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Accounting for Seasonal Soil Moisture Retrieval Errors in the Generation of Climate Data Records

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Multi-decadal climate data records of soil moisture (SM) are generated by merging distinct satellite microwave remote sensing data sets to serve countless Earth System applications. Such products generally outperform the individual sensor records as they provide a least squares solution to the merging of SM. Within the well known European Space Agency's (ESA) Climate Change Initiative (CCI) for SM product, it was demonstrated that a performance leap is achieved by informing the averaging of multiple retrievals with Triple Collocation Analysis (TCA)-based uncertainty estimates of the input data sets. However, while the approach taken to generate the ESA CCI SM product assumes a constant random error variance for an entire sensor period, it has become evident that errors in SM remote sensing retrievals fluctuate throughout the year. This has been linked to the fact that environmental parameters---foremost vegetative growth---are characterized by a seasonality, such that their impact on the SM retrieval varies with the same cycle. Therefore, taking this seasonal component into account in the least squares formulation of the merging problem is a logical next step. This study examines whether a seasonal adaptation of TCA leads to a performance improvement in the merging, using input data from the ASCAT, AMSR2, and SMAP missions and the GLDAS2.1 model as a climatology baseline. The two key findings are that i) since seasonal uncertainty variations affect all sensors in a similar way, they cause only marginal changes in their relative weighting, which leads to the merged SM estimates not changing significantly from the static to the seasonal merging; yet ii) an evaluation against in situ data suggests that the estimated uncertainties of the new merged product are more representative of their actual seasonal behavior. Such improved uncertainty representation is potentially beneficial to various applications, for instance in the weighting of SM observations for assimilation in physical models. Based on these findings, we conclude that using a dynamic TCA approach can add value to merged products such as the ESA CCI SM by providing a more realistic characterization of data set uncertainty---in particular its temporal variation.