Geophysical Research Abstracts
Vol. 15, EGU2013-3734, 2013
EGU General Assembly 2013
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De-noising of microwave satellite soil moisture time series

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The use of satellite soil moisture data for scientific and operational hydrologic, meteorological and climatological applications is advancing rapidly due to increasing capability and temporal coverage of current and future missions. However evaluation studies of various existing remotely-sensed soil moisture products from these space-borne microwave sensors, which include AMSR-E (Advanced Microwave Scanning Radiometer) on Aqua satellite, SMOS (Soil Moisture and Ocean Salinity) mission and ASCAT (Advanced Scatterometer) on MetOp-A satellite, found them to be significantly different from in-situ observations, showing large biases and different dynamic ranges and temporal patterns (e.g., Albergel et al., 2012; Su et al., 2012). Moreover they can have different error profiles in terms of bias, variance and correlations and their performance varies with land surface characteristics (Su et al., 2012). These severely impede the effort to use soil moisture retrievals from multiple sensors concurrently in land surface modelling, cross-validation and multi-satellite blending. The issue of systematic errors present in data sets should be addressed prior to renormalisation of the data for blending and data assimilation. Triple collocation estimation technique has successfully yielded realistic error estimates (Scipal et al., 2008), but this method relies on availability of large number of coincident data from multiple independent satellite data sets. In this work, we propose, i) a conceptual framework for distinguishing systematic periodic errors in the form of false spectral resonances from non-systematic errors (stochastic noise) in remotely-sensed soil moisture data in the frequency domain; and ii) the use of digital filters to reduce the variance- and correlation-related errors in satellite data. In this work, we focus on the VUA-NASA (Vrije Universiteit Amsterdam with NASA) AMSR-E, CATDS (Centre National d'Etudes Spatiales, CNES) SMOS and TUWIEN (Vienna University of Technology) ASCAT data sets to identify two types of errors that are spectrally distinct. Based on a semi-empirical model of soil moisture dynamics, we consider possible digital filter designs to improve the accuracy of their soil moisture products by reducing systematic periodic errors and stochastic noise. We describe a methodology to design bandstop filters to remove artificial resonances, and a Wiener filter to remove stochastic white noise present in the satellite data. Utility of these filters is demonstrated by comparing de-noised data against in-situ observations from ground monitoring stations in the Murrumbidgee Catchment (Smith et al., 2012), southeast Australia.

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