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 is 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 $F=AD/\Delta x$

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

or

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

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. $\nu$ 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 $\nu$ 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 $R$?

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