Surface soil moisture retrieval at high spatio-temporal resolution over bare soil from Sentinel-1 radar and Landsat thermal data

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Radar data have been used to retrieve and monitor the surface soil moisture (SM) changes in various conditions. However, the calibration of radar models whether empirically or physically-based, is still subject to large uncertainties especially at high-spatial resolution. To help calibrate radar-based retrieval approaches to supervising SM at high resolution, this paper presents an innovative synergistic method combining Sentinel-1 (S1) microwave and Landsat-7/8 (L7/8) thermal data. First, the S1 backscatter coefficient was normalized by its maximum and minimum values obtained during 2015-2016 agriculture season. Second, the normalized S1 backscatter coefficient was calibrated from reference points provided by a thermal-derived SM proxy named soil evaporative efficiency (SEE, defined as the ratio of actual to potential soil evaporation). SEE was estimated as the radiometric soil temperature normalized by its minimum and maximum values reached in a water-saturated and dry soil, respectively. We estimated both soil temperature endmembers by using a soil energy balance model forced by available meteorological forcing. The proposed approach was evaluated against in situ SM measurements collected over three bare soil fields in a semi-arid region in Morocco and we compared it against a classical approach based on radar data only. The two polarizations VV (vertical transmit and receive) and VH (vertical transmit and horizontal receive) of the S1 data available over the area are tested to analyse the sensitivity of radar signal to SM at high incidence angles (39°-43°). We found that the VV polarization was better correlated to SM than the VH polarization with a determination coefficient of 0.47 and 0.28, respectively. By combining S1 (VV) and L7/8 data, we reduced the root mean square difference between satellite and in situ SM to 0.03 m3 m-3, which is far smaller than 0.16 m3 m-3 when using S1 (VV) only.