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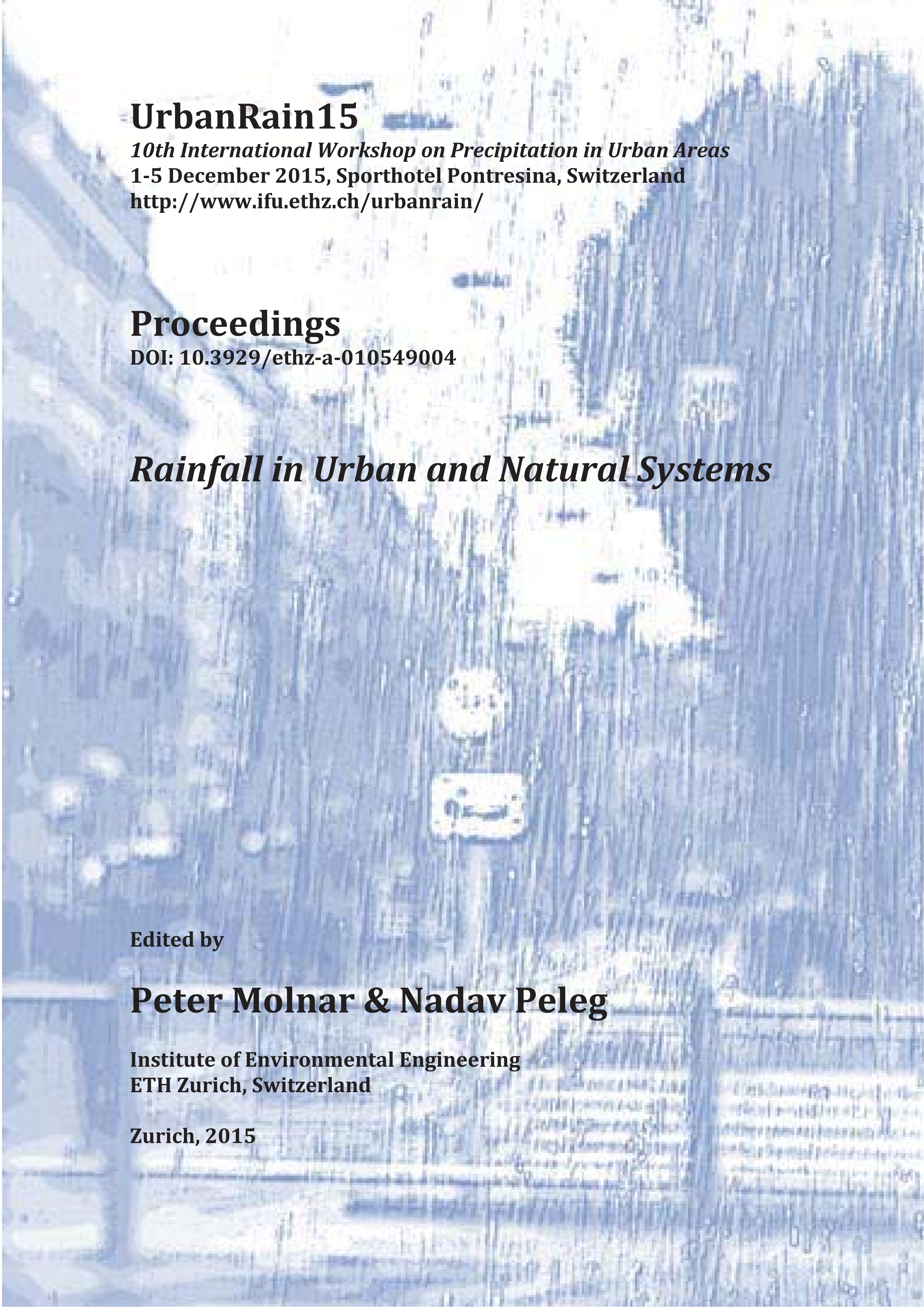

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On extracting information from numerical weather prediction ensemble precipitation forecasts to anticipate urban runoff flow domains

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Abstract

Weather forecasts can provide valuable information to improve operational performance of urban drainage systems (UDS) and wastewater treatment plants (WWTPs). For example, radar-based rainfall nowcast are increasingly being used within real-time control (RTC) concepts. Numerical weather prediction (NWP) models can also contribute to forecast rainfall with the advantage of an increased lead-time. NWP models are already used in various fields from streamflow forecasting (Shrestha et al. 2013) to solar and wind energy prediction (Bacher et al. 2009).

Using uncertain information, such as NWP, to optimize storm- and wastewater systems in real time is generally challenging. Indeed, NWP is embedded with a significant uncertainty but such forecasts do however contain information that can contribute to optimization especially when utilizing multiple ensemble model runs. Therefore, we decided to create a method to extract information from NWP ensembles in order to distinguish the incoming flow domains rather than quantitatively predicting the flow values directly.

The method is elaborated around (i) a set of strategies for utilizing the information in the NWP ensemble, (ii) a model for predicting catchment outlet flow from NWP precipitation forecasts, and considering (iii) different sources of uncertainty (spatial, temporal) and (iv) forecast consistency. The strategies are designed with a view to obtaining more or less conservative predictions. The skill of each forecast strategy is evaluated using a threshold exceedance contingency table on the catchment outlet flow. Furthermore weights are assigned to each outcome of the contingency table to determine the expected benefit/damages of each strategy.

The urban scale in focus here requires precipitation data with fine spatial and temporal resolution, which is challenging for NWP models. Indeed, precipitation is one of the most difficult variables to forecast, due to it a large variability both in space and in time. In our case study we use the HIRLAM-DMI-S05 model, which has a horizontal resolution of 0.05° (approx. 5km) and hourly time steps (Feddersen 2009).

Figure 1 illustrates a conservative approach to cope with spatial uncertainty. The rainfall input to the runoff model is based on an area up-scaled beyond the physical catchment to include neighboring cells and differentiating convective and stratiform rains.

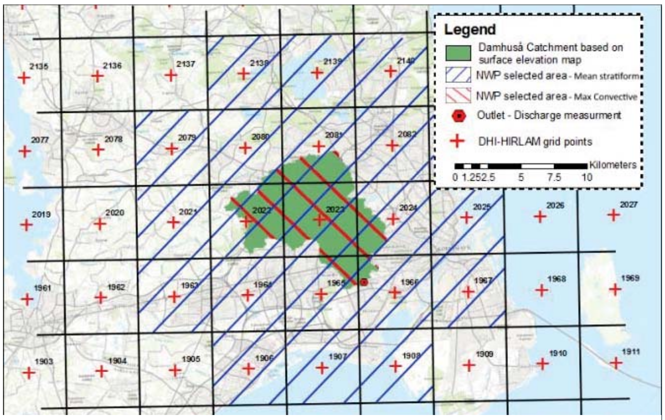

Fig 1: Dahmusåen catchment (Case study) and NWP grid point selection (up-scaled spatial strategy).

Figure 2 displays the runoff model output for a NWP and the high flow prediction for 7 different strategies that utilize the NWP ensemble information in different ways. The upper panel represents the modelled discharge at the catchment outlet considering the conservative up-scaled approach describe in Figure 1, which leads to very conservative estimates of flow threshold exceedances. The middle panel is based on the average precipitation over the catchment, which as expected provides more realistic flow forecasts. The last plot shows prediction of threshold exceedance for different strategies.

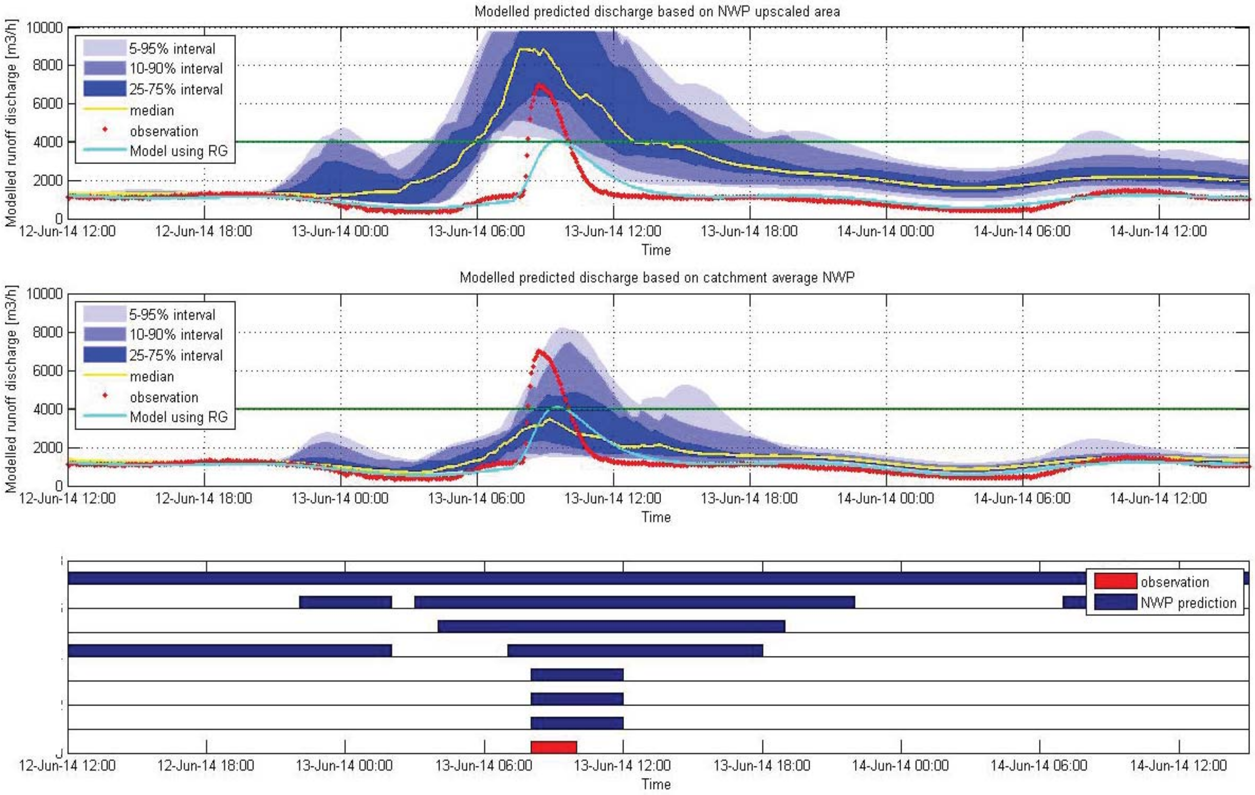

Fig 2: Runoff model flow forecasts (upper and middle panel) for a two-day period in June 2014, based on two different NWP rainfall selection strategies and (lower panel) high flow prediction for a set of 7 strategies utilizing the NWP ensemble information differently. The strategies 1 to 4 are based on the middle panel and the strategy 5 to 7 on the upper panel. The strategies 5 and 7 are also considering the previous forecast.

Such predictions can, for example, be used to disable a dry period optimization scheme (pumping strategy, WWTP inflow smoothing, energy consumption, etc.) when dealing with high flows has priority. The decision making to start the optimization is motivated by the prediction confidence resulting from the different strategies. The flow threshold and the strategies parametrization need to be adjusted to the prediction purpose.

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