Towards real-time assimilation of crowdsourced observations in hydrological and hydraulic modeling

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The continued technological advances have stimulated the spread of low-cost sensors that can be used by citizens to provide crowdsourced observations (CO) of different hydrological variables. Citizen observatories (COs) present an interesting case of strong multi-facet feedback between the physical (water) system and humans. CO is a form of crowdsourcing ensuring a data flow from citizens observing environment (e.g. water level in a river) to a central data processing unit which is typically part of a more complex social arrangement (e.g. water authorities responsible for flood forecasting). An example of such low-cost sensors is a staff gauge connected to a QR code on which people can read the water level indication and send the measurement via a mobile phone application. The goal of this study is to assess the combined effect of the assimilation of CO coming from a distributed network of heterogeneous sensors, and the effect of different involvement levels, on the performance of a semi-distributed hydrological model.

The methodology is applied to the Bacchiglione catchment, North East of Italy, where an early warning system is used by the Alto Adriatico Water Authority to issue forecasted water level along the river network which cross important cities such as Vicenza and Padua.

In this study, forecasted precipitation values are used as input in the hydrological model to estimate the simulated streamflow hydrograph used as boundary condition for the hydraulic model. Observed precipitation values are used to generate realistic synthetic streamflow values with various characteristics of arrival frequency and accuracy, to simulate CO coming at irregular time steps. These observations are assimilated into the semi-distributed model using a Kalman filter based method. Different citizen involvement levels are generated by means of a simplified theoretical social model.

The results of this study show that CO, asynchronous in time and with variable accuracy, can still improve flood prediction when integrated in hydrological models. When both physical and low-cost sensors are located at the same places, the assimilation of CO gives the same model improvement than the assimilation of physical observations only for high number of non-intermittent sensors. However, the integration of observations from low-cost sensors and single physical sensors can improve the flood prediction even when small a number of intermittent CO are available. Finally, in the case of different citizen involvement levels, this research shows that sharing crowdsourced observations motivated by a feeling of belonging to a community helps in improving flood predictions. In particular, the model results can benefit from the additional observations provided by enthusiast citizens. This study is part of the FP7 European Project WeSenseIt Citizen Water Observatory (www.http://wesenseit.eu/).