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High-resolution soil moisture retrieval using a Neural Network approach from Sentinel-1 SAR data

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High-resolution soil moisture product is important for agriculture-related managements including irrigation. We have investigated the Change Detection (CD) method using Sentinel-1 data for 100 m resolution soil moisture retrieval and got a Root Mean Square Error (RMSE) about 0.6 m^3/m^3. However, the result of this approach is not accurate enough for high-density crops like corn. Another approach needs to be studied to get better accuracy over all types of crops. The artificial neural network (NN) technique, which involves nonlinear parameterized mapping from an input vector to an output vector, is an appropriate tool for retrieving geophysical parameters from remote sensing data. Many studies have explored the NN approach for processing remotely sensed data, including retrieving soil moisture, however, only a few studies [Notarnicola et al., 2010; Paloscia et al., 2013, etc.] had investigated NN for soil moisture estimation over vegetation-covered areas, especially in a large scale.

The objective of this study is to develop an approach based on neural networks to estimate soil moisture at high resolution over vegetation-covered areas from Sentinel-1 C-band SAR data. The quality of the output results depends directly on the quality of the input data used to train the NN and the reference data for the training, therefore, we performed our study over Catalonia, where we have many auxiliary data. The study is performed using both VV and VH polarization over the whole Catalonia. Apart from Sentinel-1 SAR data, auxiliary data including Sentinel-2 NDVI, SMAP soil moisture, CCI (ESA Climate Change Initiative) land cover, SIGPAC (Sistema de Información Geográfica de Parcelas Agrícolas) land cover, irrigation index and crop type information from SIGPAC, and DEM (Digital elevation model) are also used for approach development. DISPATCH (Disaggregation based on Physical and Theoretical scale Change) soil moisture product at 1 km resolution is considered as the target in the Neural Network training, adding great value to our study. To prepare the Neural Network training, all data sets are co-registered at 1 km resolution within the same size and resampled for the same dates within one year (2017). Two indexes describing the normalized backscatter difference and soil moisture are introduced as equation (1) and (2):

$$Index_1 = (\sigma^0_i - \sigma^0_{min}) / (\sigma^0_{max} - \sigma^0_{min}) \quad (1)$$

$$Index_2 = SM_{min} + (SM_{max} - SM_{min}) * Index_1 \quad (2)$$

Different parameters were tested to train the Neural Network approach, the preliminary results show a correlation value compared with DISPATCH product about 0.71 over croplands, 0.73 over irrigated fields, and 0.65 over forests, considering Index1, Index2 and SMAP soil moisture. Works are still on-going to try to improve the results by better analyzing the SAR data performance over different fields and conditions. The final goal of the study is to produce 100 m resolution soil moisture product. After 1 km resolution study, we will apply the approach at 100m resolution, and the in-situ soil moisture will be used for validation.

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