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High-resolution soil moisture map using Cosmic-Ray Neutron Sensors data and Sentinel-1

Content

Global climate change has a major impact on the availability of water resources for agricultural production. Sustainable agricultural productivity requires good agricultural water management. Thus, measuring soil moisture is a key point in agricultural water management. Moreover, soil moisture is an important variable for hydrological modelling, ground water recharge monitoring, flood and drought forecasting. Cosmic Ray Neutron Sensors (CRNS) have the capability to estimate field-scale soil moisture in large areas up to 20 to 30 ha and has demonstrated its ability to support agricultural water management, hydrology studies and land surface modelling. However, measurement of soil moisture on a global or regional scale can only be achieved from satellite remote sensing. Recently, active microwave remote sensing Synthetic Aperture Radar (SAR) imaging has emerged as an effective tool to estimate surface soil moisture. The Sentinel-1 (SAR) satellite shows great potential for high spatial resolution soil moisture monitoring and for producing soil moisture maps. CRNS technology can be used for calibration and validation of remote sensing imagery predictions at field and area-wide level. Therefore, the main aim of this work is to create a conversion model to retrieve soil moisture from Sentinel-1 (SAR) using CRNS data from temperate environments (Austria). This model was then used to set up a soil moisture map with high-spatial and temporal resolution. The study is performed using only the VV (vertical-vertical) polarization which is highly sensitive to soil moisture. The results showed that soil moisture measured by the CRNS, and the radar backscattered signal (σVV) have a similar trend (Figure 1a). Therefore, a simple linear regression model could be made (R^2=0.81) (Figure 1b). Once calibrated, the linear model was integrated into Google Earth Engine to convert VV polarization radar data into soil water content maps. In a next step, a web application was created for easy-access soil moisture estimation based on the satellite imagery data. Further, Normalized Difference Vegetation Index (NDVI) data from Sentinel-2 and rainfall data from Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) were also integrated in the prediction to consider soil moisture and vegetation dynamics due to irrigation. This study is a major step in the monitoring of soil moisture at high spatial and temporal resolution by combining remote sensing data and the CRNS based nuclear technology. The CRNS technology bridges the critical gap between satellites and point-scale ground sensors and enables the calibration of satellites, such as Sentinel- 1, to improve soil moisture data estimated by remote sensing. However, the model is sensitive to vegetation density and further research will be conducted to incorporate this important parameter using advanced mathematical techniques, such as machine learning. The developed web application is an important tool not only for agricultural water management, but also for hydrology, drought and flood prediction, and may be even useful in desert locust preventive management in the future.

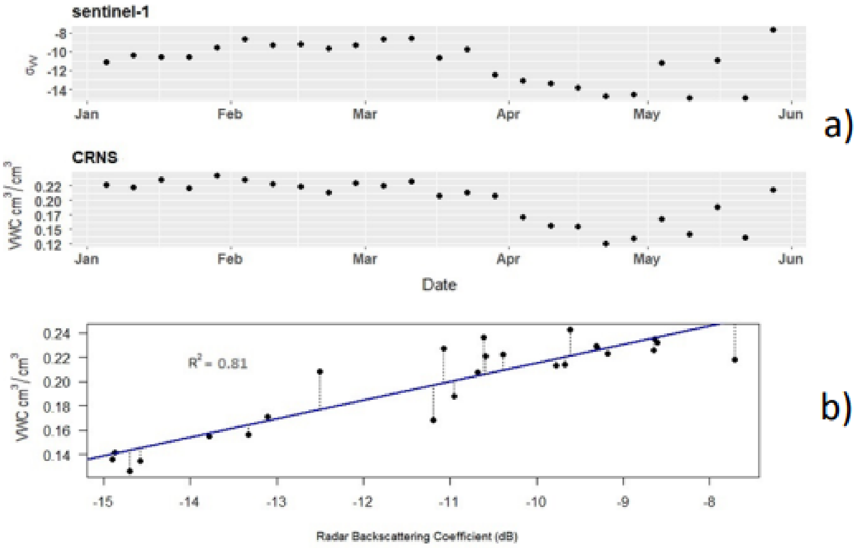

Figure 1. (a) Sentinel-1 radar backscattered coefficient (σVV) and soil moisture measured with Cosmic Ray Neutron Sensor in a test case in Kuwait and. (b) Linear regression model between σVV and soil moisture for the same test case

Keywords: Cosmic-Ray Neutron Sensor, field scale Soil moisture, Sentinel-1, Synthetic Aperture Radar (SAR)

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