Linking thermal UAV and Cosmic-Ray Neutron Sensing data

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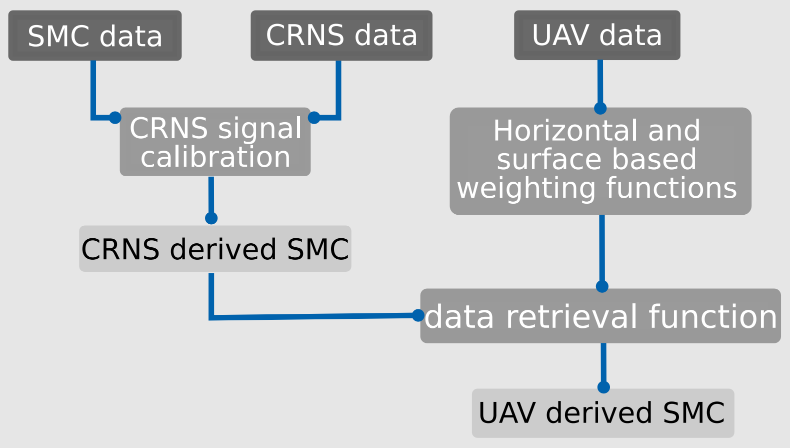
Background: Cosmic-Ray Neutron Sensing (CRNS) enables the measurement of soil moisture content (SMC) over larger footprints [1]. This footprint provides high potential for the validation of remotely sensed SMC.

Motivation: Recent modelling results of the CRNS community have shown that the characteristics of the footprint are influenced by various factors (see below). Those need to be considered in using CRNS as a validation product.

Novelty: We are deriving an approach to relate remote sensing data at different spatial resolutions to the CRNS signal, taking the footprint characteristics into account.

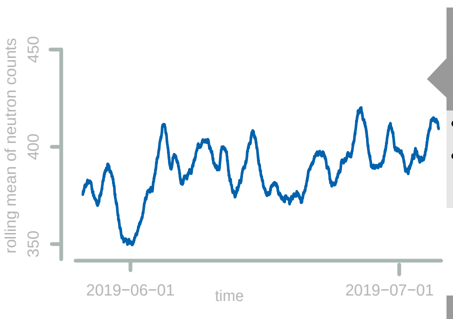
Methods:



Footprint and signal characteristics:

the characteristic...
...and how we take it into account

CRNS is a temporally continuous measurement method
UAV data aquisition at different time scales

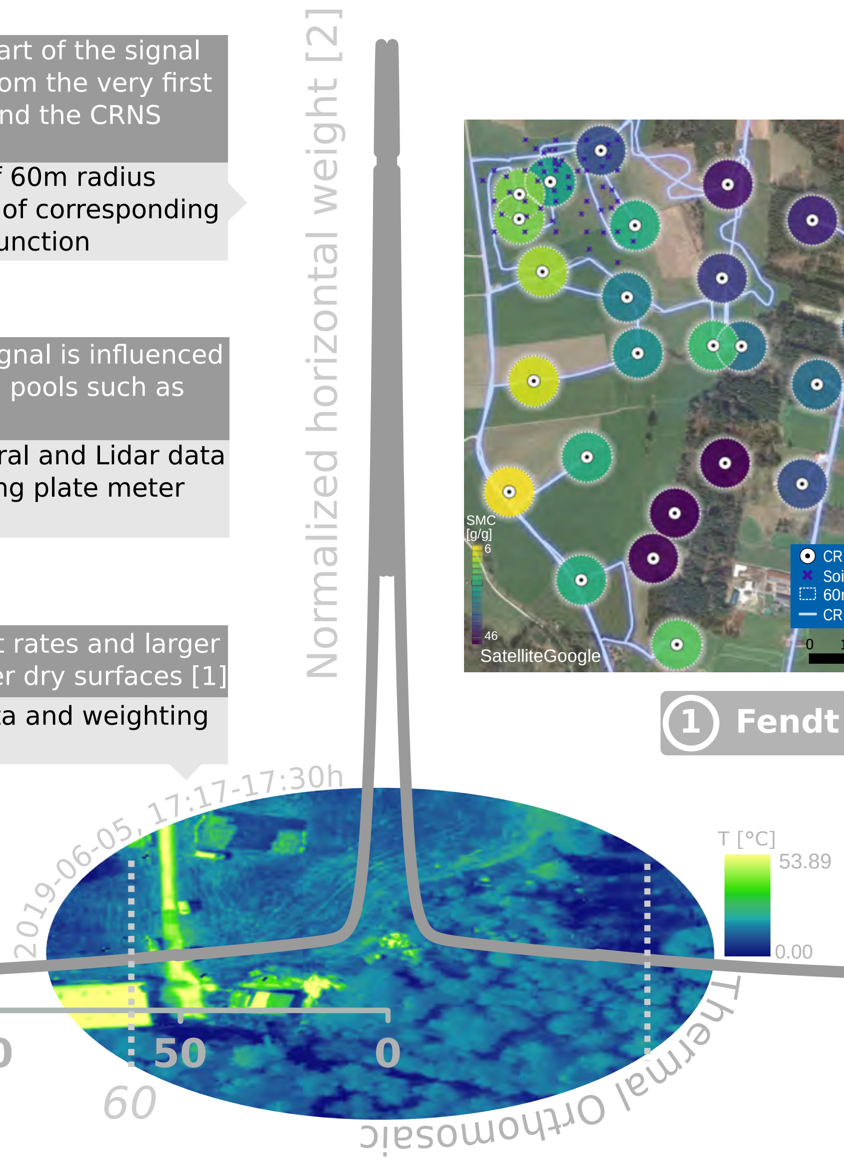


The major part of the signal originates from the very first meters around the CRNS probe
- UAV data of 60m radius
- Application of corresponding weighting function

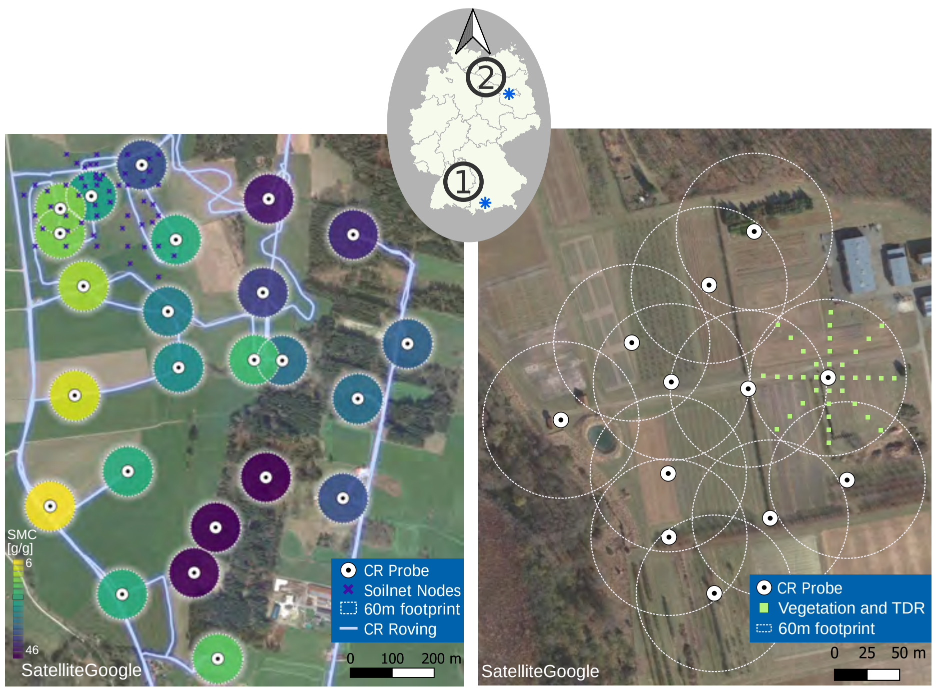
The CRNS signal is influenced by hydrogen pools such as biomass [3]
- Hyperspectral and Lidar data
- LAI and rising plate meter samples

Higher count rates and larger footprint over dry surfaces [1]
Thermal Data and weighting functions

Footprint extent is sensitive to vegetation [1]
Hyperspectral Data



Study sites:



① Fendt ② Marquardt

Drones and sensors

Vehicles	Sensor	Spectral Range	FOV in deg (HxV)
DJI Matrice 600 Pro	Headwall Nano-Hyperspec	400-1000 nm (270 Bands)	15.3 x 15.3
	Velodyne Puck Lite	905 nm 300 000 p/sec	360 x 15
MK Okto XL 6S12	TeAx Flir Tau 2 336	7.5 - 13.5 µm (1 Band)	35 x 27

Data sets:

		TM	HL	Vege-tation	TDR
Massive coverage	Nr CR signals	51	30	14	x
	Nr CR footprints	22	17	6	x
Diurnal variation	Nr CR footprints	7x4	6	6	7x4
Phenological change (Apr., May., Jul., Aug., Sep., Okt.)	Nr CR footprints	1	1	1	1
	Radius [m]	60	100	100	60

Thermal data preprocessing:

preprocessing steps...
...and used Software

1. Raw DN to °C conversion — Thermo Viewer
2. Blurry image extraction — Metashape
3. Determination of best setting for image alignment: Contrast enhancement; GPS/IMU data inclusion; Temperature correction [4]; lens calibration — R, ExifTool, Metashape
4. Sparse Point Cloud — Metashape
5. Tiepoint extraction — Metashape
6. noise quantification and noisy image extraction — R
7. Orthomosaic creation — Metashape

Outlook:

Analysis of the benefit of different weighting functions at different spatial scales, identification of optimal temporal and spatial scales of remote sensing data and identification of the optimal sensor (combination) for the linkage of CRNS measurements to remote sensing data.

References

[1] Köhli et al. 2015, 'Footprint characteristics revised for field-scale soil moisture monitoring with cosmic-ray neutrons', Water Resour. Res. 51/7, pp. 5772-5790.

[2] Schrön et al. 2017, ' Improving calibration and validation of cosmic-ray neutron sensors in the light of spatial sensitivity', Hydrol.Earth.Syst.Sci. 21/10, pp. 5009-5030.

[3] Baatz et al. 2015, 'An empirical vegetation correction for soil water content quantification using cosmic ray probes', Water Resour. Res. 51/4, pp. 2030-2046.

[4] Maes et al. 2017, 'Optimizing the processing of UAV-based thermal imagery',Remote Sens. 9/5, pp. 476.

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