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A parameter identifiability study of two Chalk tracer tests

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As with most karstic and fissured rock formations, Chalk is highly heterogeneous. Therefore, meaningful estimates of model parameters must be obtained at a scale comparable with the process of concern. These are frequently obtained by calibrating an appropriate model to observed concentration-time data from radially convergent tracer tests (RCTT). Arguably, an appropriate model should consider radially convergent dispersion (RCD) and Fickian matrix diffusion. Such a model requires the estimation of at least four parameters. A question arises as to whether or not this level of model complexity is supported by the information contained within the calibration data. Generally modellers have not answered this question due to the calibration techniques employed. A dual-porosity model with RCD was calibrated to two tracer test datasets from different UK Chalk aquifers. A multivariate sensitivity analysis, which assumed only a priori upper and lower bounds for each model parameter, was undertaken. Rather than looking at measures of uncertainty, the shape of the multivariate objective function surface was used to determine whether a parameter was identifiable. Unidentifiable parameters were then removed and the procedure was repeated until all remaining parameters were identifiable. The shape of the multivariate plots clearly showed that the fracture-spacing parameter was unidentifiable and that mechanical dispersion was very small. Consequently, the most appropriate model (in terms of identifiability and fit), for both tests, assumed a single fracture with matrix diffusion and no mechanical dispersion. These results suggest that tracer flow occurred through only a small number of discrete pathways, yield little information about the upscaled properties of the heterogeneous system and question the value of RCTT for obtaining solute transport parameters for regional contaminant transport models.