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Interactive Comment

Interactive comment on "Revised predictive equations for salt intrusion modelling in estuaries" *by* J. I. A. Gisen et al.

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Dear Referee ♯ 1,

Thank you very much for your detailed reading, your nice summary, thought provoking questions and excellent suggestions.

Page 741, lines 14-17: ". . ., makes use of new observations. . .". Unclearly written. Please rephrase.

We have rephrased this sentence in Page 74, lines 14 and 15.

Page 742, lines 4-6: "Making use . . ...to be". This does not result in Eq. (2). Eq. (1) and Eq. (2) result in Eq. (3) as described later. Please rephrase.

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We have rephrased this sentence in Page 742, lines 5 to 8.

Page 744, Eq. (11): Savenije (2012) gives 0.3x10^{-3} as a coefficient.

Corrected in page 744, line 12, Eqn. (11).

Page 744, line 12: Savenije (2012) gives r^2 = 0.93.

Corrected in page 744, line 15.

Page 745, line 19: please give references to WES flume and Delft flume.

We have added the references in Page 745, lines 19 and 20.

Page 746, Eq. (14). I would prefer $N_R^{0.5}$ rather than $\sqrt{N_R}$ as the exponent has been derived from a fit on data.

Corrected in page 746, line 8, Eqn. (14).

Page 747, line 2: The p-values in Eq.'s (15) and (16) do not need calibration as they have been given in the paper by Kuijper and Van Rijn (2011). As such their equation is also predictive. Please correct.

We have changed our arguments and the format of the equations. In the revision, we used the final equations obtained from their results and not the hypothetical equations as shown in the old manuscript. The changes can be found in page 746, lines 14 to 22, and page 747, lines 2 to 8.

Page 747, Eq. (20): As far as I know this equation was not mentioned in Rigter (1973). Please check.

The equation is cited in the book "Salinity and Tides" by Savenije (2012), page 140, equation (5.63). It is mentioned that Eqn. (20) is derived by Rigter (1973) based on the flume data of the Waterways Experiment Station (WES).

Page 750, line 12: Please define the river regime width B_f.

The definition river regime width B_f has been further elaborated in Page 750, lines 12 and 13.

Page 750, line 12: Add T to $\lambda_1 = T\sqrt{gh_1/r_s}$.

Corrected in page 750, line 13.

Page 750, line 12: The wave length is for a frictionless wave in a prismatic channel. Why is this used for a convergent estuary with friction?

The parameter λ is a physical parameter representing the wave length of a shallow water wave. In a frictionless prismatic channel, this wave length is indeed equal to the 'observed' wave length, equal to the product of the tidal period T (which by accident was forgotten in line 12, as you rightly indicated) and the 'observed' or 'apparent' wave celerity. The 'apparent' wave celerity is in fact the phase speed, which equals c_0 in a prismatic infinite frictionless channel, but also in an ideal estuary (see e.g. Savenije et al., 2008). In the case of a fully reflected wave (in a prismatic frictionless closed channel), the phase speed (the apparent wave celerity) is infinite, but the wave length is still $c_0.T$. Recent research demonstrates that friction and convergence modify the phase speed, but not the actual properties of the wave itself. The wave length is essentially determined by the depth and the storage width, but due to convergence and friction the phase speed (and the phase itself) change (see the phase lag and celerity equations in Savenije et al. (2008), also summarized in Table 3.4 of Savenije (2012)). In any case, the wave length λ is a basic property of a tidal wave for a given channel configuration. The actual phase speed subsequently depends on friction and convergence, which are parameters that are also taken into account in (24). However, because most alluvial estuaries are close to ideal, the actual phase speed is not so much different from c_0. This is, maybe, a lengthy reply, but your completely legitimate question requires some background.

Section 4.2: It is not clear why D_0^{TA} is computed here from D_1^{TA}. D_0^{TA} is not being used in the procedure as described in this section, i.e. for the different sections:

$0 \leq x \leq x_1$ en $x > x_1$. This is important for those who want to use the model. For instance, Eq. (33) only describes the salinity distribution for $x > x_1$.

We agree that we have missed some explanations here. The dispersion coefficient D_0^{TA} is computed in order to simulate a complete salinity curve starting from the estuary mouth where $x = 0$. Hence, in the revised manuscript, we added the salinity equation for the first part of the estuary where $0 \leq x \leq x_1$ in Eqn. (33).

Eq. (38): please include the standard deviations for the estimated exponents of the dimensionless groups. This will show the significance of the individual terms in the regression analysis. The authors could also comment on the fact that the predictive equation for K does not necessarily result in values less than 1.

We have included the detailed result including the standard error obtained from the regression analysis in Table S4 (supplementary material). The reason K is limited between 0 and 1 can be explained by the curvature of the salt intrusion curve. Detailed explanation is given in the book "Salinity and Tides" by Savenije (2012), page 119 to 121, Section 4.8. Attention to equation (4.30).

Page 755, line 15: it is strange to state that gravity acceleration has a large influence on K as its value is spatially almost constant on earth and thus was not tested.

You are right. The way it is written gives the wrong perception. In fact the gravity constant should be outside the bracket, together with π. What we do see from the power of g is that it shows the importance of the wave length. We have adjusted Eq.(40) (previously Eqn. (39)) to bring g outside the brackets, and we also changed the text as shown in page 755, lines 13 to 15.

Page 755, line 20-21: For prismatic channels . . .. If b_2 approaches infinity (prismatic case) then Eq. (38) predicts $K = 0$. In that case dispersion is constant

according to Eq. (33) (after moving K to the left hand side) as the authors also state. It means that density effects as described by the Richardson number do not affect dispersion. Could the authors explain why density effects are absent for prismatic channels or does it show the limitations of the predictive equation for K?

This is also a good observation. $K = 0$ means that the dispersion is constant. Combination of (1), (2) and (4) leads to:

If $K = 0$, then (2) and (4) show that $D = D_0$, irrespective of dS/dx or S, which can both assume any value. In prismatic estuaries, where $A = A_0$ we see from (1) that if $D = D_0$, then $1/(S - Sf)\cdot$ dS/dx is constant. The solution then is an exponential function with exponentially declining salinity:

So it does not mean that density effects don't play a role anymore. It only means that dS/dx is tuned in a way that D is constant and S declines exponentially.

Eq. (40)-(42): please also include the standard deviations for the estimated exponents in these equations.

We have included the detailed results including the standard error obtained from the regression analyses in Table S5 (supplementary material).

Page 757, line 8: please give a reference to these laboratory experiments.

We have added the references in Page 757, lines 6 and 7.

Eq's (43)-(45): u_1 has not yet been defined as the river flow velocity (I think).

We have added the missing definition in Page 758, line 10.

Page 759, line 2: "without calibration of K and D_1". It is meant that this is in predictive mode?

We have rephrased this sentence in Page 759 lines 1 and 2.

Page 760, line 27: "it also decreases or decreases towards upstream". Not clear what is meant. Please rephrase.

We have rephrased this sentence in Page 761 lines 1 and 2.

Page 761, line 16: "the performance in predicting K is rather low". But on page 762, line 10 it is stated that "the predictive equation for K is rather good". Please clarify.

We have rephrased the argument in Page 762 lines 13 and 14.

Table 1: Please include rs in the table as it is used in the derivation of K (through λ).

In our study, we assumed that the value of r_s is about 1.2 for all cases because we do not have enough information on the storage width.

Technical corrections

Page 740, line 2: predictive equations

Corrected in page 740, line 4.

Page 740, line 23: data are

Corrected in page 740, line 22.

Page 741, line 5: equations

Corrected in page 741, line 4.

Page 743, line 4: replace "into the" by "into".

Corrected in page 743, line 8.

Page 743, line 16: replace "of" by "in".

Corrected in page 743, line 19.

Page 744, line 7: expanded

Corrected in page 744, line 10.

Page 749, line 18-19: "...based on Savenije's (1993b, 2005, 2012) method ...".

Page 749, line 17-18, this has to be corrected by copernicus. We will inform them for correction.

Page 750, line 20: "is of the second reach and not of ..."

Corrected in page 750, line 21.

Page 755, line 20-21: For prismatic channels .....

Corrected in page 755, line 20.

Page 758, line 17: Eq.'s (43), (44) and (45) should be (40), (41) and (42).

Corrected in page 758, line 18.

Page 759, line 3-4: change "do not performed very well" in "did not perform very well".

Corrected in page 759, line 4.

Page 759, line 8: underestimated and overestimated.

Corrected in page 759, line 8 and 9.

Page 759, line 9: Is reference to Eq. (45) correct?. See also references to the equations in lines 11 and 14.

Corrections on the equations references have been made from line 10 to 14.

Page 761, line 14: there.

Corrected in page 761, line 17.

Page 761, line 21: decreases.

Corrected in page 761, line 23.

Page 762, line 14: "of the K and D_1".

Corrected in page 762, line 17.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/12/C842/2015/hessd-12-C842-2015-supplement.pdf

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