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A downscaling methodology for SMOS soil moisture retrievals

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Remote sensing observations offer a valuable tool for monitoring soil moisture at the global to regional scales. The spatial resolution however is too coarse to accommodate most hydrologic and climatic models. Downscaling of coarse remotely sensed observations, is therefore required to produce soil moisture estimates at finer scales, using in situ soil moisture measurements. The main concept of downscaling is to use in situ observations to calibrate a linear model between soil moisture and remote sensing observations, using auxiliary information from optical/thermal data along with other commonly monitored meteorological parameters such as precipitation and air temperature. In this work we developed a downscaling approach for the Soil Moisture Ocean Salinity Mission (SMOS) remotely sensed soil moisture observations obtained by a synthetic aperture radiometer which measures microwave radiation at the L- band (1.4 GHz) at a spatial resolution of $\sim$ 40 km. In-situ soil moisture observations were obtained from a network of 6 stations operating in the geographical area of North Greece, since early 2017.

Main objective of our work was to develop a downscaling approach incorporating readily available environmental information, in the form of simple vegetation indices such as Normalized Difference Vegetation Index (NDVI) along with precipitation and temperature data. Initially, diagnostic tests were applied to explore and conclude on the potential parameters that could serve as predictors for estimation of soil moisture at fine resolution of 1km at a daily time step. Covariance of in-situ soil moisture with SMOS coarse resolution soil moisture retrievals, precipitation, temperature and vegetation data indicated that all those parameters may contribute to the estimation of fine resolution soil moisture estimates. A regression equation was therefore developed incorporating SMOS L2 soil moisture, Moderate Resolution Imaging Spectroradiometer (MODIS) 16-day NDVI, daily precipitation and mean daily air temperature data. Additionally, land use information introduced during the development of the regression equation provided improved performance to our methodology. Preliminary results of our approach incorporating in-situ observations of approximately 1.5 years indicated that SMOS soil moisture data can be effectively downscaled using auxiliary environmental information. Accuracy of our estimates was determined examining the residual standard error (RSE) and multiple R squared (R^2). The high R^2 value of 0.68 that was achieved and the low RSE of 0.038 $m^3 \cdot m^{-3}$ suggest a promising methodology for acquiring fine resolution soil moisture estimates. The whole downscaling process was developed incorporating freely available remotely sensed data while data processing was performed within the R free and open statistical computing platform, offering thus an inexpensive approach towards reliable soil moisture estimates at fine resolution.