**Multi-frequency Observation of Soil Moisture and Vegetation Optical Depth from Space**

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***ABSTRACT***

Numerous soil moisture (SM) products have been developed for satellite-based microwave remote sensing systems operating at various frequencies. However, it is challenging to make a fair comparison of their sensing capabilities and depth of different frequencies/sensors due to the use of different retrieval algorithms in existing soil moisture products. This study compares two new enhanced-resolution soil moisture datasets from the L-band Soil Moisture Active Passive (SMAP) and the Advanced Microwave Scanning Radiometer 2 (AMSR2) by utilizing the same multi-channel collaborative algorithm (MCCA), termed MCCA SMAP and MCCA AMSR2. The assessment involves a comparison of the satellite soil moisture with 40 globally distributed soil moisture observation networks at regional (dense network) or grid scales. The findings first indicate that both MCCA SMAP and AMSR2 soil moisture products demonstrate superior performance at the regional scale compared to the grid scale. Secondly, for the first time, we have provided evidence that SMAP outperforms AMSR2, with both sensing capabilities decreasing as vegetation cover increases. Furthermore, the analysis of global soil moisture dry-down patterns reveals that SMAP exhibits a lower soil moisture loss rate, an extended soil moisture retention duration, and an effective higher wilting point than AMSR2, which suggests that the L-band contribution depth surpasses that of C-, X-, and Ku-bands at the satellite scale.

**Keywords:** MCCA, SMAP, AMSR2, soil moisture, dry down