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Remote Sensing of the Soil Moisture at the Agricultural Test Field in Volgograd Region with The Using Sentinel-1 Observations and Neural Network-Based Algorithm

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In this contribution, the opportunity to use Sentinel-1 radar data (S-1RD) to monitor the soil moisture (SM) of the soil surface (SS) is presented. Ground & Space monitoring event (G&SME) was carried out on 20/08/2019 at the experimental field (48°36′31.86″, 44°10′50.65″) of All-Russian Scientific Research Institute of Irrigated Agriculture (VNIIOZ, Volgograd region, Russian Federation). At the moment of G&SME the southern part of the plot was represented by fallow field and the northern part of it was covered by sparse coverage of alfalfa with NDVI varied within: a) 0.154-0.188 according to Sentinel-2 MSI; b) 0.091-0.202 according to Planet satellite constellation. The field was 190 m wide and 300 m long with presence of the 1,5 degrees slope in south to north direction. In west-eastern direction the field is flat with surface microrelief formed by plowing across to the slope. After data obtained with photogrammetric survey from UAV the SS roughness varied within 1.1-2.6 cm. Due to heavy clay content of soil it shows low permeability that caused by soil runoff generation during previous irrigation water application. Part of this runoff was stored at local depressions located near the southern border. During monitoring event a 40 not disturbed georeferenced soil samples were collected from 0-5cm layer. In vitro, these samples were used to obtain a SM for verification of the radar data.

Backscattering coefficient was acquired from Sentinel-1A in the interferometric broadband mode at the frequency of 5.4 GHz at VH and VV polarizations. Standard processing of S-1RD was carried out using ESA SNAP software (precision orbits, calibration, speckle filtering (sequential use of two Gamma map filters with a size of 3x3 pixels), geometric correction based on a DEM done after UAV photogrammetric survey data). Due to the fact that sensing angle within the field varied little, normalization of the backscattering coefficient with respect to one sensing angle was not carried out. For slightly covered and bare parts of the field a polarimetric analysis (H-a decomposition using complex images with VH and VV polarizations) revealed mainly a SS scattering mechanism (zones 6 and 9 in the H-a diagram). To retrieve SM retrieving from Sentinel-1 an algorithm based on the neural network (NN) was used. In contrast to the existing approaches, in our approach, a nadir reflectivity was used as the main output parameter of NN, as the input parameters were used backscattering coefficient measured at VH and VV polarizations. The NN was used to predict the reflectivity of the SS. Then reflectivity was inverted to SM with the use of Levenberg-Marquardt minimization algorithm and Mironov's dielectric model, taking into account a soil clay content. Based on S-1RD, the proposed NN, consisting of two hidden layers of 12 neurons in each, allows to predict SM relative to ground based SM with the determination coefficient of 0.948 and the standard deviation of 2.04%. The developed technique was tested for both bare and sparsely vegetated parts of the field.

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