Ocean Science Discussions

Ocean Sci. Discuss., author comment AC2
https://doi.org/10.5194/os-2021-30-AC2, 2021

Reply on RC1

Ole Anders Nøst and Eli Børve

Author comment on "Flow separation, dipole formation, and water exchange through tidal straits" by Ole Anders Nøst and Eli Børve, Ocean Sci. Discuss., https://doi.org/10.5194/os-2021-30-AC2, 2021

Thanks for the recommendation to accept the paper with minor revisions.

We appreciate the comments on variable names, language, figure labels and captions. These will be taken very seriously when writing a revised manuscript, but in this reply we focus on the more scientific questions.

Figure 14: Why is the tracked velocities lower than the theoretical values in a, but higher than theoretical values in b?
It is hard to know the exact answer to this question, and it could be a coincidence since Figure 14 only shows two examples. However, the explanation may be the mesh resolution. Figure 14a shows dipole propagation velocity for a narrow strait where the dipole travels a large distance from the strait (it is the same simulation as presented in Figure 4). Figure 14b shows dipole propagation velocities for a wider strait where the dipole travels a much shorter distance (see Figure 5). Figure 1 illustrates how the mesh is defined for narrow and wide straits. The area of fine mesh resolution depends on the strait width and a narrow strait has a smaller area of fine mesh resolution than a wide strait. So, in the narrow strait shown in Figure 14a, the dipole moves far away from the region of fine resolution, while in Figure 14b, the dipole stays in the fine resolution much longer. Generally, the dipole in 14a travels in a coarser grid than the dipole in 14b. Although we cannot prove that this is the reason for tracked velocities being lower than theoretical values in 14a and higher in 14b, it is a likely explanation.
This question is interesting also when considering sensitivity of the results to mesh resolution. We have run simulations in 82 different geometries, and for the reason explained above, the dipoles move in different mesh resolution dependent on their travel speed and the strait width. Despite this, the propagation velocity agrees well with the theoretical values (Figure 15) and the tracer transport agrees with the kinematic model for all straits (Figure 18). In addition to how we have argued in our reply to reviewer #2, this is another indication that our results are not affected by mesh resolution.

Line 374: Equation 31 is important because it provides understanding to the processes. The agreement with the simulation results strongly indicates that the kinematic model contains the main processes at play. So, the main point of equation 31 is to provide understanding and not estimate transport. However, it can also be used to make rough estimates of transport if no simulations are present. Estimates on transport can be made from the strait velocity and geometry, estimating dipole propagation velocity from Equation 18. This requires an estimate on the aspect ratio of the vortices, which largely

depends on the strait width.
The main simplification leading to Equation 31 is that we estimate the fraction of the tracer inside the sink radius by assuming the dipole and jet has the form of a rectangle. This is of course not true, but it gives a simple expression for the effective transport. The improvement in the agreement with simulations resulting from adjusting r/Ld tells us that it is important to include in the model that only a fraction of the dipole escapes the return flow.
When it comes to ignoring the higher order terms, we see when going through this again, that this is not necessary to do. In the manuscript we use a constant value of r/Ld=0.4, for all simulations, which corresponds to (1-r/Ld) = 0.6. If not ignoring the higher order terms the expression for qe (Equation 31) becomes
qe = (1-SL)*(1-Sd / (1+r/Ld)).
Setting 1/(1+r/Ld)=0.6, will give the exact same fit to the simulation data as in the manuscript. So, ignoring the higher order terms actually has no effect, and including all terms also gives a rather simple expression for qe. In a revised manuscript we will use the full expression for qe without ignoring the higher order terms. Thanks for setting focus on this and apologize for making this a little too complicated in the manuscript.

- Figure 19: The point of this work is not to come up with a parameter that works better than the Strouhal number. The point of showing that Sd is similar to St is that the understanding provided by this work can also be used to understand St.
St is more like a scaling, using values of strait velocity, strait width and tidal period, while Sd comes from a kinematic model of tracer transport. However, it is hard to know which value of St which will give net transport. Figure 19 shows Sd plotted against St/Stc, where Stc is the threshold value of St, such that St<Stc is gives non-zero tracer transport. In making the plot we have picked Stc from the simulated tracer transports. A threshold value of 0.13 is given by several authors, but this is likely to change with geometry. Then Sd is a simpler parameter, because it depends on sink radius and dipole travel distance. If these can be estimated, we know that Sd<1 may give transport if also SL<1.