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Hydrology and Earth System Sciences Discussions

Interactive comment on "Using flushing rate to investigate spring-neap and spatial variations of gravitational circulation and tidal exchanges in an estuary" *by* D. C. Shaha et al.

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This is a very interesting and well-written paper that applies the flushing rate theory to a Korean estuary and which demonstrates how the relation between tide-driven mixing and gravitational mixing changes as a function of tidal range and river discharge, and how this relationship varies along the estuary axis. This is one of the few papers where this theory is checked with a consistent set of observational data.

I have a number of minor editorial corrections and remarks which I list at the bottom of this review, but I have a few observations of substance which I would like the authors to reflect on and deal with in their final paper.

1. The most important issue is the definition of the flushing rate F. The way it is defined in the paper (based on Officer and Kester, 1991; and Dyer, 1997) is in my view not completely correct. If we consider the salt balance near the estuary mouth, then this reads:

$$FS_0 = RS_1 + FS_1$$

where S0 is the salinity at the seaward boundary and S1 the salinity in the segment. Furthermore:

$$\frac{S_1}{S_0} = 1 - -f$$

and

$$S_0 - S_1 = fS_0$$

This leads to a new equation (4a):

$$F = \frac{R}{f}(1 - f)$$

The difference with Eq.(4) is the factor (1-f). Near the estuary mouth, this difference is not likely to be large, since there (1-f)≈1. However, the asymptote of Eq.(4) for upstream segments is wrong (R=F) whereas in the river part F should be zero. The equation derived above (4a) has the correct asymptote, in the sense that F=0 if the water is completely fresh (f=1). Eq.(4) yields F=R if f=1, which is clearly not correct. I don't know if this makes a lot of difference in the calculations made, but it would be worthwhile trying it out.

2. Regarding the Figures 7, 8 and 9. It is not clear to me what the value of G_c mentioned in the graphs refers to. Surely the value is related to a certain discharge. It looks as if it relates to the maximum discharge observed. I suggest the authors select one particular discharge (say 50 m3/s) and provide the G_c of that particular discharge. Furthermore, the linear regression line presented seem to me as arbitrary. Realising that, on the

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basis of Eq.4, the relationship found should asymptotically approach the line F=R for large values of R, maybe a regression curve of the following type should be tested:

$$F = F_{\text{int}} \exp\left(R/a\right) + R$$

The discharge scale 'a' defines the slope of the curve. If however the proposed Equation (4a) is used, then the line should approach F=0, and the relation would become:

$$F = F_{\text{int}} \exp\left(R/a\right)$$

Obviously this changes the definition of G_c. I am curious to hear what the authors think of this.

Moreover, I think the steepness of the line for spring tide in segment 1 is too steep, leading to a far too high value of F_{int} for that segment. Of course the large scatter makes it difficult to draw a reliable line, but maybe the suggested regression equation performs better.

3. In Figure 10, it is not mentioned to which point along the axis this refers. I presume it is for the mouth of the estuary (segment 1?)

4. Overall, it is not clear what the distance to the mouth is of the different segments. I recommend you include the distance to the mouth in Table 2.

5. Finally I have some editorial corrections and suggestions:

p.1622 l.19: I suggest to delete: "for instance" and "planktonic"

p.1624 l.13-20: The unconventional wording triggered me to google this text and it is indeed an almost literal copy-paste of Kimmerer et al. Don't do these things, even when the citation is given one should use his own words to cite an author or, if one wants to use the literal text, then it should be cited between quotes. The word 'loss' is not appropriate in hydrology (in hydrology there is no loss but conservation of substance), nor are

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the ecological terms used comprehensible for hydrologists. I suggest you delete the line: "Where gravitational circulation does not occur, behavioral mechanisms can still reduce dispersive and advective losses." This sentence refers to activities that organisms may develop to counteract flushing. This is not relevant here. Further I suggest to adjust the following sentence as follows: "In general gravitational circulation increases in strength with increasing river flow, which may cause a depletion of estuarine resident populations by advection from their resident position, particularly larval forms of bottom feeders and deep-water organisms, but also copepods and larval fish (Hough and Naylor, 1991; Jassby, et al., 1995; Morgan et al., 1997, Kimmerer et al., 1998; Kimmerer et al., 2002; Monismith et al., 2002)."

p.1624 l.18: delete 'almost'. This value is very accurate already.

p.1624 l.19: replace 'to' by 'in'

p.1624 l.20: replace 'to' by 'in'

p.1624 l.23: write: "The mean precipitation is 1418 mm a-1". Rainfall is always a flux !! This is important in a hydrological journal. Also there is no need to give the rainfall with a digit behind the decimal point.

p.1628 l.18: write "of the tidal exchange and the gravitational circulation exchange,"

p.1630 l.9: replace "than" by "compared to"

p.1630 l.16: replace 'whereas' by 'and'

p.1634 l.11: replace 'have' by 'be'

p.1634 l.19: delete 'well'

p.1636 l.17: 'should be conducted'

p.1654 Fig.11: legend of vertical axis: delete / and put unit between brackets

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 1621, 2010.