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L-band soil moisture retrievals using microwave based temperature and filtering. Towards model-independent climate data records

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The CCI Soil Moisture dataset (CCI SM, Dorigo et al., 2017) is the most extensive climate data record (CDR) of satellite soil moisture to date and is based on observations from multiple active and passive microwave satellite sensors. It provides coverage all the way back to 1978 and is updated yearly both in terms of algorithm and temporal coverage. In order to maximize its function as a CDR, both long term consistency and (model-)independence are high priorities in its development.

Two important satellite missions integrated into the CCI SM are the ESA Soil Moisture and Ocean Salinity mission (SMOS, Kerr et al., 2010) and the NASA Soil Moisture Active Passive mission (SMAP, Entekhabi et al., 2010). These missions distinguish themselves with their unique L-band (1.4 GHz) radiometers, which are theoretically more suitable for soil moisture retrieval than the prior available higher frequencies like C- X- and Ku-band (6.9 to 18.0 GHz).

However, these L-band missions are lacking onboard sensors for observations from higher frequencies Ku-, K- and Ka-band, which are normally used within the Land Parameter Retrieval Model (Owe et al., 2008), the baseline algorithm for passive microwave retrievals within the CCI SM, for retrieving the effective temperature (Holmes et al., 2009) and providing filters for snow/frozen conditions (Van der Vliet et al., 2020). Therefore, the retrievals from the current L-band missions make use of temperature and filters derived from global Land Surface Models (LSM, Van der Schalie et al., 2016). For a CDR that should function as an independent climate benchmark, this is a strong disadvantage.

Within this study the aim is to evaluate the impact of replacing the LSM based input for L-band soil moisture retrievals with one that comes from passive microwave observations. We use an inter-calibrated dataset existing of 6 different sensors that cover the complete SMOS and SMAP historical record (and further), consisting of AMSR2, AMSR-E, TRMM, GPM, Fengyun-3B and Fengyun-3D. These satellites are merged together using a minimization function that also penalizes errors in the Microwave Polarization Difference Index (MPDI) for a higher level of stability compared to using traditional linear regressions.

As currently the 6 am L-band retrievals are seen as the most reliable, and are currently the only ones used within the CCI, the main focus will be on the effects of using the 1:30 am observations from the inter-calibrated dataset as input. However, to make the method also applicable for daytime observations, the 6 pm retrievals have also been tested using an average of 1:30 pm and 1:30 am (next day) observations.

This evaluation will provide an overview of the differences, giving insight on how this affects coverage, mean values, standard deviations and their inter-correlation. Secondly, we will test the resulting quality against both in situ observations and ERA5. A similar performance of this new dataset shows this is a good way to standardize input on temperature and filtering within the CCI SM, further improving its consistency and function as a model-independent CDR.