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Integrating Deep Learning to GIS Modelling: An Efficient Approach to Predict Sediment Discharge at Karstic Springs Under Different Land-Use Scenarios

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Sediment Discharge (SD) at karstic springs refers to a black-box due to the non-linearity of the processes generating SD, and the lack of accurate physical description of karstic environments. Recent research in hydrology emphasized the use of data-driven techniques for black-box models, such as Deep Learning (DL), considering their good predictive power rather than their explanatory abilities. Indeed, their integration into traditional hydrology-related workflows can be particularly promising. In this study, a deep neural network was built and coupled to an erosion-runoff GIS model (*WATERSED*, Landemaine et al., 2015) to predict SD at a karstic spring. The study site is located in the Radicatel catchment (88 km² in Normandy, France) where spring water is extracted to a Water Treatment Plant (WTP). SD was predicted for several Designed Storm Project ($DSP_{0.5\text{-}2\text{-}10\text{-}50\text{-}100}$) under different land-use scenarios by 2050 (baseline, ploughing up 33% of grassland, eco-engineering (181 fascines + 13ha of grass strips), best farming practices (+20% infiltration)). Rainfall time series retrieved from French *SAFRAN* database and *WATERSED* modelling outputs extracted at connected sinkholes were used as input data for the DL model. The model structure was found by a classical trial and error procedure, and the model was trained on two significant hydrologic years (n_{events} = 731). Evaluation on a test set suggested good performance of the model (NSE = 0.82). Additional evaluation was performed comparing the 'Generalized Extreme Value' (GEV) distribution for the five DSP under the baseline scenario. The SD predicted by the DL model was in perfect agreement with the GEV distribution (R^2 = 0.99). Application of the model on the other scenarios suggests that ploughing up 33% of grasslands will increase SD at the WTP to an average 5%. Eco-engineering and best farming practices will reduce SD in the range of 10-44% and 63-80% respectively. This novel approach offers good opportunities for SD prediction at karstic springs or WTP under multiple land use scenarios. It also provide robust decision making tools for land-use planning and drinking water suppliers.