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A new physically-based catchment modelling tool for reservoir re-engineering and renaturalisation

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The hydrological regimes of European catchments have been considerably modified by anthropogenic features such as dams, weirs and water abstractions, with nearly every major river fragmented. The negative impacts of such physical modifications on freshwater ecosystems are being increasingly recognised. Currently, European dam removal initiatives are being driven by factors such as the EU Habitats Directive, and the costs associated with maintaining redundant infrastructure. Climate change and the rewilding agenda may encourage further hydrological renaturalisation initiatives. In the English Lake District, several reservoirs are being actively considered for decommissioning within this decade. To understand how such catchments would respond to lake renaturalisation, robust catchment hydrology models are needed that can represent the effects of changes in physical infrastructure on the hydrological regime. However, many models tend to neglect such human impacts.

We present a new tool that incorporates reservoirs, including impounding structures, river regulations and abstractions. The method involved development of an enhanced version of the freely-available catchment modelling software, SHETRAN. A new 'reservoir' module was developed which includes the effects of hydraulic structures and sluice operations on lake stage and river flow. Results for the Crummock Water catchment and reservoir show that the reservoir model generates notably fitter simulations, particularly during dry periods where reservoir operations cause a distinct deviation from the regime expected in natural lake-river systems. Further simulations demonstrate quantitatively how lake renaturalisation might affect future hydrological regimes compared with the baseline scenario. Finally, we discuss the implications of this model for decision-making in the Crummock Water catchment, and the utility of the software for other anthropologically-modified catchments.