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Machine learning based urban water demand forecasts incorporating stochastic weather inputs

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Outdoor water use is of particular concern to many urban water supply system operators and managers since it is intimately tied to meteorological conditions. Data driven urban water demand (UWD) forecasts using historical UWD and meteorological records to derive forecasts have gained popularity due to their abilities to improve forecast performance by including auxiliary variables. However, UWD becomes increasingly difficult to forecast at longer lead times as information on meteorological conditions at future times are increasingly uncertain and unavailable. Incorporating forecasts of each meteorological record at future lead times as input to a data driven UWD forecast also increases the uncertainty since these forecasted meteorological variables incorporate modelling errors. Instead, what is needed is a method to incorporate the variability contained within each meteorological record and to stochastically derive ensembles of these inputs at future times. To this end, we devise a new UWD forecasting approach that uses machine learning methods to derive forecasts at daily lead times using past UWD observations in combination with a stochastic weather generator that provides air temperature and rainfall time series at future times. We demonstrate the gains in UWD forecast performance that may be realized when using the stochastic weather generator to provide inputs to the machine learning models instead of relying on only past meteorological conditions. Forecasting UWD time series with inputs produced from stochastic weather generators can be very useful for operating urban water supply systems since the models can incorporate inherit climate variability and reduce forecast uncertainty by pooling forecasts from different meteorological conditions simulated by the stochastic weather generator.