Geophysical Research Abstracts
Vol. 17, EGU2015-5660, 2015
EGU General Assembly 2015

Surface soil moisture retrieval over a Mediterranean semi-arid region using X-band TerraSAR-X SAR data

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Mapping surface soil moisture with meter-scale spatial resolution is appropriate for multi- domains particularly hydrology and agronomy. It allows water resources and irrigation management decisions, drought monitoring and validation of multi-hydrological water balance models. In the last years, various studies have demonstrated the large potential of radar remote sensing data, mainly from C frequency band, to retrieve soil moisture. However, the accuracy of the soil moisture estimation, by inversing backscattering radar coefficients (σ°), is affected by the influence of surface roughness and vegetation biomass contributions. In recent years, different empirical, semi empirical and physical approaches are developed for bare soil conditions, to estimate accurately spatial soil moisture variability.

In this study, we propose an approach based on the change detection method for the retrieval of surface soil moisture at a higher spatial resolution. The proposal algorithm combines multi-temporal X-band SAR images (TerraSAR-X) with different continuous thetaprobe measurements. Seven thetaprobe stations are installed at different depths over the central semi arid region of Tunisia (9°23' - 10°17' E, 35° 1'-35°55' N). They cover approximately the entire of our study site and provide regional scale information. Ground data were collected over agricultural bare soil fields simultaneously to various TerraSAR-X data acquired during 2013-2014 and 2014-2015. More than fourteen test fields were selected for each spatial acquisition campaign, with variations in soil texture and in surface soil roughness. For each date, we considered the volumetric water content with thetaprobe instrument and gravimetric sampling; we measured also the roughness parameters with pin profilor.

To retrieve soil moisture from X-band SAR data, we analyzed statistically the sensitivity between radar measurements and ground soil moisture derived from permanent thetaprobe stations. Our analyses are applied over bare soil class identified from an optical image SPOT / HRV acquired in the same period of the measurements. Results have shown linear relationship for the radar signals as a function of volumetric soil moisture with high sensitivity about 0.21 dB/vol%. For estimation of change in soil moisture, we considered two options: On the first one, we applied the change detection approach between successive radar images ($\Delta\sigma^\circ$) assuming unchanged soil roughness effects. Our soil moisture retrieval algorithm was validated on the basis of comparisons between estimated and in situ soil moisture measurements over test fields. Using this option, results have shown an accuracy (RMSE) of about 4.8 %. Secondly, we corrected the sensitivity of the radar backscatter images to the surface roughness variability. Results have shown a reduction of the difference between the retrieved soil moisture and ground measurements with an RMSE about 3.7%.