Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.34586

# Noble gas data worth in alluvial aquifer systems : combining the explicit simulation of tracer concentrations with data space inversion

HUGO DELOTTIER[1], **MORGAN PEEL**[2], JOHN DOHERTY[3], PROF. OLIVER S SCHILLING[2,4] AND PHILIP BRUNNER[1]

[1]Université de Neuchâtel
[2]Eawag, Swiss Federal Institute of Aquatic Science and Technology
[3]Watermark Numerical Computing
[4]University of Basel

Alluvial systems are dynamic and structurally complex environments that provide an important source of groundwater for domestic consumption. Numerical models are widely used to aid in the sustainable management of such systems. For models to effectively support decision-making, they must assimilate data that are informative of the spatial and temporal dynamics of operationally relevant quantities, such as groundwater (GW) residence times, or surface water (SW)–GW mixing ratios. In principle, incorporating measured noble gas concentrations into numerical modelling frameworks, where dissolved gas concentrations are explicitly simulated within a mass transport model, has the potential to reduce uncertainty in several management-relevant predictions. However, this potential has not been systematically assessed in a decision-support context.

We present a modelling framework that integrates noble gas tracer concentrations ($^{222}$Rn, $^{37}$Ar, and $^{4}$He) with conventional hydrological observations (hydraulic heads, soil saturation) using data space inversion (DSI), a data-space approach that leverages the statistical relationship between historical and predicted data of a complex numerical simulator. The framework is applied in a series of simulation experiments spanning a wide range of plausible hydraulic and hydrological conditions. We assess the extent to which noble gas concentrations help reduce the uncertainty of management-pertinent predictions in an integrated surface–subsurface hydrological model.

Results show that $^{222}$Rn and $^{4}$He measurements substantially reduce uncertainty in temporally variable predictions, including SW–GW exchange fluxes and solute breakthrough curves that indicate contaminant residence times following aquifer pollution events. Measurements of $^{37}$Ar also provide important constraints on SW–GW interactions, particularly with respect to bank filtrate residence times.