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High-resolution soil moisture estimation from ALOS PALSAR Fine Mode (Dual Polarization) data in agricultural areas

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Understanding the temporal and spatial patterns of soil moisture is important for a wide range of applied tasks such as water and agricultural management, as well as research tasks such as understanding local impacts of large scale processes. Numerous studies have shown that spaceborne microwave remote sensing has the potential to provide spatially distributed patterns of near-surface soil water contents. Within the Transregional Collaborative Research Centre 32 entitled "Patterns in Soil-Vegetation-Atmosphere Systems: Monitoring, Modelling and Data Assimilation" we seek to improve the understanding of spatio-temporal patterns of soil moisture in agricultural landscapes on different scales. The PALSAR sensor has a higher spatial resolution ($\tilde{1}$0 m) than SAR systems onboard ERS-2, RADARSAT-1, and ENVISAT ($\tilde{3}$0 m). In the presented study we used ALOS PALSAR Level 1.1 Fine Mode Dual Polarization (PSRFBD) data provided by JAXA. The SAR images were moderately despeckled using an adaptive 3x3 Lee filter, orthorectified and radiometrically calibrated. Precision terrain correction was carried out using an airborne laser scanner DEM.
After this basic SAR processing the horizontally co-polarized (HH) backscattering coefficients were correlated with in situ surface soil moisture measurements for 3 different land covers (bare soil, grassland, winter wheat) from 2 test sites within the river Rur catchment, Western Germany. Surface soil moisture measurements taken within a time frame of 2 hours prior to and after the satellite pass in the uppermost soil layer (0 – 6 cm) were used. For bare soil 48 measurements were available, for grassland and winter wheat 96 and 59 measurements, respectively. Strong linear correlations with high significance were found on all fields. The following coefficients of determination were ascertained: bare soil ($R2 = 0.64$, $p < 0.01$), grassland ($R2 = 0.64$, $p < 0.01$), and winter wheat ($R2 = 0.43$, $p < 0.01$). Our results indicate that ALOS PALSAR data can be used to derive large scale soil moisture patterns as well as within-field spatial heterogeneities. Agricultural management as well as soil texture shows clear impacts upon the moisture patterns. To highlight advances in spaceborne Radar Earth Observation technologies we also compare ALOS PALSAR soil moisture retrievals with 15 m resolution to coarser ENVISAT ASAR products with 30 m resolution.