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A gap-filled global long-term satellite soil moisture climate data record from ESA CCI SM

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ESA CCI Soil Moisture is a multi-satellite climate data record that consists of harmonized, daily observations coming at present from 19 satellites operating in the microwave domain. The wealth of satellite information, particularly over the last decade, facilitates the creation of a data record with the highest possible data consistency and coverage.
However, data gaps are still found in the record. This is particularly notable in earlier periods when a limited number of satellites were in operation, but can also arise from various retrieval issues, such as frozen soils, dense vegetation, and radio frequency interference (RFI). These data gaps present a challenge for many users, as they have the potential to obscure relevant events within a study area or are incompatible with (machine learning) software that often relies on gap-free inputs.
Since the requirement of a gap-filled ESA CCI SM product was identified, various studies have demonstrated the suitability of different statistical methods to achieve this goal. A fundamental feature of such gap-filling method is to rely only on the original observational record, without need for ancillary variable or model-based information. Due to the intrinsic challenge, there was until present no global, long-term univariate gap-filled product available.
In this study we address this requirement and introduce the ESA CCI SM GAP-FILLED product. We present the framework around a widely used discrete cosine transform based method (DCT-PLS), and discuss the interpolation of soil moisture in the case of frozen soils and dense vegetation cover. We demonstrate a method to model the expected uncertainty introduced by the interpolation process. We evaluate the impact of gap-filling on the data set and thereof derived statistics such as anomalies and long-term trends.