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Modeling the discharge behavior of an alpine karst spring influenced by seasonal snow accumulation and melting based on a deep-learning approach

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Karst systems are challenging to model due to their heterogeneous hydraulic properties resulting in highly variable discharge behavior. Distributed models can be applied to karst aquifers but require detailed system knowledge and extensive hydraulic parameter datasets; lumped-parameter models are less complex, but still require parametrization. In this work, we demonstrate the application of a data-driven approach to model the discharge behavior of the Aubach spring in the Gottesacker karst system in the northern Alps, a well-investigated study site for which previous models are available for comparison (Chen et al. 2018; Fandel et al. 2020). Our approach is based on convolutional neural networks (CNN), which have proved to be well suited for time series forecasting in water-related contexts like runoff modelling or groundwater level prediction (Wunsch et al.). The approach is comparably simple in terms of data requirements as we rely mainly on widely available and easy-to-measure parameters such as precipitation and temperature. By implementing Bayesian techniques (Monte-Carlo dropout) we are able to report the predictive uncertainty of the CNN based forecasts. Our results challenge existing modelling results based on lumped-parameter models in terms of common error measures such as Nash-Sutcliffe efficiency. Furthermore, we explore the important role of snow accumulation and melting by coupling our model with a snow-routine to better represent their influence on spring discharge and further improve model performance. Our results demonstrate that the presented machine-learning approach can be applied to simulate karst spring discharge and has certain advantages in comparison with conventional karst modelling approaches, which require hydraulic parameters that are often not available.

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