ARPHA Conference Abstracts 8: e152106
doi: 10.3897/aca.8.e152106

OPEN ACCESS

Conference Abstract

Identifying processes impacting groundwater level at local scale through lumped modelling based investigations: a case study of the Upper Rhine alluvial cross-border aquifer.

Manon Lincker[‡], Jean-Charles Manceau[§], Marc Ohmer[|], Elodie Giuglaris[‡], Tanja Liesch[|], Damien Salquèbre[‡], Sonia Heitz[‡]

‡ BRGM, F-67118, Geispolsheim, France
§ BRGM, F-45060, Orléans, France
| Karlsruhe Institute of Technology (KIT), Department of Hydrogeology, Karlsruhe, Germany

Corresponding author: Manon Lincker (m.lincker@brgm.fr)

Received: 05 Mar 2025 | Published: 28 May 2025

Citation: Lincker M, Manceau J-C, Ohmer M, Giuglaris E, Liesch T, Salquèbre D, Heitz S (2025) Identifying processes impacting groundwater level at local scale through lumped modelling based investigations: a case study of the Upper Rhine alluvial cross-border aquifer. ARPHA Conference Abstracts 8: e152106. https://doi.org/10.3897/aca.8.e152106

Abstract

The quaternary alluvial aquifer system in the Upper Rhine Valley, located in northeastern France and southwestern Germany, across the French-German border, is one of Europe's largest freshwater reserves. This aquifer system, which is essential for local anthropic uses, also plays a vital role in supplying water to numerous ecosystems due to the phreatic nature of its groundwater. Additionally, the hydrographic network of the alluvial plain is very dense and characterised by strong groundwater – surface water interactions, influenced by seasonal dynamics.

The Interreg GRETA project (GRoundwater EvoluTions and resilience of Associated biodiversity - Upper Rhine) arises from the increasing climatic and anthropogenic pressures on the environment, focusing on the southern part of the Upper Rhine Graben aquifer. Its objectives are to provide key knowledge on the impact of climate change on the quantitative dynamics of the water table and the associated consequences for

ecosystems by adopting an integrated approach to the system studied, at the heart of the critical zone.

In order to study piezometric variations at different points in the Upper Rhine aquifer, around fifty lumped models have been developed using GARDENIA, a modelling tool developed and updated by BRGM (French Geological Survey). However, given the specificities of the groundwater in the Upper Rhine Valley (shallowness, high hydraulic conductivity of 10^{-4} to 10^{-3} m/s (Majdalani and Ackerer 2010), anthropic management of the hydrographic network, water abstraction for irrigation, etc), it is essential to identify the main driving forces behind groundwater dynamics locally and to include these drivers in the modelling tools used to establish hydrogeological projections under a future climate.

GARDENIA uses a series of reservoirs to simulate the main mechanisms of the water cycle of a catchment (rainfall, evapotranspiration, infiltration and run-off) (Thiéry 2014). This model considers a global ‘input’ (an ‘incoming water level’ in the basin and potential evapotranspiration) and a single ‘output’, which is, in this case, the piezometric level at a point in the underlying water table.

Transfers from one reservoir to another are governed by simple laws that are specific to each reservoir and controlled by model parameters (soil capacity, transfer times, groundwater specific yield, etc.). These parameters cannot be deduced a priori from the specific physiographic characteristics of the catchment and are calibrated through adjustment to observation time series.

A baseline model considering only climatic inputs has been applied to all points. Then, based on the Nash–Sutcliffe model efficiency coefficient and on visual inspection, several different model configurations were tested on the points where the initial model results were unsatisfactory. These new models were constructed by adding new potential driving forces as inputs such as a proxy for vegetal water demand or flowrates of the Rhine or other rivers located near observation points.

Calibrated models show good results in reproducing historic groundwater levels and allow to identify the main local driving factors of the groundwater dynamics. Further analysis of the influence function weight associated with each additional process over rainfall and potential evapotranspiration allows to decipher first order contributions of the added processes (summer withdrawals or river contributions).

In the GRETA project, convolutional neural network models were also built at the observation points database. Initial comparison results show that both methods are valuable for building local hydrogeological models that consider interactions with surface water or land use.

These lumped models can then be fed with climatic or hydrological time series estimated in the context of climate change, to be discussed in relation to the ecological monitoring conducted on a selection of pilot sites and upscaled in the study area to assess the impact of changes in piezometry on the associated ecosystems.

Keywords

Lumped model, alluvial aquifer, groundwater dynamics, groundwater - surface water interactions

Presenting author

Dr Manon Lincker

Presented at

ORAL

Hosting institution

BRGM

Author contributions

Manon Lincker: Investigation, Methodology, Writing original draft.

Jean-Charles Manceau: Conceptualization, Methodology, Validation, Writing - review and editing.

Marc Ohmer: Methodology, Writing - review and editing.

Elodie Giuglaris: Supervision, Funding acquisition.

Tanja Liesch: Writing - review and editing.

Damien Salquèbre: Project administration.

Sonia Heitz: Project administration, Writing - review and editing.

Conflicts of interest

The authors have declared that no competing interests exist.

References

- Majdalani S, Ackerer P (2010) Identification of Groundwater Parameters Using an Adaptative Multiscale Method. Ground Water 49 (4): 548-559. https://doi.org/10.1111/j.1745-6584.2010.00750.x

- Thiéry D (2014) Logiciel GARDÉNIA, version 8.2. Guide d'utilisation. BRGM (RP-62797-FR)-137. [In French]. URL: http://infoterre.brgm.fr/rapports/RP-62797-FR.pdf