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Conjunctively optimizing flash flood control and water quality in urban water reservoirs by model predictive control and dynamic emulation

Stefano Galelli (1), Albert Goedbloed (2), Petra Schmitter (2), and Andrea Castelletti (3)

(1) Pillar of Engineering Systems and Design, Singapore University of Technology and Design, Singapore, Singapore (stefano_galelli@sutd.edu.sg), (2) Singapore-Delft Water Alliance, National University of Singapore, Singapore, Singapore, (3) Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano, Milano, Italy

Urban water reservoirs are a viable adaptation option to account for increasing drinking water demand of urbanized areas as they allow storage and re-use of water that is normally lost. In addition, the direct availability of freshwater reduces pumping costs and diversifies the portfolios of drinking water supply. Yet, these benefits have an associated twofold cost. Firstly, the presence of large, impervious areas increases the hydraulic efficiency of urban catchments, with short time of concentration, increased runoff rates, losses of infiltration and baseflow, and higher risk of flash floods. Secondly, the high concentration of nutrients and sediments characterizing urban discharges is likely to cause water quality problems.

In this study we propose a new control scheme combining Model Predictive Control (MPC), hydro-meteorological forecasts and dynamic model emulation to design real-time operating policies that conjunctively optimize water quantity and quality targets. The main advantage of this scheme stands in its capability of exploiting real-time hydro-meteorological forecasts, which are crucial in such fast-varying systems. In addition, the reduced computational requests of the MPC scheme allows coupling it with dynamic emulators of water quality processes.

The approach is demonstrated on Marina Reservoir, a multi-purpose reservoir located in the heart of Singapore and characterized by a large, highly urbanized catchment with a short (i.e. approximately one hour) time of concentration. Results show that the MPC scheme, coupled with a water quality emulator, provides a good compromise between different operating objectives, namely flood risk reduction, drinking water supply and salinity control. Finally, the scheme is used to assess the effect of source control measures (e.g. green roofs) aimed at restoring the natural hydrological regime of Marina Reservoir catchment.