



## **The ESA CCI Soil Moisture climate data record: recent improvements and contributions to Earth system sciences**

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Climate Data Records of soil moisture are fundamental for improving our understanding of long-term dynamics in the coupled water, energy, and carbon cycles over land. In response to this need, the European Space Agency (ESA) released in 2012 - as part of its Climate Change Initiative (CCI) program - the first multi-decadal, global satellite-observed soil moisture (SM) dataset. ESA CCI SM combines various single-sensor soil moisture products from active and passive microwave sensors into three harmonised products: a merged ACTIVE, a merged PASSIVE, and a COMBINED active+passive product. Recently, the ESA CCI SM product saw a large number of enhancements, e.g., with respect to the merging methodology, the inter-calibration of sensors, and the characterisation of errors. Besides, due to the inclusion of recently launched sensors like the Soil Moisture Ocean Salinity (SMOS) mission, the Advanced Microwave Scanning Radiometer 2 (AMSR2) and the Advanced Scatterometer (ASCAT) onboard the MetOp-B satellite, the latest product release now covers the period 1978-present.

In this study, we first give an overview of the latest ESA CCI SM developments and its product and error characteristics. We show that the product quality has increased since its first release but that for certain surface conditions (e.g., dense vegetation, organic soils) uncertainties are still substantial. Second, capitalising on a large number of research studies that made use of the ESA CCI SM data, we show how ESA CCI SM has contributed to improve our process understanding in various Earth system domains, including climate variability and change, land-atmosphere interactions, global biogeochemical cycles, hydrological and land surface modelling, drought applications, and meteorology. Based on these results we identify unexploited potential in the use of the ESA CCI SM products and possible improvements that should receive highest priority in future updates.