# Pedotransfer function perspectives in Earth system science

**PTF workshop ISMC - 10 Dec 2017,** AGU Fall Meeting

SOILWAT Initiative ISMC-GEWEX

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# What‘s a PTF?

- Inference based on basic soil properties
- Knowledge rule
- Tool to apply soil information

- Yet, Earth system is

complex environment with highly nonlinear processes

**Challenge:**
**- improved soil information**
**- improved understanding, detection**
**- improved data mining methods**

**‘Basic‘ soil properties**

texture

porosity

soil minerals

*organic matter*

*bulk density*

**PedoTransfer Function**

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**Hydraulic parameters**

e.g., water retention

hydraulic conductivity

**Solute transport parameters**

preferential flow

solute transport velocity

**Thermal parameters**

heat capacity

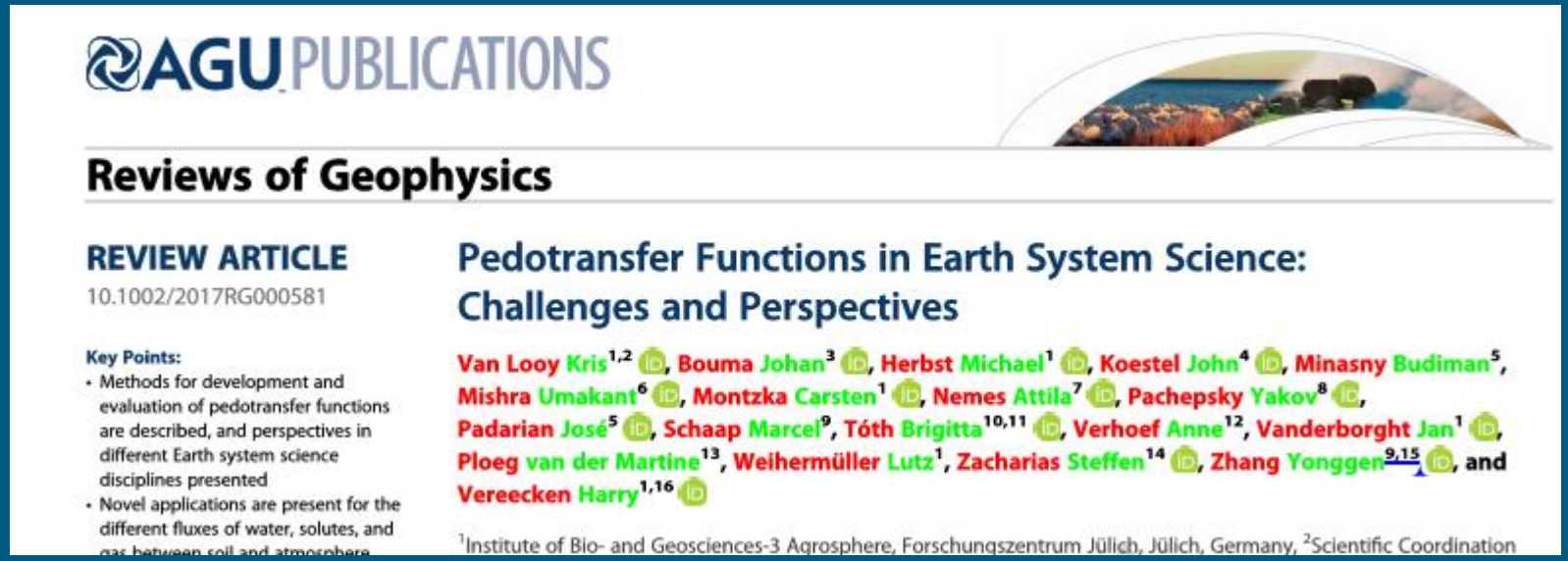
thermal conductivity

**Biogeochemical parameters**

adsorption isotherm

carbon stocks

# Challenges and Perspectives



AGU PUBLICATIONS

Reviews of Geophysics

REVIEW ARTICLE

10.1002/2017RG000581

Key Points:
- Methods for development and evaluation of pedotransfer functions are described, and perspectives in different Earth system science disciplines presented
- Novel applications are present for the different fluxes of water, solutes, and gas between soil and atmosphere

## Pedotransfer Functions in Earth System Science: Challenges and Perspectives

Van Looy Kris[1,2], Bouma Johan[3], Herbst Michael[1], Koestel John[4], Minasny Budiman[5], Mishra Umakant[6], Montzka Carsten[1], Nemes Attila[7], Pachepsky Yakov[8], Padarian José[5], Schaap Marcel[9], Tóth Brigitta[10,11], Verhoef Anne[12], Vanderborght Jan[1], Ploeg van der Martine[13], Weihermüller Lutz[1], Zacharias Steffen[14], Zhang Yonggen[9,15], and Vereecken Harry[1,16]

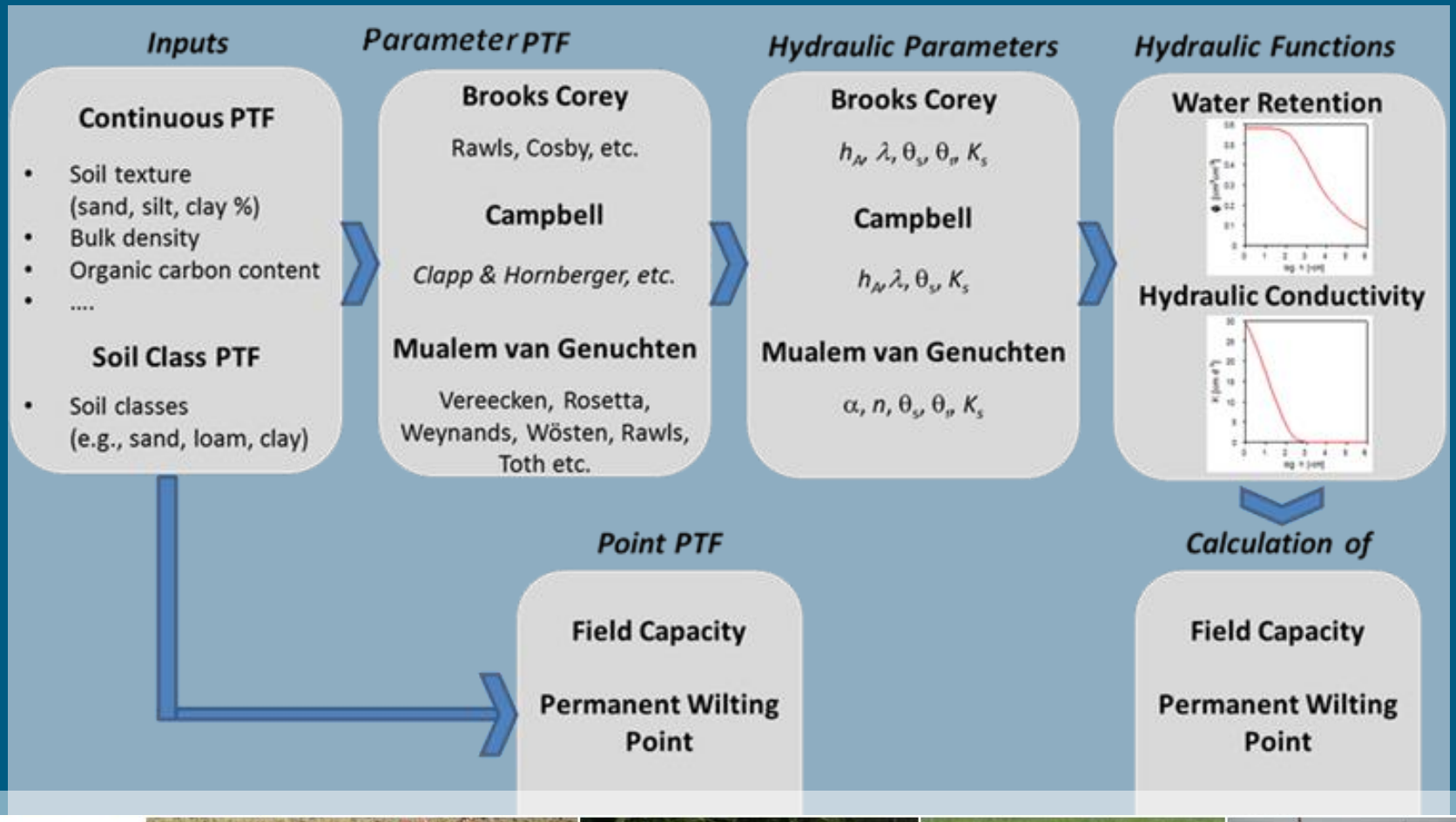
[1]Institute of Bio- and Geosciences-3 Agrosphere, Forschungszentrum Jülich, Jülich, Germany, [2]Scientific Coordination

‚Current rudimentary representation of hydrologic and soil processes in ESM land models limits our capability to simulate land-atmosphere fluxes and biochemical cycles‘ Clark ea. 2015 WRR.

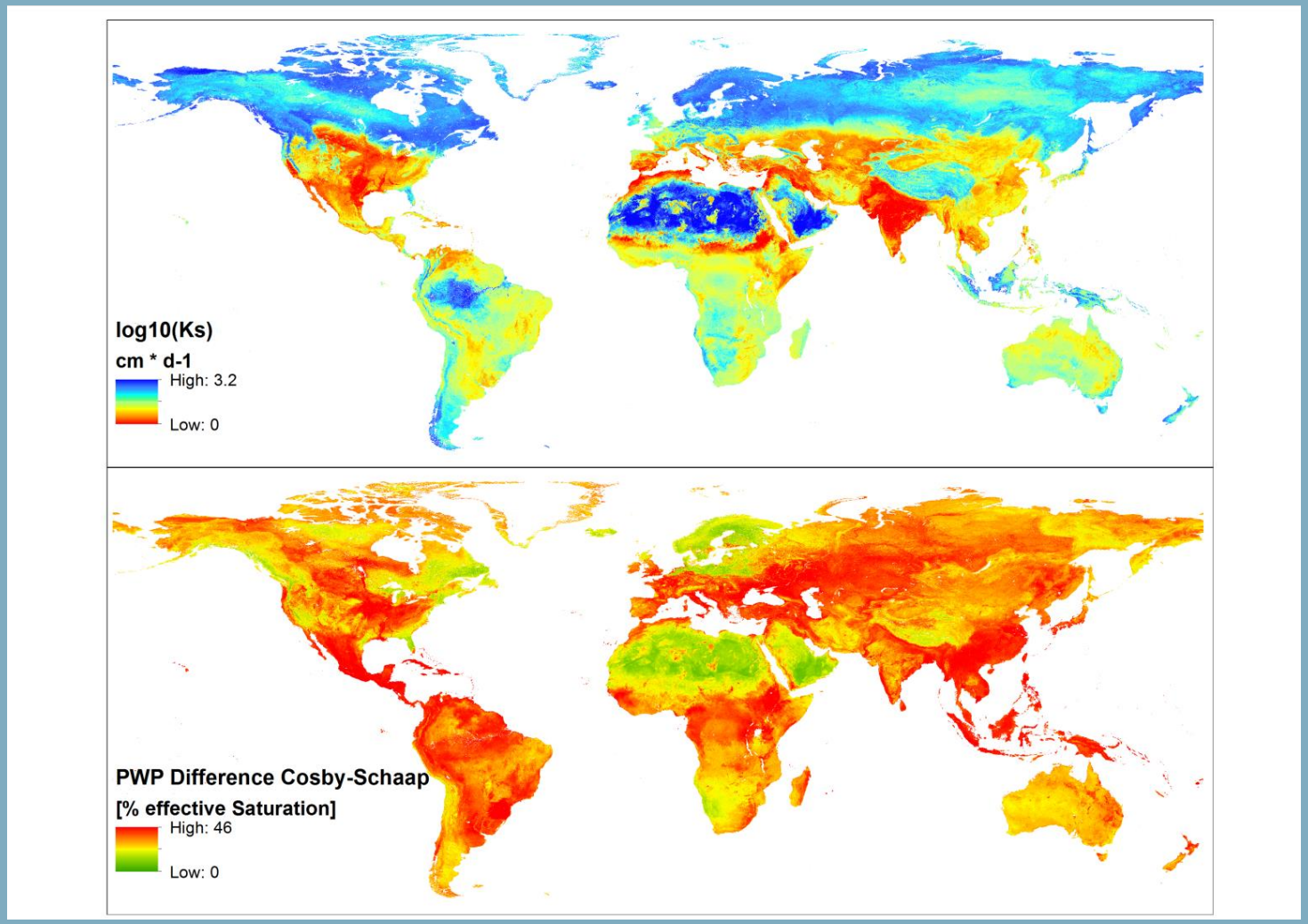
Timely effort:

- Many new PTF identifications: heat exchange, root density/water uptake, carbon decomposition
- New data at hand at high resolution
- New technological developments in sensing/identification relationships

# The classics... we will focus novel applications



# With global modeling challenges, the input matters, and the method



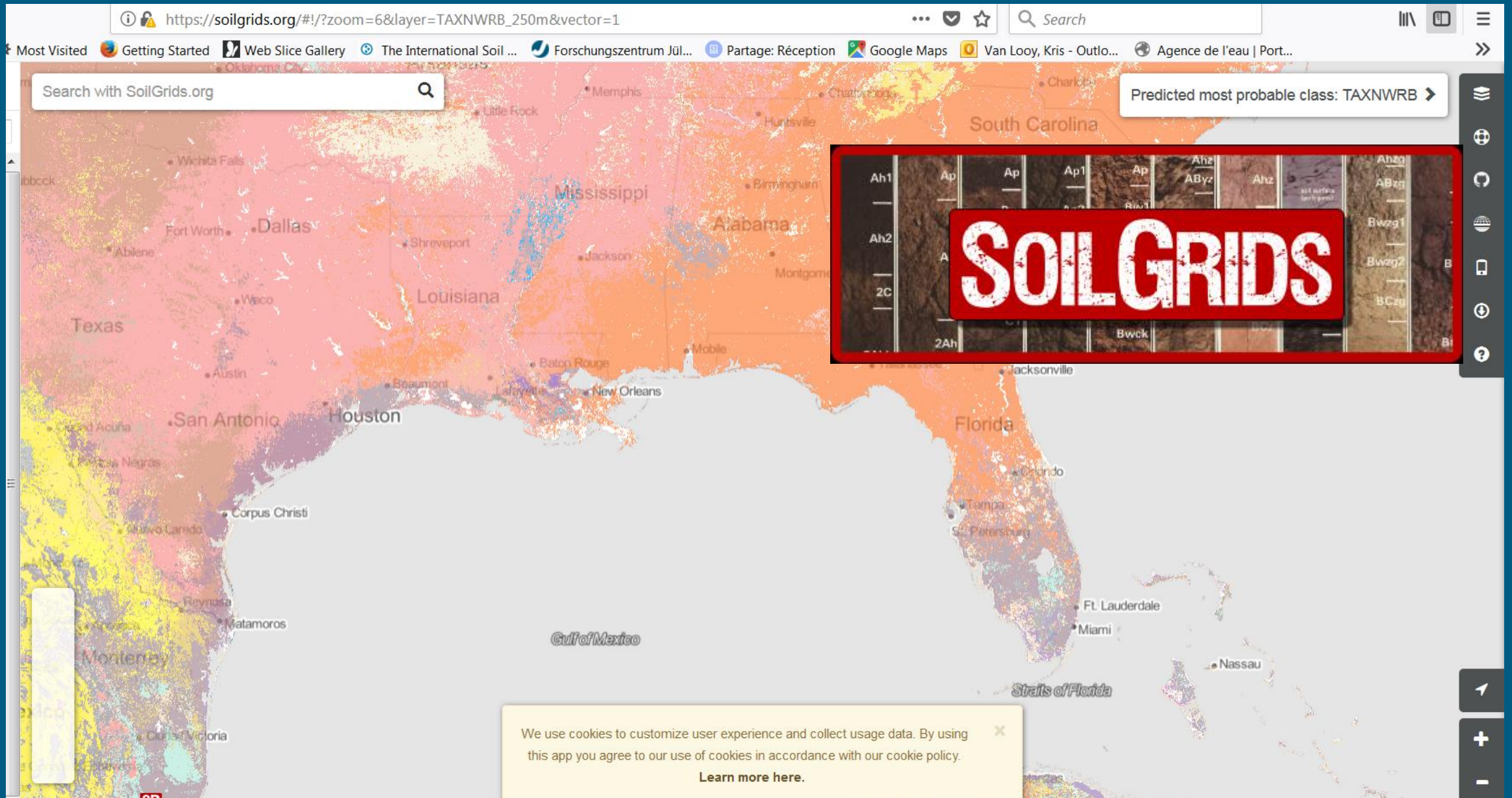

Montzka, C., M. Herbst, L. Weihermüller, A. Verhoef & H. Vereecken (2017), A global data set of soil hydraulic properties and sub-grid variability of soil 2012. A pseudo-continuous neural network approach for developing water retention pedotransfer functions with limited data. Journal of Hydrology 442

# A global data/analysis question

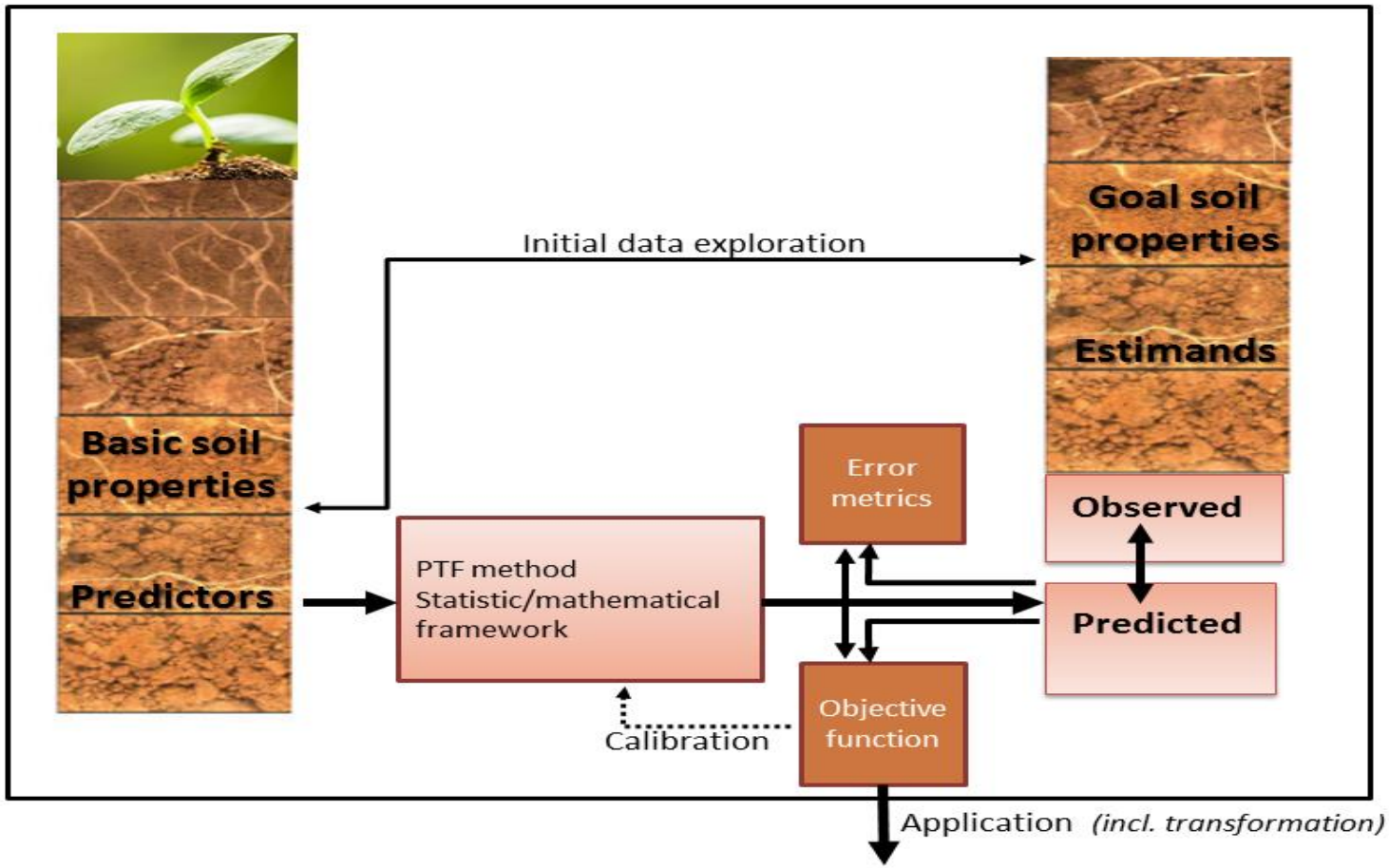
Global Critical Zone Exploration Network

CZEN

# Global soil databases



# PTF development methods

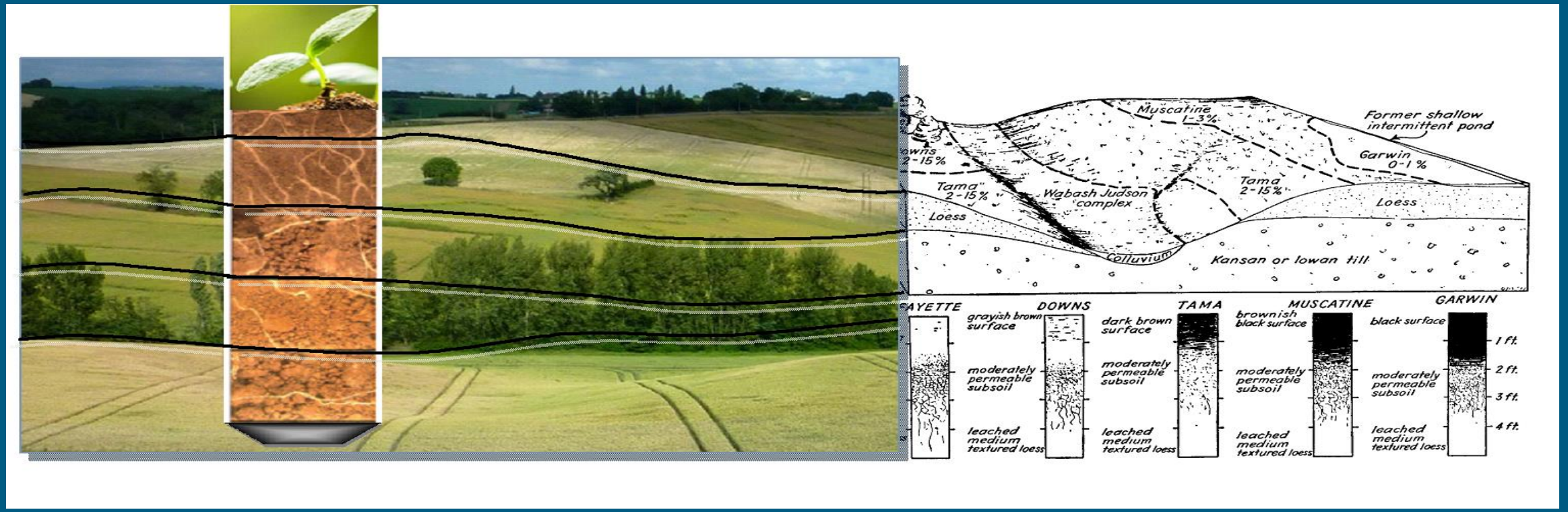



Look-up table
Linear regression
BRT
ANN

No best..
depends on conditions/ datasets

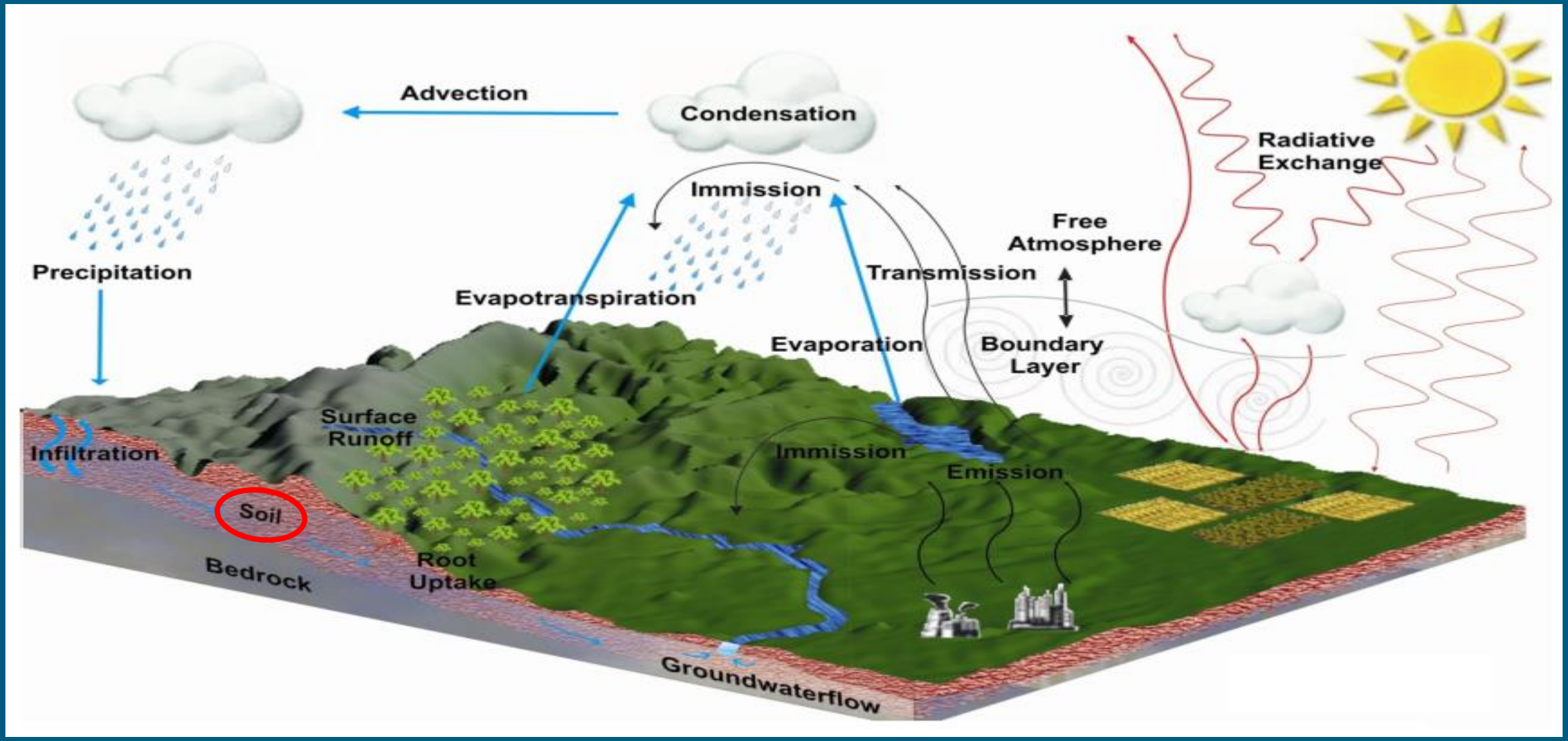
new data acquisition and data mining techniques, allow for a wide range of novel developments and applications.

# PTFs still serve for agricultural schemes, but challenges are mainly for wider applications, needing improved extrapolation and upscaling




PTF development has to go hand in hand with suitable extrapolation and upscaling techniques such that the PTFs correctly represent the spatial heterogeneity of soils.

# Earth system models: soils govern crucial exchanges



# Land Surface Model processes infered with PTFs

**soil information is rich and abundant!**

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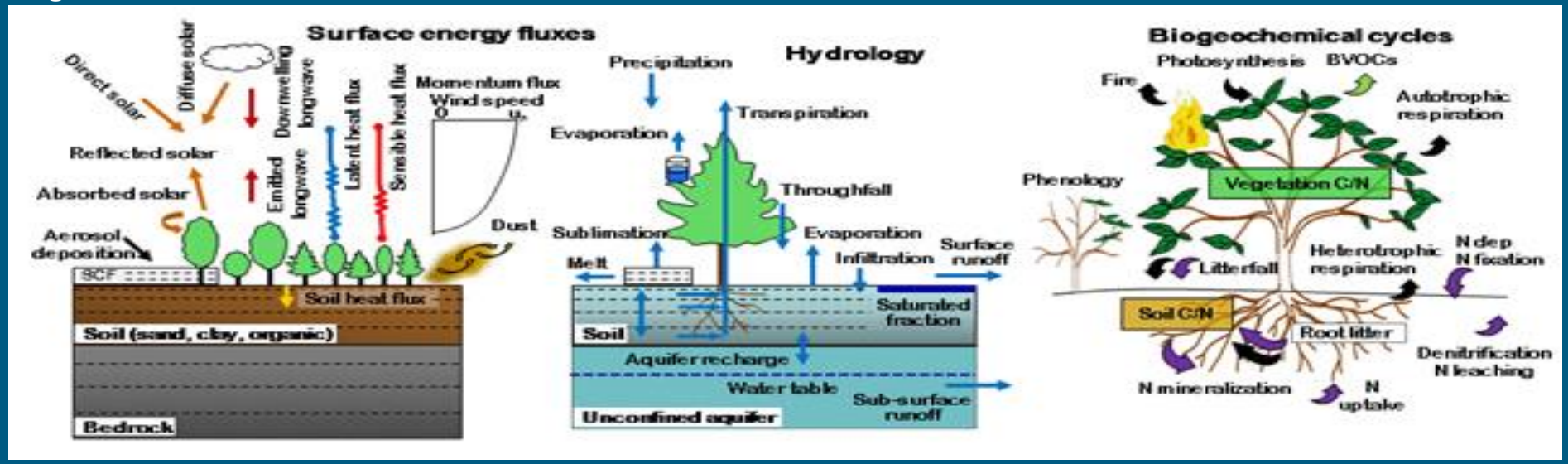
Heat exchange

Water flow

Solute transport

Vegetation Water content

Vegetation water uptake




Root density

Water retention capacity

Soil Organic Carbon storage

Decomposition

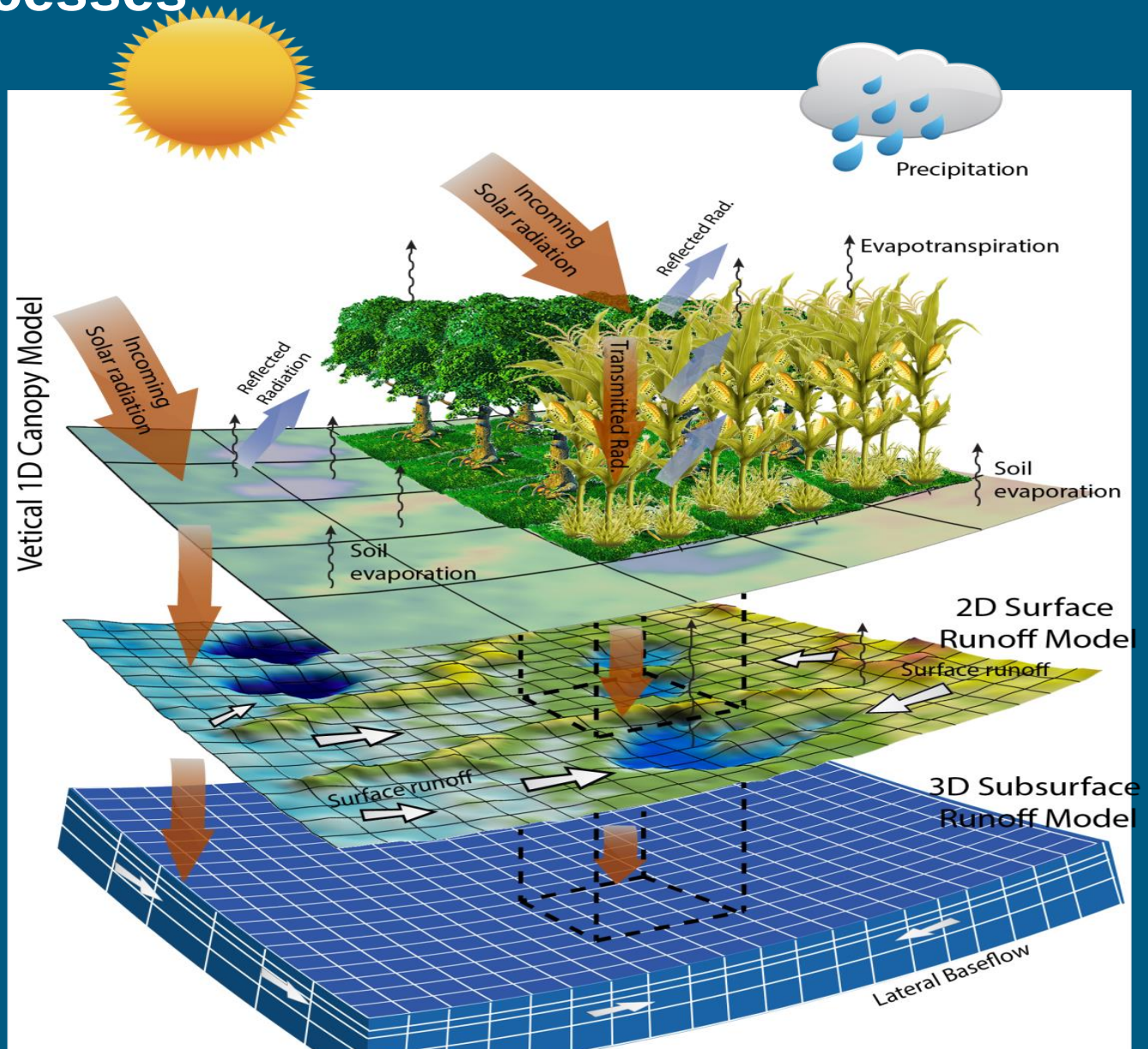
Mineralization

Run-off

Water erosion

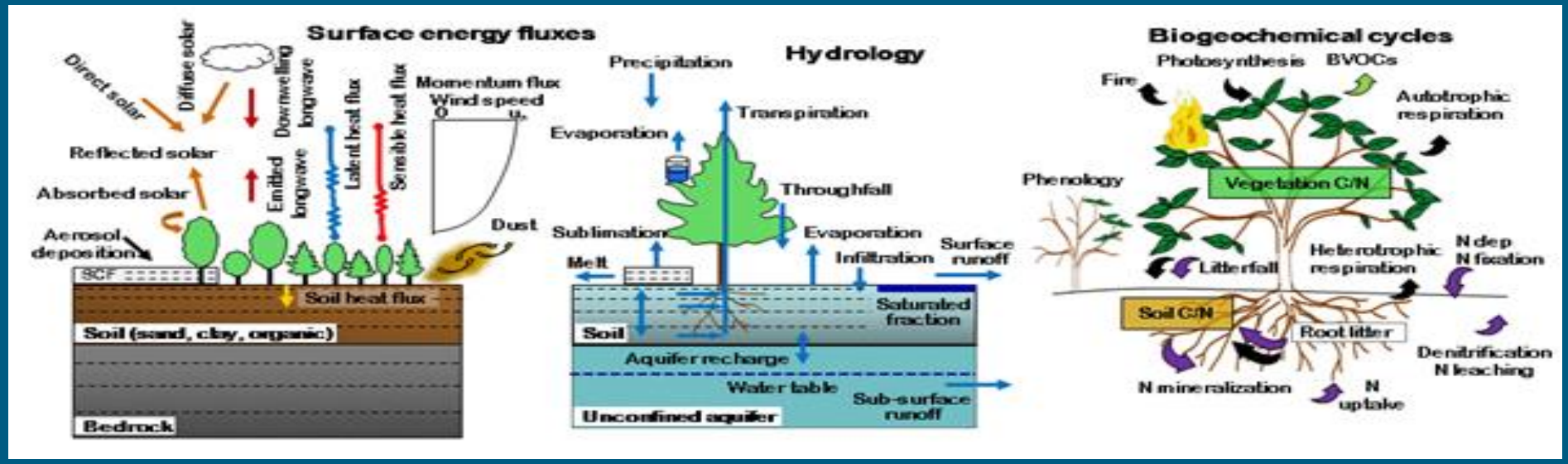
# Models are coupled for their processes

- Care needed for PTFs used; Carsten‘s image
- Suites of PTFs could be proposed for LSMs

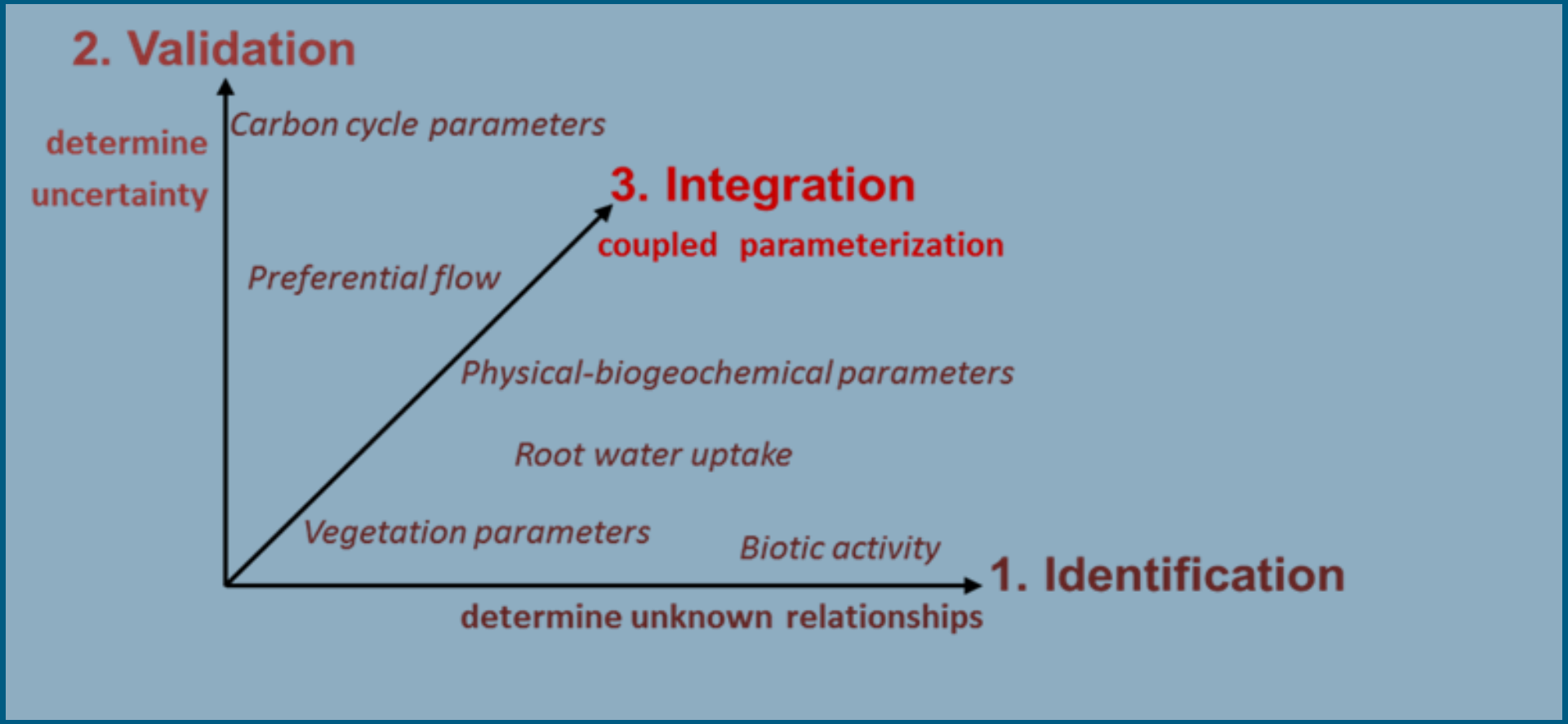


# Towards a suite of PTFs

- Coupled dynamics related to basic soil properties; like Carbon and nutrient cycling processes
- But also energy, hydrology and biogeochemical cycles are ‚coupled' and ‚gridded' at soil unit



# Key research perspectives



# Agenda for the ISMC PTF Workshop conference pre-AGU

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- Introduction: (H. Vereecken) 9.00
- Pedotransfer functions perspectives: K. van Looy 9.10
- PTFs for water related processes: (Y. Zhang)
- PTFs for energy related processes: (A. Verhoef)
- On the role of structure in PTFs: (J. Koestel)
- PTFs for infiltration processes (Lutz Weihermüller/Herbst)
- Methodological challenges for PTFs (A. Nemes)
- Informing LSMs using soil observations and geospatial science (U. Mishra)
- Global mapping / modeling possibilities (Carsten Montzka)

Lunch break
Afternoon:  present new projects and future perspectives: round table discussions.

Discussion:
Where from here with group of PTF developers
Where from here with SOILWAT
Where can ismc help/invest

Topics:
1) hydrology, 2) methodological advancements, 3) soil structure/soil data, 4) Land Surface Models,5) broader perspectives C-N cycling, vegetation

Discussing needs for 1) identification, 2) validation, 3) integration

Like infiltration paper, addressing LSM community where improvements possible

Suggestion:
- White paper with identification/validation/integration needs
- Project ‚Suites of PTFs for LSMs‘

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# Many thanks
# for your attention!