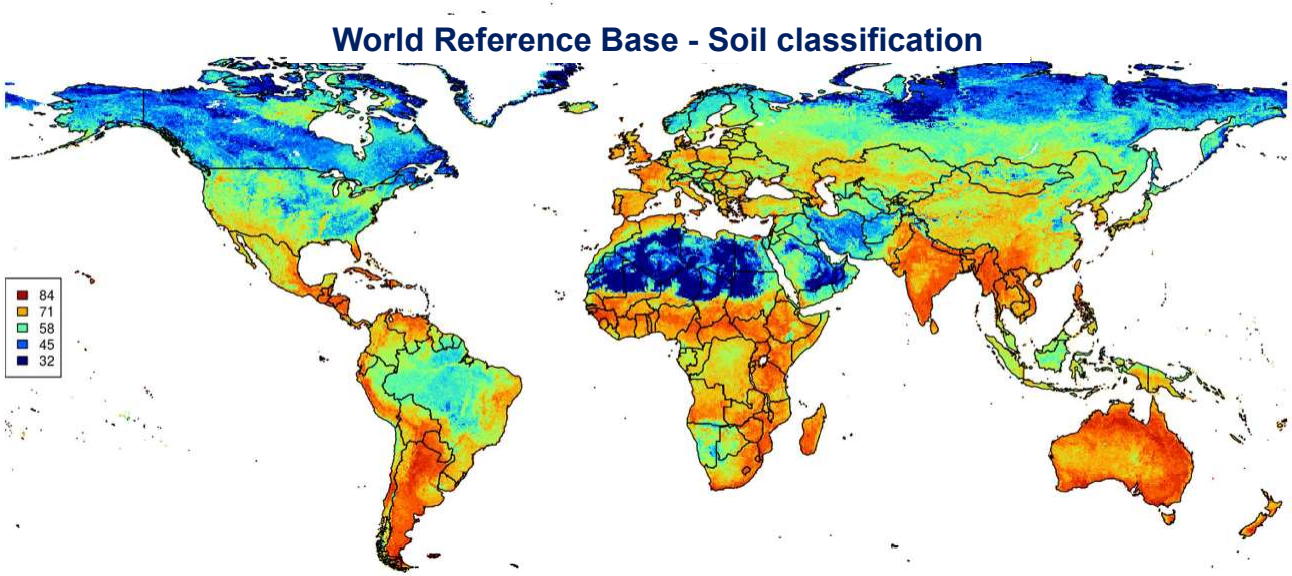
PTFs

Toth et al 2017 *Hydrol. Proces.*

Saturated Water Content, θ_{sat} [-]



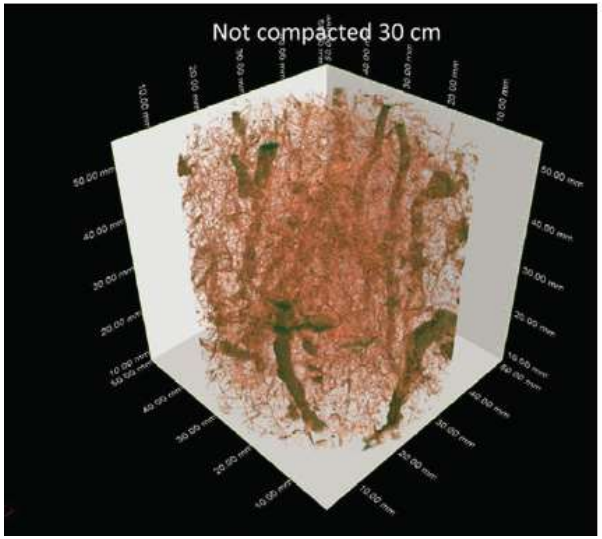
World Reference Base - Soil classification



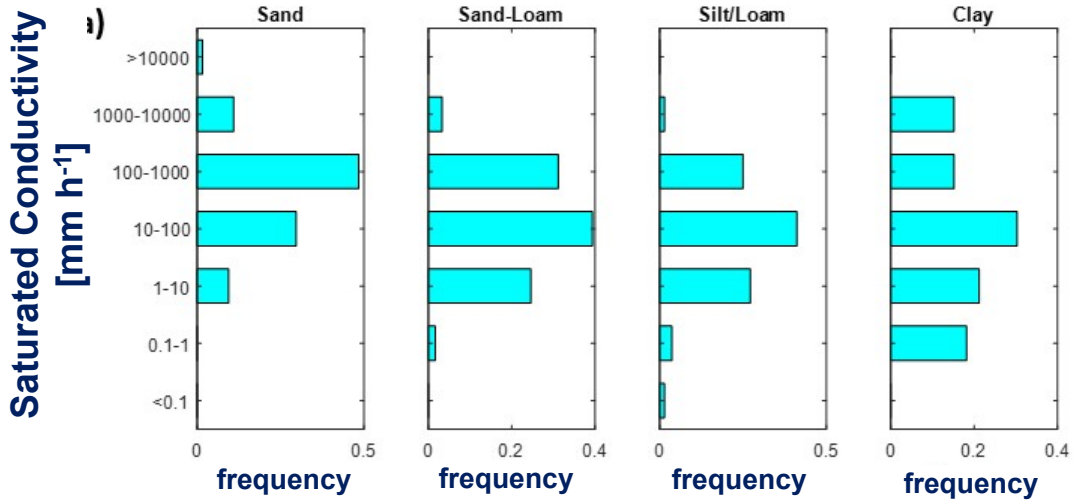
Hengl et al 2017 *PLOS one*

Soil structure: an importance absence in Land Surface Models

Keller et al. 2017 *VZJ*



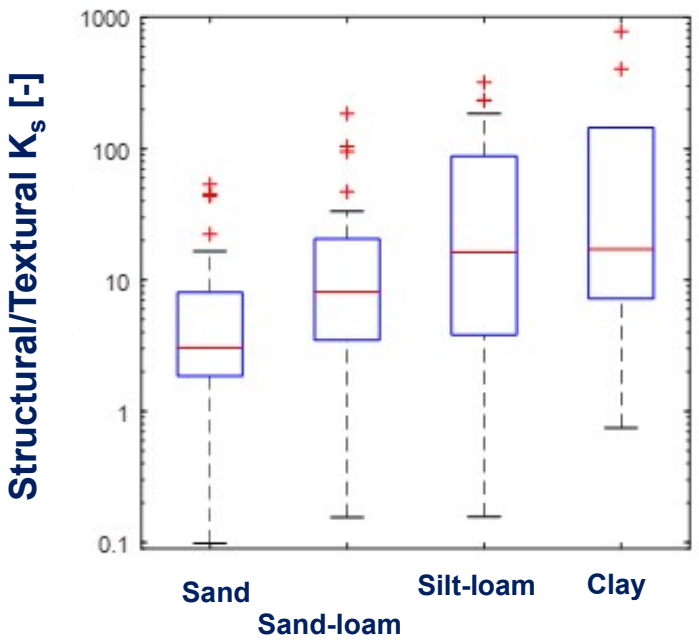
UNSODA database – Undisturbed samples

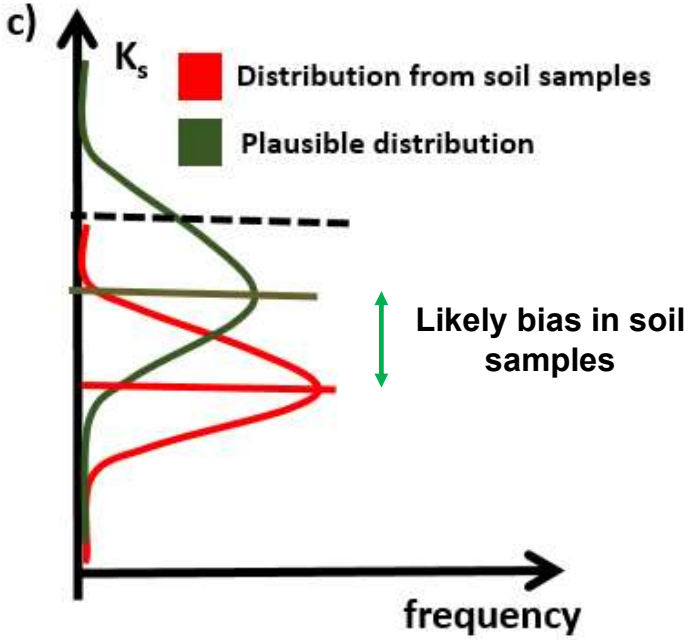


Data from Nemes et al 2001; *JoH*

Soil structure: an importance absence in Land Surface Models

Effect of soil structure on saturated hydraulic conductivity





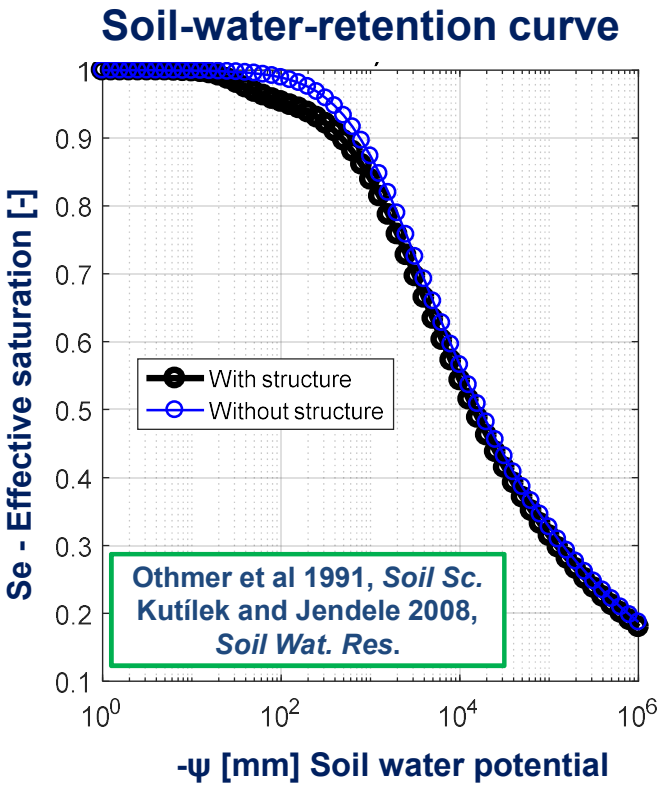
Data from Weynants et al 2009; *VZJ*

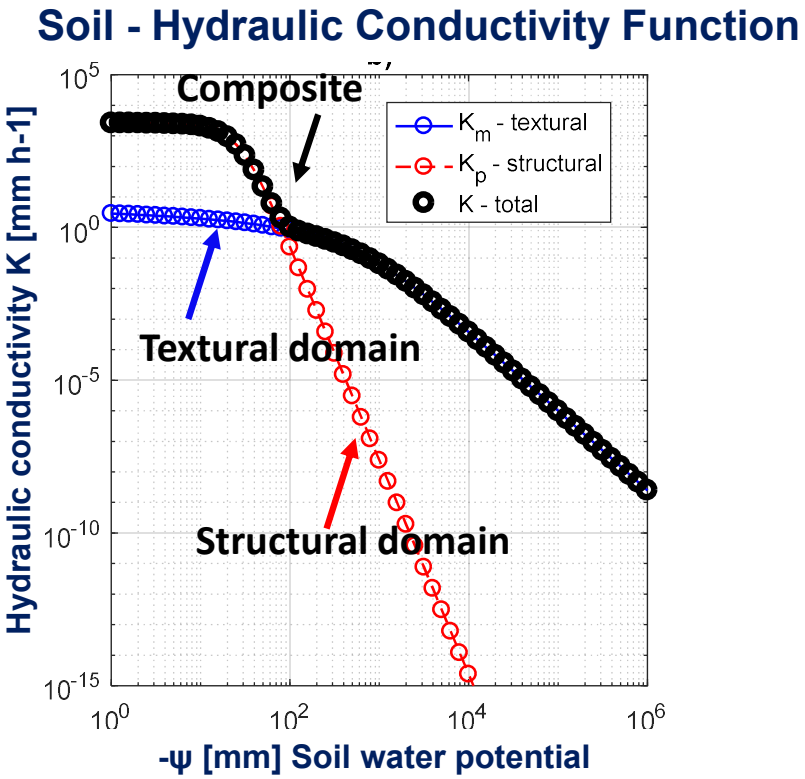
RESEARCH QUESTIONS

Does introducing soil-structure modify the hydrological and land-surface fluxes?

Could soil structure affect large-scale climate?

Modifying soil-hydraulic functions

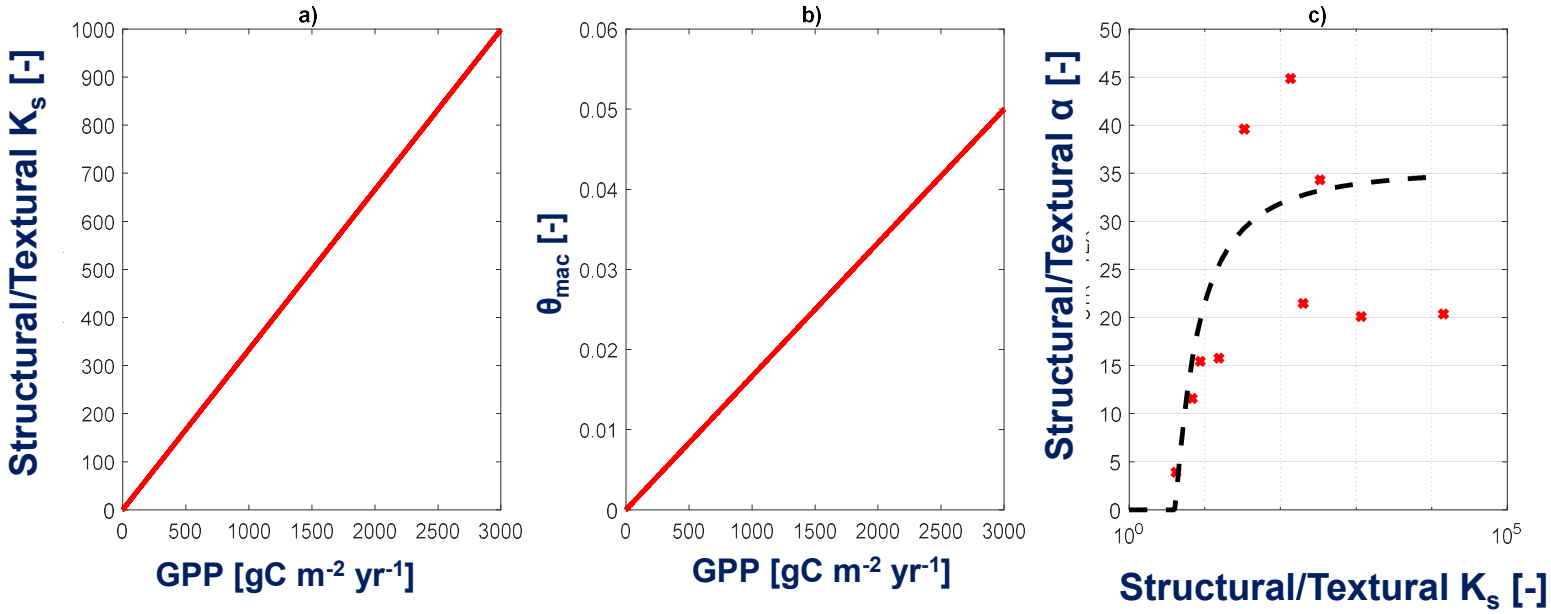




Modifying soil-hydraulic functions

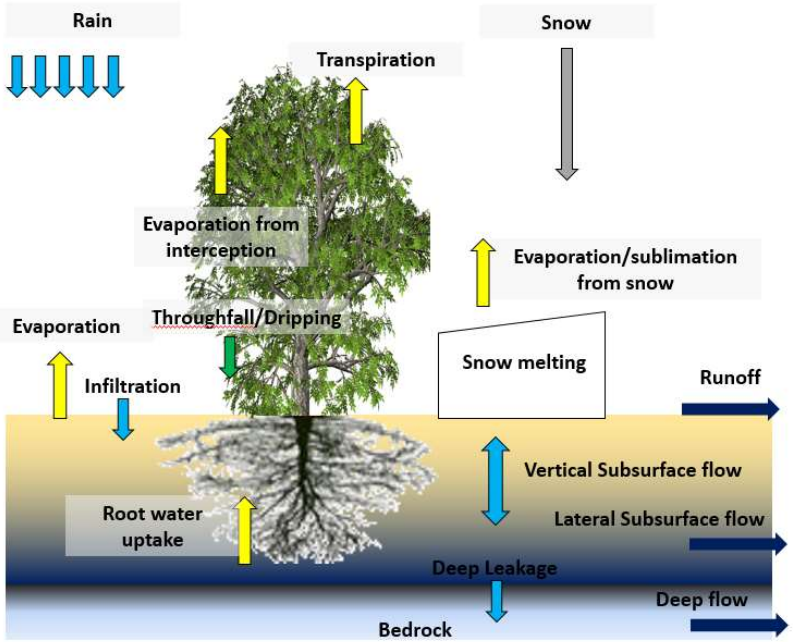
GPP (Gross Primary Production)

Additional Parameters: $K_{s,str}$ θ_{mac} α_{str} n_{str}



MECHANISTIC TERRESTRIAL ECOSYSTEM MODEL

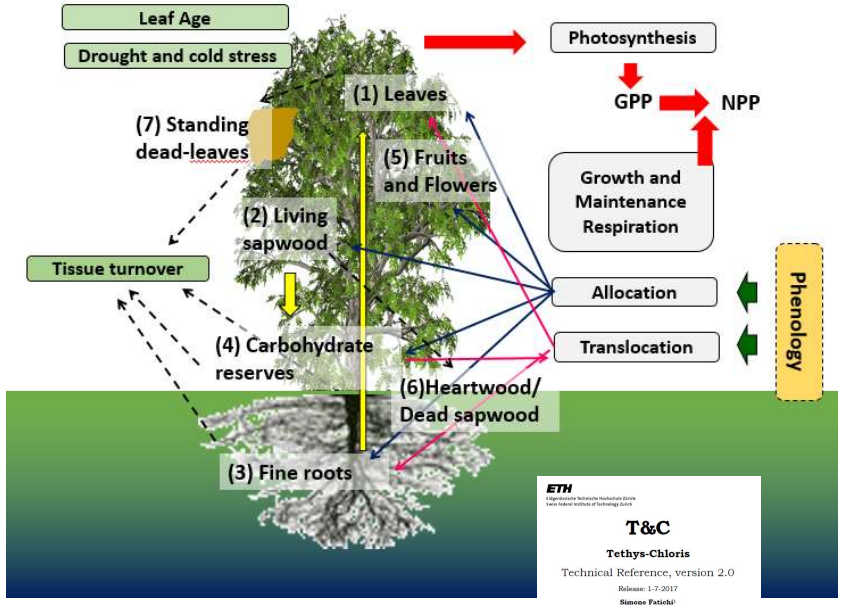
Hydrological Part



Fatichi et al., 2012a,b, *J. Advances in Modeling Earth Systems*
Fatichi and Leuzinger 2013, *Agr. For. Met.*
Fatichi et al., 2014, *WRR;* Fatichi and Ivanov 2014, *WRR;*
Fatichi et al 2016, *PNAS*
Pappas et al. 2016 *NP;* Paschalis et al. 2015 *JGR*
Fatichi and Pappas, 2017, *GRL*
Mastrotheodoros et al 2017, *JGR*

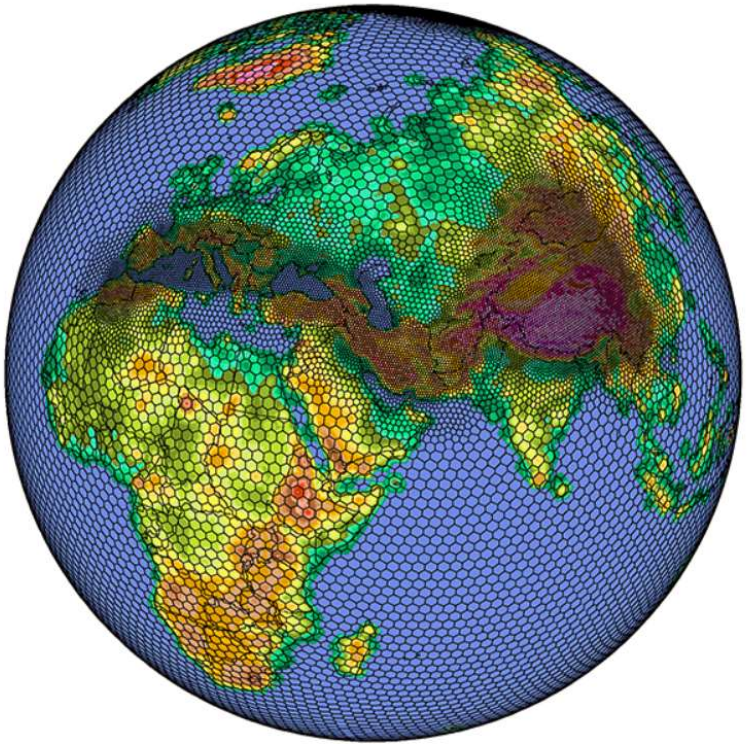
Tethys-Chloris (T&C)

Vegetation Part



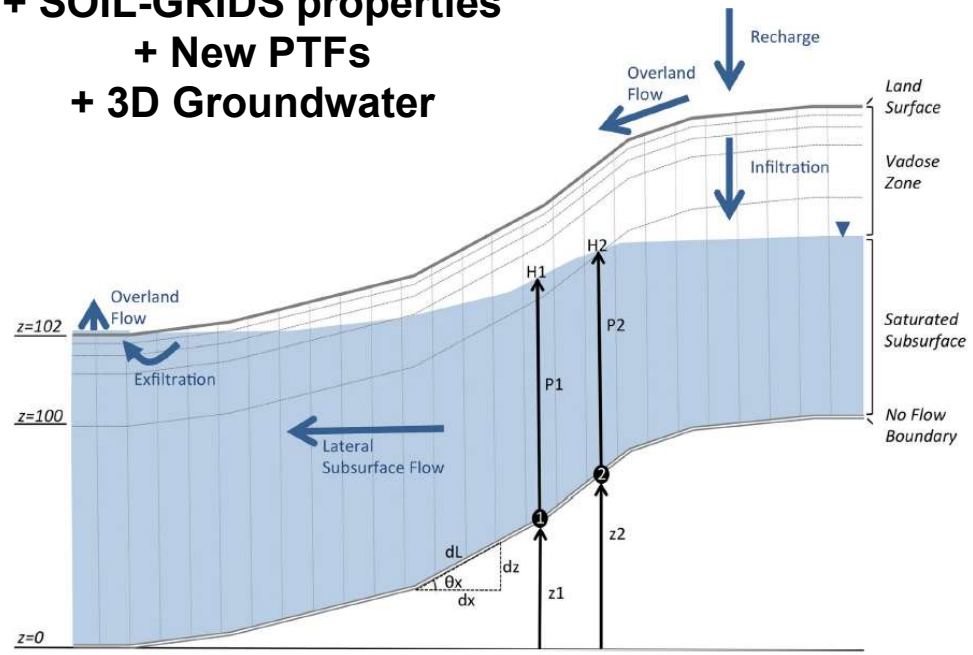
Technical Reference

GLOBAL OCEANIC-ATMOSPHERIC MODEL OLAM-SOIL



Walko and Avissar 2008a,b 2011; *Month. Weath. Rev.*

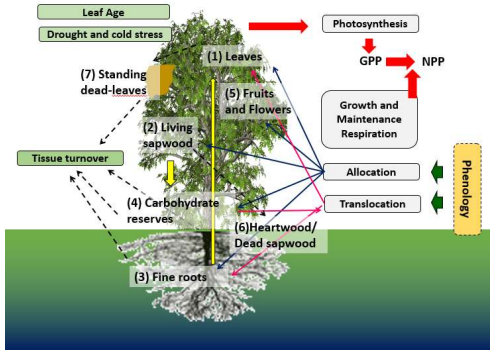
+ SOIL-GRIDS properties
+ New PTFs
+ 3D Groundwater



Condon and Maxwell 2015, *WRR*

Design of the Experiment

20 locations with different biomes and climates



T&C

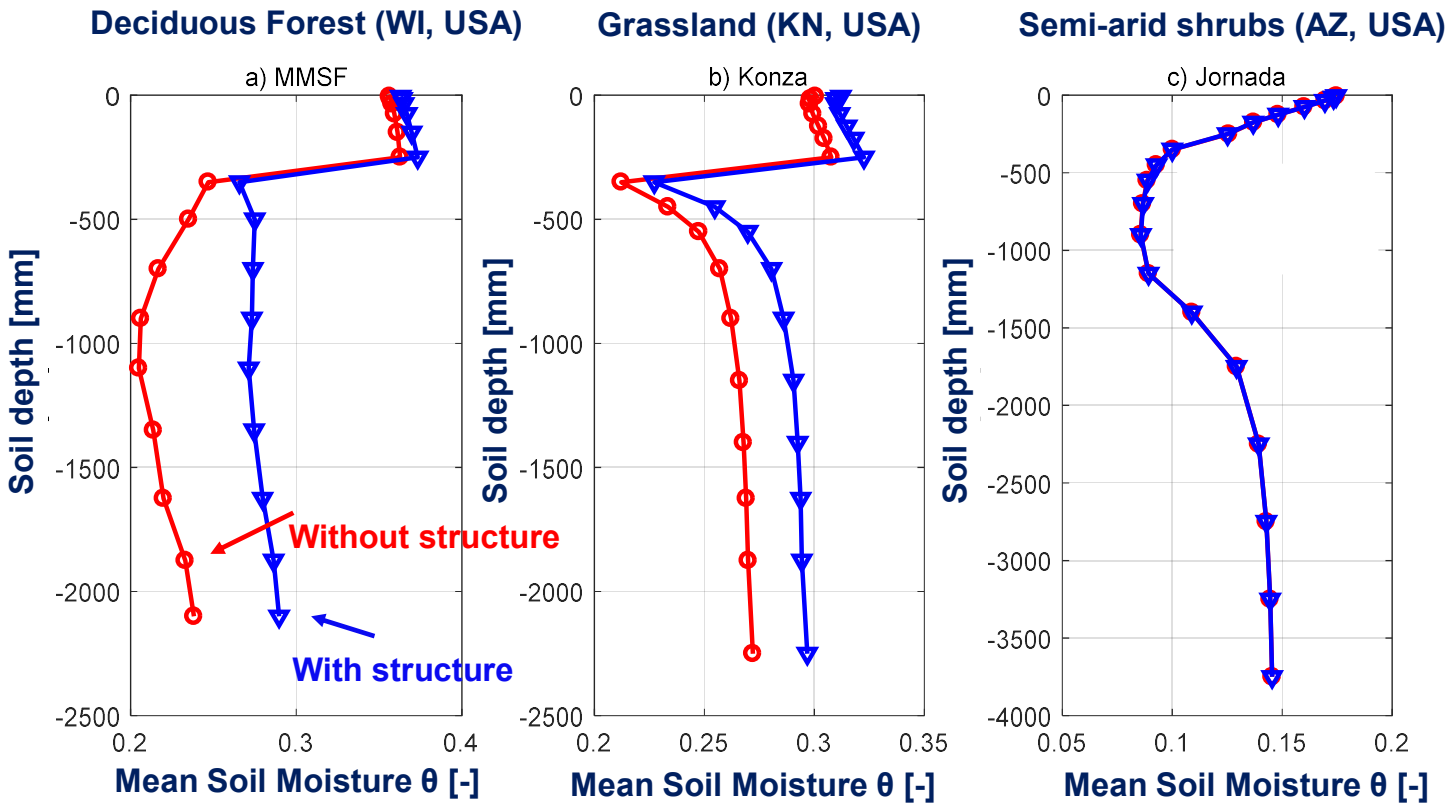
1) **Soil texture** from SOIL-GRIDS and PTFs HiHydroSoil**. No-soil structure.**
2) **Soil texture** from SOIL-GRIDS and PTFs HiHydroSoil. **With parameterized soil-structural effects.**
3) **Original T&C** with local soil properties and tuning.

Global-scale simulations

OLAM-SOIL

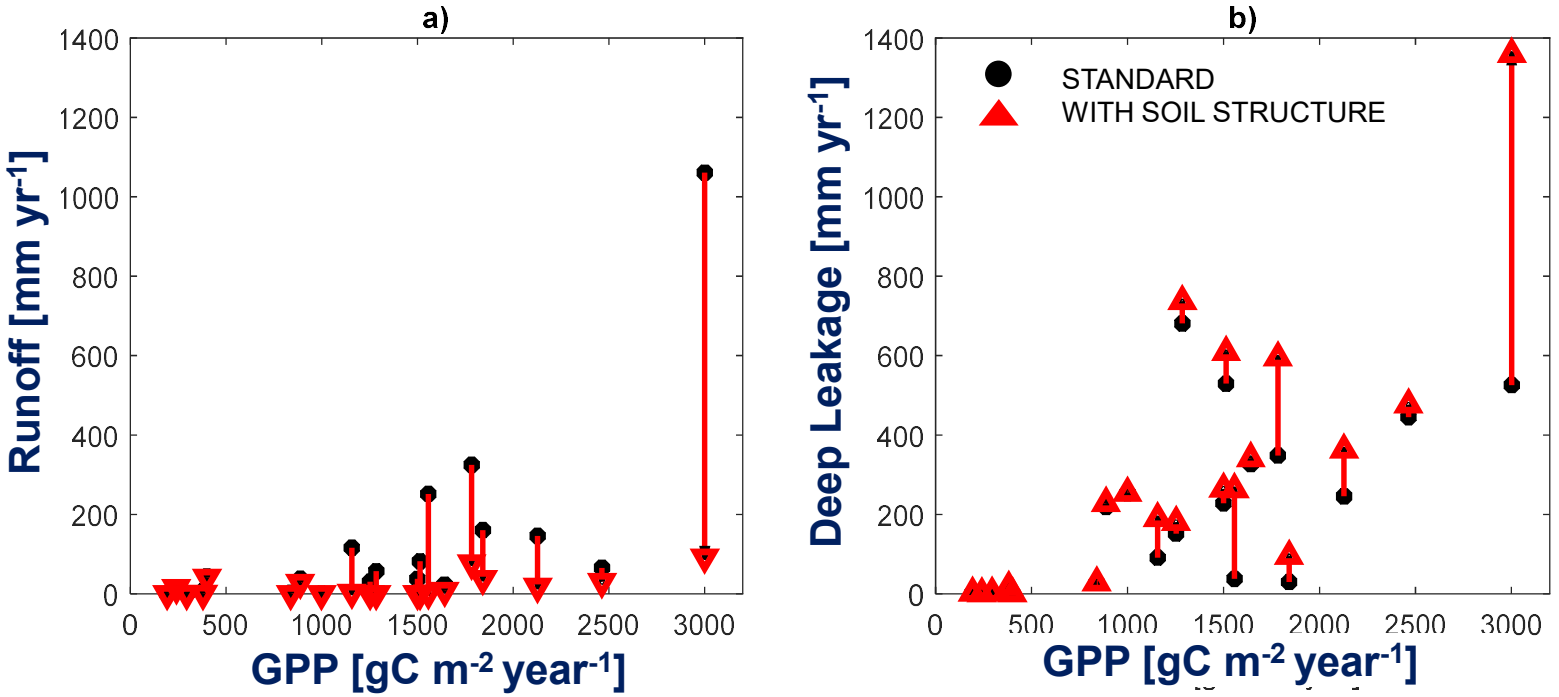
1) **Soil texture - No-soil structure.**
2) **Soil texture with parameterized soil-structural effects.**

Changes in the soil water content profile



T&C Simulations with hydraulic properties from global SOIL-GRIDS map

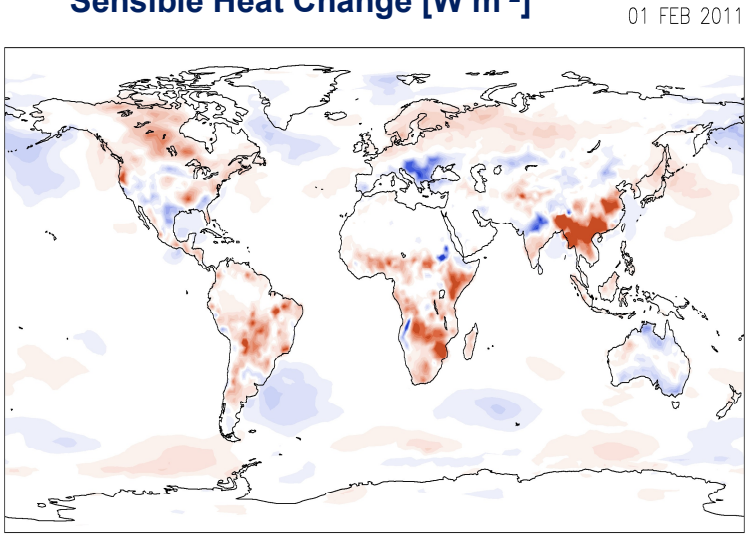
Changes in the partition between runoff and recharge



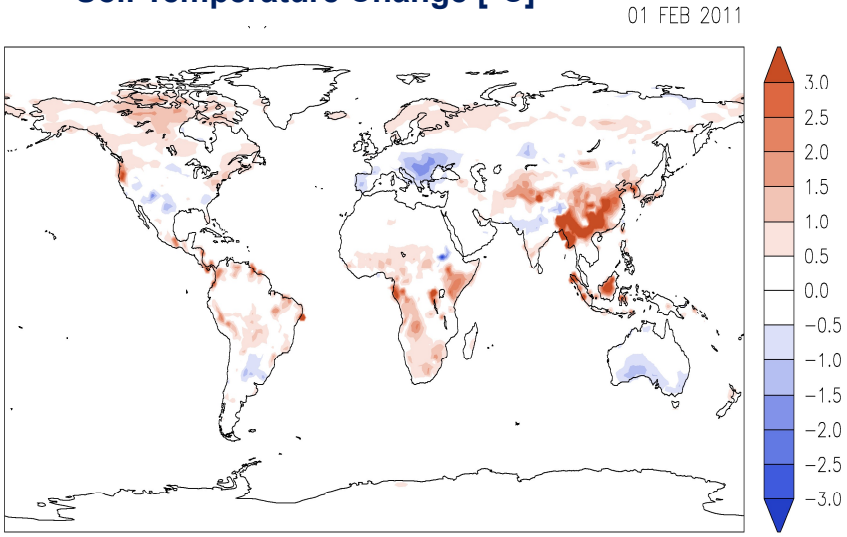
T&C Simulations with hydraulic properties from global SOIL-GRIDS map

Soil structure: large-scale implications

Sensible Heat Change [W m^{-2}]



Soil Temperature Change [°C]



OLAM-SOIL Simulations

Simulations from Robert Walko

CONCLUSIONS

- **We tested a simple systematic solution that modifies soil hydraulic parameterization and accounts for soil structural features at ecosystem scale and thus can be used in land-surface models.**
- **Soil structural effects strongly modify the hydrological partition between fast surface runoff and recharge.**
- **Changes in runoff and groundwater recharge when are propagated spatially can affect regional energy fluxes and climate patterns.**
- **Small-scale soil structural features can have large-scale implications in water and carbon cycles and ultimately on climate.**

Fatichi et al., *In preparation*


Thanks for your
attention !