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Homogenization of structural breaks in the global ESA CCI multi-satellite climate data record

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ESA's Climate Change Initiative (CCI) creates a global, long-term soil moisture (SM) data record (currently over 38 years) by merging multiple available earth observation products with the goal to provide a product for climate studies, trend analysis, and risk assessments. The blending of soil moisture time series derived from different active and passive remote sensing instruments with varying sensor characteristics, such as microwave frequency, signal polarization or radiometric accuracy, may lead to structural breaks in the dataset. These artificially caused discontinuities may mask natural phenomena and therefore adversely affect studies assessing long-term variability and change.

We detect this type of breaks in ESA CCI SM using relative, non-parametric statistical tests (Fligner-Killeen test for homogeneity of variances and Wilcoxon rank-sums test for shifts in population mean ranks) against reference datasets, which are soil moisture time series from in-situ measurements as well as from land surface model simulations. To quantify and consecutively adjust breaks in the dataset, we fit linear regression models between reference data and ESA CCI SM for each of in total eight potential break times (corresponding to the introduction or removal of various satellite missions in the merged dataset). Adjustment is performed iteratively, so that for each detected break, time series means and variances are fit to match with more recent periods of the dataset. In this way, a mostly homogenized dataset is achieved. To investigate the impact of homogenization on the dataset, we identify monotonic, significant trends using a non-parametric Mann-Kendall test and compare our results to trends in other soil moisture and precipitation data records. The break homogenization presented in this study will be implemented in future releases of the ESA CCI and Copernicus Climate Change Service (C3S) soil moisture products.