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Soil moisture mapping in a semi-arid region, using ASAR/Wide Swath satellite data

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Soil moisture is a key state parameter of the land surface, influencing the manner in which rainwater is shared between the phenomena of evapotranspiration, infiltration and runoff [Beven et al, 1996; Koster et al, 2004]. In the case of semi-arid regions, this parameter is particularly important for irrigation management [Bastiaanssen et al., 2000]. If water resources, which are often very limited, are to be optimized and protected, an accurate estimation of the soil's water content is needed in order to determine the expected evapotranspiration flux. In this paper, an operational algorithm is proposed for the mapping of surface moisture over the northern and central parts of Tunisia, in North Africa. A change detection approach is applied, using 160 multi-incidence Envisat ASAR Wide Swath images acquired in the horizontal polarization over a 7-year period. Parameterization of this algorithm is considered for three classes of vegetation cover density (NDVI<0.25, 0.25<NDVI<0.5 and NDVI>0.5), retrieved from SPOT-VGT decadal images. A relative soil moisture index, ranging between 0 (for the driest surfaces) and 1 (for saturated soils), is proposed for each date, with a resolution of 1 km. The algorithm can be broken down into three main steps:
- Normalization of the radar data from each pixel (x,y) to a constant incidence angle of 30°. One of three possible parameterizations is selected for each pixel, as a function of the vegetation density retrieved from SPOT-VGT images (NDVI<0.25, 0.25<NDVI<0.5 and NDVI>0.5).
- Computation of the radar sensitivity of each pixel (x,y), defined as the difference between the driest and wettest radar signals, for each of these three vegetation classes. The radar signals are most sensitive to the soil moisture of bare soils and areas having a sparse vegetation cover, and least sensitive in the north of the studied site, which is characterized by a dense vegetation cover.
- Estimation of the relative moisture index, defined as the ratio between the difference between the recorded radar signal and the driest signal, and the sensitivity.
The proposed index was validated firstly through the use of ground measurements in central Tunisia. This comparison revealed an RMS error equal to 0.13 and a correlation coefficient equal to 0.49. The proposed index was then compared with the ERS and ASCAT scatterometer products developed by TU Wien, and covering the same area. The results show that these models are in good agreement, with an RMSE lower than 0.13 and a correlation coefficient equal to 0.8 for two studied pixels. In qualitative terms, there is a high degree of coherence between the estimated moisture dynamics and the observed levels of precipitation. The proposed approach could be used on an operational basis with the data generated by SENTINEL-1, in particular for the study of regional hydrology.