**Responses to Reviewer 3**

*This paper is a summary of rotating laboratory experiments on the 2-layer exchange through the Strait of Gibraltar carried out on the large rotating table in Grenoble. It is an astounding paper in its comprehensive review of the scaling considerations for setting up the physical model, for its detail of the measurements carried out while the laboratory exchange flows were occurring, and for its comparisons with field observations both historical and recent. Before making any new observations in the Strait of Gibraltar, future scientists will have to read this paper to understand the phenomena that will be encountered in the Strait environment. I recommend that this paper be published as soon as possible. No revisions are needed in my opinion.*

We are very grateful to the referee for the careful review and the positive comments. The referee's remarks also provided valuable ideas for additional experiments that could further complement the already extensive dataset. A point by point answer to each of the referee's raised issue is given below in blue text. All changes have been highlighted by blue text in the revised manuscript.

*The physical model is set up to imitate the real-world environment of the Strait with detailed topography extending from the Alboran Sea to the Gulf of Cadiz and with tidal forcing to include both semi-diurnal and fortnightly variations in the currents. Analysis generally includes alongstrait transects in the northern, central and southern Strait with time series of velocity and depth of the interface between Atlantic and Mediterranean waters. The hydraulic state of the exchange is illustrated with calculations of 2-layer Froude number at critical locations in the Strait. Phenomena including turbulence in the descending outflow west of the sill, vertical velocities and bottom mixing near the sill, and the bore propagating eastward into the Mediterranean are identified and quantified. When I was making observations of the 2-layer exchange and hydraulic control characteristics in the Strait in the 1980's and 1990's, the field work would have greatly benefitted if we had had access to this laboratory model. In our analyses of the observations I was always worried about unmeasured cross-strait variations in the currents at the sill, in Tarifa Narrows and downstream into the Gulf of Cadiz. The results from this laboratory model give me reassurance that the cross-strait variations were not an overwhelming issue when interpreting our limited single point measurements.*

While two-dimensional along-strait transects can indeed provide a useful overall view of the exchange and allow bulk budgets across the Strait to be estimated, our results demonstrate that cross-strait variations become important when more detailed budgets are sought. This is especially true when the tidal component is strong, as during spring tides. This point is addressed in the new Section 4.3, where we investigate the mechanisms responsible for the reduction of the net baroclinic flow with increasing tidal forcing. We show that this reduction is not due to enhanced mixing, nor primarily to eddy fluxes, but rather to fully three-dimensional effects: as the barotropic component increases, the flow tends to bypass the Camarinal Sill laterally rather than overflow it, compared to conditions with weaker tidal forcing.

A similar clarification applies to the detachment of the Mediterranean vein from the boundary. As discussed in Section 4.2.3, this feature is not associated with plume instability or an intrusion mechanism, but instead results from a boundary-flow detachment controlled by the local dynamics and geometry. One of the key messages of our article is that high-realism physical modeling can reach a level of insight comparable to regional numerical simulations, and that a comprehensive understanding of such complex processes requires the combination of all three approaches: observations, numerical modeling, and large-scale laboratory experiments. Laboratory experiments, in particular, allow systematic variation of key non-dimensional parameters and isolation of physical mechanisms, thereby enabling results to be generalized.

We have emphasized this contribution by rewriting the corresponding paragraph in the Introduction and by expanding the Conclusions section to provide an overview of the processes and regions investigated. We also encourage members of the community to contact us and make use of the dataset we collected, both for calibrating numerical models and for aiding the interpretation of observational data. We likewise benefit greatly from close collaboration with our French and Spanish colleagues working on in situ observations in the Strait, which is essential for interpreting and cross-validating the experimental results. We believe that such an integrated approach should become standard practice within the geophysical research community.

*Our observations had an overall goal of estimating the inflow, outflow and net exchange through the Strait of Gibraltar. Within the analysis of this paper, there is a focus on the exciting phenomena in the Strait but not on the overall exchange. How much inflow and outflow are found in this laboratory experiment? How do the inflow and outflow vary with the imposed density difference? With the amplitude of the tides? A result I found fascinating in our observations was the stronger 2-layer exchange* *flow during Neap tides than in Spring tides, a result also found in the laboratory model here. But the variations in exchange were compensated by tidal fluxes so the net inflow and outflow (the overall exchange of water masses) did not vary over the fortnightly cycle. It appeared that the net exchange was set by the density difference and could be accomplished either by the mean currents or by the tides.*

*In future work with the laboratory model, it would be helpful to examine the bulk effect of the processes. How does the exchange depend on the size of the imposed density difference? Does the overall exchange depend on the strength of the tides? These are questions that could be addressed by new experiments using the same physical laboratory model.*

Transports and fluxes are indeed computed in Sections 4.2.5 and, to some extent, in Section 4.3. Complementary measurements were conducted in both the Gulf of Cadiz and the Strait using an enhanced density contrast between the Atlantic and Mediterranean basins. These experiments enable the investigation of potential climate-driven variations in the density of the Mediterranean Outflow and their subsequent impact on its downstream evolution in the Gulf of Cadiz. Part of the topographic model has been preserved (specifically, the section of the Strait extending to the Espartel Sill), allowing future experiments to be conducted, as suggested by the referee. We now detail in the Conclusions section the different regions and processes that have been measured, along with the datasets that are available.

However, establishing fully closed global budgets would require a much finer resolution in the cross-strait direction. Experimentally, achieving such resolution is particularly challenging because of the complex topography, which makes three-dimensional optical measurements (e.g. 3D PIV) difficult to implement. In particular, the presence of steep slopes and intricate bathymetric features leads to optical shadowing and hidden regions that cannot be adequately sampled. To quantify these features more robustly, we rely on complementary high-resolution numerical simulations (LES) performed by our collaborators at SHOM and LOPS using the non-hydrostatic CROCO model, which faithfully reproduces the laboratory experiments conducted on the Coriolis platform. The numerical simulations initially faced significant (classical) challenges related to turbulence closure, bottom friction parameterization, and the representation of complex bathymetry. These issues have recently been addressed through careful calibration and systematic comparison with our HERCULES physical experiments. High-resolution simulations are currently underway, and we expect that these results will allow a more detailed and quantitative characterization of the transports, fluxes and influence of density difference and tide across the strait as suggested by the referee.

*The paper was very well written. My only complaint was that some missing letters had to be filled in mentally in the printed version I read: there was no "A" in the title or in "Abstract" and Vaisala came out as 3 separate phrases. Undoubtedly this is an issue with my traditional software not being compatible with that used by the journal. It was not an issue for my reading of the paper, but it may be important for the final online, published version.*

We have corrected minor typographical errors and inconsistencies throughout the manuscript. We believe that any remaining imprecisions may be related to the software used by the referee, as suggested, since we do not encounter these issues when viewing the PDF document.