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Use of ASCAT derived soil moisture product for real-time flood forecasting in the Upper Tiber River

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The role and the importance of soil moisture for meteorological, agricultural and hydrological applications is widely acknowledged. In particular, for a given storm event, different values of initial soil moisture conditions can discriminate between minor or catastrophic effects. Therefore, a real time flood forecasting system founded on a rainfall-runoff model strictly requires an accurate estimation of the initial state of the catchment wetness to obtain a reliable estimation of the flood hydrograph. It has to be pointed out that, in flood-prone areas, a Flood Monitoring and Warning System operating in real time represents the main non-structural measure to be actuated to dampen the risk.

At the catchment scale, soil moisture monitoring can be addressed by using sensors operating on remote sensing platforms. Among them, the coarse resolution scatterometers have been employed in different studies due to their high temporal resolution suitable for hydrological applications. Specifically, the Advanced Scatterometer (ASCAT) on-board of the Meteorological Operational satellite provides an operative surface soil moisture product available at global scale since March 2007. This sensor is characterized by a spatial resolution of 25/50 km and a nearly daily time step. To get profile soil moisture estimates, an exponential filter is applied to the time series of the ASCAT surface soil moisture obtaining the so-called Soil Wetness Index (SWI). The reliability of the SWI was recently evaluated through the comparison both with in-situ and modelled soil moisture data in the Upper Tiber River basin.

In this study, the effects of assimilating satellite-derived soil moisture estimates into a continuous and distributed rainfall-runoff model, named MISDc, were assessed. This topic is relevant not only for scientific purposes but also for operational applications. In fact, the MISDc model is actually operative at the Umbria Region Functional Centre for real time flood forecasting in the Upper Tiber River ($\sim$5300 km^2). The model is based on the coupling of a simple soil water balance and an event-based rainfall-runoff model through an experimentally derived relationship. Therefore, MISDc is characterized by a parsimonious structure and parameterization and, at the same time, a high computational speed that is crucial for real time operational purposes.

By using simple data assimilation techniques, the SWI derived by ASCAT was assimilated into MISDc and the model performance on flood estimation, with and without assimilation, was compared. In particular, two significant flood events occurred on December 2008 and January 2010 that produced flooding and damages were carefully investigated. Moreover, three synthetic experiments considering errors on rainfall, model parameters and initial soil wetness conditions were carried out in order to further ascertain the SWI potential when uncertain conditions take place. Results reveal that the ASCAT soil moisture estimates can be conveniently used to improve runoff prediction in the study area. These products become essential when the soil wetness conditions before a storm event are highly uncertain or unknown.