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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 discussion. If we look at your Figure 2 in the reply, you define the exchange flux F as Q_1. I, however, define the exchange flux as Q_2. If we consider x=0 at the mouth with the x-axis pointing upstream, then in your definition $F = R$ for large values of x, while in my case F=0 for large values of x. Clearly my definition is better, since upstream from the salt intrusion, the exchange flux=0.

The point is, that the exchange flux accounts for the dispersive transport and not for the advective transport. Near the mouth $Q_1 \approx Q_2$, but further upstream as R becomes larger, they become very different.

It is better to look at the steady state salt balance equation:

$$RS + AD\frac{\partial S}{\partial x} = 0$$

or

$$RS + AD\frac{\partial S}{\partial x} = 0$$

or with F=AD/Δx

$$FfS_0 = R\left(1 - f/2\right)S_0$$

or

$$F = \frac{R}{f}\left(1 - f/2\right)$$

Near the mouth where $S_1 = S_0$ this leads to $f \approx 0$ and $F \approx R/f$. Upstream, where S_1 approaches 0 this leads to $f = 1$ and $F = R/2$.

In this way, indeed, the exchange flow always increases with discharge, as you indicated should be the case, and Figure 1 shows always increasing lines. But I am not sure if this is the right approach.

I think one has to separate the advection and the exchange (the dispersion). The exchange is responsible for the dispersion. ν is the proportion of tidal mixing to total mixing, or of tidal exchange to total exchange. But this exchange flow should not include R. Hence, I think my equation (4a), based in Q_2 is correct and not Dyer's equation. Your Figure 1 shows that upstream the exchange flux becomes zero at high discharge. This is because the fresh water entirely fills the tidal prism and Q_2 is zero. This is what happens in reality as well when there is no tidal slack anymore and the flow becomes uni-directional. Or in other words there is no flood flow anymore, only a fluctuating ebb flow.

According to me, Dyer's method to calculate ν works near the mouth, but I have not yet worked out how it works further upstream. Maybe you can think about that.

By the way, I would like to know how you calculate the points in Figure 1. Is this by using eq.(4) or (4a) on observed values of f and R?

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