Soil Moisture Inversion using Dual Polarimetric TerraSAR-X Data

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Based on the radar frequency, soil surface can be modeled using theoretical models such as Bragg model [1] and Physical Optics (PO) model [2]. Physical optics model solution is suitable for higher frequency. Hence, it can be applicable for X-band like TerraSAR-X data. At present, two satellites operating at high frequency (X-band TerraSAR-X and Cosmo-Skymed) are giving data. Recently, several investigations have been carried out for soil moisture estimation using X-band SAR data [2 -5]. Similar to Bragg scattering model [1], physical optics model is extended to deal with rough surface. The extended model is known as X-PO model which was investigated by Martonea et al. (2010) using fully polarimetric TerraSAR-X data. In this paper, X-PO model has been studied using dual polarimetric TerraSAR-X data over Mumbai test site. Based on dual pol H-Alpha decomposition (Cloude, 2007), the X-Bragg coherency matrices for dual polarimetric SAR data are expressed in Eq. (1) and (2) using the relation between fully polarimetric and dual polarimetric coherency matrices. The Eigenvalue/Eigenvector decomposition is applied to this dual polarimetric SAR data and the corresponding dual polarimetric wave entropy and scattering alpha angle are calculated. TerraSAR-X HH/VV dual polarimetric X-band data acquired on April 8th, 2012 over Mumbai test site with incidence angle range from 28.40 to 29.60 was used to invert soil moisture using high frequency surface scattering model. Synchronous with satellite passes, CRs were mounted and ground truth data in terms of soil moisture, bulk density measurement with the help of cylinder, vegetation height, Ground Control Points (GCP) with the help of ‘Trimble’ hand-held GPS. TerraSAR-X Single Look Complex (SLC) data is processed for [C2] matrix using PolSARpro software with multi-look in 2 times in azimuth and 2 times in range. Later, the wave coherency matrix is filtered using Lee refined filter with window size 5x5 for speckle removal. Polarimetric parameters such as entropy and alpha parameters are then generated from the filtered coherency matrix. For soil moisture inversion, X-PO model is used to estimate soil moisture with help of incident angle of the corresponding test site. The terrain corrected soil moisture map has been obtained using NEST software with the help of external Digital Elevation Model (DEM). Firstly, we plotted the modeled H-α values for fully-pol SAR data to verify with existing literature. From the figures, it is observed that both the inversion diagram values are well located within H-Alpha boundary values of dual (N=2) and full pol (N=3) plot. However, the alpha values obtained from fully-pol X-PO model are very high and falling in dihedral region from low to medium entropy. In dual-pol case, alpha value decreases as the width of orientation angle distribution increases. After 300 width of distribution, the modeled values fall in high entropy region which indicates mixed and polarimetricaly indistinct scattering mechanism due to less polarimetric content. This test site mainly covers urban and forest area except very few isolated irrigated fields. Due to unavailability of four channels, it is not possible to discriminate bare soil fields using dual polarimetric SAR data. As the alpha values are high, smooth surface soil moisture whose alpha angle less than 300 cannot be inverted using this model. The measured ground truth soil moisture over IIT Bombay gymkhana is 26.34%. The estimated soil moisture is 8.66%. The other ground truth soil moisture values (27.9%) are located in grass with height 45cm. Due to this reason, those pixels could not be inverted for soil moisture. Hence, we could not validate this model with more points over this test site and the same will be carried out over good bare soil fields with less heterogeneity areas.