What is the uncertainty of the uncertainty and (why) does it matter? Propagating uncertainties of weight estimates through soil moisture data merging

Maud Formanek, Alexander Gruber, and Pietro Stradiotti
Department of Geodesy and Geoinformation, TU Wien, Vienna, Austria (maud.formanek@geo.tuwien.ac.at)

This study aims to improve the ESA CCI soil moisture dataset uncertainty estimates by including the sampling uncertainty of the triple collocation analysis in the uncertainty propagation of the data merging scheme. The ESA CCI soil moisture product merges data from multiple sensors through a weighted average. This strategy aims to increase both the temporal and spatial sampling density while reducing random retrieval errors. Optimal error reduction is obtained by assigning the weights according to each sensor's specific uncertainty characteristics, expressed as $\sigma_i^{-2}/(\sum \sigma_j^{-2})$. The uncertainties σ_i are determined via triple collocation analysis (TCA) applied to soil moisture estimates from a land surface model, and from a passive and an active microwave satellite instrument.

However, the uncertainty estimates obtained from TCA are themselves uncertain as a result of finite sample size. Notably, this 'uncertainty of the uncertainty' (UU) can be derived analytically for simple error models, but lacks a similar analytical solution for the affine error model (which includes both additive and multiplicative biases) employed in the CCI SM algorithm.

The magnitude of the UU has serious implications for the weighted averaging and the resulting uncertainty of the merged products: 1) it introduces an additional term in the uncertainty of the merged product stemming from the uncertainty of the weights themselves, and 2) the UU can reach a threshold, where the weighted average yields worse results than an unweighted average. In this study, we calculate the UU via bootstrapping of the TCA results for three sensors (ASCAT, SMAP and SMOS) and investigate its impact on the uncertainty of the merged dataset.