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Assessing conceptual errors and parameter errors of a transport model used for analysing a field diffusion experiment

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The assessment of the long-term safety of repositories for radioactive waste relies inherently on model predictions. It is thus very important to evaluate carefully the uncertainty of such predictions. Similarly, assessing the model uncertainties is also important when evaluating laboratory and field experiments in order to derive reliable parameter values that can be used in performance assessments for radioactive waste repositories. The uncertainty of model predictions arises mainly from two sources. The first are conceptual errors. They originate from simplifications and approximations of the complexity of the real system in the model, or from unintended neglect of important aspects or processes. The second are parameter errors, which originate from using uncertain or wrong parameter values in the model. Such uncertainties may also arise from probabilistic distributions of parameters. Different approaches are required to assess the errors from these two sources. In the case of conceptual errors, one has to guarantee that all possibly relevant processes are considered, which is often done by large compilations of "FEPs" (features, events, processes). Subsequently, more complex models can be used to evaluate the effects of the neglect of specific parts of a model. If it is not possible to account for the full system complexity, simplified analyses have to be made to decide upon the importance of single processes. Parameter errors are typically evaluated by parameter variations and by calculating time and space dependent sensitivities.

Here we assess the uncertainties of a model used for the analysis and interpretation of a field tracer test, the DR diffusion experiment in the Mont Terri rock laboratory. This experiment consisted of two injection intervals ∼7 m below the tunnel floor that were connected to reservoir tanks within the tunnel. First we estimated the influence of the mixing of the tracer solution between the surface reservoir and the downhole interval. Simulations taking into account the flow in the recirculation loops as well as within the downhole interval revealed that the mixing was sufficiently fast such that a simplified model assuming a homogeneous yet time-dependent concentration within the whole circulation loop can be used without creating large errors. Secondly, we defined relevant lumped parameters and investigated time and space dependent sensitivities for these parameters. These sensitivities were subsequently used to estimate model uncertainties. We showed that the small fluid-filled gap between the porous filters in the injection intervals and the rock is of minor importance. The porous filter has a negligible effect on the transport of mobile tracers, but its effect is important for strongly sorbing tracers. Anisotropic diffusion in the rock is relevant for non- and weakly interacting tracers, but of minor importance for strongly sorbing tracers. Finally, the sensitivities revealed also that spatial tracer profiles around the injection interval are most helpful to determine values for the apparent diffusion coefficient, whereas the borehole data are dominated by the effective diffusion coefficient (mobile tracers) or the sorption properties (strongly sorbing tracers).