Review of “A realistic physical model of the Strait of Gibraltar” by A. Tassighy et al. A very interesting paper that presents the best laboratory physical model of the Strait of Gibraltar ever made so far. Congratulations to the authors.

The experiment provides such an amount of experimental data that authors face a serious problem to select which ones are going to be presented in the manuscript, which one is the logical sequence to show the results, how are they connected to each other and so on. The final manuscript focus on tidal dynamics for different tidal forcings and compare the results with those already published in papers that deal with the same issue, either from observational or numerical approaches. There are a large number of experimental data related to high-frequency dynamics that are not addressed here (they will be covered in other ongoing articles) for obvious reasons of length. The analysis of the tidal regime alone has resulted in this extensive manuscript, which will be read with great interest by the oceanographic community working in this very special environment.

The manuscript should be published in OS, although authors must revise it with care. Below is a list of (mostly) minor or very minor points, whose extensive length is a consequence of the interest with which I have read the manuscript.

Comments to the manuscript (following the order of writing)

L35. “*the Mediterranean Outflow Water strengthens the Atlantic Meridional Overturning Circulation*” I wouldn't dare be so categorical. There is still considerable debate about the role of the Mediterranean outflow in the AMOC.

L46. “*observationally-based*” rather than “*experimental*”?

L78-86. A short phrase stating the origin, orientation and positive direction of *x* and *y*-axes would be welcome. Origin is CS summit, as stated in line 216 later, but perhaps it is a good idea to mention it here. It seems rather obvious that orientation is along (“*x*”) an across (“*y*”) Strait, with positive directions eastward and northward, respectively. However, it is not until caption of Figure 4 (around L400) that this convention is explicitly said. The reason of this suggestion is that, here and there in the manuscript appear contradictions (writing errors?) regarding velocity and coordinate signs. Therefore, the convention must be clearly stated and this Section seems to be the right place.

Although not explicitly stated, the Atlantic and Mediterranean waters have the same temperature in all simulations, right? This makes density solely a function of salinity, which is important in certain parts of the work (i.e., transports). It would be appropriate to mention this at some point in Section 2.

L122. “*In the vertical momentum equation (3c)…*” equation (3c) is horizontal momentum isn’t it?

L 135-136. “*and Hs ≃ 100m is the half water depth at CS*” Actually, water depth at CS is nearly 300m. Why this scaling factor of 100m? Does it have to see with the mean thickness of the Mediterranean layer at CS?

L158. A “*s*” is missing. 35.77s

L163. The Strouhal number is new to me. Other readers may encounter the same difficulty of understanding what does it mean. A definition and relevance of this number (similar to the one given for the Burger number in lines 151-153) would be welcome

L174. " .. *on the slope angle*.." Bottom slope? Interface slope?

L223. Delete "is"

L229-230. References within brackets.

L242. 6% is a clear overestimate. Tidal transport exceeds 3Sv (if you refer to the amplitude of the oscillation). 1.5% - 2% is more realistic.

Figure 1. Nice Figure showing the core of the experimental team (and the infrastructure). I like it

L249. Are units of the density difference ("kg/m3") correct? In fact, 0.19kg/m3 is a very tiny difference, ten times smaller than in the actual ocean, which contradicts the statement of L143-144 about enhancing the density difference (and, also, units in the color scale of some figures, i.e., Fig.9).

L260-261. No continuous red line in Figure 2a. Grey line perhaps, as stated in the caption? And *y*-axis indicate density difference, not salinity. On the other hand "..*(25cm in the ocean)*.." is 25m, right?

L276. " … *of the order of magnitude of 1m/s…*" Where? At CS? Please indicate.

L279. What is it meant by "*purely barotropic velocity*" here?. Does it refer to the amplitude of a purely barotropic tide, i.e., the tide resulting if both Atlantic and Mediterranean basins are filed with homogeneous water (no baroclinic forcing at all)?

Figure 2 caption. (L-3 says "*salinity measurement*" while *y*-axis indicate density difference. L7 mention SSH variations, L8 mention SSH anomaly. What is the difference between both SSHs? Apparently, they refer to the same process. L9-10 about the phase shift: see comment L305 below.

L291 No "red curves" in Figures 2c,d, but cyan or grey.

L305 A phase shift of $0.2T_{tide}$ between the Atlantic basin and Tarifa station is declared. Taking T_{tide} the period of M2 (12.4h approx.) the shift would be 2.5h or 70º phase difference for M2 frequency. In the actual ocean, this phase difference is hardly 15º, much less than the one reported in the manuscript (consult harmonic constants in the interactive web https://portus.puertos.es of Puertos del Estado, SPAIN). In the real ocean the phase difference is caused by the Earth rotation in order to maintain geostrophic balance at tidal scale, achieved via changing the sign of the cross-strait free surface slope at tidal time-scale. Moreover, as mentioned in lines 285-289, the relationship between the sea-surface oscillation and the tidal barotropic current in the actual ocean cannot be reproduced in the laboratory. In the experiment, eastwards flow corresponds to rising tide in the Atlantic, just the opposite that in the ocean. That means that the Coriolis force causing the cross-strait slope (and, hence, the phase shift in Tarifa) acts in opposite direction in the real ocean and in the experiment, which invalidates the comparison of results. I suggest removing these comments both here and in the caption of Figure 2.

L379. When speaking of mean density anomaly, do you refer to the ratio $\Delta\rho/\Delta\rho_0$ that appears in the top panels of Figure 4 (where $\Delta\rho = \bar{\rho}-\rho_0$, $\bar{\rho}$ being the averaged density over the seven tidal cycles ($\Delta\rho_0$ is already defined), right?). If so, it is not a density anomaly, but a ratio of density differences (dimensionless). Assigning a symbol to this anomaly, which is frequently discussed in the text, would make it easier to read.

L388. When saying " ..*waters are more diluted (about 30%)* etc..", do you mean that the density anomaly ratio is 0.3?

L390. "surface" instead of "layer"

L391. The grey line, according to Figure 4 caption, is $\Delta\rho/\Delta\rho_0 = 0.5$ (dimensionless), which corresponds to $\Delta\rho = \Delta\rho_0/2$ (units of kg/m3). Please modify so that text and figure caption do not disagree. Moreover, this specific value is used (implicitly) to define the pycnocline, as stated later in lines 413-414. In my opinion, what is said in these two last lines should be moved there (to the end of line 391, more or less).

L399. "*deepen*" or "*descend*" instead of "*lower*"?

Figure 4 caption. L3 "…*with the averaged velocities*..." Actually, it shows the vector sum of averaged *u* and *w* with the later largely exaggerated. The same applies to Figure 8 and also to Figures B1 and B2 in appendix B. L5 I guess you speak of the time-averaged composite Froude number, do you? Please indicate.

L405-406 The mean thickness computation in equation (9) requires the definition of an interface depth, which seems to be the pycnocline defined as $\Delta\rho/\Delta\rho_0 = 0.5$. This is said later in lines 413-414, but should be said before. Moving these lines (as I suggested above) will improve the text understanding.

L423-424. "… *given in figures B1 and B2 in the appendix*". Remove "*, respectively, that are given*"

L437. "*horizontal velocity*" rather than "*horizontal flow*". I have seen that the term "horizontal velocity" usually refers to the rotated (along-strait) component of the horizontal velocity throughout the text; particularly in the second half of the paper this seems to be the rule. But not always means this component. For instance, it does not in the aerial view maps of Figures 5 and 7, which actually show the "horizontal velocity". Perhaps it is convenient to state a criterion somewhere in section 2 or keep the notation "*u-component*" for the horizontal velocity in the second part (after presenting Figure 7). As you can see below in my review, there are a few comments addressing this point.

Figure 5 caption. L1 "*Averaged horizontal velocity*" instead of "*Averaged meridional and zonal velocities*". Insert "*relative*" before "*vorticity*"

Figure 6 caption. Are the presented plots time-averaged values? Please indicate. L3 "dashed" should be "dotted" and "dotted" should be "dashed". The sentence "*vertically integrated volume transport and below salt transport;*" has nothing to see with the panels. Please, remove.

L451-452. Remove the sentence "*The bottom panels …. three transects*" or, better yet, incorporate it at the caption of Figure 6.

L454. Remove "*where ……waters*". Unnecessary; it has been already said.

L466. "*…to the shallowing pycnocline..*" instead of "*…to the decreasing pycnocline depth…*"

L472-473. "*… 50% higher during neap tide compared to the spring tide condition with exception of the southern transect where values remain similar for all tidal conditions*" This is not what can be deduced from Figure 6. Actually, it is in the southern transect where G^2 differences between spring and neap tides are the greatest. Maybe you are referring to the northern transect in the caption?

L474. "*x=-30cm and x=-45cm"* instead of "*x=30cm and x=45cm*"? (this has to see with my comment to lines 78-86 above). Nice to indicate the corresponding distances in km.

L480. "*horizontal velocity*" instead of "*zonal and meridional velocities*"

L480. "*tidal average*"? Such an average would provide a unique value for the averaged period, that is, for a tidal cycle, whereas Figure 7 presents snapshots at different moments of a tidal cycle. Maybe authors are referring to the average of the seven resolved tidal cycles for "*Outflow*", "*HWS*", etc.?

L486. "*…(latter two row panels)*" Do you mean "*third row*", which is where inflow is presented

L492. "*averaged over the phases of maximum inflow*" Again, do you refer to the maximum inflow averaged over the seven resolved cycles?

L497. "*demonstrates that tidal forcing is capable of mixing the entire water column down to 500m*". Not clear to me. I think you are referring to the periodic occupancy of the whole water column by Mediterranean waters (deep red colors in Figure 9). It could be mixing, but, in my opinion, is the uprising of the interface during the outflow which can eventually reach the surface during spring tides. If so, it is advection rather than mixing. A different issue is that, in HERCULES experiment in particular, the whole Mediterranean layer is well mixed from the bottom to the interface (which eventually can reach the free surface) with clear density differences between inflow (light red) and outflow (deep red) periods. These differences can be of the order of the mentioned percentage (15-20%, normalizing the density differences by $\Delta\rho_0$, I guess. Please, indicate)

L504. "*water can still overflow*" instead of "*flow can still surmount*"

Figure 8 caption. Please, indicate what the bottom panel is.

Figure 9. Please, explain what are the numbers given at the left and right sides of the color scale. I guess, numbers on the left are the $\Delta\rho$ difference in the actual ocean, and numbers on the right are the same for waters in HERCULES experiment. If so, note that the values of the order of 10 kg/m^3 that are representative of this scale are clearly contradicting (two order of magnitude greater) the values provided in line 249 for $\Delta\rho_0$. See my comment on L249 above as well.

L419. "*The second-column panels show a clear offset between the pycnocline and the region of maximum velocity shear*" The pycnocline ($\Delta\rho/\Delta\rho_0$ =0.5) is clearly seen in Figure 9. The region (surface?) of maximum shear is not so clearly depicted. It can be inferred by the color contrast (reddish *versus* bluish shading, probably), but locating it with a certain degree of accuracy is not an easy visual issue. West of Camarinal this color contrast (shear "interface") is located in a well differentiated depth range than the pycnocline. However, both surfaces coincide acceptably well elsewhere. Maybe the comment is referring to the west of Camarinal specifically? Please clarify the quoted sentence above.

L421-423. I have read the sentence "*Vertical velocities ….. spring tide conditions*" several times and I cannot catch its meaning and the reason to be here. Can you be a bit more explicit?

L525. "*even negative velocities*"? Do you men "*even positive*"? (cf, column #2, row#4 in Fig 8, better seen in column #2, row#4 of Figure 10)

L547-549. Same comments as in L419 above. I think the mismatch is limited to the west flank of CS.

L548. "…*under spring tide*". It rather seems "*neap tide*"

Figure 11 caption. Are vertical profiles just above CS? Please indicate

L572-573. "…*or from velocity interface*" Are you meaning "velocity interface (that is, u=0) or surface of maximum horizontal (u-component) velocity shear? The surface u=0 can eventually disappear during short periods of the tidal cycle and is useless for estimating layer thicknesses

Figure 12 caption. "*velocity*" instead of "*speed*"

L593. "*(positive values of u_b)*"? isn't it "*negative*"?

L656. Add "(*see the locations indicated in Figure 1)*" after "*conditions*"

Figure 13. As far as HERCULES experiment is unable to reproduce correctly the sea level phase relationship of the surface oscillation in the Atlantic and Mediterranean basins (lines 285-290 of the manuscript), it does not seem like a good idea to show the oscillation in both basins. I think the one in the Atlantic side is enough to delimitate the inflow and outflow periods in the Hovmöller diagrams below. I suggest to remove the Mediterranean sea level curve and add vertical dashed lines across the Hovmöller diagrams showing inflow and outflow periods.

Figure 13, caption. If possible, mark with dots the locations of M02 and M05 in the bathymetry left panel of the center section.

Figure 13, caption. "*vertically averaged horizontal velocity*" or "*vertically averaged u-component of horizontal velocity*"?

L660-661. "*Moreover, we also observe that the position of this front does not happen at the same time in the three transects*" I cannot see it in Figure 13. Perhaps some indications/marks in the very Figure would clarify the issue.

L662. I cannot identify the 2s shift mentioned in the text. Perhaps the marks I suggest above may help…

L670. "*García-Lafuente et al. (1990, 2018); Sanchez-Roman et al. (2018); Roustan et al. (2024a)*" within brackets.

L673. "…*with respect to the reported phase shift between north and south*" Are you speaking of the sea-level phase difference (i.e. barotropic tide)?

L680. "x=*-30cm and x=-45cm*"?

L691. "*x=-50cm*"?

L698. "*…or the velocity interface, creating…*" or " *…or the surface of maximum shear of the u-component of the horizontal velocity, creating..*"

L708. "*the transport of salt.*" This is true as far as *T*=cte. I guess *T*=cte has been implicitly assumed in the study. I have already made a comment on the interest of stating this constancy in Section 2. Nevertheless, it wouldn't hurt to mention it again here.

L709, eq.(16). Limits of integrals in the equation are *z*=0 and *z*=bottom, aren't they? To mention the limits in the text (or in the equation) would be OK to avoid any confusion with transports in either layer.

Figure 15 caption. "*Mean transport contributions…*" Add "*(per width unit)*" so that the sentence reads "*Mean transport (per width unit) contributions….*" On the other hand, does "*mean*" here refer to tidally averaged? Also write "*transects*" instead of "*planes*"

Figure 16 caption. Indicate what the black arrows are. (Transports per width unit, aren't they?)

L726. "..*positive*"? The mean (tidally-averaged?) transports in Figure 15 are mainly negative in all sections (north section could be a small exception). Figure 16 shows that the transport can be positive in spring tides in the eastern part, but only for short periods. But, when averaging over a tidal cycle, it appears to be *negative,* as seen in Figure 15. So what does "*positive*" refer to in this line?

Lines 743-796. This part of the text should be a new sub-section 4.2.6 named "Time-variable tidal forcing amplitude" or "Transient tidal forcing" or something similar. These lines clearly deal with a different topic than subsection "**4.2.5 Transports**"

L751. "*horizontal velocity component*" I think "*along-strait*" or "*u-component*" is meant (line 755). Please, correct. Same applies to Figure 17 caption.

L761. "…*three moments*…" instead of " …*three points*…"

L763. "*In the third row*…"

Figure 17 caption. Sentence "*with a cutoff period……. Vargas et al., 2006)*" is unnecessary as it is already in the text. I suggest a short "*(see text)*" instead. Add " *in the transient tide experiment*" after "*(cyan line)*" in line 7.

L766. "… *consistent with the reduced vertical velocities*"? No vertical velocities are presented. Is it meant "…*consistent with the reduced u-component velocity in the vertical profiles*"?

L771. A similar comment about the sentence "…*shape of the vertical velocity profiles*"

L773-796. This part of the manuscript must be revised carefully. There is mention to Figures/panels that are not seen in the manuscript (i.e. L778 mention a "*color scale*" in Figure 18, as if this Figure were a sort of Hovmöller diagram); line 773 indicates "*Three possible mechanisms*", when the text only addresses two; sentence in L786-789 "*Consequently, the observed decrease in net baroclinic flux* (flow?) *at the sill cannot be attributed to tidal-to-mean energy transfer, as our results demonstrate the opposite effect*" Apparently contradicts the previous sentence in L785 "…*that the tidal flow transfers energy to the mean flow, thereby accelerating it*". The sentence "*the flow tends to bypass the obstacle laterally rather than pass over it*" in L790-791, when speaking, of a sill is confusing. How can a flow bypass laterally a sill? In my opinion, the flow either overflows the sill or remains stagnant in the upstream side

And an important question to be clarified, does the tidal flow in this final part have to see with the eddy-fluxes already discussed in several published articles in the literature. It seems that yes, but authors should clarify or comment the issue.

I have no posted comments to "*Conclusions*" section, as it should be partially rewritten by the authors in the light of the list of comments above. Neither have I revised Appendix A, as it addresses issues far from my expertise.

L904, Appendix B. "…*indicate the in-plane velocity vectors*" Actually it shows the vector sum of *u* and *w* components (with the later largely exaggerated) in the northern transect. The same applies to Figure B1 caption for the southern transect.