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Stochastic inverse modelling of groundwater flow and nitrate pollution in the Berambadi catchment

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The groundwater resources in the Berambadi catchment, South India, are under pressure. Groundwater levels are rapidly declining in areas with significant agricultural activity and nitrate (NO_3) concentrations far exceed the drinking water standard in many borewells due to poor management and excessive use of fertilizers. Physical modelling can help improve the understanding of contaminated aquifer systems and support the identification of sustainable management options. However, due to lack of data and the highly heterogeneous nature of the aquifer in Berambadi such modelling is associated with large uncertainties. The sources and extent of the NO_3 pollution are furthermore still poorly understood. Hence, there is a need for an approach, which can also rigorously capture the major uncertainty sources.

We present here a stochastic inverse modelling approach for simulating groundwater flow and nitrate transport in the catchment. The model uses the Kalman Ensemble Generator (KEG) to jointly condition the flow and transport simulations to measured groundwater level and NO_3 concentration data and thereby characterizes not only the heterogeneity of the aquifer, but also the spatial distribution of recharge and nitrate leaching. The method is demonstrated on a range of hypothetical test cases that resemble the real unconfined aquifer system in Berambadi. The complexity and number of unknowns are gradually increased to investigate under what circumstances the method successfully manages to identify the 'true' parameters. Preliminary results suggest that the method is capable of identifying the unknown aquifer heterogeneity as well as the spatial recharge and nitrate leaching fields. However, the success of the method strongly depends on the prior parameter distributions and it is therefore essential that future work focuses on constraining these priors. It is also found that inverse stochastic modelling of an unconfined aquifer with partially penetrating observation wells can result in "empty" cells in the domain and/or "empty" simulated observations, which proves challenging for the updating of the parameter field using Ensemble Kalman Filter type approaches.