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Spatiotemporal prediction of groundwater level changes with the hydrological model mHM

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Current methodologies for groundwater level prediction mainly focus on local predictions at single wells. This leaves a gap in spatiotemporal predictions at unobserved sites, particularly from the perspective of suitable target systems [1]. This study addresses this gap by adopting surface catchments as the target system to represent spatiotemporal variations groundwater levels, despite the fundamental differences between aquifers and catchments.

Therefore, groundwater levels from single wells are regionalised and then aggregated to catchment means. Prior to interpolation, groundwater levels are centered to make the data comparable across the study area. This is necessary due to the problem of spatial variability in groundwater levels even within an aquifer, e.g. with regard to distance to the river and topographical heterogeneity.

For prediction, the open-source mesoscale hydrological model (mHM) [2] is implemented for 100 catchments in Lower Saxony, Germany. While it is primarily designed for modelling surface hydrological processes and thus may overlook complex three-dimensional subsurface heterogeneity, it serves as a useful tool for groundwater level prediction in data-limited scenarios, particularly within simple hydrogeological environments like shallow unconfined aquifers. For direct groundwater level prediction, the mHM is calibrated using error measures calculated between observed and simulated groundwater level as linear transfer from simulated reservoir contents. The regression parameters and global parameters of mHM are calibrated simultaneously.

We expect good model performance in predicting groundwater level changes at the catchment scale, which represents a new regional approach for shallow, unconfined aquifers in particular.

[1] Barthel, R., Haaf, E., Giese, M., Nygren, M., Heudorfer, B., & Stahl, K. (2021). Similarity-based approaches in hydrogeology: Proposal of a new concept for data-scarce groundwater resource characterization and prediction. Hydrogeology Journal, 29(5), 1693–1709.

[2] mHM: Luis Samaniego et al., mesoscale Hydrologic Model. Zenodo. doi:10.5281/zenodo.1069202, https://doi.org/10.5281/zenodo.1069202