



Soil infrastructure evolution and its effect on water transfer processes under contrasted tillage systems

PhD student: Nargish Parvin

Supervisors: Aurore Degré, Gilles Colinet, Sarah Garré and Bernard Bodson

Unit: Soil-Water Systems
Gembloux Agro-Bio Tech

University de Liège
Belgium



- **Soil infrastructure evolution and its effect on water transfer processes under contrasted tillage systems**

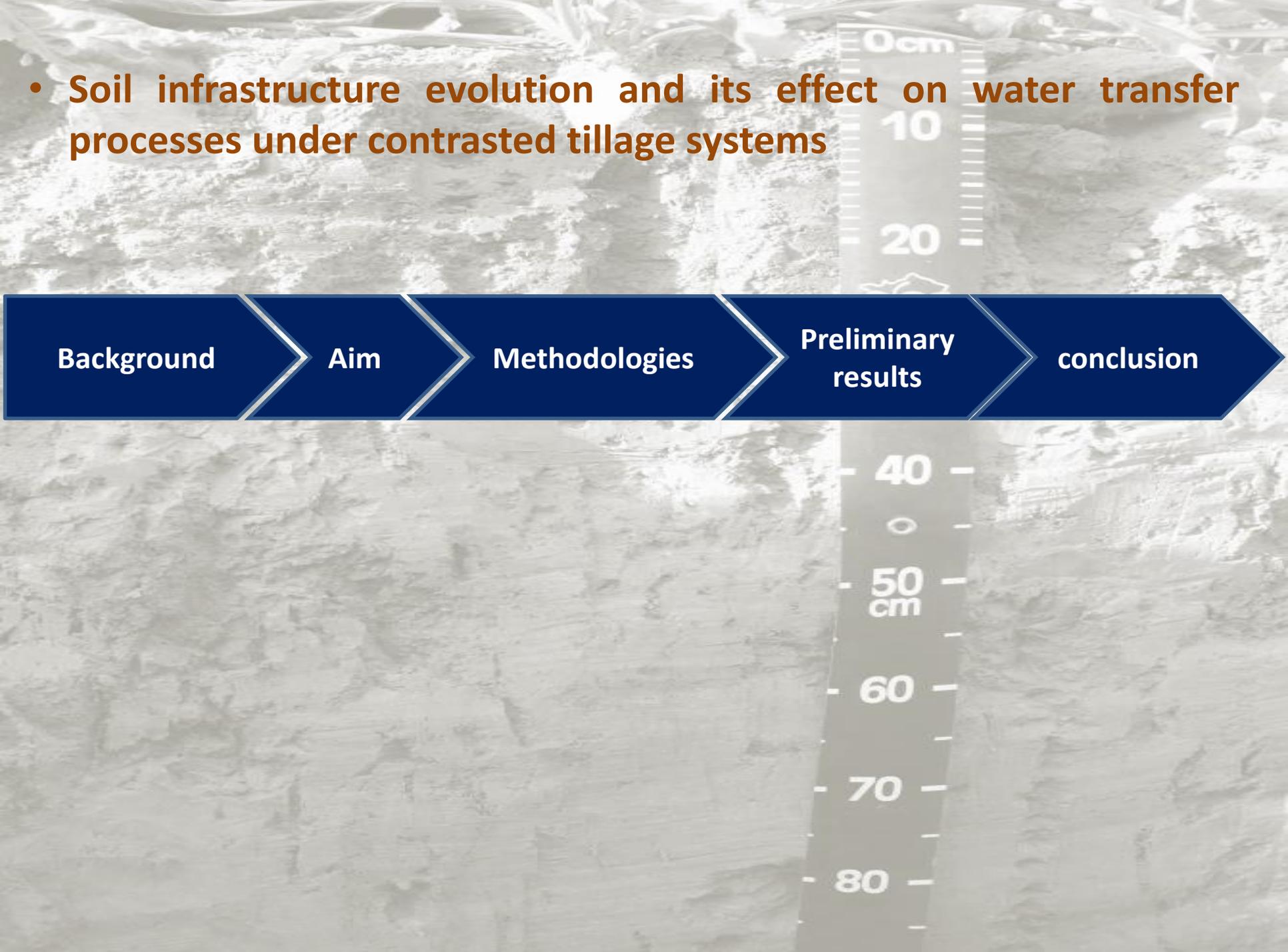
Background

Aim

Methodologies

**Preliminary
results**

conclusion

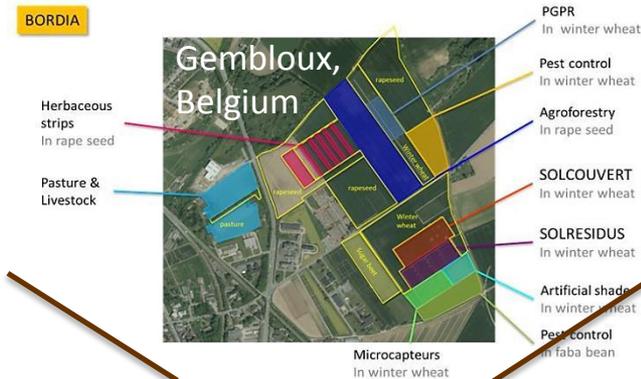


Multidisciplinary research projects 'AgricultureIsLife'

-- A research platform to develop the agriculture of tomorrow

Projects started, 2013

Common experimental farm



What are the performances of **non-conventional** agricultural practices? (6 projects)

What can an **alternative destiny** or valorization of **agricultural products**? (4 projects)

4 Research Axis

18 PhD Students

tillage and crop residues on soil infrastructure



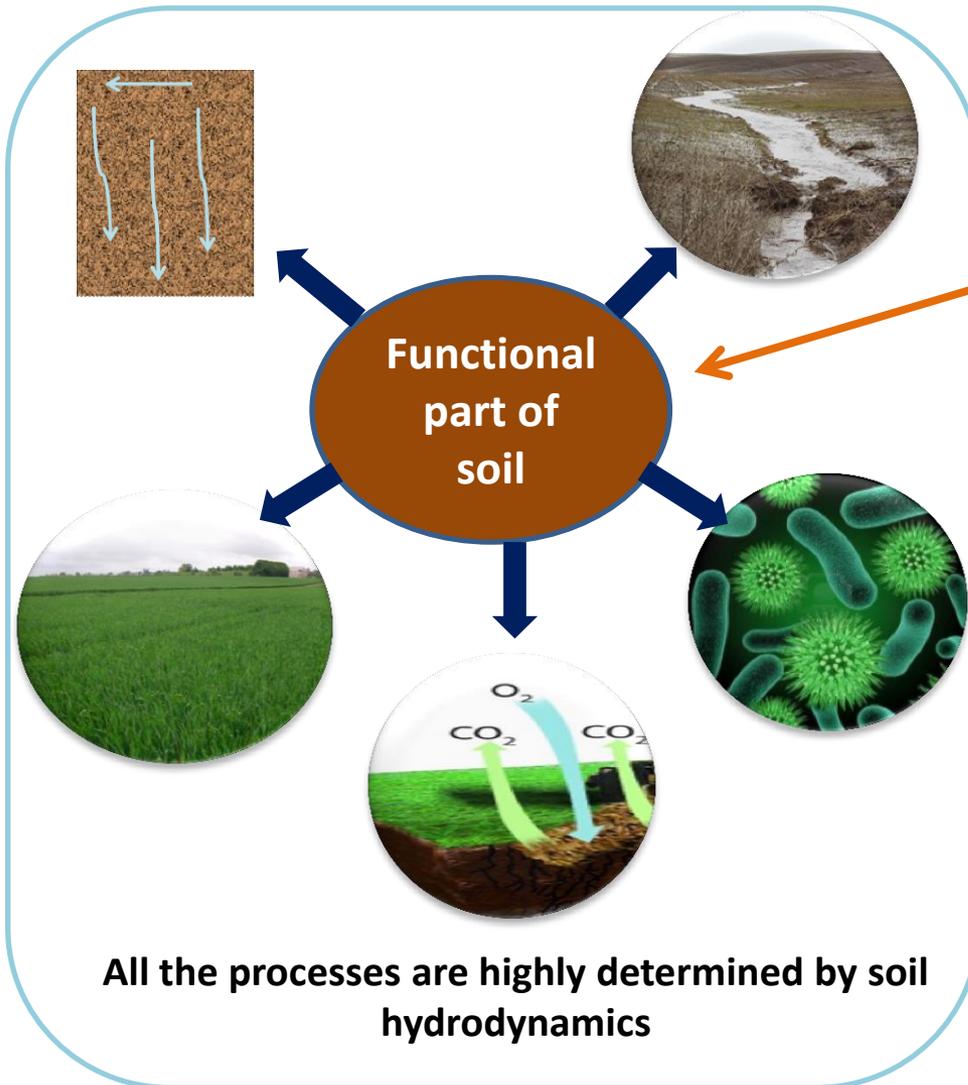
How can we **best valorize** agricultural residues: **soil-water-plant systems**? (4 projects)



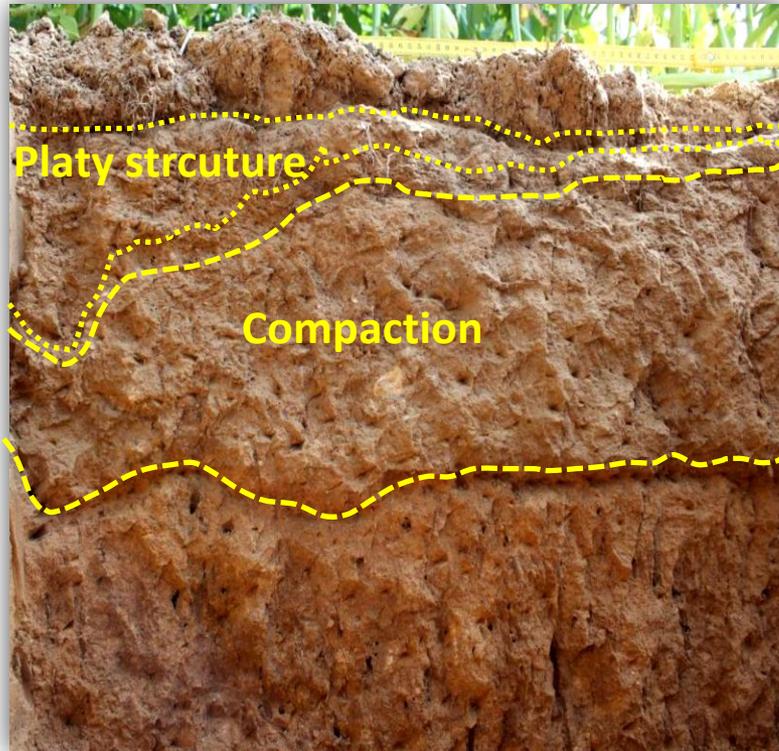
Which are the new **tools** and **technology** for crop protection? (4 projects)

Soil infrastructure (functional part of soil)

The parts of the soil pore and particle networks, their interfaces/surfaces that are active in translocation processes— water, air, gas and colloids (Jonge et al., 2009)



Soil structure and bulk density- pedon scale



At **pedon scale** heterogenous soil structure can lead to nonequilibrium conditions and uneven and rapid movement (**preferential**) of water flow of different types

Characterise preferential flow at pore scale?
Pore $>0,3\text{mm}$, connectivity, orientation, way of formation??
X-ray tomography – all the microporosity??

Modeling Structured soil - spatial variability of soil structure and bulk density

Loess belt of Belgium: different management practices -- different value and distribution of bulk density in the soil profile

Structural evolution \longleftrightarrow Hydropedological behavior

* Effect of tillage on soil structure (**Winter ploughing** (0-25 cm) and **Strip tillage** (0-10cm))



2013



2016

Before and after
the tillage

Cover crop- sugar beet-winter wheat-cover crop-maize-cover
crop-winter wheat →

* Effect of organic matter and pedofauna in the aspect of conservation tillage (**No-tillage res.in** and **No-tillage res.out**)



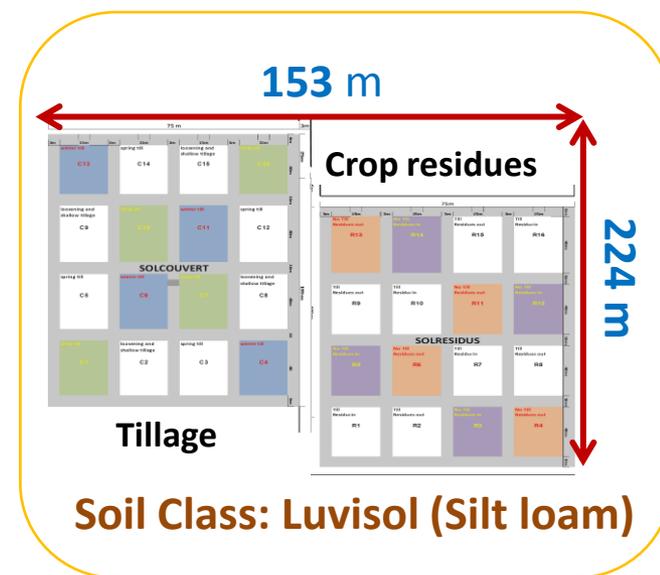
2013



2016

Before and after
residues incorporation

Cover crop-faba bean-winter wheat-cover crop-faba bean-winter wheat →



Pedostructure concept

Better understanding of the soil water system by quantitatively characterizing soil structural properties

***Core scale**

Laboratory measurement to characterize soil-water properties at both **macroscopic and **microscopic** level**

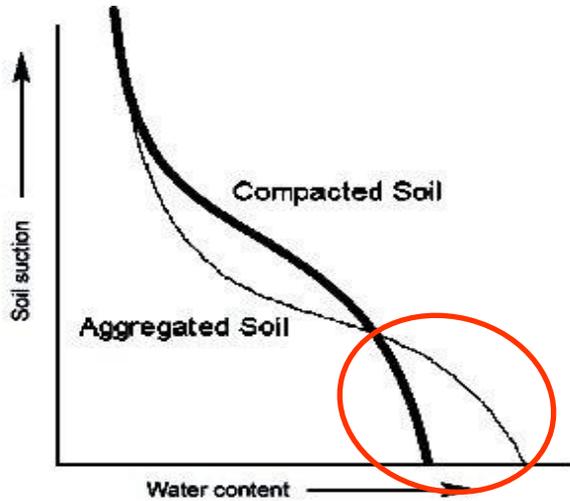
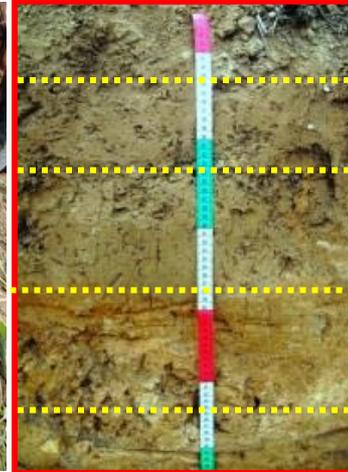
***Pedon scale**

**Unsaturated hydraulic conductivity
Soil water fluxes throughout the season**

Soil-water flow dynamics under Winter plough, Strip till and No-till res. in and out

PS parameters related to soil structure/macro-porosity will exhibit substantial changes between tillage and land management

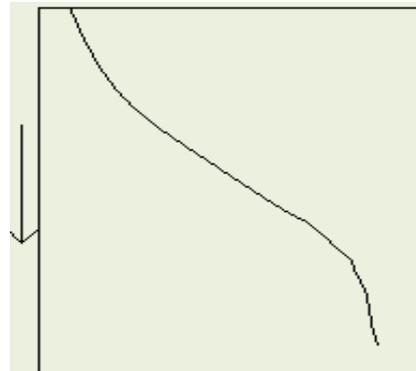
Characterization of soil-water properties – developing pedotransfer functions



Influence of structure on soil-water characteristic curve

Soil water content

Hydraulic conductivity



strongly dependent on the detailed pore geometry, water content, and differences in matric potential

- Soil texture
- Bulk density
- Soil structure
- Organic matter content

***For numerical modeling it is convenient to express analytically the soil-water characteristic curve and hydraulic conductivity of soil**

Soil water retention characteristics

Richards pressure plate technique



100 cm³



pF 1 to 4.2

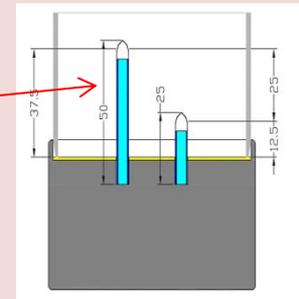
Evaporation measurement (Hyprop©)



250 cm³



pF 0 to 4.2



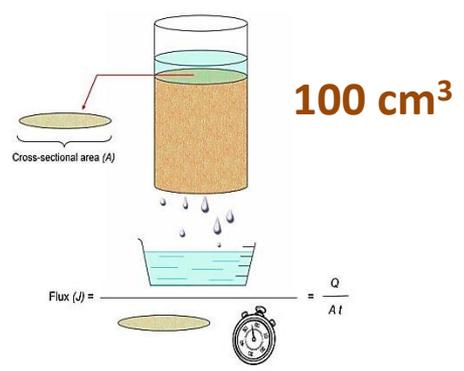
WRC near saturation
unsaturated
hydraulic conductivity

Hydraulic conductivity of soil

Movement of water through soil under saturated and unstaured condition



Permeameter



WRC and Hydraulic conductivity



Multistep outflow
(collaborative project)

1000 cm³

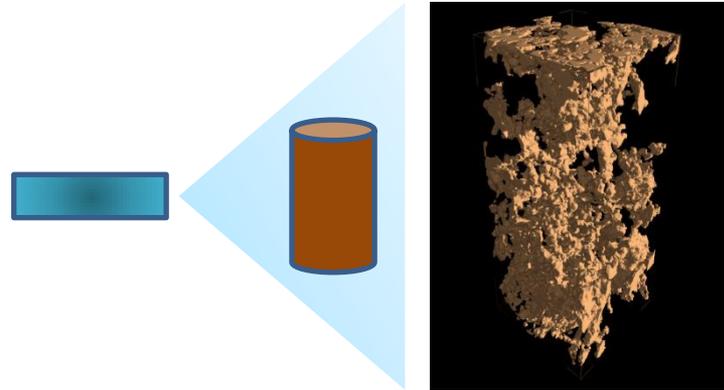
Comparison of WRC and HC – larger soil sample



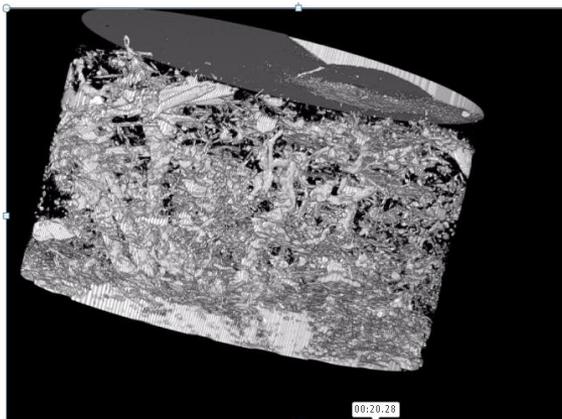
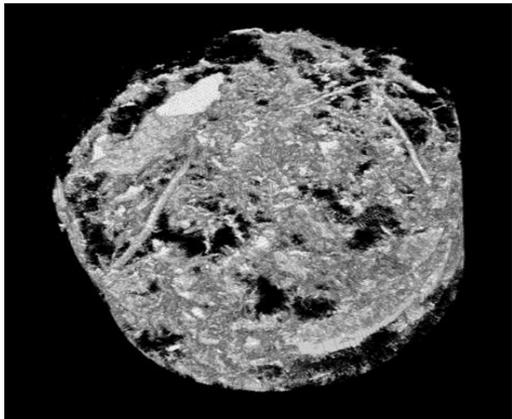
Tension infiltrometer

Compare with unsaturated hydraulic conductivity by the evaporation process

X-ray Microtomography



Fast scan - enhances the characterisation of pores near saturation (Beckers et al., 2013)



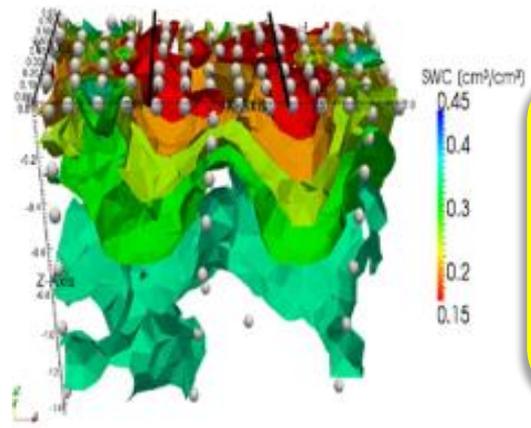
the pores, porosity distribution...

Soil moisture and temperature distribution



Water content and temperature distribution of four different trials – **validation of model**

Hydrus 2D for each tillage and residues management system

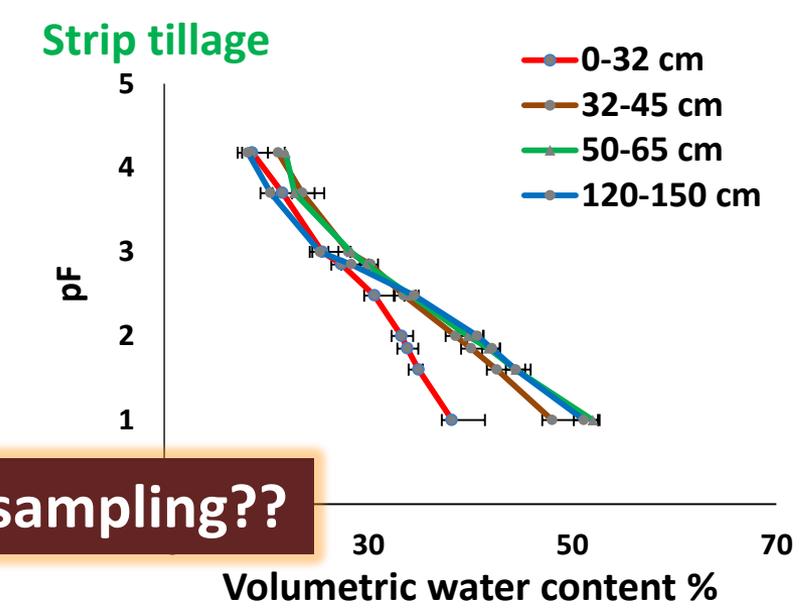
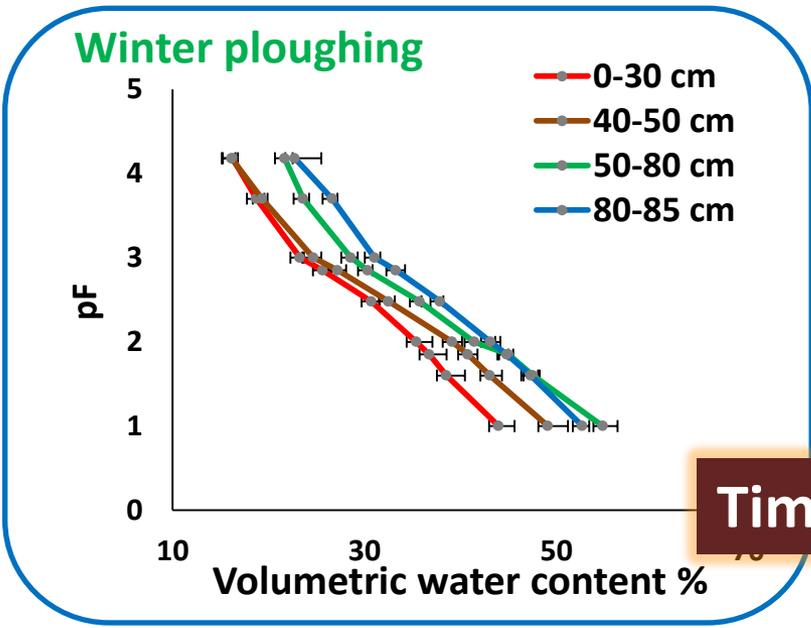


Spatio-temporal comparison by the **Electrical Resistant Tomography (ERT)** – collaborative project

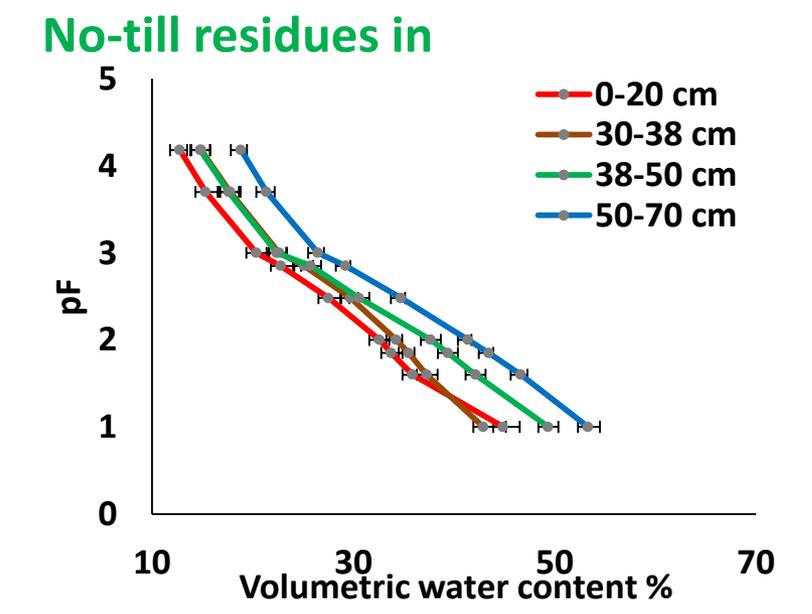
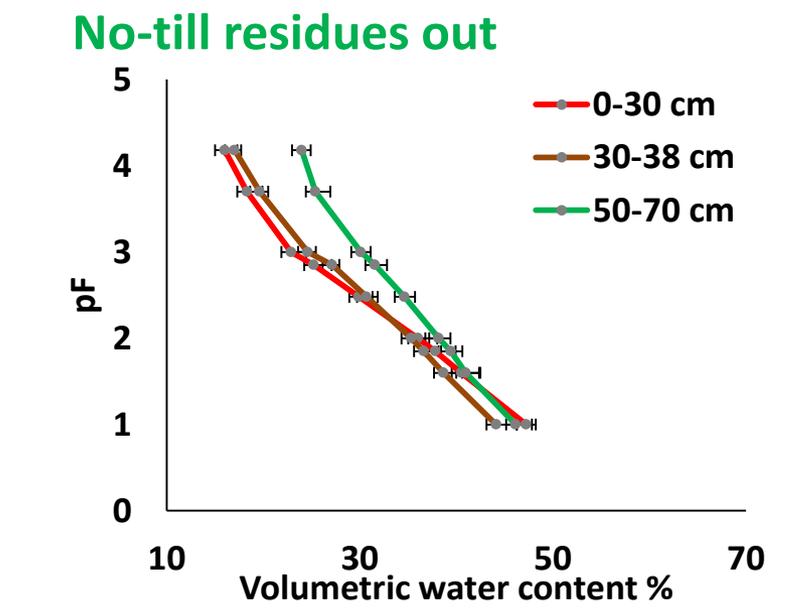
Pic: Beff et al., 2013

* **Sensors are calibrated according to the depths and sites**

Preliminary results- Soil water retention in Pressure plate

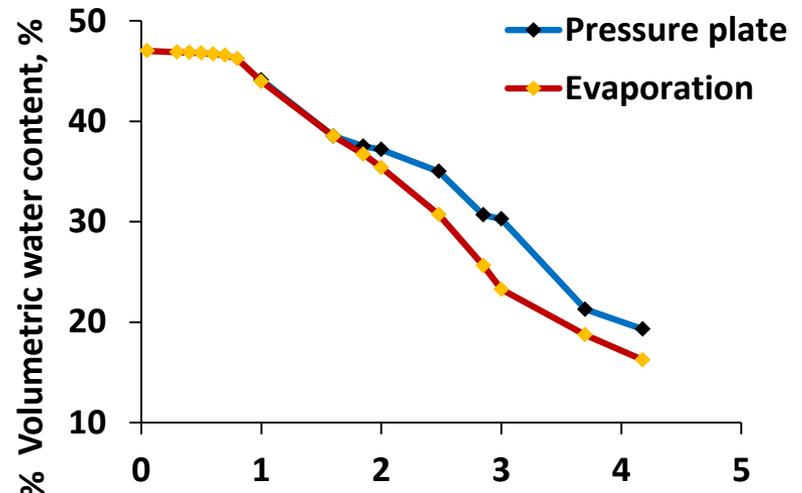


Time of sampling??

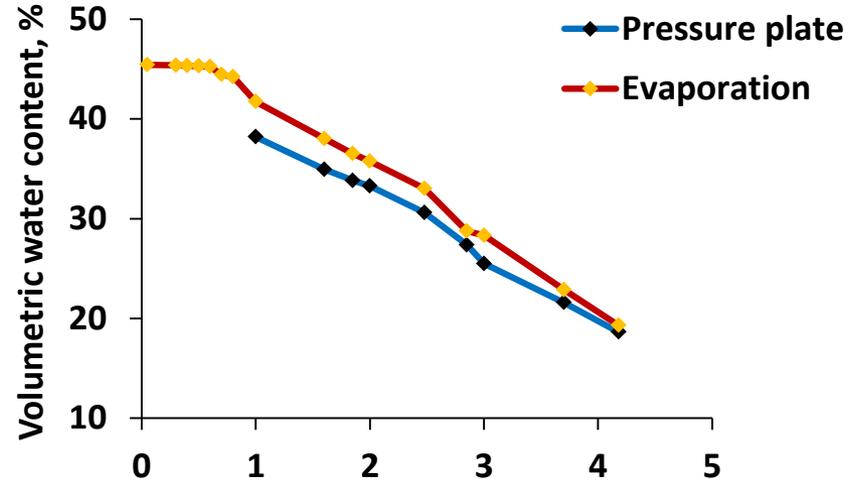


Surface soil, 0-25 cm

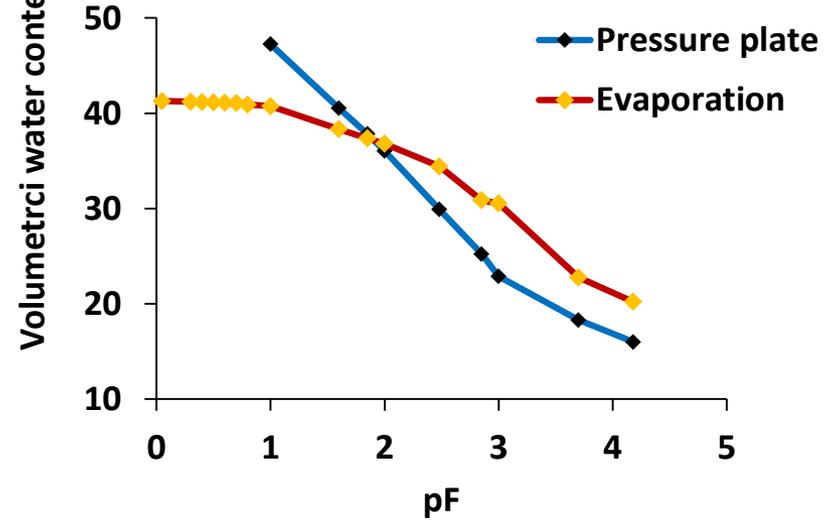
Winter plough



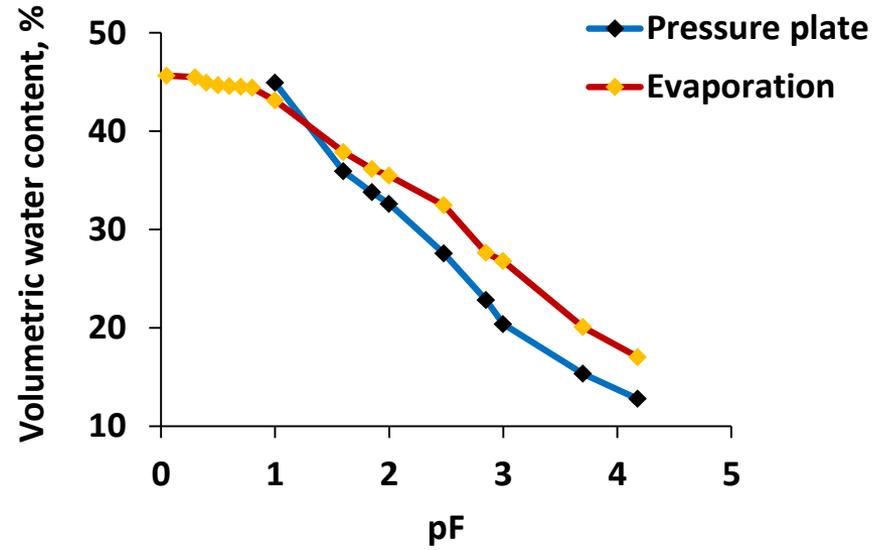
Strip tillage



No-till res out

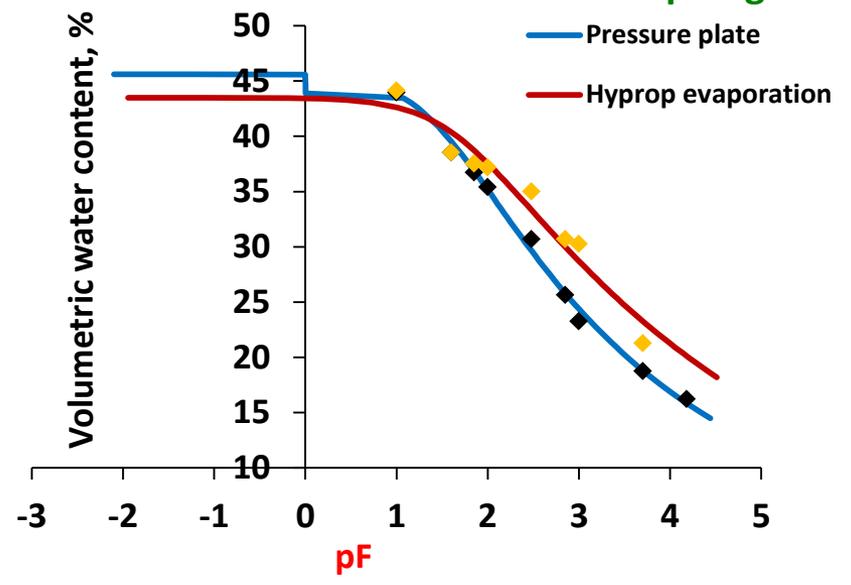


No-till res in

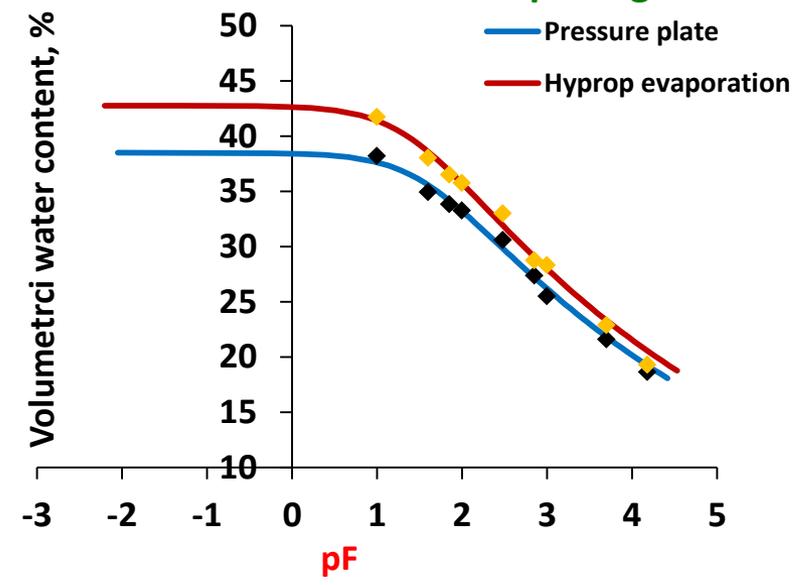


Fitted by Van Genuchten
($m=1-1/n$)- Mualem model

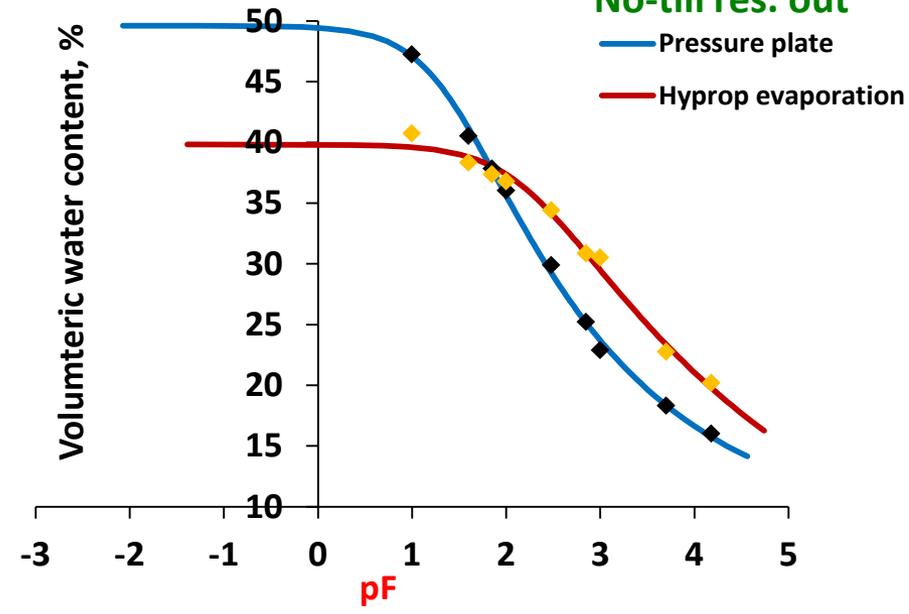
Winter plough



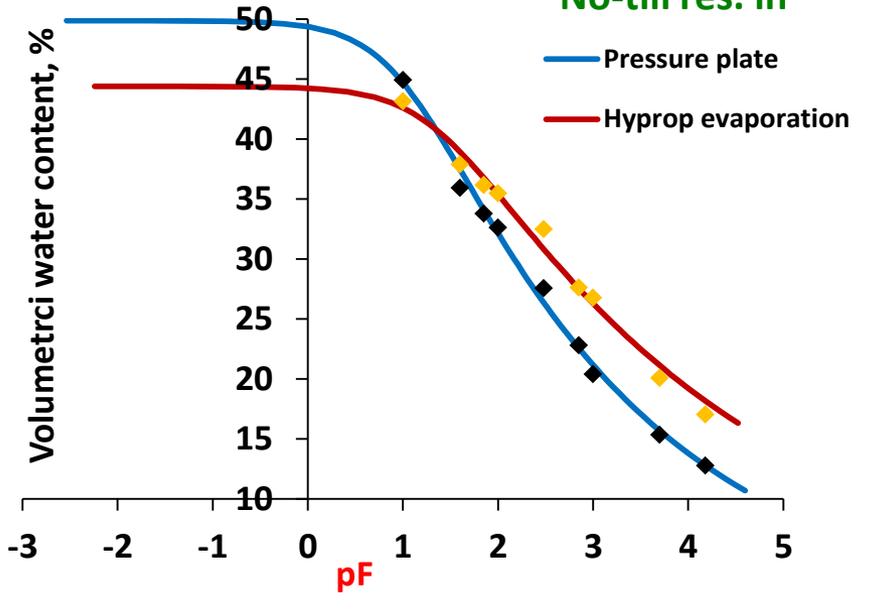
Strip tillage

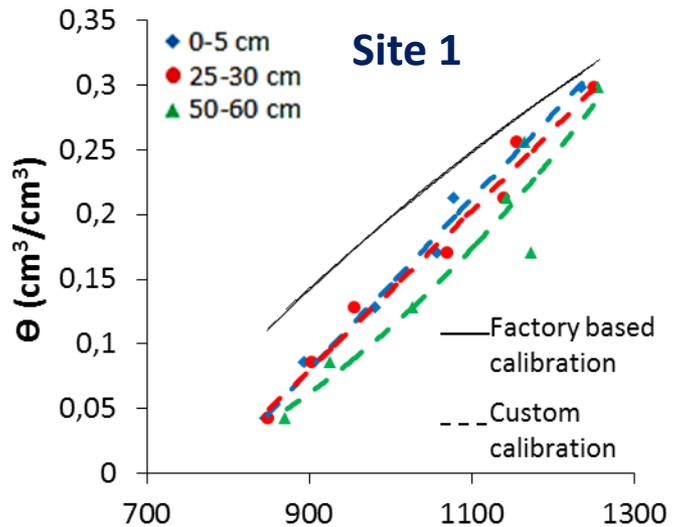


No-till res. out

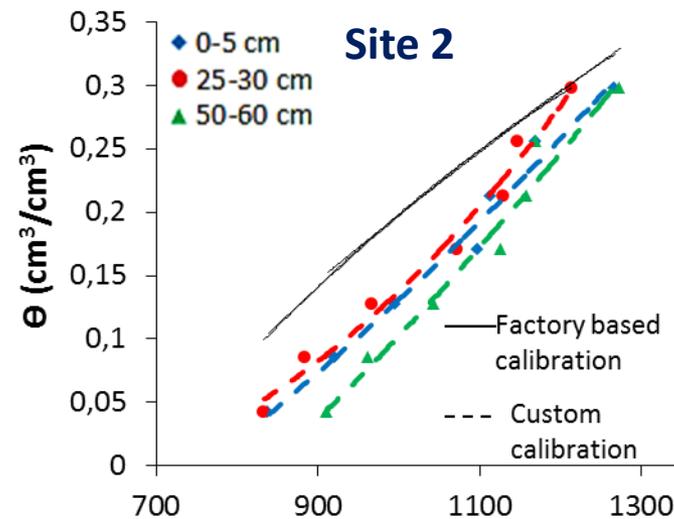


No-till res. in

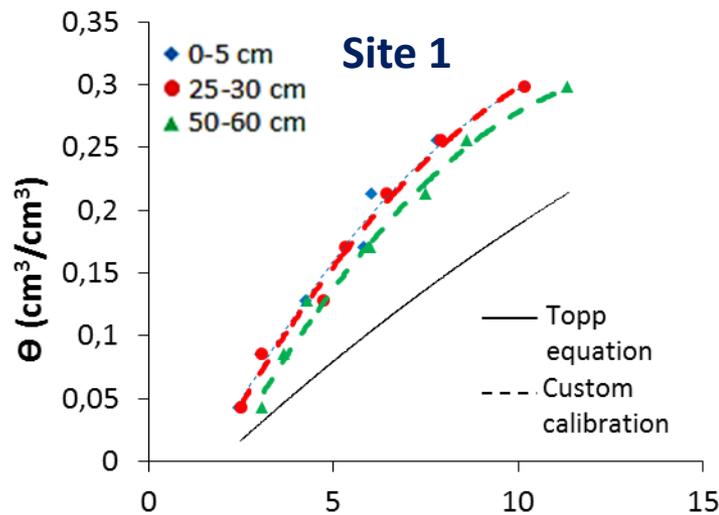




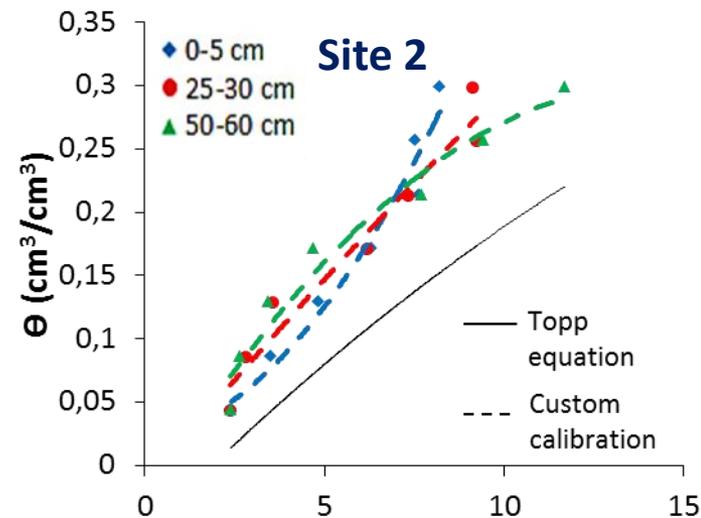
(a) Probe output (raw counts), 10HS



(b) Probe output (raw counts), 10HS



(a) Probe output (raw counts), 5TM



(b) Probe output (raw counts), 5TM

to increase the accuracy from $\pm 3-4\%$ to $\pm 1-2\%$



✓ would be the **over estimation** or **underestimation** of θ when the manufacturer based equation is used for the calculation.

Conclusion and future aspects...



Soil water retention- before land management –

Throughout the profile

Significantly higher water retention in winter plough than strip till
No significant difference in water retention due to residues management

Surface soil

No till systems retain significantly greater water content

Differences in methods

Pressure plate shows greater water retention than evaporation method at saturation – lack of conductance, differences in saturation could be the reason

Compaction effect

Sub-soil compaction under ploughing system

Collaborations

- ✓ **Effect of soil water flow process on crop development**
- ✓ **Effect of tillage and crop residues on microbial community compositions**
- ✓ **How the land management influence the spatial and vertical distribution of nutrients within soil profile**

References:

Beckers E., Plougonven E., Gigot N., Léonard A., Roisin C., Brostaux Y., and Degré A. 2013. Coupling X-ray microtomography and macroscopic soil measurements: a method to enhance near saturation functions? *Hydrol. Earth Syst. Sci. Discuss.*, 10, 4799-4827.

Beff L., Günther T., Vandoorne B., Couvreur V., and Javaux M. 2013. Three-dimensional monitoring of soil water content in a maize field using electrical resistivity tomography. *Hydrol. Earth Syst. Sci.*, 17(2), 595-609.

Jonge de LW., Moldrup P., and Schjønning P. 2009. Soil Infrastructure, Interfaces & Translocation Processes in Inner Space ("Soil-it-is"): towards a road map for the constraints and crossroads of soil architecture and biophysical processes. *Hydrol. Earth Syst. Sci.*, 13, 1485-1502.

For more details, questions? Want to join?

www.AgricultureIsLife.be

LinkedIn AgricultureIsLife

twitter # AgricultureIsLife

Thank you...

