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Exploring the relative scale of uncertainty in high-resolution soil moisture remote sensing products towards model integration

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Soil moisture (SM) is a fundamental hydrological variable for understanding processes in the land-atmosphere, biological, or geophysical domains and an output of many hydrological or land surface models. It is peculiar in that its variability reflects distinct hydrological processes moving from the field scale, where local topography plays a role, to the regional scale, where meteorological forcing is the main control. Correctly representing this variety of processes is a complex modeling task often alleviated by integrating information from well-established Earth Observation (EO) systems, which produce SM data with near global coverage at coarse (10-25 km) resolution. Still, the increasing need for fine scale (1 km, 1 day) simulations of the water cycle is to be met by EO data of similarly high resolution.

High resolution satellite-based SM data is now available from several sources. 1km datasets are multiplying following simultaneous efforts to retrieve SM from backscatter measurements of the Sentinel-1 mission with various inversion models. At the same time, physical or statistical relationships are leveraged to down-scale coarse resolution products by ingesting data from distinct observational sources, coming from the mentioned Sentinel-1 or the optical domain. However, while products of the first type are confronted with the limited sensitivity of C-band microwave to SM and reduced spatial and temporal availability, down-scaled products might retain much of the original signal and fail the fine-scale process representation. The question of which of these resources can preferably be integrated to reliably improve high-resolution modelling is therefore an open one.

In this study we perform a round robin (i.e., inter-comparative) assessment of the most prominent high-resolution SM products in the EO landscape. While adapting validation and error characterization techniques and tools (e.g., the Quality Assurance for SM service) that are routinely used at the coarse scale, we address the partial lack of 1km scale reference measurements through the application of an emerging high resolution validation framework. Such a framework demonstrates that metrics for high resolution benchmarking can be reliably retrieved with only sparse, point-scale measurements. The first results suggest that the true spatial SM heterogeneity might explain a minimum noise tradeoff between coarse- and high-resolution EO products. This work is a fundamental step to assess the current state-of-art in EO and its maturity for integration in high-resolution water cycle modelling.