ABSTRACT

Microwave remote sensing is a complementary tool for the mapping/monitoring of soil moisture. A primary advantage with microwave remote sensing is that soil moisture can be assessed regardless of weather or atmospheric conditions. The L-band (1–2 GHz) is one of the lowermost frequency bands of microwave radiations, and currently, two space-borne soil moisture datasets are available in this frequency range; Soil Moisture Active Passive (SMAP) and Soil Moisture Ocean Salinity (SMOS). Both of these data products have nearly identical pixel resolution, that is approximately 36–40 km. Though an enhanced SMAP soil moisture product is also available at the spatial resolution of 9 km. The SMAP L2 soil moisture baseline algorithm utilized the zeroth-order Radiative Transfer Model (RTM) and was named as the Single-Channel Algorithm (SCA). This approach has various essential parameters to define its accurateness, such as surface roughness parameter, scattering albedo, Vegetation Water Content (VWC), soil dielectric constant, and surface temperature. Any inaccuracy in these variables can affect the accurateness of the soil moisture estimation. Therefore, in this thesis, the SCA has been enhanced by accurately measuring two of these variables, that is the soil surface roughness parameter and VWC. The reported numerical value of the soil surface roughness parameter for croplands in the Algorithm Theoretical Basis Document (ATBD) of SMAP L2 soil moisture is 0.108, which is very low compared to India's ground measurements. Thus, an optimization process has been chosen to obtain the correct value of the roughness parameter for the agricultural fields of Northern India, and the obtained results show that its value ranges from 0.2 to 0.3.

Apart from this, the ATBD uses a 16-day Normalized Difference Vegetation Index (NDVI) (MOD13A2 from MODIS) to estimate VWC. This may induce some errors because of two reasons. First, SMAP provides soil moisture data on a daily basis, and NDVI is available

on an average of 16 days; Second, the operational frequencies of both the products are different, the MOD13A2 is an optical dataset, and the operational frequency of SMAP soil moisture data products is microwave. Therefore, the approach of SCA is enhanced in two ways; first, by including a daily NDVI product instead of a 16-day product, and second by estimating a microwave VWC from Sentinel-1. The Sentinel-1 dual Polarized SAR data is utilized for the evaluation of three vegetation indices, named as Dual Polarimetric Radar Vegetation Index (DPRVI), Radar Vegetation Index (RVI), and Cross- and Co-Polarized Ratio (CCR). These microwave vegetation indices are then utilized with three machine learning algorithms (Random Forest, Support Vector Regression, and Adaptive Neuro-Fuzzy Inference System) to determine the VWC. Afterwards, the estimated microwave VWC is incorporated into SCA, that resulted in a significant improvement in the accuracy of the soil moisture retrieval.

Besides estimating the SMAP soil moisture, the downscaling of satellite soil moisture is also a challenging task in soil moisture remote sensing. Various statistical and theoretical algorithms have been developed for soil moisture downscaling. In this thesis, intercomparison has been performed between existing algorithms such as the Triangle method, the Dispatch method, and the Approximation of Thermal Inertia (ATI) theory. ATI has been found to be the best-performing approach. In contrast, to introduce a new approach, the MODIS LST and MODIS NDVI have been utilized to derive new vegetation modulated index, termed Vegetation Modulated Soil Moisture Index (VMSMI). This index can successfully minimize the vegetation effects from land surface emission to attain a clear soil characteristic. This index is further utilized to achieve high-resolution soil moisture from the coarse resolution soil moisture.

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