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An Algorithm for Soil Moisture Retrieval using Multi-frequency Observations for Future the Water Cycle Observation Mission (WCOM)

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Soil moisture is one of the important parts in the global land surface ecosystem, water cycle and energy cycle, which control the water and heat energy exchange between land and atmosphere. Earth observation satellites play a critical role in providing information for understanding the global water cycle, which dominates the Earth-climate system. A new satellite concept of global Water Cycle Observation Mission (WCOM) is proposed in China, aiming to provide higher accuracy and consistent measurements of key elements of water cycle from space, including soil moisture, ocean salinity, freeze-thaw, snow water equivalent and etc. The expected more consistent and accurate datasets would be used to refine existing long-time series of satellite measurements, to constrain hydrological model projections and to detect the trends necessary for global change studies. The WCOM mission concept is a combination of active and passive microwave instruments. There will be three payloads: 1) an L-S-C tri-frequency Full-Polarized Interferometric synthetic aperture microwave Radiometer (FPIR); 2) a Polarized Microwave radiometric Imager (PMI) covering 6.8 GHz to 150 GHz bands; 3) an X-Ku Dual-Frequency Polarized SCATterometer (DFPSCAT). A soil moisture retrieval algorithm using the multi-frequency radiometer measurements is developed in this study. Through analyzing the simulated database of the Advanced Integral Equation Model (AIEM) under WCOM (Water Cycle Observation Mission) sensor configurations, a parameterized surface reflectivity model for multi-frequency Full-Polarized Interferometric synthetic aperture microwave Radiometer (FPIR) and Polarized Microwave radiometric Imager (PMI) are developed. In this model, influences of surface roughness parameters (e.g. RMS height, correlation length and type of autocorrelation function) on surface reflectivity are considered. It is found that the surface roughness and temperature can be cancelled out using the relationship of the multi-frequency radiometer measurements. For vegetation-covered surface, we adopt the Zero-order radiative transfer model and microwave vegetation index (MVI) in order to find a more accurate description of the vegetation emission component and vegetation transmission component. Vegetation correct is done directly from multi-frequency radiometer observations without any ancillary data. This leads to a new method for estimation of the soil dielectric properties directly from the radiometer measurements. The simulated data and field experimental radiometer measurements of bare surface obtained from Beltsville Agriculture Research Center (BARC) during 1979–1981 are used for validation. The inversion accuracy with RMSE (root-mean-square error) for simulated data and bare surface experimental data are 0.012 m3/m3 and 0.033 m3/m3, respectively. The soil moisture retrieval in vegetated area is performed using the PALS radiometer measurements during Soil Moisture Experiments in 2002 (SMEX02) and SMAP Validation Experiment 2012 (SMAPVEX12). The inversion accuracy with RMSE for the vegetation surface experimental data are 0.035 m3/m3 and 0.046 m3/m3, respectively. The retrieval error is higher for SMAPVEX12 data due to the high vegetation water content. All the results indicate that the algorithm performed satisfactorily over all surface cover conditions including bare and vegetated region with the accuracy very close to the 0.04 m3/m3 for WCOM mission.