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Validation of spaceborne soil moisture products using a cosmic ray neutron sensor in Petzenkirchen, Austria,

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Contrary to traditional soil moisture sensors, which provide point measurements, Cosmic Ray Neutron Sensors (CRNS) provide soil moisture (SM) estimates over a larger area (depending on SM conditions several hectares). This is a big advantage as most geoscientific applications require area-representative SM data. For this reason CRNS data is expected to be particularly useful for validating satellite SM estimates. However, CRNS is also sensitive to water in vegetation and biases have been observed with satellite-based soil moisture estimates over croplands.
We present an inter-comparison of CRNS measurements with in situ and satellite-based soil moisture retrievals. For this study data from the CRNS installed by the International Atomic Energy Agency in December 2013 in an agricultural region in Petzenkirchen Austria was used. First the CRNS measurements were compared with in situ SM measurements to identify the effect of vegetation on the CRNS. Results showed that the CRNS captures SM dynamics well, demonstrated by the high correlation with in situ SM both for anomalies and absolute values, with Spearman R of 0.81 for both. However, a wet bias was observed for some years during the main growing season when dense crops were present within the CRNS footprint (of about 20 hectares). CRNS measurements were then used to validate satellite-based SM datasets from two spaceborne active microwave sensors, Metop ASCAT and Sentinel-1. Correlations with ASCAT are slightly lower, between 0.72 and 0.77, and are comparable to other studies. Lowest correlations are found with Sentinel-1, 0.39 and 0.37 for absolute values and anomalies respectively. When limiting the observation period to the growing season (March-September), biases and correlations varied between years depending on crop and SM conditions. Where the CRNS measured lower soil moisture than the in situ network in 2014 and 2015, with a bias of 0.003 and -0.007 m3/m3, in 2016 the bias was positive with 0.013 m3/m3. 2014 and 2015 were relatively dry years and the majority of the crops was wheat and barley, whereas in 2016 the majority of the crops was canola and corn and the study site experienced a wet spring and summer. Correlations between CRNS and the in situ network was high for all years where Spearman R > 0.8. The correlation between CRNS and ASCAT was lower in 2016 than in the previous years, with correlation coefficients of 0.30 for 2016 and 0.73 and 0.72 for 2014 and 2015 respectively. The results demonstrate the potential of the CRNS for field scale SM monitoring and as a validation dataset for satellite-based products but also emphasize the need for further research into the effect of vegetation water.