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A generalized Advection-Dispersion equation for solute transport in highly heterogeneous aquifers

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Transport of an inert solute takes place in a heterogeneous aquifer, of random spatial distribution of the hydraulic conductivity $K(\boldsymbol{x})$. Steady flow is driven by a constant mean head gradient and a plume of inert solute is injected in the vertical plane $x=0$. Transport is quantified by the BTC (breakthrough curve) at control planes at x. The 3D structure is modeled by MIM (multi-inclusion model): an ensemble of identical rectangular blocks of independent K tessellating the space. The structure is completely characterized by the PDF (probability distribution function) of $Y=lnK$ and the horizontal and vertical blocks sizes. Flow and transport are solved by SCA (self-consistent approximation): the travel time in each block is derived by regarding it as submerged in a homogeneous medium of effective conductivity K_{ef}. Comparison with numerical simulations for lognormal PDF with logconductivity variance $\sigma_Y^2 \leqslant 8$ has revealed that the MIMSCA solution is quite accurate. It was also found to be in good agreement with findings of the MADE field experiment. MIMSCA solution can be regarded as a time domain random walk with total travel time equal to the sum of independent time steps associated with the blocks lying in the space between $x=0$ and x. We generalize MIMSCA by deriving an ADE for the BTC which is regarded as a continuous function of x and t. The ADE generalizes the usual one satisfied by the Inverse Gaussian distribution by supplementing it by an apparent mass transfer term, which is quantified by a memory function. The aim of the presentation is to analyze the properties of the new memory function and compare it with similar processes.