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Interactive comment on "The physics behind Van der Burgh's empirical equation, providing a new predictive equation for salinity intrusion in estuaries" *by* Zhilin Zhang and Hubert H. G. Savenije

Anonymous Referee #2

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Van der Burgh's equation is a widely used formulation for the saline water intrusion in alluvial estuaries. While the simple one-dimensional equation has be shown to be sufficiently accurate to predict the salinity distribution, the physical explanation suffers. The authors therefor physically explain the equation for an parameter range 1/2 < K < 2/3. The theoretical derivation ends with an analytical expression for the Van der Burgh's coefficient K. The authors conclude that their comparison with a theoretical study gives a solid foundation for the use of K in one-dimensional models.

In the second part of the study the authors provide an analytical solution for the saline

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Discussion paper

water intrusion additional including the residual circulation, if the estuary is wide. In the last section the authors validate their formulations by testing them with 18 different estuaries.

Major comments

1) The authors give a solid explanation for a physical range of the K value ($1/2 < K < 2/3$). Therefore I would expect a substantially critical handling with the values achieved by the calibration ($0.45 < K < 0.78$). For predictive use in real applications uncertainties of about 16 % could not be seen as “quite similar”. The reader of the study will not be sufficiently aware of possible uncertainties in the application of the formulations. What could be reasons for the uncertainties? What are the uncertainties of calibration process itself? Which physical expressions are still missing in the estimations? 2) In figure 5 a 1:1 plot is presented. The plot shows not only a dot of white noise, but something like a linear correlation between predicted and calibrated K. This correlation allows the assumption that a systematic underestimation occurs in the prediction of K. What could be reason for that bias? Which terms should be considered in future work? In the same figure 5 three estuaries (1, 8, 12) can be identified as outliers in the relation between predicted and calibrated K. What is different in these estuaries that the relation between predicted and calibrated K differs to the other 15 estuaries. 3) In the second part of the study the authors include the effect of the residual circulation; the strength of the influence is controlled by the coefficient C2. The results shown in appendix C do not convince me. I cannot find 14 estuaries which "perform perfectly". Here a more critical view on the complex three-dimensional and also non-linear terms in equations explaining the mixing and straining processes in the mouth regions of estuaries should be given.

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