UQ methods for groundwater problems - a case study

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We present the application of Gaussian Process Emulator (GPE) and Sparse Grid Stochastic Collocation (SC) methods to a real world groundwater flow problem. In particular, the problem we consider derives from a site assessment study for a radioactive waste repository known as WIPP (Waste Isolation Pilot Plant) in New Mexico (USA). The quantity of interest (QOI) is the travel time of radioactive particles released within the repository and transported through a conductive layer above the site in case of a future accidental breach. When uncertainty in the hydraulic conductivity of the ambient rock formation is modelled as a lognormal random field, computing the travel time requires the solution of a stationary diffusion equation with random coefficient. A simple, but usually inefficient, numerical treatment for models with random data is the Monte Carlo method (MC). In contrast with MC, e.g. SC methods attempt to exploit the smooth dependence of the solution of a PDE with random data on the random parameters. We investigate how these techniques perform relative to MC for approximating the travel time. Our objective is to approximate its cumulative distribution function (cdf) rather than merely its mean or variance. To this end, we apply the GPE and SC method and investigate to what extent they allow computational savings over MC at comparable accuracy. We gauge accuracy with the Kolmogorov-Smirnov test to verify whether the approximate cdf's of the QOI thus obtained are statistically indistinguishable, i.e., if the approximation error of the GPE resp. SC method is smaller than the sampling error of the MC method.