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On the value of SMOS MIRAS-derived volumetric soil moisture for hydrological monitoring and prediction applications: a field evaluation over Luxembourg and Central Italy

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Soil Moisture and Ocean Salinity (SMOS) is the first space mission dedicated to soil water content observations. The brightness temperature measurements at L-band (6.9 GHz) of the Microwave Imaging Radiometer with Aperture Synthesis (MIRAS) are particularly insensitive to vegetation optical depth and other perturbation factors. Soil moisture values can be retrieved with an expected RMSE of ±4% m3.m-3. In this paper in situ soil moisture data from the Bibeschbach experimental catchment (10.8 km2) in Luxembourg and the Colorso catchment (12.9 km2) in Central Italy are used to evaluate the usefulness of the SMOS MIRAS-derived Level 2 surface soil moisture product for hydrological monitoring and prediction applications. The two basins are equipped with a dense observation network, monitoring soil moisture at various depths at catchment scale. According to the pre-storm soil moisture deficit hypothesis the filling of the moisture deficit in the soil is a pre-requisite for initiating rapid subsurface flow. Hydrological systems thus often exhibit a non-linear threshold-like behavior. In order to understand the value of remote sensing-derived soil moisture for hydrological predictions, it is thus important to evaluate its ability to distinguish between the two main states of river system dynamics. For this reason this study focuses on SMOS MIRAS data acquired between August and December 2010, thereby investigating the capability of the sensor to capture the transition from dry to wet conditions and to predict the onset of rapid stormflow. The data sets are provided by the European Space Agency.

Our results suggest that satellite-derived surface soil moisture may serve as a proxy of soil storage that enables the monitoring of abrupt switches in river system dynamics appearing when an effective field capacity is exceeded and rapid subsurface stormflow is initiated. We further show that in catchments where soil moisture is the main control factor of rapid subsurface flow, remote sensing-derived soil moisture has the potential to help monitoring how a river system approaches a critical threshold. SMOS MIRAS-derived soil moisture is strongly correlated with discharge measurements at the outlet of the experimental catchments and the SMOS Level 2 product reliably distinguishes between the two main hydrological states. A soil moisture data assimilation experiment shows that moisture recordings are particularly useful for improved discharge predictions during transition periods from wet to dry in early spring and from dry to wet in early autumn.

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