# Estimating uncertainty in remotely sensed soil moisture at continental to global scales

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**Abstract:**

Remotely sensed soil moisture observations have traditionally been validated against predefined (unbiased) Root Mean Square Errors (RMSE) target accuracies, estimated by comparison to in situ observations from a limited number of well-observed pixels. However, errors from a limited number of locations will not necessarily be representative of continental-plus domains, and validation at these well-observed pixels should be complemented with distributed methods for estimating soil moisture uncertainty over larger domains. In the absence of a globally recognized truth for soil moisture, this is not straight forward, and this presentation examines some of the approaches available for extending the validation of remotely sensed soil moisture to continental to global domains.

It is unclear how RMSE target accuracies for soil moisture could be interpreted for larger domains. Different soil moisture estimates, from different remote sensors or models, describe different soil moisture climates, as measured by the mean and variance, and the true soil moisture climatology is unknown. It has then become standard practice to focus on the temporal agreement between different soil moisture estimates, by rescaling them to have statistics consistent with an arbitrarily selected 'reference' data set. A RMSE based on rescaled data sets is then quoted in units relative to the reference climatology. An obvious problem with this approach is the dependence of the RMSE on the temporal standard deviation of the selected reference. Additionally, the choice of reference can determine the rankings of the domain-wide mean RMSE of different soil moisture estimates, due to non-linear differences in the spatial patterns of temporal variability of different references. Extending the evaluation (or specification of target accuracies) of remotely sensed soil moisture to larger domains then requires using alternative metrics to the RMSE. One option, which is presented here, is to normalize the (unbiased) RMSE by the time series standard deviation. This metric is referred to as the fractional RMSE (fRMSE), and is closely related to the correlation.

Two methods for estimating the fRMSE are demonstrated here: i) triple collocation, and ii) error propagation through the retrieval models. Both are used to estimate the fRMSE over a continental scale domain centered on North America for soil moisture estimates retrieved from the passive microwave AMSR-E, and the active microwave ASCAT sensors. The strengths and weaknesses of both methods are reviewed, and their results are compared. It is concluded that both can accurately detect the large scale spatial variability in soil moisture uncertainty, in that regions with relatively high and low fRMSE from both methods agree with each other, and with expectations based on land cover class.

***Keywords:*** *Remote Sensing, Soil Moisture, Error Estimation.*