

Response to the comments of Referee by C-M Chang and H-D Yeh

We would like to thank Dr. Ababou (Referee) for the thoughtful comments and suggestions. The following are the modifications in response to his comments and suggestions.

1. In the Introduction (last paragraph of section 1), it should be added more clearly that the “closed form expressions developed” in this paper “have never been presented before”...except in the case of zero recharge, where they correspond directly to the results of Albitar and Ababou (2005), which have been validated numerically.

Reply

We would rewrite the sentence in the Introduction as

“...closed form expressions developed in this paper have never been presented before. Note that Albitar and Ababou (2005) have been done similar analyses numerically in the case of zero recharge.”

2. All the figures show results for the same weak heterogeneity ($\sigma_f^2 = 0.1$). It is worth noting that the numerical validations by Albitar and Ababou (2005) were conducted for stronger heterogeneity ($\sigma_f^2 = 1.6$) and higher (Albitar, 2007).

Reply

We would add the following sentence in section 5:

“It is worth noting that Albitar and Ababou (2005) conducted the numerical validations for stronger heterogeneity ($\sigma_f^2 = 1.6$) and higher (Albitar, 2007).”

3. It would be worthwhile to also display the sensitivity of the interface with respect to σ_f^2 and in particular, including also the wedge tip position.

Reply

(i) It is apparent from Eq. (54) that the variation of the interface is linearly related to σ_f^2 . Therefore, there may be no need to plot the sensitivity of the interface with respect to σ_f^2 . However, we would mention that in section 5 as

“Equation (54) suggests that the variation of the interface increases linearly with the heterogeneity of the medium.”

(ii) To take the advantage of an analytic solution, although we do not neglect the boundary conditions of the mean model in the development of mean position of the salt-wedge tip, we do neglect the boundary conditions of the perturbation equation in the development of the variance of mean position of the salt-wedge tip. The position of the wedge tip is therefore independent of the heterogeneity of the medium. In other words, the prediction of the reliability of the mean model near the medium boundary

(the wedge tip) using our theoretical result would not be appropriate. However, it is expected that the perturbation-boundary effect is largely limited to a small zone next to the medium boundary.

4. It would be useful to emphasize the necessity and usefulness of future numerical simulations to confirm or complete the analyses presented in this paper.

Reply

We would add the following in section 5:

“The analysis leading to analytical results is restricted to relative small hydraulic conductivity variations (weak heterogeneity) so that second-order terms may be neglected in the flow perturbation equation. In addition, the perturbation-boundary effect is also neglected. Therefore, there arises a need for comparing analytical results with numerical simulations to give some indication of the range of applicability of these results.”

5. Another issue needs to be addressed concerning the position (X_G) of the “wedge tip”. From Fig.3, it seems that the authors assume that X_G is a deterministic constant.

Reply

Please see the reply (ii) to comment 3. We would add the information about the random X_G in section 5 as

“In this paper, the position of the wedge tip is independent of the heterogeneity of the medium due to the neglect of perturbation-boundary effect. It is worth noting that the simulation results by Albitar and Ababou (2005) show a significant increase in mean of X_G with heterogeneity.”

6. There seems to be a mistake in Eq. (2) and Eq. (8) (confusion between X_L and X_G ?).

Reply

In our paper, X_L is defined as the domain size in the X_1 -direction, between the two prescribed head boundaries. The location of the wedge tip is $X_1 = X_L \rightarrow X_G$, so X_L is assumed to be less than X_G .

7. “This implies that the assumption of negligible perturbation-boundary effects is applicable, at least far enough from the sea and the salt-wedge tip”.

This sentence should be replaced by:

.....only far enough....

Reply

As suggested, the sentence would be replaced by “...only far enough...”

8. We would include the following two articles in the revised manuscript:

“Ababou, R. and Al-Bitar, A.: Salt Water Intrusion with Heterogeneity and Uncertainty : Mathematical Modeling and Analyses. Proceedings CMWR’04, Comput. Meth. in Water Resources, Special Session on Coastal Aquifers, 13-17 June 2004, Chapel Hill, N.Carolina, 12 pp, 2004.

Al-Bitar A.: Modélisation des écoulements en milieu poreux hétérogènes 2D/3D, avec couplages surface / souterrain et densitaires. Ph.D. thesis. IMFT Institut National Polytechnique de Toulouse, Juin, 2007.”