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Soil moisture assimilation into rainfall-runoff modelling: which is the impact of the model structure on runoff predictions?

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Rainfall-runoff models are usually the main tool of operational real-time flood forecasting systems. However, uncertainties in the structure, parameters and input/output observations highly impact the accuracy of the predictions of these models. To reduce these uncertainties, data assimilation of remotely sensed data into rainfall-runoff modelling has became an important issue for hydrological research and applications.
Nowadays, also in view of the satellite missions dedicated to soil moisture estimation (i.e. SMOS and, in the near-future, SMAP), soil moisture estimates from satellite sensors are becoming more readily available with a spatial-temporal resolution and an accuracy that can be considered suitable for hydrological applications. However, even after a decade of attempts, genuine 'success stories' continue to be rare, arguably due to differences in the quality of data and models used in different applications.
A recent study by Brocca et al. (2010) demonstrated the capability of the root-zone soil moisture product, named Soil Water Index, derived from the Advanced Scatterometer (ASCAT). to improve runoff prediction for several catchments located in central Italy. However, the assimilation of the surface soil moisture product, directly sensed by ASCAT, has only a little impact on runoff prediction (Brocca et al., 2012). This can be due to the not optimal structure of the used rainfall-runoff model, named MISDc.
In this study, an enhanced version of the MISDc model is used to analyze the role of the rainfall-runoff model structure on the assimilation performance. The Ensemble Kalman filter is adopted as data assimilation technique and in situ and satellite soil moisture observations for the Upper-Middle Tiber Basin (6000 km^2) are employed as case study. Specifically, in situ data are obtained by a dense soil moisture network, named UMBRIA, recently set up and consisting of 15 stations operating in real-time while satellite data are obtained by the ASCAT sensor.
Results reveal that a more detailed characterization of the water movement in the soil through the structure of the rainfall-runoff model is necessary to achieve a significant impact of the assimilated data in the model itself. The structure of the model is found to be depending on the layer depth of the observations, which is different for satellite and in situ data.

References

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