

Interactive comment on “Groundwater withdrawal in randomly heterogeneous coastal aquifers” by Martina Siena and Monica Riva

Anonymous Referee #3

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The authors study seawater intrusion in a three-dimensional heterogeneous aquifer using a stochastic approach. The aquifer characteristics are inspired by the Argentona aquifer in the Maresme region of Catalonia, Spain. The authors investigate the joint effect of heterogeneity and groundwater withdrawal on the width of the mixing zone and toe position (defined in terms of salt concentration isoline) of the saltwater wedge in a fully coupled variable density flow and transport scenario. First the authors consider the impact of heterogeneity on mixing zone and toe confirming the finding of previous studies. Then the effect of three different pumping scenarios is studied. Scenarios S1 and S2 pump at a location landward outside the transition zone between sea and freshwater, S3 is located within the transition zone. In S1, the well is screened in the upper part of the aquifer, for S2 and S3 and additional screen is added in the lower part

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of the aquifer. It is found that S1 and S2 cause the toe to move inland and spread at the aquifer bottom while the width of the mixing zone is not affected much. For S3 in contrary, the toe location moves seaward rapidly and then stabilises. The width of the mixing zone initially increases and then decrease toward a stable value of the order of the value without pumping. It is concluded that S3 is the most efficient scenario in reducing toe penetration. Heterogeneity leads to a reduced toe penetration for S1 and S1 compared to the equivalent homogeneous scenario, while it is similar for S3. The ensemble averaged concentration field leads consistently to an overestimation of the mixing zone as observed without pumping.

The numerical Monte-Carlo analysis is sound. However, while the authors provide a thorough literature review in the Introduction, it does not become clear, which are the open questions that are addressed in the manuscript compared to the state of the art. This is of particular interest because many aspects of heterogeneity and pumping in variable density scenarios have been discussed in the literature. This is the case, for example for the effect of three-dimensional heterogeneity in Section 3.1. Thus, the authors should make an additional effort of identifying the knowledge gaps in the light of the state of the art, formulate their research objectives and clearly indicate which of their findings go beyond the state of the art.

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