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Adaptive real-time forecasting using model-driven monitoring of catchment inflows and water supply reservoir dynamics

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Real-time monitoring networks are increasingly prevalent in supporting the management of environmental systems as the technology for live data collection becomes more accessible. Additionally, ecosystem and water resource pressures have persisted and intensified under climate pressures and an expanding anthropogenic footprint. The way in which models and data are fused in the day-to-day management of water resources operations, as well as for long-term planning and investment, has been a critical field of research. An adaptive real-time monitoring-integrated learning modelling approach was developed and applied to improve the understanding of the mixing dynamics in a water supply reservoir in Queensland, Australia. This was accomplished through the combination of sequentially linked catchment and reservoir models with in situ real-time measurements of temperature and flow along with meteorological forecasts from an Australian numerical weather model, to produce short-term water quality forecasts. An adaptive learning catchment model was developed and linked for each inflow arm of the reservoir using the Australian Water Balance Model. This framework enabled automated online communication to researchers and managers around the current performance of the inflow predictions and the confidence expected in the current forecasts. Moreover, this live learning catchment model was coupled with a real-time adaptive three-dimensional hydrodynamic model of the reservoir iteratively training using data from the deployed real-time temperature monitoring system. A prototype internet-connected remotely operable autonomous surface vessel was deployed with a winching system for conducting dynamic water quality profiling operations under the guidance of waypoints guidance generated from the real-time adaptive modelling forecasts. Data collected by ASV was subsequently provided back to the modelling system in real-time. The complete system facilitated the online adaptive forecasting of mixing dynamics in the reservoir and the automated identification of features of interest for water quality profiling, as well as dynamically monitoring the areas potentially most valuable for model learning development to improve system-wide understanding and forecast certainty through addition into the live dataset for ongoing training and evaluation. Evidence was found in support of a rolling iterative calibration procedure for increasing model skill sensitivity to different processes occurring over temporal and spatial scales across both catchment and receiving water models. Dynamically guided spatial monitoring generated from maximum predicted areas of variation and parameter sensitivity in the real-time adaptive receiving water model demonstrated that monitoring of the receiving water

inflow arms during inflow events was necessary during inflow events to train the model on the strongest signal of the driving force of changes in the receiving water environment. Overall, the uncertainty in rainfall events from both forecasted and observed sources cascading with the uncertainty in catchment simulations with only static indirect monitoring of flow (ungauged at any of the inflow arms to the reservoir) was found to be the most significant hindrance to the utility of the applied real-time adaptive modelling framework. The application of an adaptive computer vision-based stream gauging approach was then trialled on one of the ungauged inflow arms in order to supplement this gap.