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## Using fiducial reference measurements for assessing soil moisture product stability

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The Global Climate Observing System Essential Climate Variables (GCOS ECVs) requirements define a target threshold of 0.005 m<sup>3</sup>/m<sup>3</sup> per decade for satellite soil moisture product stability. As admitted by GCOS, this threshold lacks robust justification in the scientific literature, prompting critical assessment. Moreover, no commonly-accepted method exists to assess satellite soil moisture product stability to begin with.

In this study, we investigate the suitability of existing in situ soil moisture monitoring networks contained in the International Soil Moisture Network (ISMN) for stability assessment. The selection of such stable reference sites is based on two criteria: (i) sites that are considered “fiducial reference sites” as defined by the Fiducial Reference Measurements for Soil Moisture (FRM4SM) project; and (ii) sites that provide suitable temporal coverage for the time spans over which satellite product stability is required (i.e., 10 years or more). Using these select reference sites, we assess the stability of various common satellite soil moisture products (e.g., ASCAT, SMOS) using Theil-Sen slopes that are calculated for various validation metrics (e.g., median annual Pearson correlations or unbiased Root Mean Square Differences). In addition, we investigate the impact of data gaps and scarcity on the calculated stability metrics.

Analyses were carried out using the the python toolbox for evaluating soil moisture observations (pytesmo; <https://github.com/TUW-GEO/pytesmo>). The goal is to include stability metrics as part of the QA4SM online validation service in the future (<https://qa4sm.eu/>).