Synergistic soil moisture observation: an interdisciplinary multi-sensor approach to yield improved estimates across scales

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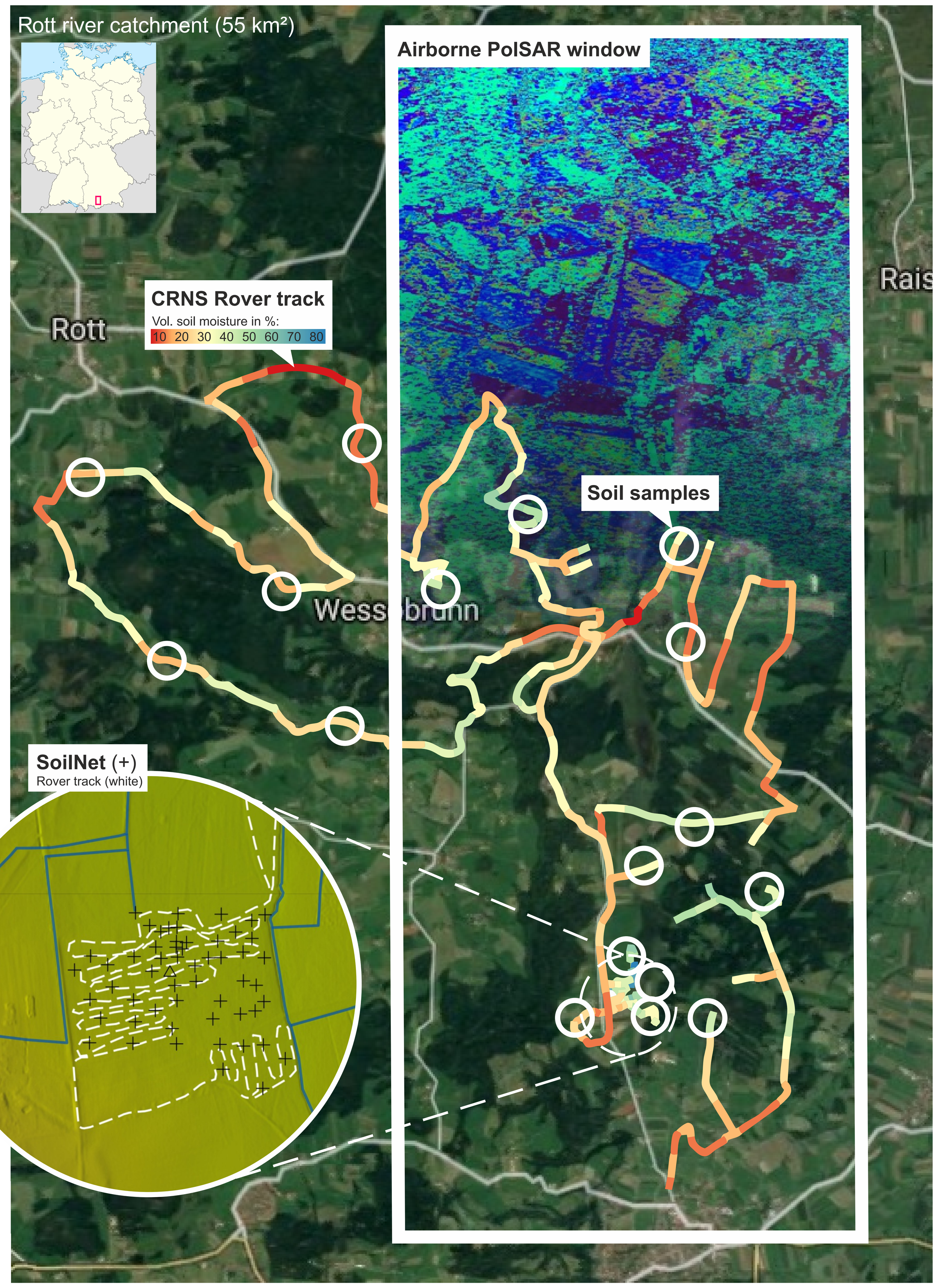
MOTIVATION

- Soil moisture observation methods differ in extent, spacing, and support.
- A single method for soil moisture retrieval under vegetation cover does often not provide suffcient accuracy (remote sensing methods) or spatial extent (in situ methods).
- How well is the performance of the individual retrival methods? Do they have potential to assist each other (synergistic approach)?
- The ScaleX campaign 2015 conducted by KIT within the Rott catchment, Germany, provided a great opportunity to combine in situ, car-, and air-borne passive and active sensors for soil moisture observation.

STUDY AREA

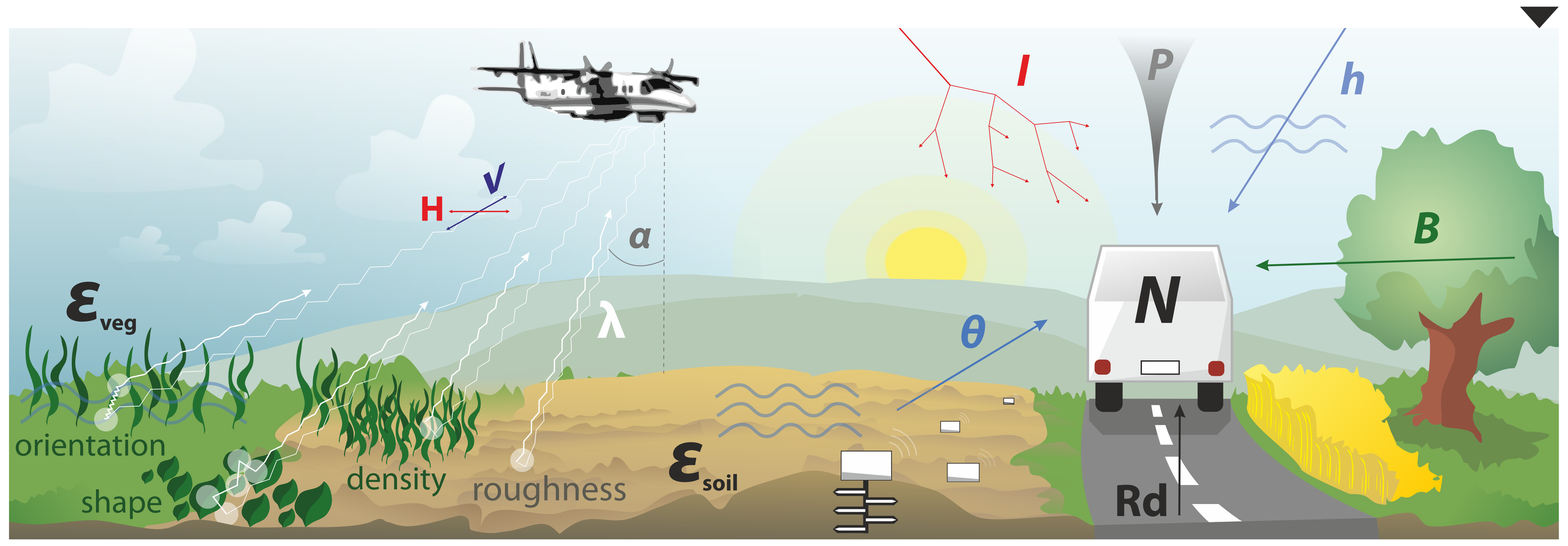
Fig. 1: Overview of location and extent of soil moisture observations used in this study.



METHODS

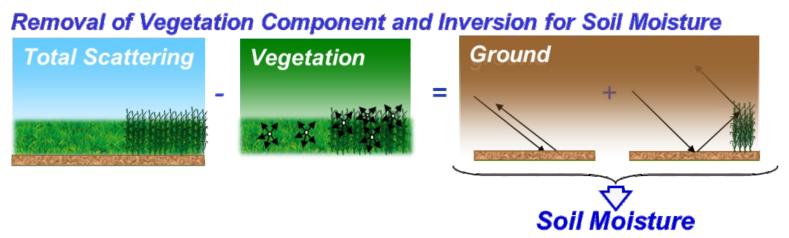
	Airborne Polarimetric SAR	Soil Monitoring Network	Cosmic-Ray Neutron Rover
extent	++	--	+
spacing	++	+	o
horizontal support	++	--	+
vertical support	--	++	+
complexity	--	++	o

Fig. 2: The soil moisture observation techniques used in this study: (left) airborne polarimetric SAR, (middle) in situ soil moisture network, and (right) car-borne cosmic-ray neutron sensor. Various steps are required to extract soil moisture information from the integrated signals that are influenced by various environmental factors.



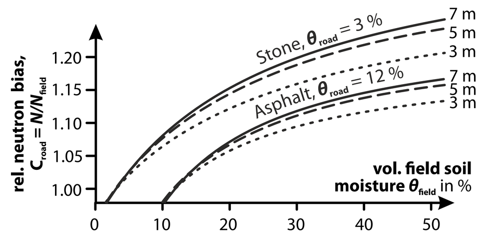
Polarimetric SAR
based partly on Jagdhuber et al. (2015)

NOVEL: grassland vegetation removal using a grassland-specialized, fully adaptive PolSAR decomposition and inversion for soil moisture



CRNS Rover
road-effect correction
based on Schrön et al. (2017)

$N' = N / C_{road}$



CRNS Rover

NOVEL: vegetation correction using the hv-backscatter product from PolSAR.

B in units of dB
(ranges from -35 to -1)

$N'' = N \exp(\alpha B)$

RESULTS

1. CRNS Rover performance benefits from PolSAR backscatter vegetation proxy data

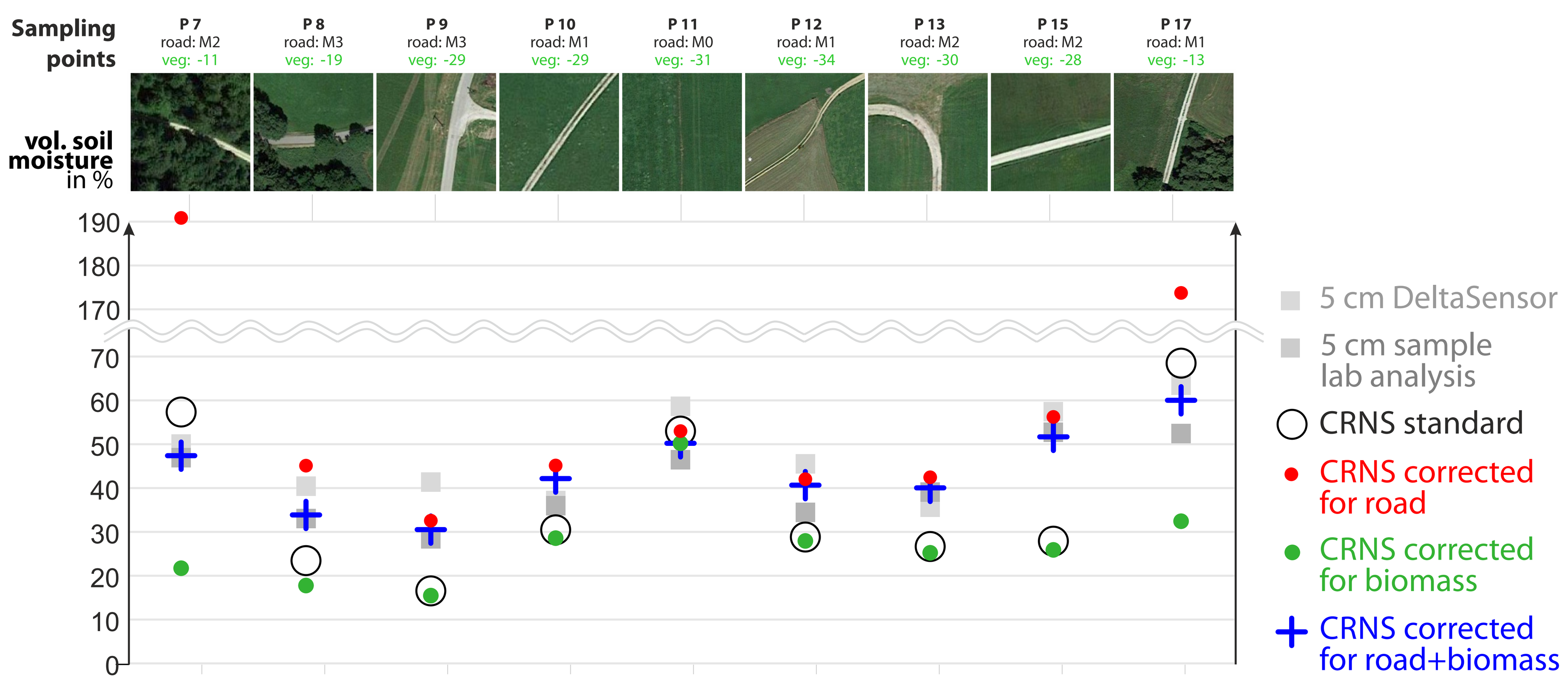


Fig 3: Measured soil moisture from point samples (gray squares) at 9 locations along the rover path. These locations show different road properties (M0--3) and vegetation cover (measured by PolSAR in units of dB). In comparison, soil moisture from CRNS rover using the standard methods (black circles), with road-effect correction (red), with the novel vegetation correction (green), and with both corrections combined (blue crosses).

RESULTS (cont'd)

2. PolSAR vegetation removal algorithm for grass landcover benefits from SoilNet data

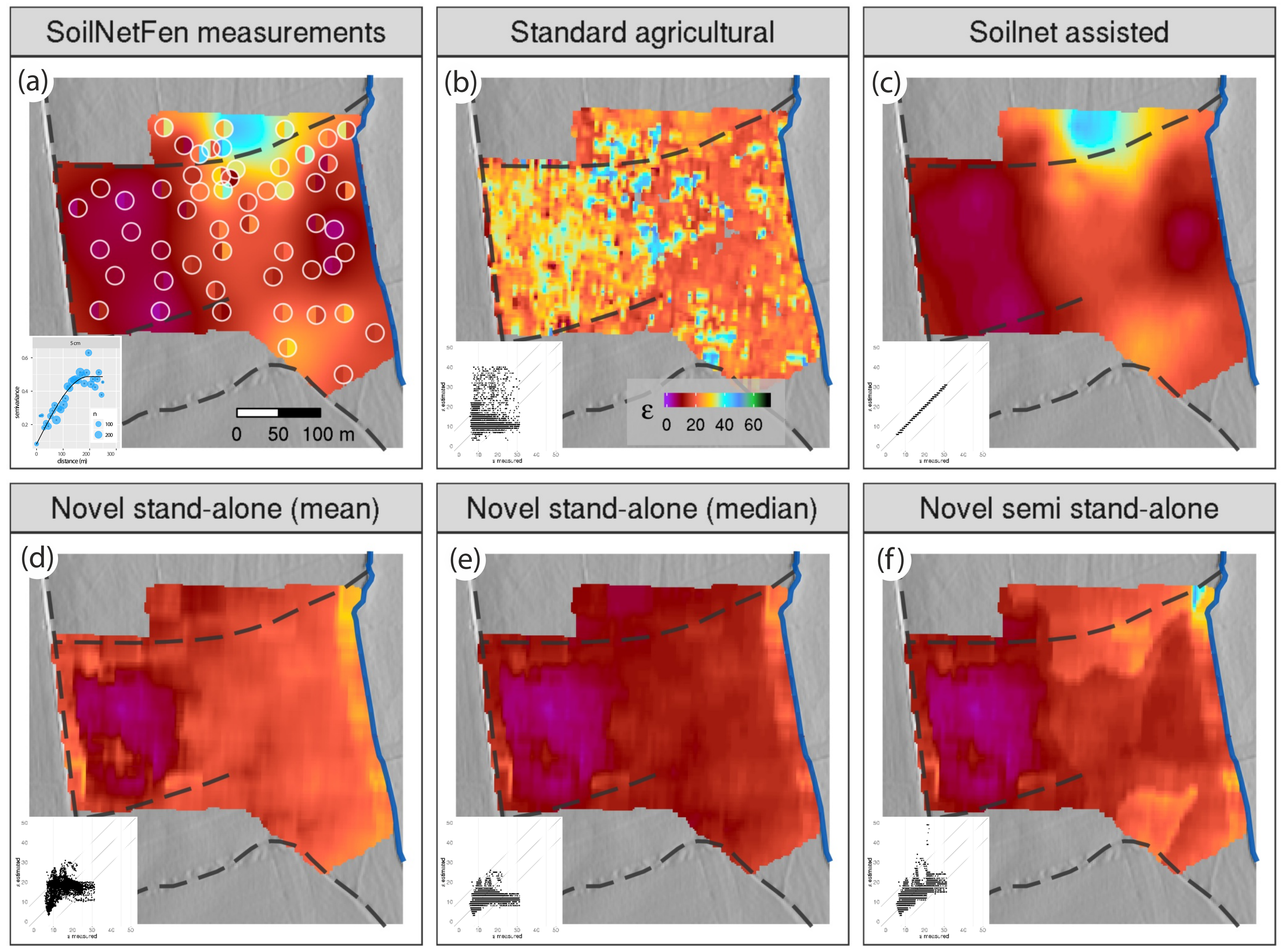


Fig. 4: Comparison of (a) SoilNet-based measurements of surface relative permittivity (real part) in 5 cm depth, with PolSAR-based estimates using (b) the standard approach (Jagdhuber et al. 2015), (c) assisted, and (d-f) (semi-) stand-alone retrieval techniques for moisture estimation below grass covered land.

3. CRNS Rover benefits from baseline calibration (N0) using data from the SoilNet

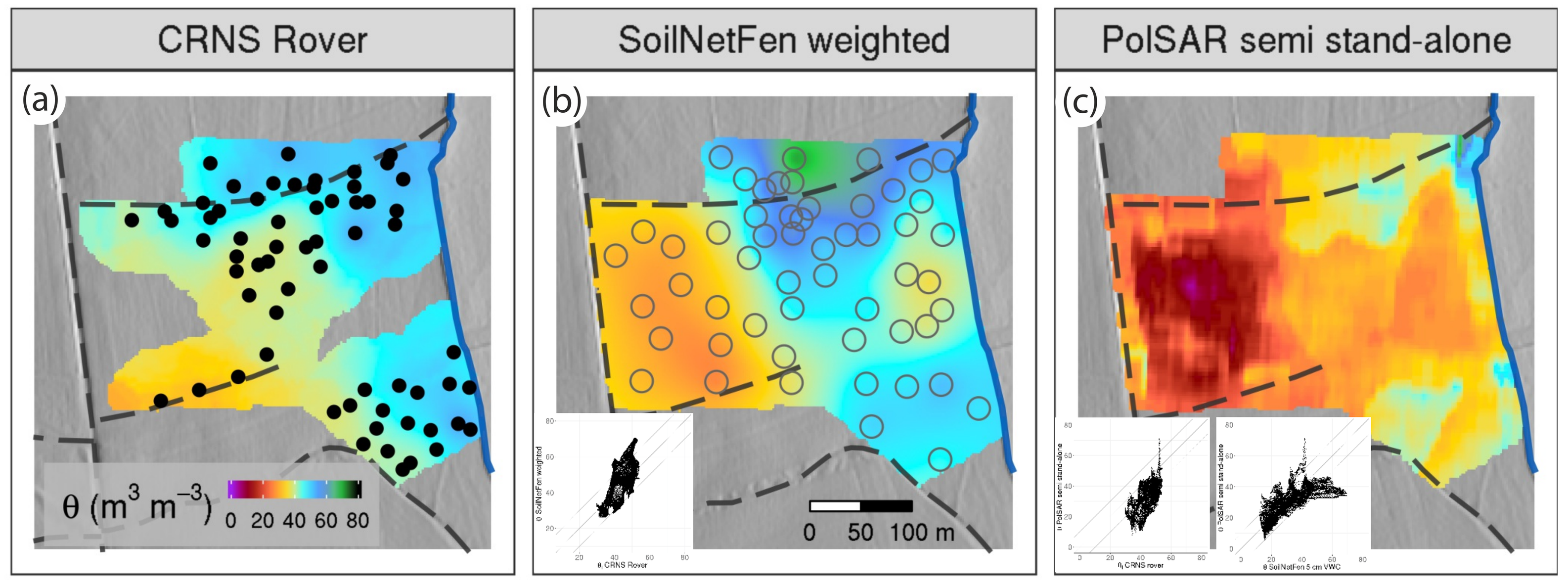


Fig. 5: Comparison of (a) root-zone integrated soil moisture from the CRNS Rover with (b) weighted root-zone estimate from the SoilNet, and (c) the surface soil moisture estimate using the PolSAR semi stand-alone retrieval.

CONCLUSIONS

- In situ data provides valuable information to calibrate the CRNS Rover and helped to improve the vegetation removal part of the PolSAR decomposition algorithm for grassland.
- CRNS Rover performance against local soil samples improved when corrected with vegetation proxy data from PolSAR's hv-backscatter product.
- The comparison of the 3 individual methods indicates an uncertainty range of approx. ± 10%.
- The synergistic approach has the potential to bridge different scales and to provide reasonable soil moisture observations for the regional scale.

Acknowledgements:
We are greatful to Ralf Horn (DLR) for PolSAR data acquisition, Marc Jäger (DLR) for PolSAR data processing, to Max Kasner (UFZ) for CRNS rover data processing and to Ingo Völksch (KIT) for the SoilNetFen data.
We thank the Helmholtz REKLIM, TERENO, and ACROSS initiatives for funding.

References:
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Jagdhuber, T., et al. (2015) " An Iterative Generalized Hybrid Decomposition for Soil Moisture Retrieval under Vegetation Cover Using Fully Polarimetric SAR", IEEE J. Sel. Topics Appl. Earth Observ. in Remote Sens., 8., pp. 3911-3922
Schrön, M., Rosolem, R., Köhli, M., et al. (2017). The Cosmic-Ray Neutron Rover-Mobile Surveys of Field Soil Moisture and the Influence of Roads. arXiv preprint arXiv:1709.04756.