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On the impact of the conductivity microstructure on longitudinal and transverse macrodispersivities

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In groundwater flows, the spread of pollutants is dominated by large variations of hydraulic conductivity. In order to model the heterogeneity of the conductivity field, we represent the porous medium as an ensemble of inclusions of different conductivity placed randomly in a homogeneous matrix. By this method, we can obtain an analytical expression for the velocity field for any degree of heterogeneity, depending on the particular geometry of the inclusions, which characterizes the “medium microstructure”. In the present work we considered spheroidal inclusions. Considering pure advection and isotropic media, we aim to analyze how different microstructures affect plume dispersion, by comparing porous formations with the same spatial statistics. This way, we calculate longitudinal and transversal dispersivity for binary media, as a function of the conductivity contrast, and for unimodal media, as a function of the variance of the logconductivity field. In the binary case, i.e for inclusions of uniform conductivity contrasting with the conductivity of the underlying matrix, longitudinal and transversal dispersivities display an antisymmetrical behavior depending on the value of conductivity contrast. In particular, the larger longitudinal dispersivity is generated by low conductive inclusions, which stuck the contaminant and stretch the plume. On the other hand, high conductive spheroids produce the larger transversal dispersivity, which is therefore mostly influenced by the flow compression. In the unimodal case, i.e, for inclusions with constant conductivity drawn from a lognormal distribution, we observe that the impact of microstructure depends on the heterogeneity degree of the formation. In fact for low heterogeneity, the shape of the inclusions doesn’t influence the dispersivity value and the results are consistent with the first order approximation. As the variance of the logconductivity increases, the effect of microstructure emerges clearly. In particular, we observe that, in highly heterogeneous media, the larger dispersivity is produced by thinner inclusions.