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An Early Warning System for water quantity and quality of reservoirs based on operational hydrological and ecological short-term forecasting.

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A fully operational service line for generating real-time water quality forecasts in reservoirs has been developed, by integrating satellite technology and in-situ monitoring data with state of the art hydrologic and water quality modelling using advanced ICT tools. The service is provided through a web based platform which has been designed in order to facilitate increased interoperability, data hosting, exchange and sharing among EO, in situ monitoring and modelling components in order to establish a complete value adding chain from the science to water business sector customized according to specific end-users needs.

Hydrological forecasting is performed by the pan-European setup of HYPE catchment modelling. HYPE is an open-source, process-oriented, semi-distributed hydrological model which simulates and provides 10-days forecasts of river discharges, water temperatures, nutrient and sediment loads in the upstream sub-basins of the reservoir. Hydrodynamic and water quality simulation are performed with the open-source FLOW and DELWAQ modules of Delft3D suite by Deltares. Hydrological forecasts, along with local weather forecasted parameters (wind, humidity and air temperature) are fed into the hydrodynamic model which is used to estimate forecasts of velocity fields, water temperature and water elevations in the reservoir domain. Near real-time water level observations from in-situ monitoring stations are incorporated as positive or negative corrective water fluxes in the hydrodynamic model in order to keep simulated water level as close as possible with measured. The results of the hydrodynamic model are coupled with the water quality model which is used to estimate the spatial and temporal distribution of critical water quality parameters for the next 10 days. Simulated parameters include various algae species, nitrogen, phosphorus, dissolved oxygen, suspended sediment, etc. Operational data assimilation of satellite imagery of water temperature, turbidity and chlorophyll-a concentrations obtained from Landsat 7&8 and Sentinel 2 missions are used to correct the model state using the Ensemble Kalman Filter technique. An ensemble of 30 coupled hydrodynamic and water quality members with random noise both in forcing data and model parameters is constantly evolved through time and is used to correct model state when observations are available using an assimilation window of 7 days.

Forecasted data are fed into an Early Warning System (EWS) aiming to create interpretable warnings on water quantity- and quality-related parameters. Specifically, the EWS issues warnings on (a) river inflows exceeding critical thresholds that are calculated for various return periods, (b) the stratification and mixing patterns of the reservoir (e.g. thermocline depth, lake number etc.), (c) physicochemical parameters such as nitrate concentration and turbidity, and (d) phytoplankton-related metrics such as the chlorophyll-a concentration, the biovolume of cyanobacteria, the species evenness index, and the bloom intensification index. Ultimately, the EWS, supported by a fully operational short-term forecasting service line, promptly indicates high impact changes of water quantity and quality enabling, thereby, proactive informed decision making for water reservoir managers.

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