Combining conventional soil sampling, agro-ecosystem modelling and proximal soil sensing to identify soil texture in the subsoil

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patchCROP

Background

- patchCROP is a landscape experiment which was set up 2020 in a 70 ha field surrounded by 750 ha of agricultural fields to study how newly diversified field arrangements, that consider field heterogeneities, affect the multifunctional response of agro-ecosystems
- However, detailed soil information over the entire rooting depth is needed to understand the spatial heterogeneities and the effects on crop growth and resource use
- For this, agro-ecosystem models and proximally sensed soil data have the potential to be combined to derive soil characteristis such as soil texture
- Electrical resistivity measurements are highly influenced by soil moisture → in order to interpret the data referring to subsoil, information about soil water content is important

Objective

A) Calibrate and validate the soil water balance at different soil depths for heterogeneous soil conditions

B) Simulation of subsoil moisture levels at the day of proximal soil sensor measurements to be used in the development of a subsoil texture map

Key results

- ➢ The model was able to reasonably simulate the seasonal dynamics of soil moisture for heterogeneous soil profiles under different crop rotations
- ➢ Differences in topsoil moisture levels on the day of Geophilus measurements were captured by the model, but moisture in very sandy topsoils was underestimated

Materials and Methods:

Field data:

- Soil auger info (layering & soil textural class up to 1m depth)
- Daily weather data
- Continous soil moisture data (TDR-310N, Acclima; recorded every 15min, used at daily scale) at 30, 60 and 90 cm depth
- Proximally sensed electrical resistivity data by Geophilus in October 2019

Model:

- Crop model <LINTUL5> (Wolf, 2012) implemented in the modeling framework SIMPLACE (www.simplace.net) combined with <SlimWater> for soil water balance simulation (point-based simulation, tipping bucket approach applied to soil layers)
- Model previously calibrated and validated for crop growth and grain yield (seasons 2020-2023)

Run of SIMPLACE in daily time steps for soil augers closest (max. distance 3 m) to soil moisture sensors

Model calibration for the soil water balance based on 8 soil profiles for calibration and 7 for validation.
Calibration was conducted by adjusting bulk density, selection of pedotransfer function to derive soil hydraulic parameters, reinitalization and addition of a cover crop.

Validation results 2021-2022

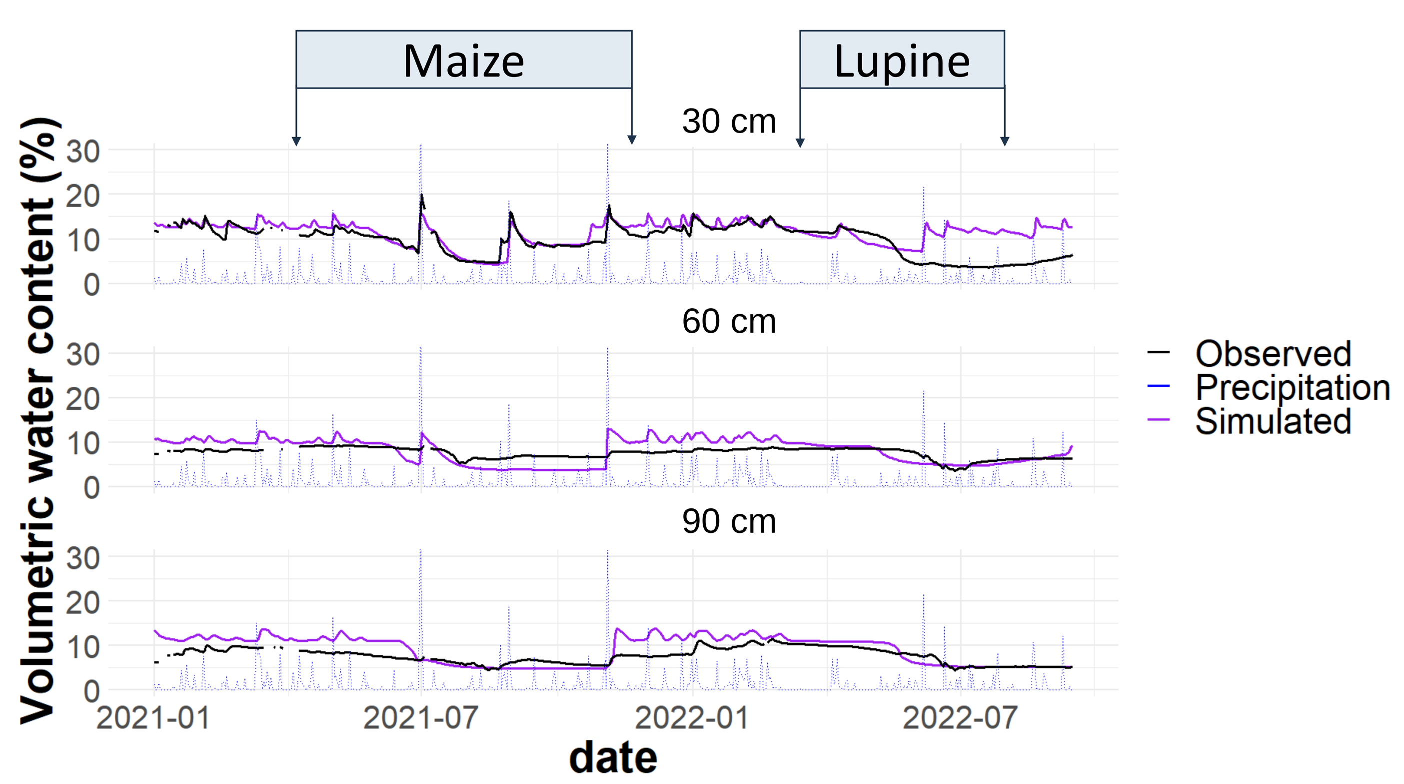


Fig. 1: Simulated and observed volumetric water content in % at 30, 60 and 90 cm soil depth in **profile A**; blue= precipitation (mm), black= observed soil moisture, purple= simulated soil moisture; boxes above indicate crop rotation

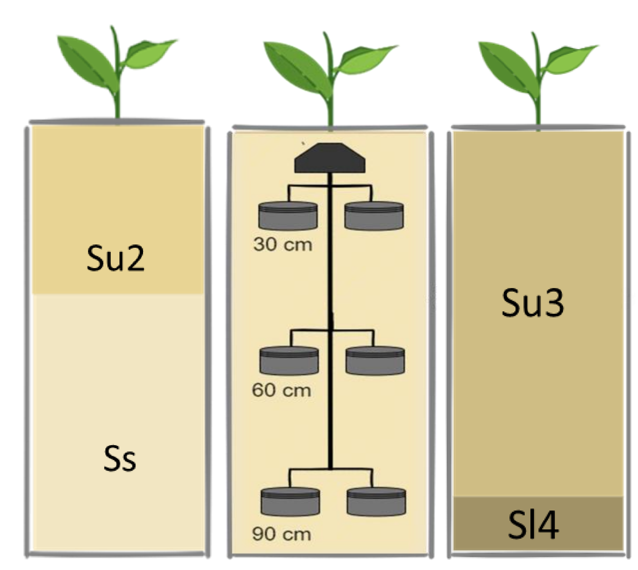


Fig. 2: Schematic depiction of two contrasting soil profiles A (left) and B (right) and soil moisture sensor installation (middle); Su2=slightly silty sand, Ss= sandy sand; Su3=medium silty sand; Sl4= strong loamy sand

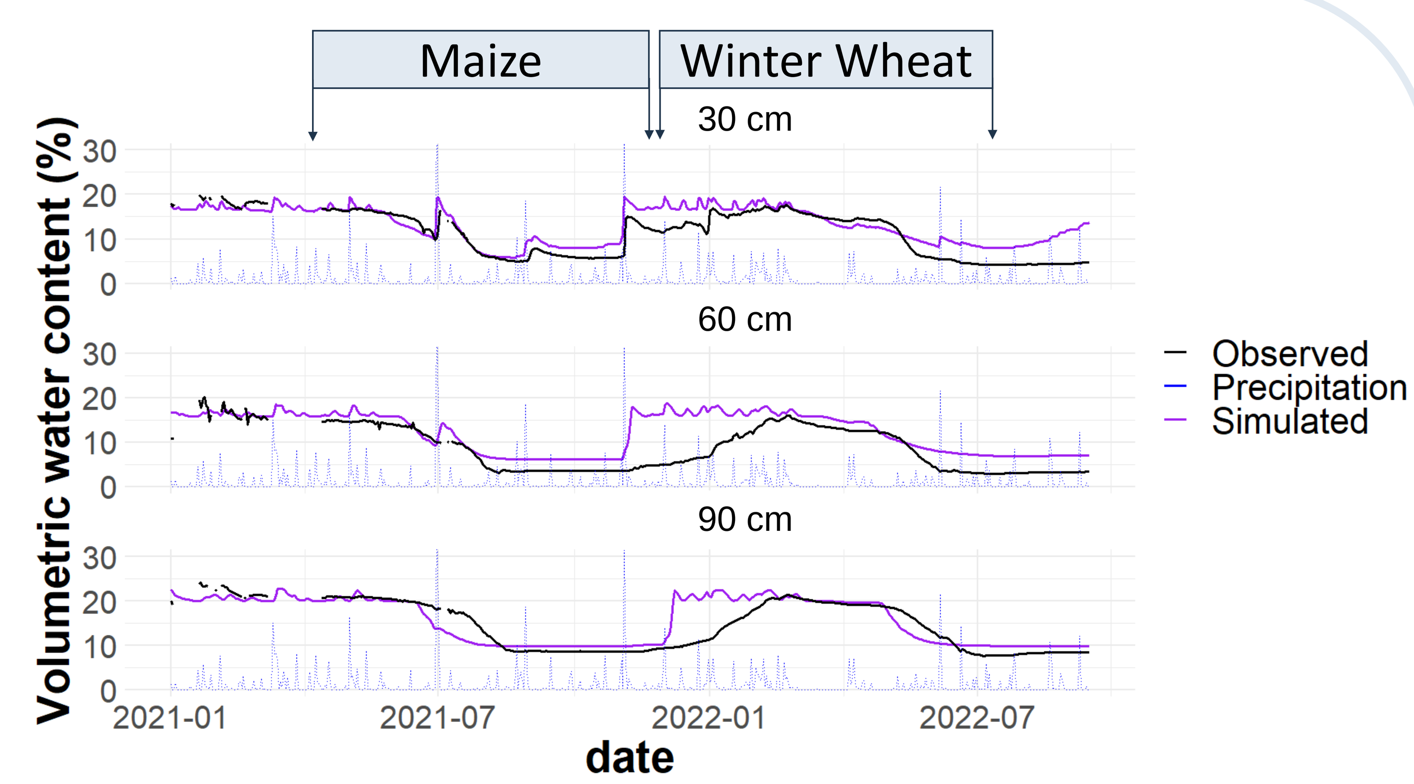


Fig. 3: Simulated and observed volumetric water content in % at 30, 60 and 90 cm soil depth in **profile B**; blue= precipitation (mm), black=observed soil moisture, purple= simulated soil moisture; boxes above indicate crop rotation

Validation results 2019

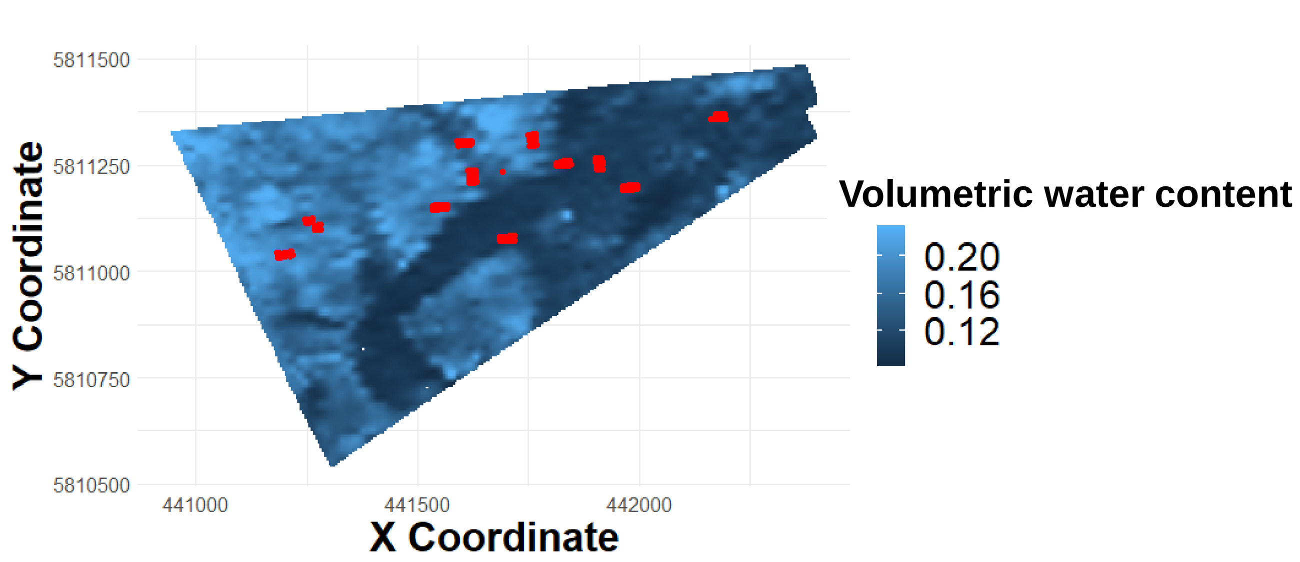


Fig. 4: Map of soil volumetric water content (1=100%) derived through calibration of the Geophilus Wetness Index (GWI) map with TDR point measurements on the 17th of October 2019. The GWI represents the ratio of the gamma-activity and apparent electrical resistivity (ERa) of the upper 30cm soil layer; red points indicate location of soil augers used for comparison (s. Fig. 5)

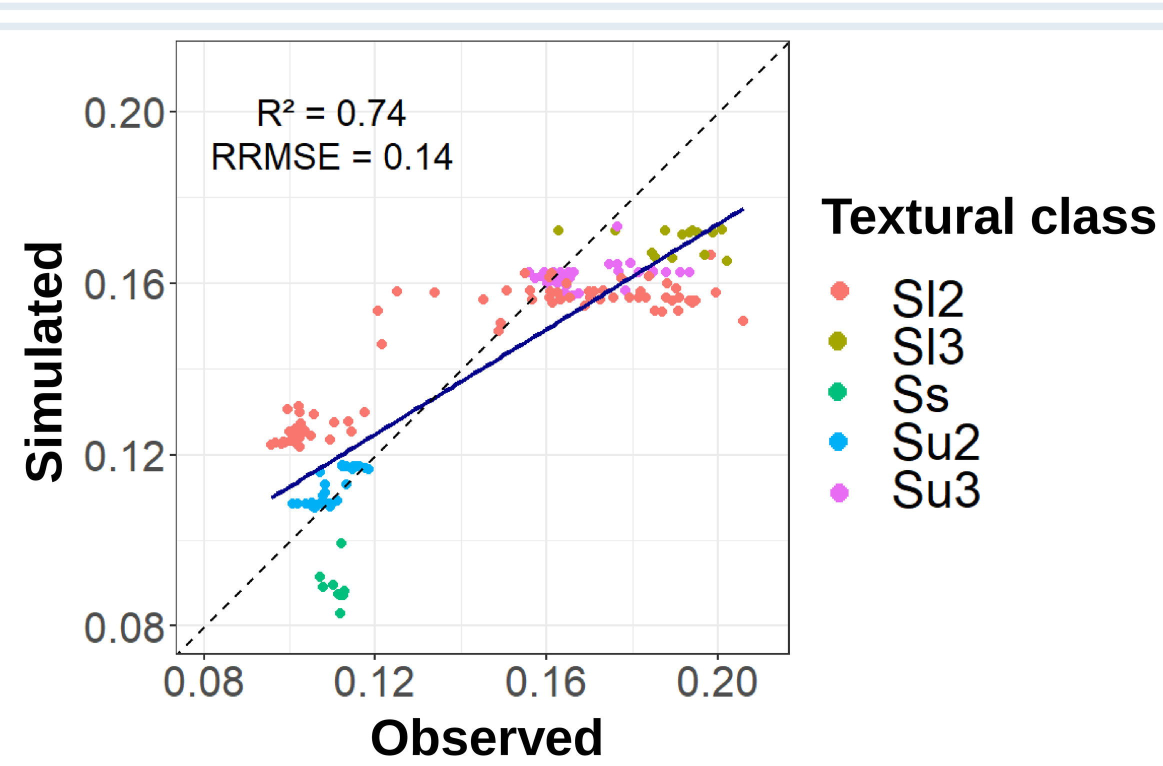


Fig. 5: Simulated (SIMPLACE model output) vs. observed (based on GWI) **volumetric water content** (1=100%) on the 17th of October 2019 in the first 30cm of soil by textural class, N=170; RRMSE=relative root mean squared error; Sl2= slightly loamy sand; Sl3= medium loamy sand; Ss= sandy sand; Su2= slightly silty sand; Su3= medium silty sand)

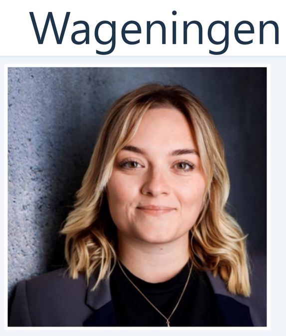
Next steps

Future advances focus on using the simulated volumetric water content of the subsoil to improve inversion algorithm of electrical resistivity data to identify soil texture in the subsoil.

Validation for a subset of soil augers & application for the whole field.

References

Wolf J. (2012). User guide for LINTUL5: Simple generic model for simulation of crop growth under potential, water limited and nitrogen, phosphorus and potassium limited conditions. Wageningen UR



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