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On the potential of high-resolution C-band SAR for mapping within-field soil moisture variability

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The spatial distribution of soil moisture within agricultural fields has a large impact on runoff, erosion, plant growth and the chemical behaviour of fertilizers, which is important to agriculture and the environment. As ground measurements of soil moisture only provide local information at specific time instants, remote sensing offers a useful alternative, as it allows for observing soil moisture both across time and space.
This paper analyses the potential of two high resolution C-band VV/HH-polarized SAR (Synthetic Aperture Radar) sensors, respectively, onboard ENVISAT and RADARSAT-2, for mapping the within-field variability of soil moisture in two agricultural bare soil fields located in the Alzette river basin, Grand-Duchy of Luxembourg. The applied soil moisture retrieval technique is based on the Integral Equation Model, in combination with a statistical model that allows for estimating improved surface roughness parameters based on SAR backscatter observations. The retrieved soil moisture maps from SAR are compared with very high resolution soil moisture maps obtained from GPR (Ground Penetrating Radar) surveys, and soil moisture maps obtained through dense gravimetric sampling during three intensive field campaigns in March 2009.
It is shown that SAR captures the spatial soil moisture patterns as observed through GPR surveys and gravimetric sampling. At a pixel level (12.5 m), the correlation between SAR- and GPR-derived soil moisture maps is generally low (i.e. $R < 0.3$). However, a significant increase in correlation is observed after performing a spatial averaging of the soil moisture retrieval results, with $R > 0.7$ from a window size of 12 x 12 pixels onwards. In addition to this increase in correlation, the RMSE between SAR-retrieved and field measured soil moisture decreases after spatial averaging, with errors of approximately 7 vol% for a 12 x 12 window size. Finally, semi-variogram analysis is performed to evaluate the ability of RADARSAT-2 and ENVISAT to preserve the spatial correlation of soil moisture values.