Response letter

This paper deals with numerical modelling of several tidal constituents propagating in an estuary. This is an important problem: estuary models tend to deal with a single constituent at a time (to keep the run length down). However, the friction felt by that constituent will depend on the size and nature of the other tidal constituents in the estuary. The paper is thorough: the problem is first dealt with in an analytical way, numerical solutions are obtained and compared to observations in two estuaries in the Iberian peninsula. Agreement is good.

Our reply: We thank the Reviewer for his overall positive assessment of our work.

I'm not a numerical modeller but I know that the effect of frictional interaction between different tidal constituents has been well studied (the important papers on the subject are referenced here). I would appreciate being told exactly what is new about this paper. Is it the first time that estuaries with an exponential shape have been considered in this way?

Our reply: In the revised paper, we shall explicitly mention that "*Unlike the previous studies exploring the effect of frictional interaction between different tidal constituents by quantifying a friction correction factor only (e.g., Dronkers, 1964; Le Provost, 1973; Pingree, 1982; Fang, 1987; Godin, 1999; Inoue and Garrett, 2007), in this study, for the first time, the mutual interactions between tidal constituents in the frictional term were explored using* ***a conceptual model*** *by means of expanding the quadratic velocity using a Chebyshev polynomials approach which allows for defining a friction correction factor for each constituent.*" The advantage of such conceptual model lies in the deterministic description of the mutual frictional interaction among tidal constituents, which avoids the need of an independent calibration of the friction parameter for the single constituent. The proposed method can be used as a prognostic tool to study the propagation of different tidal constituents in convergent estuaries where the cross-sectional area can be described by an exponential function.

Also, I would be interested to know if the problem could be approached just by matching model results to observations to get the best fit (as I suspect many modellers would do) without worrying too much about the theory.

Our reply: Exactly! Similar to our previous analytical studies for a single tidal constituent (e.g., Toffolon and Savenije, 2011; Cai et al., 2016), the implementation of the new model accounting for the nonlinear interactions between tidal constituents also requires a few dimensionless input parameters representing the external tidal forcing and estuary geometry, which are independent of the tidal hydrodynamics along the estuary. Hence, the problem does solve by matching the model results to observations.

The paper is well written, but it is long and technical. I don't suggest doing anything about it now, but I would encourage the authors to go for a more concise style in the future. Having said that, I found myself wondering why the estuaries behave as they do. WHy does the tidal amplitude first reduce before increasing towards the tidal limit. I think I undesrtand that, but it would be interesting to read the authors opinion in the discussion section.

Our reply: We thank the Reviewer for the useful suggestion. In the revised paper, we shall explicitly mention the underlying mechanism of tidal hydrodynamics (i.e., damping/amplification along the channel) in these two estuaries. In particular, the tidal damping along the first half of the estuaries is mainly due to the damping of the dominant M_2 wave owning to the fact that the impact of bottom friction dominates over the channel convergence. Along the upper reach, enhanced morphological convergence and reflection effects (that reduce the overall friction experienced by the propagating wave) result in the overall amplification of the tidal wave. For more details of the tidal hydrodynamics in these two estuaries, readers can refer to Garel and Cai (2018) for the Guadiana estuary and Diez-Minguito et al. (2012) for the Guadalquivir estuary.

There were some small points I noticed which could benefit from correction:
line 83 the storage width Bs is not defined here as far as I can see, although it is defined in the figure. At this stage I am confused about whether the model considers just a rectangular channel (with constant width) or whether the width is allowed to change with the tide.

Our reply: In the revised paper, we shall explicitly define the storage width B_S as "***width of the channel at averaged high water level***". In this study, we assume a rectangular cross-section with a constant width since the variation of width $\Delta\bar{B}$ with time is usually negligible (i.e., $\Delta\bar{B}/B \ll 1$). On the other hand, the overall influence of storage area is represented by the storage width ratio, defined as the ratio of the storage width B_S (width of the channel at averaged high water level) to the tidally averaged width (i.e., $r_S = B_S/\bar{B}$).

line 115 Why would there be different celerities for elevations and velocities?

Our reply: It was shown by Savenije et al. (2008) that for an infinitely long channel the wave celerities for elevation and velocity are almost the same due to the combined impacts of bottom friction and channel convergence. However, for a semi-closed channel the wave celerities for elevation and velocity would deviate due to the additional impact of reflected wave at the closed end (e.g., Toffolon and Savenije, 2011). Such a celerity difference was recently investigated and detailed by Garel and Cai (2018) for the case of the Guadiana estuary.

equations 10 and 11 it looks line - signs occur where there should be = signs (although
that may be a trick of PDF).

Our reply: This is probably due to the PDF viewer, as there is not such typing error on our version.

References

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