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The impact of non-Gaussian logconductivity distributions on transport: Application to the MADE experiment.

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It is well known that advective solute transport in natural aquifers is governed by spatial variations of the fluid velocity, which in turn are mainly determined by the spatial distribution of the hydraulic conductivity K. The latter is often treated as a space random function, and a common assumption is that the logconductivity $Y = lnK$ is normally distributed. Past work indicates that the shape of the probability density function (pdf) of Y has little impact on solute transport in porous media with low heterogeneity ($\sigma_Y^2 \ll 1$, where σ_Y^2 is the log conductivity variance). Matters are different when heterogeneity is strong, i.e. when $\sigma_Y^2 > 1$. In such formations, the particular shape of the distribution of Y may affect some of the transport features observed in aquifers. For example, a logconductivity pdf with a lower tail that is thicker than Gaussian may lead to a large fraction of low velocity regions in the field, leading to significant solute retention. Opposite considerations can be drawn for the upper tail of the Y distribution, in which fast, preferential flows may occur. The matter is studied through an analytical model that has been developed in recent years, which was recently applied to the MADE-1 experiment. The model solves approximately the equations of flow and transport in complex heterogeneous systems, for any level of heterogeneity in $Y = lnK$, using solutions available from the fluid mechanics literature after adopting a Self-Consistent argument. The analysis is applied to the MADE site, for which extensive information is available through high-resolution direct-push hydraulic conductivity profiles, with a vertical sample spacing (1.5 cm) ten times finer than the earlier MADE site flowmeter data. The probability density function of $Y = lnK$ is inferred first, after data declustering, and the deviation from Gaussianity is quantified. The inferred pdf model and the empirical density function derived from the raw data are introduced in the flow and transport model in order to explore the differences from the Gaussian model, both in terms of mass distribution and breakthrough curve. The differences are discussed and some general conclusions are drawn.