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Homogenization and effective parameters for heterogeneous coastal aquifers under pumping conditions

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We study the effects of heterogeneity in the hydraulic conductivity field on the 3D dynamics of seawater intrusion in coastal aquifers under pumping conditions. A confined coastal aquifer of infinite areal extent with a fully penetrating well was considered. The effect of heterogeneity on seawater intrusion was studied by generating several sets of heterogeneous hydraulic conductivity realizations. Three-dimensional simulations of density dependent flow and solute transport were carried out on each of these hydraulic conductivity fields by increasing gradually the constant pumping rate at the well initially under non-pumping, steady state conditions. For each test, the pumping rate is constant until steady state. In order to investigate whether the mean behavior of this setup can be approximated by a homogeneous equivalent medium we analyze models result in terms of two variables of interest: the dimensionless salinity at the well and concentration distribution in the plane that contains the well. The ensemble salinity at the well of the heterogeneous realizations and the ensemble of concentration distributions were compared with the solution of the homogeneous equivalent medium to evaluate which effective flow and transport parameters provide a satisfactory representation of the mean behavior of seawater intrusion under pumping condition in heterogeneous media. Our numerical results indicate that: (1) the ensemble of concentration distributions was approximated adequately with the anisotropic effective permeability value, (2) the appropriate longitudinal dispersivity for the problem corresponds to the local dispersion coefficient and (3) the optimal effective transverse dispersivity to reproduce the ensemble salinity at the well depends on the pumping rate at the well.

Keywords: Heterogeneity, density-dependent flow, seawater intrusion, effective flow and transport parameters.