Estimation of Soil Moisture in Bare Soils of the Northern Dry Zone of the Deccan Plateau, Karnataka, using Sentinel-1 Band C imagery

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Introduction
Soil moisture information is a critical input to water resource allocation, irrigation scheduling and climate risk management. The data of sowing is an important decision for farmers take after initial rainfall occurs based on traditional knowledge and physical estimation of soil moisture. The present study was conducted on bare agriculture fields of Siruguppa sub-district in Karnataka state in India to estimate surface soil moisture using radar remote sensing with the aim of developing an accurate and scalable methodology.

Hypothesis
VV (σv) dB and VH (σh) dB together can improve the accuracy of soil moisture in bare soil, based on the fact that VV (σv) dB has more contribution from soils and VH (σh) dB has more contribution from vegetation and surface roughness.

Objective
- The main goal of this study is to estimate soil moisture over bare soils using both VV and VH polarization at 1cm depth.
- A semi-empirical model is proposed for retrieval of soil moisture using VV, VH polarization and surface roughness of soil over a large area (1024 sqkm) with minimum in-situ samples.
- Proposed soil moisture model is validated at same locations during the year 2018.

Data
Volumetric soil moisture (θ)
- Volumetric soil moisture (θ), at 1cm depth, surface roughness (hrms) was collected during satellite overpass.
- Soil samples were stratified random sampled during 2017 and 2018 at the same locations in the study area to develop the model and validate.

Semi-empirical model
- A semi-empirical model was proposed to estimate θ, over bare soils in agriculture areas from σv based on theoretical relationships.
- The contribution of VV (σv) is more than from VH (σh) to soil moisture.
- Modeled VH (σh) in addition to VV (σv) to improve the soil moisture estimate.

\[ F(\theta) = T + H(\sigma_v)VV + G(\sigma_h)VH + P \text{ (HRMS)} \]

Where mV is the volumetric soil moisture, hrms surface roughness, T, G, H and P are empirical constants which depend on radar wave length, polarization, frequency, incidence angle and soil texture

Summary
- The scatter plots, clearly indicate that inter-year variation in the backscatter values, behave almost similar for both polarization, except for the energy response indicating a bare soil condition and the importance of VV polarization along with VH in increasing the accuracy of mV estimate.
- VV polarization is more sensitive to soil moisture at 30°-35° incidence angle and a depth of 1cm during March 4, 2017 to May 22, 2018 than VH σh for same period
- For surface roughness VH polarization is more sensitive than from VV
- The model validation r² ranged from 0.72 to 0.84 and the rmse value was mostly 0.02 m3/m3 for all the dates except 16th April which was 0.03 m3/m3
- Soil moisture maps generated from 4 March, 2017 to 27 May, 2017 clearly shows that the model is able to capture the weather variability in precipitation, directly influencing the soil moisture

Conclusion
- VV polarization along with VH in the model improved accuracy from (previous studies) 3-6% to 2-3%.
- More accurate and scalable estimates of spatial variation of surface soil moisture can be used to trigger sowing date advisories or parametrize crop models for prediction

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