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A novel combined approach for bridging scales in spatiotemporal soil moisture monitoring applying metrological principles

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One of the key environmental variables and essential climate variable is soil moisture, with its high relevance for applications such as agriculture, forestry, water management including hydrometeorological extreme events or hydrological modelling. Yet accurate measurement of soil moisture is limited by its high natural spatiotemporal variability, given spatially (vertically and horizontally) variable hydraulic properties of soil, and events that are highly variable themselves (in time, extension and intensity).

One geophysical method to close the gap between point-scale measurements and satellite-based remote sensing is Cosmic Ray Neutron Sensing (CRNS). Its integration area of about 0.1 km² is above the coverage of wireless sensor networks and at least when combined to CRNS clusters can cover several pixels of high resolution satellite remote sensing, e.g. by the ESA Sentinel-1 Earth Observation mission. We combine these three methods to bridge the scales in monitoring of soil moisture, and this within a novel metrological framework on validation and standardization.

The basis for that is an EU-wide collaboration project of 18 institutions called SoMMet[1]. Its approach is to thoroughly establish CRNS as a bridging method at intermediate scale by linking it to point-scale soil moisture sensors with certification according to newly established metrological standards while testing a range of CRNS detector designs in facilities for neutron metrology. The aim is to achieve an improved comparability and reliable estimates of uncertainty and provide recommendations on network design and validation practices, which shall result in a more widespread transfer into remote sensing applications and hydrological modelling.

A central component is to conduct field comparison and testing campaigns covering the different scales at three high-level field sites across Europe. One of the candidate sites is located close to Potsdam, Northern Germany. Having evolved from temporary soil moisture field campaigns it

hosts the sole long-term CRNS cluster (currently 15 CRNS probes) that covers a conjoined area. This is somewhat similar to wireless in-situ sensor networks, but working non-invasively, with partially overlapping footprints and last not least on larger scale, here about 0.6 km² altogether. We will present examples of SoMMet field test sites, and especially first results of this CRNS cluster from 2023 in its recently extended coverage set-up that now brings it further up to satellite remote sensing resolution.

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