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Remote Sensing of Surface Soil Moisture from FengYun MicroWave Radiation Imager (MWRI) Data Using a Machine Learning Technique

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In the past, soil moisture can be retrieved from microwave imager over most of land conditions. However, the algorithm performances over Tibetan Plateau and the Northwest China vary greatly from one to another due to frozen soils and surface volumetric scattering. The majority of western Chinese region is often filled with invalid retrievals. In this study, Soil Moisture Operational Products System (SMOPS) products from NOAA are used as the learning objectives to train a machine learning (random forest) model for FY-3C microwave radiation imager (MWRI) data with multivariable inputs: brightness temperatures from all 10 MWRI channels from 10 to 89 GHz, brightness temperature polarization ratios at 10.65, 18.7 and 23.8 GHz, height in DEM (digital elevation model) and statistical soil porosity map data. Since the vegetation penetration of MWRI observations is limited, we exclude forest, urban and snow/ice surfaces in this work. It is shown that our new method performs very well and derives the surface soil moisture over Tibetan Plateau without major missing values. Comparing to other soil moisture data, the volumetric soil moisture (VSM) from this study correlates with SMOPS products much better than the MWRI operational L2 VSM products. R^2 score increases from 0.3 to 0.6 and ubRMSE score improves significantly from 0.11 m^3 m^{-3} to 0.04 m^3 m^{-3} during the time period from 1 August 2017 to 31 May 2019. The spatial distribution of our MWRI VSM estimates is also much improved in western China. Moreover, our MWRI VSM estimates are in good agreement with the top 7 cm soil moisture of ECMWF ERA5 reanalysis data: R^2 = 0.62, ubRMSD = 0.114 m^3 m^{-3} and mean bias = -0.014 m^3 m^{-3} for a global scale. We note that there is a risk of data gap of AMSR2 from the present to 2025. Obviously, for satellite low frequency microwave observations, MWRI observations from FY-3 series satellites can be a benefit supplement to keep the data integrity and increase the data density, since FY-3B\-3C\-3D satellites launched in November 2010\September 2013\November 2017 are still working today, and FY-3D is designed to work until November 2022.