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Validation of SMOS and ASCAT Soil Moisture Products - Time Series Analysis in the Rur and Erft Catchments

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As soil moisture is an important driver for various climatic and hydrological processes, area-wide time series of soil moisture data are important for numerical weather predictions, for example at the European Centre for Medium-Range Weather Forecasts (ECMWF), as well as for climate and hydrological modeling.
The Soil Moisture and Ocean Salinity (SMOS) satellite, launched in 2009, is an attempt to provide global soil moisture data in the required temporal resolution. SMOS records brightness temperatures in the L-Band at 1.4 GHz, which are converted into soil moisture through inverse modeling.
This study uses reprocessed SMOS Level 2 soil moisture data from the year 2010 for a long-term validation in the Rur and Erft catchments in Northrhine-Westfalia, Germany. They are compared to time-series of soil moisture derived from Advanced Scatterometer (ASCAT) data. ASCAT is a real-aperture radar that measures surface backscattering coefficients in the C-band at 5.255 GHz with a resolution of 30 to 50 km. Through a time series-based change detection approach relative soil moisture is retrieved from the backscattering coefficients, which is then converted to absolute soil moisture with data on soil properties.
The individual accuracy and suitability of both datasets for the further use in numerical weather prediction and hydrological modeling are analyzed with the help of a soil moisture reference calculated by WaSiM ETH, a grid-element-based hydrological model. The model was calibrated with soil moisture data from the wireless sensor network at two test sites in the study area. Regression between the in situ data and the model values shows good results, despite a small bias, with an overall RMSE coefficient of 0.05. Time-series of the observed and modeled data also indicate a good agreement.
A first comparison of SMOS data with the soil moisture reference does not show a high correlation. Furthermore, the temporal development of the data is different for SMOS soil moisture and the reference. A strong bias can be observed for the whole period: SMOS shows constantly lower values of soil moisture than the reference data. Partition into ascending and descending nodes does not show better results. Calculation of RMSE for every SMOS footprint over the whole period displays smaller values in the northern part of the study area than in the southern part. That can be due to the mountainous terrain but also to the dense vegetation with much forest in this area.
When comparing a L-band radiometer like SMOS and a C-band scatterometer like ASCAT, disparities in the time series can occur because of different vegetation penetration abilities and soil penetration depths, distinct sensitivities to surface roughness, and sensitivity to radio frequency interferences (RFI).