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Area-representative validation of remotely sensed high resolution soil moisture using a cosmic-ray neutron sensor

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Reliable measurements of soil moisture (SM) are required for many applications worldwide, e.g., for flood and drought forecasting, and for improving the agricultural water use efficiency (e.g., irrigation scheduling). For the retrieval of large-scale SM datasets with a high temporal frequency, remote sensing methods have proven to be a valuable data source. (Sub-)daily SM is derived, for example, from observations of the Advanced Scatterometer (ASCAT) since 2007. These measurements are available on spatial scales of several square kilometers and are in particular useful for applications that do not require fine spatial resolutions but long and continuous time series. Since the launch of the first Sentinel-1 satellite in 2015, the derivation of SM at a spatial scale of 1 km has become possible for every 1.5-4 days over Europe (SSM1km) [1]. Recently, efforts have been made to combine ASCAT and Sentinel-1 to a Soil Water Index (SWI) product, in order to obtain a SM dataset with daily 1 km resolution (SWI1km) [2]. Both datasets are available over Europe from the Copernicus Global Land Service (CGLS, https://land.copernicus.eu/global/). As the quality of such a dataset is typically best over grassland and agricultural areas, and degrades with increasing vegetation density, validation is of high importance for the further development of the dataset and for its subsequent use by stakeholders.

Traditionally, validation studies have been carried out using in situ SM sensors from ground networks. Those are however often not representative of the area-wide satellite footprints. In this context, cosmic-ray neutron sensors (CRNS) have been found to be valuable, as they provide integrated SM estimates over a much larger area (about 20 hectares), which comes close to the spatial support area of the satellite SM product. In a previous study, we used CRNS measurements to validate ASCAT and S1 SM over an agricultural catchment, the Hydrological Open Air Laboratory (HOAL), in Petzenkirchen, Austria. The datasets were found to agree, but uncertainties regarding the impact of vegetation were identified.

In this study, we validated the SSM1km, SWI1km and a new S1-ASCAT SM product, which is currently developed at TU Wien, using CRNS. The new S1-ASCAT-combined dataset includes an improved vegetation parameterization, trend correction and snow masking. The validation has been carried out in the HOAL and on a second site in Marchfeld, Austria's main crop producing area. As microwaves only penetrate the upper few centimeters of the soil, we applied the soil water index concept [3] to obtain soil moisture estimates of the root zone (approximately 0-40 cm) and thus roughly corresponding to the depth of the CRNS measurements. In the HOAL, we also incorporated in-situ SM from a network of point-scale time-domain-transmissivity sensors distributed within the CRNS footprint. The datasets were compared to each other by calculating correlation metrics. Furthermore, we investigated the effect of vegetation on both the satellite and the CRNS data by analyzing detailed information on crop type distribution and crop water content.

[1] Bauer-Marschallinger et al., 2018a: https://doi.org/10.1109/TGRS.2018.2858004
[2] Bauer-Marschallinger et al., 2018b: https://doi.org/10.3390/rs10071030
[3] Wagner et al., 1999: https://doi.org/10.1016/S0034-4257(99)00036-X