Sea-Level Rise Impacts on Heterogeneous Coastal Aquifers: A Numerical Study on Salt Water Intrusion Behavior

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ABSTRACT

The combined impacts of geological heterogeneity and sea-level rise (SLR) are systematically studied on the behavior of salt water intrusion (SWI) in coastal aquifers. Monte-Carlo simulations of log-normally permeability (Ln*k*) fields are conducted to consider the heterogeneity of the aquifer media. Also, instantaneous and gradual SLR with and without the associated land-surface inundation (LSI) are considered in these simulations. USGS code SUTRA is used as a numerical density-dependent flow and solute transport simulation model. The applicability of the developed methodology is investigated by a two-dimensional case study with realistic parameters, which has been previously used by Ketabchi et al. (2016) under homogenous field. The width of the transition zone and the SWI length are defined as diagnostics to compare the behaviors of the heterogeneous simulations and their homogeneous counterparts. For example, in Figure 1 the salinity distribution of SWI is shown for the equivalent homogeneous model and three heterogeneous realizations with a log-permeability variance of 0.5, 1 and 2 after 100 years imposing a gradual SLR of 1 m with the associated LSI.

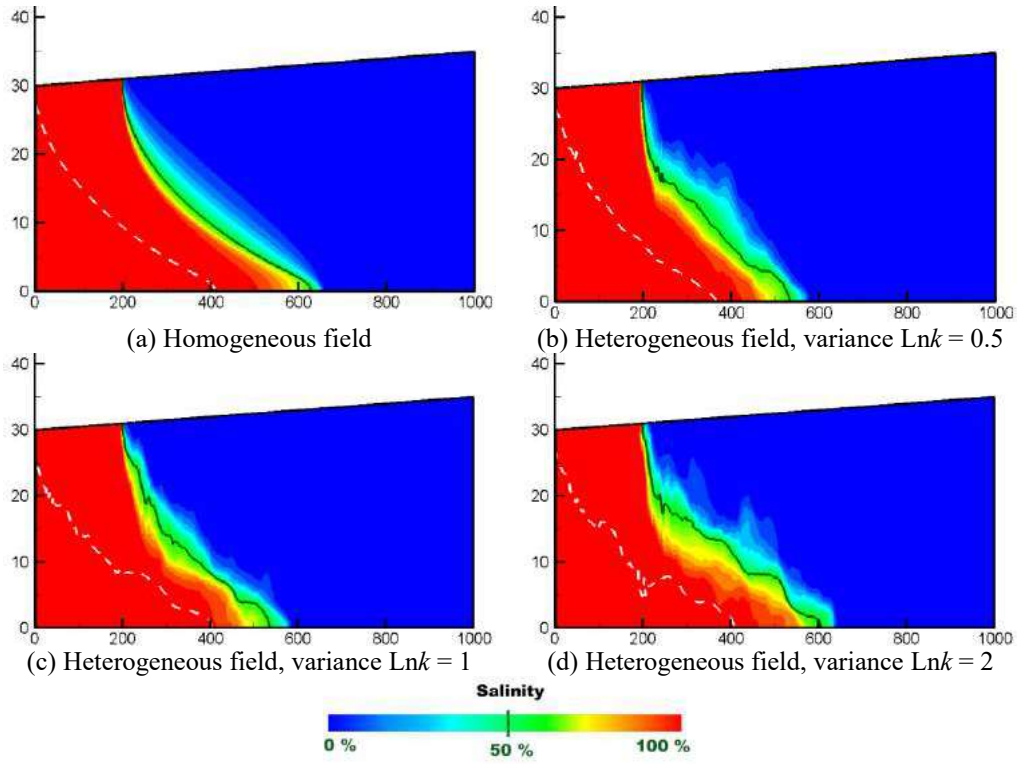

Figure 1. The salinity distributions, 100 years after a gradual SLR of 1 m with LSI under the equivalent homogeneous and three geological heterogeneous fields (Solid lines indicate the 50% seawater interface and dashed lines show the 50% seawater interface of the initial steady-state salinity distributions).

As shown in Figure 1, heterogeneity causes the smaller SWI lengths and the wider transition zones in comparison with the homogeneous case under our two-dimensional simulations, which is in agreement with the observations of Abarca (2006) and Kerrou and Renard (2010). The observations indicate that aquifer heterogeneity can have a considerable impact on SWI length and especially on transition zone shape and width. Although the considerable impacts of SLR-induced LSI are exhibited in the heterogeneous coastal aquifer, the order of such impacts are extremely related to the geological heterogeneity characteristics and the instantaneous or gradual occurrence of SLR. This study leads to a better understanding of the SWI behavior in heterogeneous fields in coastal aquifers under SLR.

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