Sensor based soil mapping to enable precision agriculture

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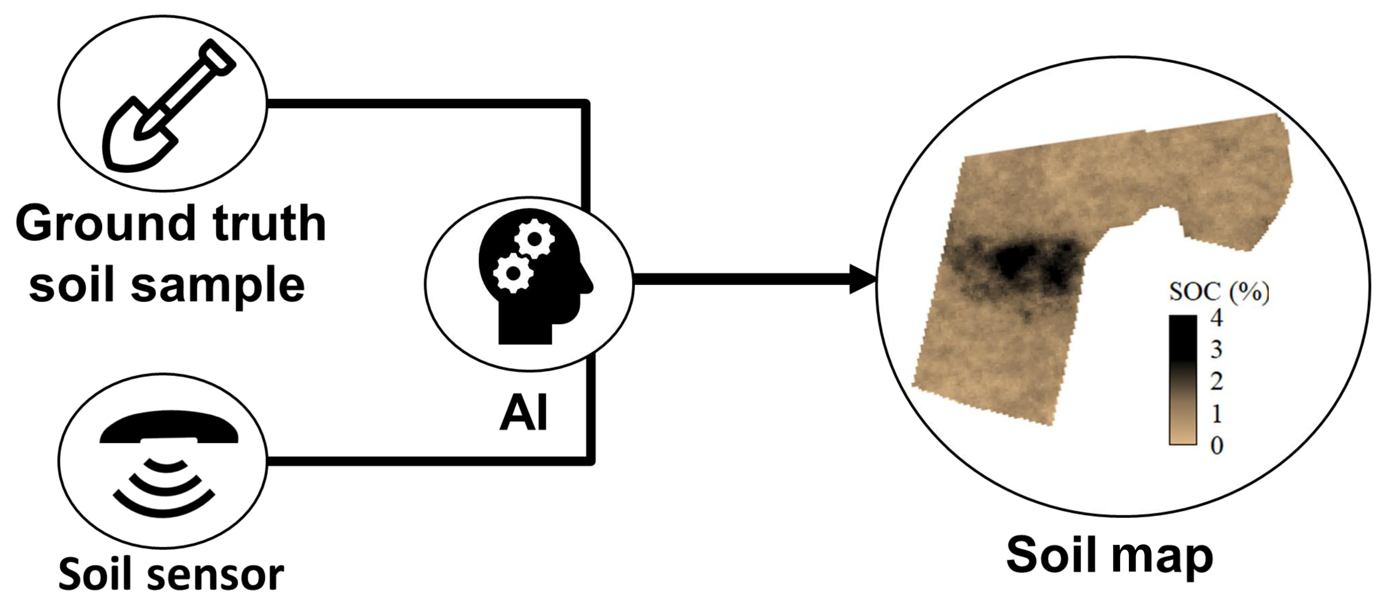


Why do we care about soils?

Soils are the medium for plant growth. They release plant essential nutrients, regulate water availability and provide stability to the plants.

Why do we need to map soils for precision agriculture?

Soils are heterogenic in space. E.g., the nutrient content of the soil may change dramatically within just few meters. Hence, we should spatially adapt the dosage of fertilizers to maximize plant growth while reducing fertilizer input.

Why do we need sensors for mapping?

Sensors can be used directly within the field and their measurements remain cost-efficient. They measure attributes related to important soil properties, e.g., the color of the soil gives us information about the SOC content (Humus).

Two example case studies

Determining the number and combination of sensors needed for accurate soil mapping

Background

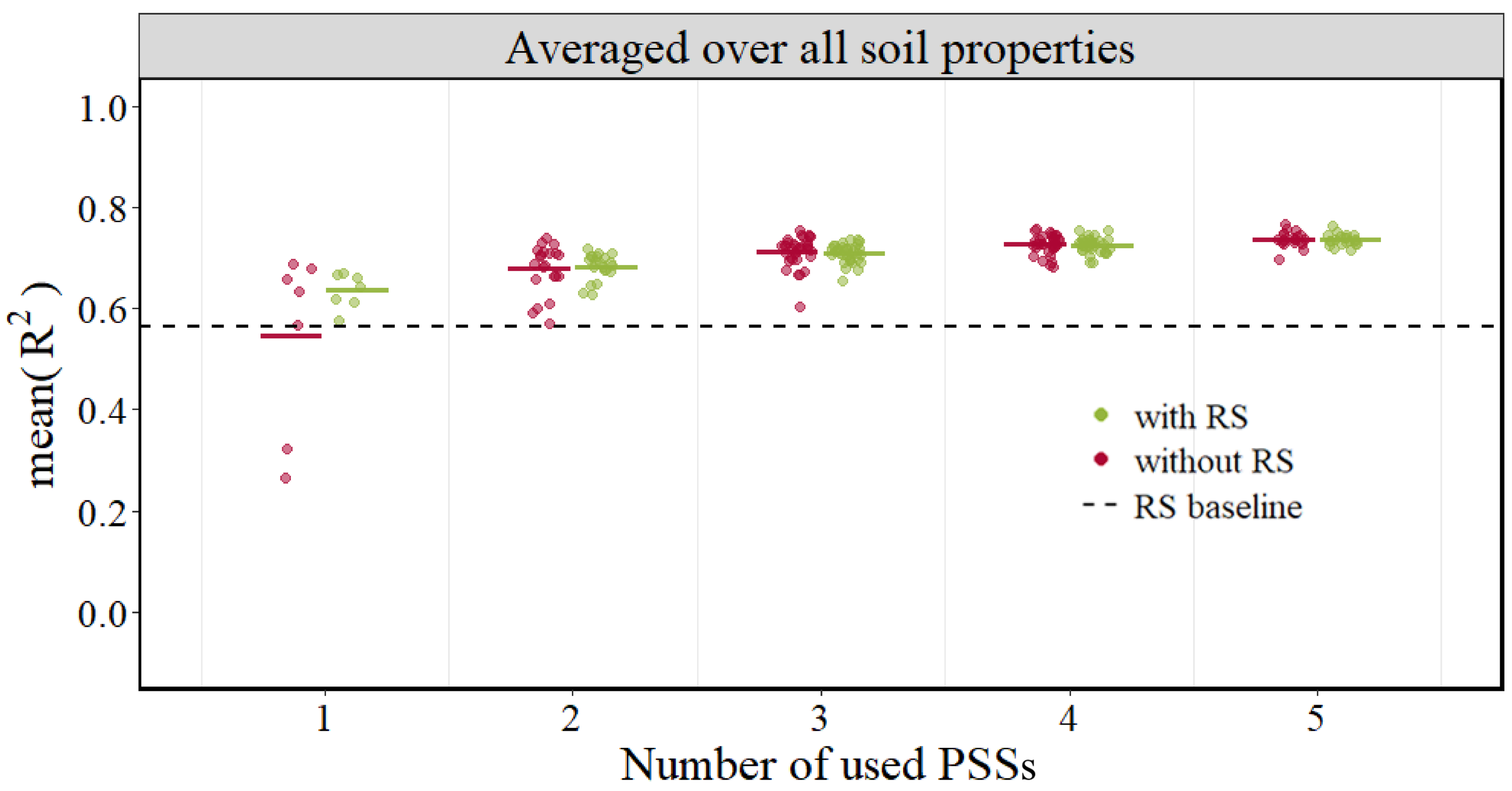
A single sensor is not enough to determine multiple soil properties with high accuracy. Hence, platforms with multiple sensors are currently developed. Though, it has to be determined which sensors and how many we need for accurate predictions.

Material & Methodology

In a case study, we tested different numbers and combinations of proximal soil sensors (PSSs) to map six important soil properties of the topsoil (SOC, pH, moisture, P, K and Mg). We also compared how remote sensing (RS) data from satellites compares to PSSs.

Conclusion

As expected, more sensors led to more accurate predictions but there are diminishing returns. About three PSSs seemed to be reasonable. Just using RS gave us reasonable predictions but most PSSs will outperform it.



Modelling with reduced training sample sizes

Background

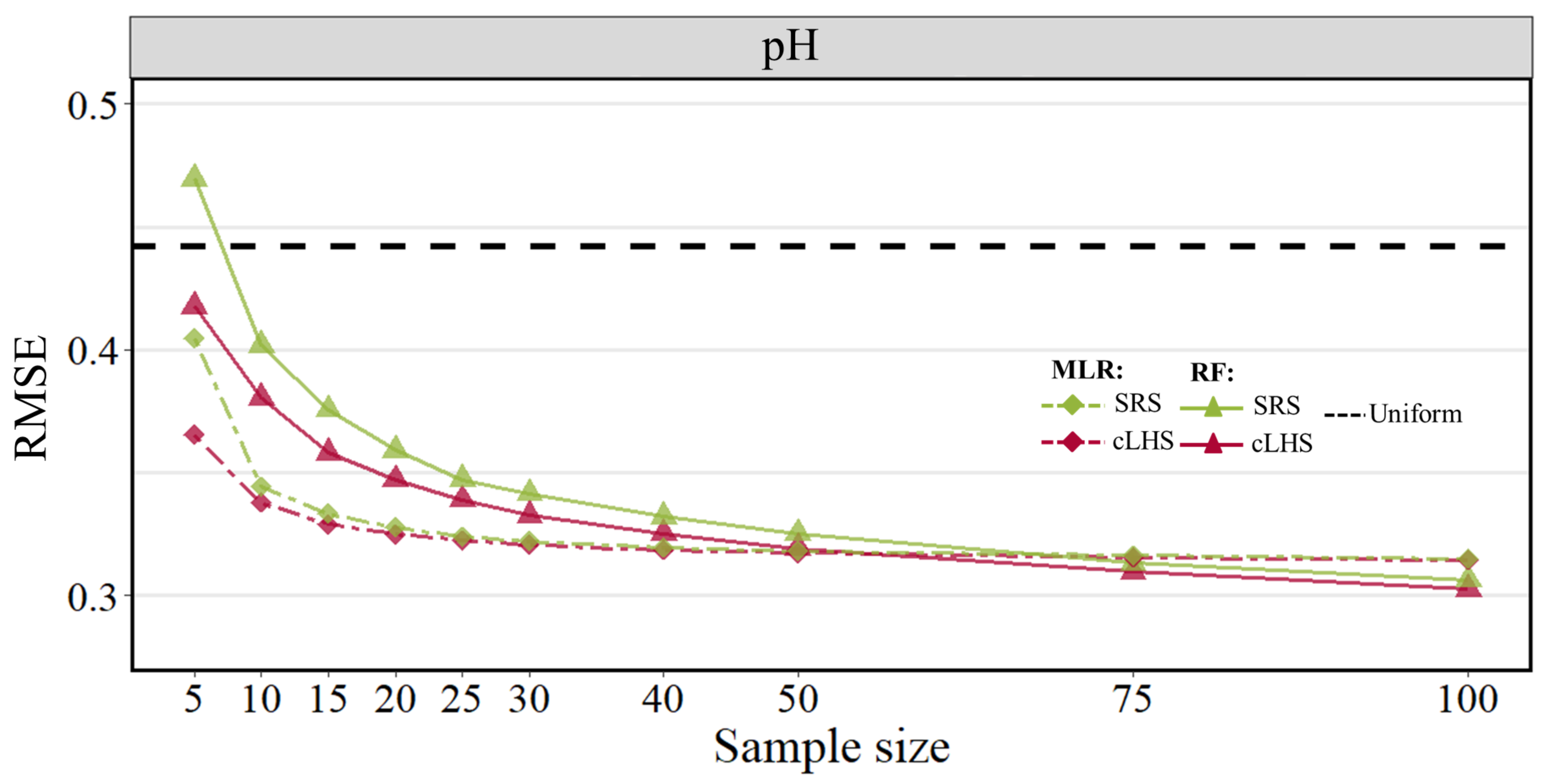
To relate sensor measurements to the target soil property, we need some ground truth data i.e. training samples, to fit the prediction model. However, more training samples usually increases the prediction accuracy but it simultaneously increases the costs.

Material & Methodology

We compared how a simplistic multiple linear regression (MLR) and a more data-driven random forest (RF) perform with different training sample sizes when predicting different soil properties (SOC, clay and pH). Additionally, we tested different sampling designs (cLHS and SRS).

Conclusion

With lower sample sizes, the more simplistic MLR showed advantages over RF but with abundant sample sizes, the advantage of machine learning presented by RF became evident. While sampling designs can improve predictions, it was less important than the sample size or model.



Publications

Schmidinger, J., & Heuvelink, G. B. (2023). Validation of uncertainty predictions in digital soil mapping. Geoderma, 437, 116585.

Schmidinger, J., ... & Vogel, S., (2024). Effect of sample size, sampling design and calibration model on generating soil maps from proximal sensing data for precision liming. Precision Agriculture

Acknowledgment

This research was supported by the Lower Saxony Ministry of Science and Culture (MWK), funded through the zukunft.niedersachsen program of the Volkswagen Foundation