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## Study of unregulated flow conditions in Norwegian rivers- Strategy for improving lake outflow using HYPE model

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Norway's authorities are delayed in implementing the European Water Framework Directive (EU-WFD). A common challenge for the implementation of EU-WFD is finding natural reference conditions in water bodies, which can be challenging for lakes that have been regulated and used for hydropower production before any physical variables were made. Hydrological modelling of unregulated lakes can be a solution. Modelling water level fluctuations in unregulated lakes allow us to determine the ecological functioning of the lake and the water storage that could be used for different sectors such as hydropower, agriculture and others.

Previous studies showed that lakes had a strong influence on the performance of models when using the Hydrological Predictions for the Environment (HYPE) model. This study aims to develop model strategies for improving lake dynamic modelling with natural flow conditions in terms of discharge and water stage in HYPE. We modelled seven lakes in Norway with areas more than 5 km<sup>2</sup> and a gauging station at the output. Each lake was calibrated independently, and each model was set up from an existing one for the mainland of Norway. Stepwise calibration was implemented to create separate discharge and water stage models. Rating curves for lakes were calculated and introduced to the model for water discharge and stage calibration following the equation  $Q=k(w-w_0)^p$ . Where  $w$  is the observed water level,  $w_0$  is the reference water level,  $k$  is the rate, and  $p$  is the exponent. The model performance was evaluated in terms of Kling-Gupta efficiency (KGE). Preliminary results showed improvement of model performance for water stage modelling when employing a pre-calibrated model with discharge time series data. Also, improved model performance in discharge was found when using rating curves for calibration