Response to Reviewer 3 for "Eight years of continuous Rockall Trough transport observations using moorings and gliders"

We thank the reviewers for their constructive comments which help us improve the quality of our manuscript. Below, we provide detailed responses to each comment.

During the revision, we are implementing the following improvements to the transport calculations, which we are making independently to strengthen the analysis:

- **Extending the mooring dataset to 10 years**, now overlapping with the entire glider observation period. We are changing the title of the manuscript to reflect this update: "A decade of continuous Rockall Trough transport observations using moorings and gliders"
- **Correcting the EOF analysis** by using the original time steps of glider transects instead of 15-day averages, which previously included an irregular number of transects.
- **Correcting an error in the new methodology:** The EOF analysis and regression are applied to velocity anomalies. In the earlier version, we mistakenly subtracted the glider mean at EB1 and RTADCP positions from EB1 data and GLORYS12V1 output instead of subtracting the mean of each respective dataset. This introduced a systematic offset, which has now been corrected. The glider mean field is added at the final step to define the mean of the reconstructed section, eliminating the need for bias correction of the GLORYS12V1 output.

The paper presents an 8-year time series of volume, heat, and freshwater transports through the Rockall Trough in the eastern subpolar North Atlantic. The estimates utilize glider and mooring measurements, together with data from an ocean reanalysis product. These transports are critical in inducing hydrographic changes downstream within the subpolar gyre as well as further north in the Nordic Seas, which makes accurate estimates highly desirable. In particular, this analysis emphasizes a new method that it introduces for the wedge transport estimates, along with the new freshwater/heat transport estimates. However, I have two main concerns about both: it is hard to see a clear improvement from the new method compared to the old method, so it would require thorough validation; the seemingly arbitrary definitions of freshwater/heat transport would limit the usefulness of the estimates, e.g., when comparing them to other existing estimates in the region. I recommend a moderate/major revision with more detailed comments outlined as follows.

Main comments:

1. The authors proposed a new method for reconstructing the velocities in the eastern wedge for the upper 1000 meters, which had been previously reconstructed primarily using velocity data from an ocean reanalysis product. However, the robustness of these new glider-based estimates requires careful and more thorough validation. The first main issue is related to the velocity derived from the glider paths. The authors acknowledge this issue (lines 84-85) but unfortunately did not address the associated uncertainty and its subsequent impact. A related issue concerns the comparisons with various other estimates, which are briefly discussed in section 3.1. As this new method is poised to be a key improvement over previous estimates, a thorough discussion and stronger evidence of its superiority are needed.

Thank you for raising this important point regarding the robustness of the transport estimates. We agree that additional clarification is needed and are expanding the manuscript to address uncertainty and validation in detail.

For the old methodology, Houpert et al. (2020) previously assessed errors associated with horizontal extrapolation and reliance on ocean reanalysis at the eastern wedge by comparing against LADCP data from cruises along the section. For the eastern wedge transports, they reported a mean bias of –0.21 Sv and an RMS error of 0.59 Sv (see their SI text S1.3, Table S1, Figures S6 and S8). The glider product used here is an extension of the Fraser et al. (2022) dataset, which has undergone peer-reviewed scrutiny. In the revised analysis, the glider and mooring observation periods now overlap, allowing direct comparison. As shown in the manuscript (Figure 5) and in the extended time series (refer to Figure 1 in our responses: Reviewer 1 on page 3 and Reviewer 2 on page 9), the glider-derived transports agree well with those obtained using the previous methodology. This consistency across independent data products supports the robustness of both approaches.

As noted in our responses to Reviewer 1 and 2, we see the following main advantages of the revised new methodology:

- Improved accuracy of the mean strength and structure of the ESC, based on multiyear glider observations rather than a bias correction of GLORYS12v1 data using only eight months of ADCP measurements.
- Enhanced ability to reproduce extreme events, likely associated with mesoscale variability, through inclusion of the first two EOF modes.

- High-resolution ESC product in both space and time, reducing aliasing effects caused by temporally scattered glider data.

We are editing the text throughout the manuscript to clarify these points and ensure that the discussion section clearly communicates the value of this methodology.

2.The overall results and the analysis are comparatively limited. Much of the focus is on the volume transport and is similar to the previous publication based on shorter records. The authors indicated that the heat and freshwater transport estimates are presented for the first time here; if so, I believe they deserve a more in-depth analysis. Some questions could be readily addressed by the data, e.g., what is the relative contribution of velocity versus T/S variations to the transport variability? Which subregion dominates the T/S transport variability? Caution is needed regarding the definition of the heat and freshwater transports, as this may introduce uncertainties and make it difficult to interpret the results when comparing them to other estimates in the region. I would suggest the authors clarify what they are presenting and include sufficient information on how to contextualize the presented estimates with those in previous publications.

Thank you for highlighting the need for a more comprehensive treatment of heat and freshwater transport. We agree that the initial presentation lacked sufficient detail and are revising the manuscript accordingly.

First, we are expanding the data and methods section to clarify our approach. Specifically, we are now including an assessment of using mooring-based hydrographic profiles by comparing transports derived from full ship and glider sections with those calculated using profiles subsampled at mooring positions. This comparison is being detailed in the revised manuscript and summarized in the response to Reviewer 2 (page 4).

In addition, we are extending the analysis of heat and freshwater transports to address the reviewer's suggestions:

- Quantify the relative contributions of velocity versus temperature/salinity variations to heat and freshwater transport variability.
- Identify which subregions dominate variability.
- Discuss the sensitivity of the estimates to the chosen reference values for temperature and salinity, and how these choices influence interpretation.
- Provide context by comparing our estimates with those from previous studies in the region, highlighting similarities and differences.

These additions aim to improve clarity, reduce uncertainty, and ensure that the presented results can be meaningfully interpreted and compared within the broader framework of subpolar North Atlantic transport studies.

Other comments:

Line 10: This is a commendable goal, but the framework's validity requires more thorough demonstration.

Thank you for pointing this out. Please see answer to first main comment.

Line 77: Add more details on the common section?

Thank you for highlighting. We are revising the section for clarity.

Figure 1: Please label all moorings in the main and inset plots. For the caption: is 'RTWB1' the same as 'WB1'? Same question for 'RTWB2' and 'WB2'.

Thank you for highlighting. We are revising Figure 1 and caption for clarity and consistency.

Figure 2 and the related text: The notation 'WB 1/2' is confusing. Please clarify if it referes to a single mooring location or a composite of WB1 and WB2.

Thank you for pointing this out. We are revising Figure 2 and the related text to improve clarity. In the updated manuscript, WB1/2 is explicitly defined as a composite of WB1 and WB2. Additional details are provided in our response to Reviewer 2 (page 6, comment on lines 93–95)

Section 2.3: Please elaborate on why the supplementary datasets are necessary and how they are specifically used in the analysis.

Thank you for pointing out the lag of clarity for what the auxiliary dataset are use. We are editing the section accordingly.

Line 117: Please provide clear definition for 'western wedge', 'mid basin' and 'eastern wedge'. Their spatial extents are not clear.

Thank you for highlighting. We are editing Figure 1b, to show the extent of the different sections. The western wedge extends between 12.5°W to 13°W, the mid basin extends between 12.5°W and 9.6°W and the eastern wedge extends between 9.6°W and 9.2°W over the upper 1760m.

Line 140: Please label 'RTADCP' in the relevant figures.

This is being done.

Line 151: What is 'glider data at EB1'? If velocity data from gliders are used at EB1, I would suggest additional tests to validate the reconstruction. For instance, compare a reconstruction using: (a) mooring velocity at EB1 + first EOF, (b) velocity from GLORYS at the ADCP location + first EOF. These two tests would better quantify importance of the EB1 and ADCP velocities for the eastern wedge transport.

Thank you for highlighting this point and for suggesting additional validation tests. To clarify, we subsampled the glider data at the positions of EB1 and RTADCP to verify the reconstruction approach. Following your recommendation, we have revised the methodology to strengthen the comparison. Specifically, we are now averaging the mooring data and GLORYS output within ±1 day of each glider time step, ensuring consistency in temporal alignment. Details of this revision are provided in Figure 1 of our response to Reviewer 2 (page 9).

Line 160 (Figure 4): To directly assess the impact from the new method, please include a comparison of the transport time series from the new and old methods.

Thank you for this suggestion. We confirm that the comparison between the old and new methodologies is already included in the manuscript. Specifically, both transport time series are shown in Figure 5a in the manuscript, and additional comparisons are provided in Figures 4 and 6 as well as in Section 4.2 in the manuscript.

Line 174: The description of the velocity reconstruction is confusing. Please elaborate with more details. Specifically, clarify what 'WB1/2' refers to and where the 'WB1/2 position' is, both in the text and on the figures.

Thank you for highlighting this point. WB1/2 refers to the midpoint between WB1 and WB2. We are revising the text for clarity and are adding labels in Figure 1b to clearly indicate its position.

Line 185: How was the reference temperature determined? Elaborate on how to the choice of the reference influences the interpretation of the resulting temperature transport.

The reference temperature and salinity are defined as the mean values observed at WB1 and WB2, which are located in the southward-flowing current west of the NAC (Figure 1b in manuscript). This choice sets the mean heat and freshwater transport through the western wedge to zero, so that the transports calculated for the mid basin and eastern wedge primarily reflect the signals of the NAC and ESC, respectively. We are adding this information to the data and method section and are discussing the choice in the discussion section.

Line 189: Similar for the choice of salinity reference (Sref). A discussion on the sensitivity of the freshwater transport results to different Sref values is needed to understand the robustness of the estimates.

See answer to comment above.

Line 219: The reconstruction relied on a reanalysis product in addition to the mooring data. Please clarify.

Thank you for this comment. To clarify, our comparison of total volume transport through the Rockall Trough includes previous reconstructions for shorter time periods (Houpert et al., 2020; Fraser et al., 2022). All three estimates rely on the same mooring data and GLORYS reanalysis output. We did not introduce an additional total transport product, so we believe the current description is sufficient.

Figure 5: The labels are confusing. Please specify what each line represents in the caption. Also, provide more details on how the estimates were obtained. For example, what is the difference between 'old' and 'old resampled'?

Thank you for highlighting this point. We are revising Figure 5 and caption to improve clarity (see Figure 1 in our response to Reviewer 1, page 3).

Lines 203-204: Be cautious with phrases like 'differ notably'. Specify what the numbers after plus/minus represent (e.g., standard errors). And discuss the statistical significance of the mean differences.

Thank you for highlighting. For the revised and extended transport calculations (April 2020 – Feb 2023), the mean transport for the glider and the new eastern wedge reconstruction is 1.0±0.3 Sv, while the old methodology gives 1.5±0.2 Sv. The uncertainties overlap, so although the agreement is marginal, the estimates agree within their respective uncertainties. We are editing the text accordingly.

Line 206: The analysis should consider the error bars (uncertainty) for both estimates when comparing them.

See answer to comment above.

Line 212: How does the gliders' irregular sampling affect the mean transport estimate? The glider-based transport is used as a benchmark in section 4.1, but its own robustness should be evaluated more thoroughly earlier in the paper.

Thank you for raising this important point. With a total of 166 glider transects over a three-year period and strong agreement with independent estimates from the previous methodology, we consider the mean transport estimate derived from glider data to be robust. We recognize, however, that this is a critical aspect of our analysis and are adding a paragraph in the discussion section to explicitly address the implications of irregular glider sampling on transport estimates, including a comparison with mean EW values from previous studies (1.3 ± 0.2 Sv in Fraser et al., 2022 and 1.4 ± 0.3 Sv in Houpert et al., 2020).

Figure 6: The black line is also dashed – does it represent the old method? Please clarify in the caption.

Thank you for pointing this out. We are updating Figure 6 to use consistent solid lines for all transports derived using the new methodology.

Line 223: The heat and freshwater transport values are highly sensitive to the arbitrary choice of the respective reference, especially given the non-zero volume transport across the section. This major caveat should be emphasized.

Thank you for pointing this out. We are emphasising this in our discussion.

Figure 7bdf: what do the vertical color bars represent? The mean value appears to be incorrectly placed in panel f – please verify.

Thank you for highlighting this point. In panels (b) and (d), red shading marks periods when the filtered time series exceeds the mean plus one standard deviation, and blue shading marks periods when it falls below the mean minus one standard deviation. In panel (f), the shading is reversed. We are editing the caption for clarity and confirmed that the mean value text is positioned to avoid overlapping with the time series and improve readability.

Line 240: The analysis would be significantly enhanced by investigating the potential causes of the observed differences. For example, what is the relative contribution by T/S vs velocity changes? How is it related to volume transport and T/S properties in the specific wedges and mid basin?

Thank you for these suggestions. We agree and are incorporating additional analysis as outlined in our response to the second main comment above.

Line 248: How do property changes in the region subsequently affect the corresponding transports across the Trough? This would provide a strong linkage to the broader analysis.

Thank you for pointing this out. Figure 8 illustrates how temperature and salinity influence transport estimates in the mid basin, which dominates the total transport variability. We acknowledge that the manuscript currently includes only a brief discussion of this relationship and are enhancing the results section with additional detail to strengthen the linkage to the broader analysis.

Line 253: It would be valuable to contextualize these transport estimates within the broader understanding of subpolar volume, heat, and freshwater transports.

Thank you for this suggestion. We agree and are revising the paper structure to include a new discussion section that places our transport estimates within the broader context of subpolar volume, heat, and freshwater transports. In this section, we are comparing our results with those from Dotto et al. (2025), which focus on NAC branches west of the Rockall–Hatton Bank, and with OSNAP observations (e.g., Fu et al., 2025) to highlight similarities and differences. We are also discussing our findings in relation to broader subpolar variability, including the subpolar gyre and dominant atmospheric modes of variability.

Line 256: While the new method is a key novelty, its necessity and efficacy have not been thoroughly validated. A more rigorous comparison with the old method and a clear demonstration of its improvement are necessary.

Please see answer to first main comment.

Line 267: It would be great to include an analysis for assessing the effect of salinity changes.

Thank you for this suggestion. We agree and are extending the result section to include an analysis of salinity changes, as shown in Figure 8 and S2.

Line 270: Again, my suggestion is to separate and quantify the impact of volume transport variability in different parts of the section on the overall property transport variability.

Thank you for these repeated suggestions. We agree and are addressing them as outlined in our response to the second main comment above.

Line 272: Consider adding a discussion on how the presented results are related to the other transport estimates within the subpolar region.

See response to comment of line 253.