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A Dry Bias Mitigation Scheme for Soil Moisture Active Passive (SMAP) Passive Soil Moisture Retrieval Using Time Series Observations

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Since its launch in January 2015, the NASA Soil Moisture Active Passive (SMAP) mission has returned nearly three years of L-band (1.41 GHz) brightness temperature observations at both horizontal and vertical polarizations. The data have enabled routine operational production of passive soil moisture estimates at 9 km and 36 km grid resolutions with an average global revisit period of 2-3 days.

A primary SMAP product validation methodology involves comparison between satellite retrieval and in situ soil moisture data at a spatial scale representative of the native resolution of observing instrument. Extensive post-launch validation analyses have shown that the current passive soil moisture products, while demonstrating decent levels of random errors and correlation against the in situ data, exhibit moderate dry bias over a majority of core validation site locations. Such a dry bias has recently become more pronounced upon the latest release (Version 4) of the SMAP Level 1B brightness temperatures.

Various causes have been proposed to explain the observed dry bias, ranging from systematic uncertainties in the spatial aggregation of in situ data, inadequate modeling of soil moisture variability over soil depth, and uncertainties in ancillary data. In addition to these possible causes, non-optimal forward model parameters and systematic bias in effective soil temperature may also play a significant role, causing the resulting soil moisture estimates to bias in one way or the other.

In this presentation, an iterative data processing scheme was proposed to mitigate the dry bias of the current SMAP passive soil moisture products. This approach makes use of SMAP Level 1B brightness temperature time series observations to model parameters and physical processes that contribute to soil moisture geophysical inversion at different time scales. By using observations from long-term multiple overpasses as constraints, this approach can be used to provide correction in forward model parameters and effective soil temperature. Specifically, vertically and horizontally polarized brightness temperature observations were used in a dual channel algorithm (DCA) formulation in this approach. As the length of time series observations grows, there are enough known quantities needed to solve for soil moisture estimates, polarization-dependent forward model parameters, and adjustment factors in NDVI-based vegetation opacity climatology. It was found that this bias mitigation approach resulted in significant reduction in dry bias (0.030 m3/m3 → less than 0.010 m3/m3, which is well within the bias uncertainty of in situ data in core validation sites) between satellite soil moisture estimates and in situ soil moisture data over a majority of core validation data, while retaining other performance metrics (e.g. unbiased RMSE and correlation) of the existing operational algorithm. The resulting soil moisture time series estimates demonstrated improved retrieval accuracy with low random errors, high correlation, and lower systematic bias. It is expected that the global correction produced by this approach, along with further advances in soil moisture depth profile modeling and in situ soil moisture aggregation, will continue to have a positive impact on the SMAP passive soil moisture product development.