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Use of distributed water level and soil moisture data in the evaluation of the PUMMA periurban distributed hydrological model: application to the Mercier catchment, France

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Distributed hydrological models are used at best when their outputs are compared not only to the outlet discharge, but also to internal observed variables, so that they can be used as powerful hypothesis-testing tools. In this paper, the interest of distributed networks of sensors for evaluating a distributed model and the underlying functioning hypotheses is explored. Two types of data are used: surface soil moisture and water level in streams. The model used in the study is the periurban PUMMA (Peri-Urban Model for landscape Management, Jankowfsky et al., 2014), that is applied to the Mercier catchment (6.7 km2) a semi-rural catchment with 14% imperviousness, located close to Lyon, France where distributed water level (13 locations) and surface soil moisture data (9 locations) are available. Model parameters are specified using in situ information or the results of previous studies, without any calibration and the model is run for four years from January 1st 2007 to December 31st 2010 with a variable time step for rainfall and an hourly time step for reference evapotranspiration.

The model evaluation protocol was guided by the available data and how they can be interpreted in terms of hydrological processes and constraints for the model components and parameters. We followed a stepwise approach. The first step was a simple model water balance assessment, without comparison to observed data. It can be interpreted as a basic quality check for the model, ensuring that it conserves mass, makes the difference between dry and wet years, and reacts to rainfall events. The second step was an evaluation against observed discharge data at the outlet, using classical performance criteria. It gives a general picture of the model performance and allows to comparing it to other studies found in the literature. In the next steps (steps 3 to 6), focus was made on more specific hydrological processes. In step 3, distributed surface soil moisture data was used to assess the relevance of the simulated seasonal soil water storage dynamics. In step 4, we evaluated the base flow generation mechanisms in the model through comparison with continuous water level data transformed into stream intermittency statistics. In step 5, the water level data was used again but at the event time scale, to evaluate the fast flow generation components through comparison of modelled and observed reaction and response times. Finally, in step 6, we studied correlation between observed and simulated reaction and response times and various characteristics of the rainfall events (rain volume, intensity) and antecedent soil moisture, to see if the model was able to reproduce the observed features as described in Sarrazin (2012). The results show that the model is able to represent satisfactorily the soil water storage dynamics and stream intermittency. On the other hand, the model does not reproduce the response times and the difference in response between forested and agricultural areas.

References:

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