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Earth System Dynamics Discussions

Interactive comment on "Maximum power of saline and fresh water mixing in estuaries" *by* Zhilin Zhang and Hubert Savenije

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1. The paper presents interesting view for saline intrusion in estuaries. It deserves a publication after some revisions.

Reply: Thank you for your positive comment.

2. For salt intrusion in estuaries, the driving agents are diverse, rather than the gravitational circulation only. As mentioned in the manuscript, tidal mixing is another key element. Even in the upstream part of an estuary, the gravitational circulation is still not the main driver, other processes like tidal pumping, tidal trapping are more important. How to ensure the validity of your concept?

Reply: Indeed, the tide generally plays a dominant role downstream, particularly if

the estuary is wide. As shown in Appendix B, D_MP is always smaller than D_VDB, which is the total dispersion we simulated by the traditional Van der Burgh method and which comes close to the dispersion distribution that can be derived from the observed salinity distribution and the salt balance equation. The difference between the D_MP and the D_VDB represents the tide driven dispersion.

Over a tidal cycle, tidal trapping is minor in well-defined single-channel estuaries. Tidal pumping is apparent in preferential ebb and flood channels (occurring in wide estuaries) and by the interaction of the tidal flow with an irregular bathymetry, which both can be important near the estuarine mouth.

However, at the location where the salinity gradient is largest, the dominant mechanism is the gravitational circulation.

3. I have not got any expression of the Mex in your manuscript. How the Mex is expressed and how it can reach a maximum?

Reply: As you have noticed, our approach to analyse the energy dissipation in estuarine systems is different from traditional research. The accelerating moment exercised by the freshwater discharge transfers energy either into dissipation by friction or into work by the executing moment, M_ex, which drives the gravitational circulation, lifting up saline water against gravity and pushing down fresh water against gravity. We did not know the exact expression for M_ex, but at maximum power, half of the accelerating moment is converted into work: the executing moment.

The maximum power happens when dP/dM_ex = 0, this is because the power is a function of the execution moment (Figure 2) and there is a maximum value of the quadratic Power function.

4. The dispersion of salinity is rather a very ambiguous term, what is its physical meaning? how to define and describe it?

Reply: Indeed, the dispersion coefficient is a mathematical artifact of averaging. Depending on the spatial and temporal scale of averaging, it arrives at different values. In this manuscript, we consider the tidal average and cross-sectional average dispersion along the estuary. The nice thing is that if we use the tidal period and tidal excursion length as the temporal and spatial scale, that the dispersion gets physical meaning: it represents the mixing (the exchange) of fresh and saline water over a tidal cycle within a cross-section. A box model demonstrates that this dispersion coefficient then is the product between the tidal excursion and the velocity of salinity exchange between two sections a tidal excursion apart. The latter is supposed to be proportional to the tidal velocity amplitude and to be a function of the degree of stratification.

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