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Hydrology and Earth System Sciences Discussions

Interactive comment on "Buffering of the salinity intrusion in estuaries by channel convergence" *by* P. S. Gay and J. O'Donnell

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The paper is an interesting attempt to obtain more insight into the process of topographical buffering in a tapering estuary. The paper uses a simple linearly tapering estuary with a constant dispersion coefficient to analyse the dependency of salt intrusion length to river discharge. One of the main conclusions is that the 'buffering' in the tapering estuary reduces the dependency of intrusion length to discharge: It reduces the value of gamma.

However, I find the paper rather confusing and it does not really add much to what we already know. We know that the intrusion length depends on both river discharge and the taper, as for instance demonstrated clearly by Savenije (2005) where:

$$L = a\ln\left(1+\frac{1}{\beta}\right) = a\ln\left(\frac{1+\beta}{\beta}\right)$$

where beta is proportional to the root of the discharge.

In the appended document I show that in a prismatic estuary this leads to a gamma value of 0.5. Hence γ-max = 0.5. I also show that in a strongly tapering (exponential) estuary, the gamma value is 0.17. This completely fits with the empirical evidence of the authors, but as a result of a generally applicable theory.

Unfortunately the authors have not used a solid theory, where they use many assumptions which are sometimes conflicting. They assume that: 1. the taper is linear. I accept that this assumption is a decent approximation and could be useful to illustrate first order effects 2. that the dispersion K is constant (spatially uniform). This is a strong assumption which in natural estuaries seldom applies 3. that dS/dx is constant (HR65 assumption). This is an equally strong assumption, which may apply in a certain section of the estuary (the middle) but not in the tail (which is generally exponential) nor near the mouth in strongly tapering estuaries. 4. at the bottom of page 15 dS/ds is considered proportional to S again, so that K is not constant.

However, these strong assumptions are not required to explain the effect of taper, as the attached document shows. It clearly shows that in a prismatic channel L is proportional to the inverse root of the discharge and that in a strongly tapering channel L is proportional to the discharge to the power -0.17. So depending on the convergence, the exponent of the fresh water discharge in this relationship varies between -0.5 for prismatic channels to -0.17 for strongly tapering channels, or in the symbols of GO'D: 0.17<γ<0.5, or γmax=0.5. Hence the tapering strongly affects the dependency of the salt intrusion length on the fresh water discharge, which GO'D call "buffering". Moreover, this relationship strongly depends on the convergence length.

This implies that gamma values of 1 are not realistic, as presented in figures 5, 6 and 7. And I am not sure if equations (4) and (5) have an upper boundary of 0.5.

As an overall conclusion, I don't recommend publication of the paper in HESS and I also do not think that through a revision the paper can become acceptable. There are too many weak assumptions made to simplify the process, while other equally simple or even more simple solutions exist that provide more insight into the dependence of intrusion length to river discharge.

Please also note the Supplement to this comment.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 6007, 2009.