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# Multi-frequency radar signals for the retrieval of soil roughness parameters in a Mediterranean semi-arid region

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Over bare agricultural areas, backscattered radar signal is very sensitive to physical soil characteristics particularly roughness and soil water content. Hence, different radar backscattering algorithms (theoretical, semi-empirical and empirical) were developed to modeling the relationship between backscattering coefficient and the soil parameters. Moreover, to retrieve these surface characteristics, mainly soil moisture content, by inversing backscattering models. However, the accuracy of the soil moisture estimation is affected by the influence of surface roughness parameter on backscattered radar signals.
In this context, we propose to analyze the potential of a synergy between ALOS2 (L band), Sentinel1 (C band) and TerraSAR-X (X band) SAR measurements over bare soils to retrieve surface parameters.
Ground campaigns were realized in central Tunisia (9°23' - 10°17' E, 35° 1'-35°55' N) during four years (2013-2017). The climate in this region is semi-arid, with an average annual rainfall of approximately 300 mm per year, characterized by a rainy season lasting from October to May. Ground campaigns were carried over agricultural bare soil fields simultaneously to various radar measurements acquired in different configurations (multi-polarizations, multi-incidences, multi-resolution). Firstly, we analyzed statistically the backscattering coefficient behaviour as a function of various roughness parameters (the root mean surface height Hrms and the Zs parameter developed by (Zribi and Dechambre, 2002) at three radar frequency (L, C and X bands) and different radar configuration (incidence angle and polarization). Results show a high sensitivity of the SAR signals to all roughness parameters (Hrms and Zs). The correlation between backscattering coefficient $\sigma^{\circ}$ and roughness parameters increases clearly with increasing values of radar wavelengths. The strongest correlation (R2=0.54) is obtained with L band images. The second axis was a validation of the calibrated version of the Integral Equation Model (IEM) and the new empirical backscattering model of Baghdadi et al (2016). This validation uses different SAR wavelengths, incidence angles and polarizations coupled with in situ measurements (soil moisture and surface roughness) over bare soil. Results have shown that the new model simulates correctly the radar response with a bias better than -1,5 dB for different radar wavelengths (L, C, X). Finally, by inverting the new empirical model in L band, we produced the surface roughness parameter “Hrms” maps at high resolution scale. Our approaches are applied over bare soil class identified from an optical image Sentinel2 acquired in the same period of measurements. Then, we proposed an approach for the retrieval of surface soil moisture from Sentinel1 images. We corrected the sensitivity of the radar backscatter images to the surface roughness variability using the produced roughness map.