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The role of vegetation growth on the estimate of soil moisture in a grass field using Sentinel-1 and Sentinel-2 observations and data assimilation

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The state of soil moisture is a key variable controlling surface water and energy balances. Nowadays remote sensors provide the unprecedented opportunity to monitor soil moisture at high time frequency on large spatial scales. The high spatial resolution of radar is a key element for soil moisture mapping of small hydrologic basins with strong spatial variability of physiographic and land cover properties, such as typical of Mediterranean basins. In addition, in the Mediterranean basins, soil moisture changes with strong dynamics, due to both interannual and seasonal rain variability, becoming a key term for water resources management and planning.

The new constellation of synthetic aperture radar (SAR) satellites, Sentinel-1 A and Sentinel-1B, provides images not only at the high spatial resolution (up to 10 m), typical of radar sensors, but also at high temporal resolutions (6-12 revisit days), with a major advance in the development of an operational soil moisture mapping at the plot.

Several models have been used for estimating soil moisture over bare soil surfaces from synthetic aperture radar satellites varying from physical models [e.g., the Integral Equation, the Advanced Integral Equation Model and the Integral Equation Model for Multiple Scattering, empirical models (e.g., Dubois model), and semi-empirical models. The main difficulty with SAR imagery is that soil moisture, surface roughness, and vegetation cover all have an important and nearly equal effect on radar backscatter.

In this work, the potentiality of Sentinel 1 for soil moisture retrieving in a water limited grass field have been tested using three common models for soil moisture retrieval from radar images: the empirical Change detection method, the semi-empirical Dubois model, and the physically based Fung model. For considering the growth vegetation effect on radar signal we propose an empirical model, which used simultaneously the optical Sentinel 2 images.

The case study is the Orroli site in Sardinia (Italy), a typical semi-arid Mediterranean ecosystem which is an experimental site for the ALTOS European project of the PRIMA MED program.

The 2016-2018 observation period was characterized by strong interannual rainfall variability, alternating wet and dry years, becoming an interesting opportunity for testing Sentinel 1 and 2 potentiality on soil moisture estimate in a wide range of climate conditions.

Using the Dubois model for soil moisture retrieval and the proposed model for accounting vegetation growth and surface roughness variability soil moisture was well estimated in both wet and dry conditions when compared with field observations

The unprecedented high temporal frequency of Sentinel 1 observations provides the opportunity to finally achieve operational procedures for soil moisture assimilation to guide ecohydrologic models. An operational procedure for assimilating soil moisture estimates from Sentinel 1 images in a land surface model using an Ensemble Kalman filter based assimilation scheme has been tested successfully, demonstrating the potentiality of the new generation of Satellite sensors for soil water balance predictions.