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Study on transport upscaling of Advection or Diffusion dominated process

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Regional scale transport models are needed to support the long-term evaluation of groundwater quality and to develop management strategies aiming to prevent serious groundwater degradation. The transport dominant process, advection or diffusion, was identified for flow fields with different primary flow directions. The capacities of Multi-Rate Mass Transfer (MRMT) and adaptive Multi-rate Mass Transfer (aMMT), modified from MRMT by updating mass transfer rates with changing velocities, to adequately describe the main solute transport processes, including the capture of late-time tails under changing boundary conditions were evaluated. Advective-dispersive contaminant transport simulated in a 3D heterogeneous medium was used as a reference solution. Equivalent transport under homogeneous flow conditions was then evaluated by applying the MRMT or aMMT models for upscaling. Results indicated that for advection-dominated transport, both the MRMT and aMMT methods can upscale the anomalous transport dynamics affected by sub-grid heterogeneity under transient flow conditions. Whereas, for diffusion-dominated systems, the MRMT model failed to capture the tails of tracer breakthrough curves (BTCs) after the boundary condition changed, but the results from the aMMT model were significantly improved. However, if the overall flow direction changed, both MRMT and aMMT failed to represent the BTC tail generated by the heterogeneous system. In this study, an indicator that describe the primary flow direction in anisotropic heterogeneous domain was developed, and the relationship between the flow direction and the dominant transport process was investigated. The ranges of the indicator, within which the advection or diffusion is dominant, are determined. Therefore, this study not only show the capability of upscaling methods on describing the transport that dominated by different processes, but provides a guide on choosing upscaling methods in field site, which supports long-term management of groundwater.