

## Response to Reviewer 1 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.

Reviewer 1:

Burmeister et al. present a new method of resolving spatiotemporal differences in sampling between moorings and gliders at the Rockall Trough sector of the Ellett Array. This region is one of repeat monitoring and an important region for North Atlantic circulation. With greater integration of autonomous platforms (gliders, AUVs) to traditional repeat monitoring methods (fixed moorings), the authors are tackling a very relevant problem to the community. While the science is worthwhile, we have concerns about the paper itself and suggest major revisions are needed before this manuscript can become a suitable paper.

Major comments:

The overall structure of the paper is inconsistent and confusing, taking focus from the science and making it very difficult to read. The paper lacks well defined methods, results, and discussion sections. Throughout the paper, the authors seem to jump between methods, results, and discussions no matter the actual location in the paper. I would highly recommend the authors follow a more traditional paper structure.

Thank you for highlighting that the structure of the paper can be improved for clarity. We are revising the entire paper accordingly.

The paper relies extremely heavily on a previous paper from the second author (Fraser et al., 2022). The paper doesn't seem to sufficiently introduce this paper in a clear manner. Currently, to understand the full context of Fraser et al., and how their method differs from this previously published method, the reader needs to go and seek out Fraser et al. Additionally, we noticed some portions of the text between the two papers was very, very similar with only a word or two of difference between the two. We suggest that the authors take care not to copy themselves.

Thank you for pointing this out. We are revising the section for clarity. While the methodology is published in detail in Fraser et al. (2022), we recognise that it is relevant to the theme of this special issue. To support accessibility and transparency, we are adding more detailed methodological information in the supplementary information. Please note that this study extends the dataset and approach presented in Houpert et al. (2020) and Fraser et al. (2022). As such, some overlap in the methods section is unavoidable due to the use of consistent techniques. Nonetheless, we are taking care to ensure that the presentation is clear and appropriately contextualised.

Please keep consistency in grammar, capitalization, etc. throughout the paper. For example, figure captions are sometimes “longitude”, “lon”, “Longitude [degE]”, or “Longitude [°E]”.

Thank you for highlighting. We are editing all text and figures accordingly.

The authors only briefly mention an important difference between the model and observation output; the model does not capture the extreme events that the glider does. In a region like the North Atlantic that is known to be physically dynamic (Holliday et al., 2006; Johnson et al., 2024), this difference is noteworthy and the implications of such should be discussed more. Can you explore the implications of this more? One method could be to calculate monthly and annual budgets with and without the extreme events to better understand the net impact they have?

Thank you for highlighting this important point. We agree that the difference between model output and glider observations, particularly regarding extreme events, is noteworthy in such a physically dynamic region. During the revision, we identified an error in the application of

our methodology: prior to regression, the mean of the glider at EB1 and RTADCP location had been incorrectly subtracted from both the EB1 data and GLORYS12V1 output. After correcting this, the revised approach now reproduces extreme events more realistically (Figure 1) by incorporating the second EOF mode, which we interpret as representing mesoscale eddies. This improvement significantly enhances the fidelity of the reconstructed fields. We are updating the results and discussion sections to emphasise the implications for extreme events and their potential impact on transport estimates.

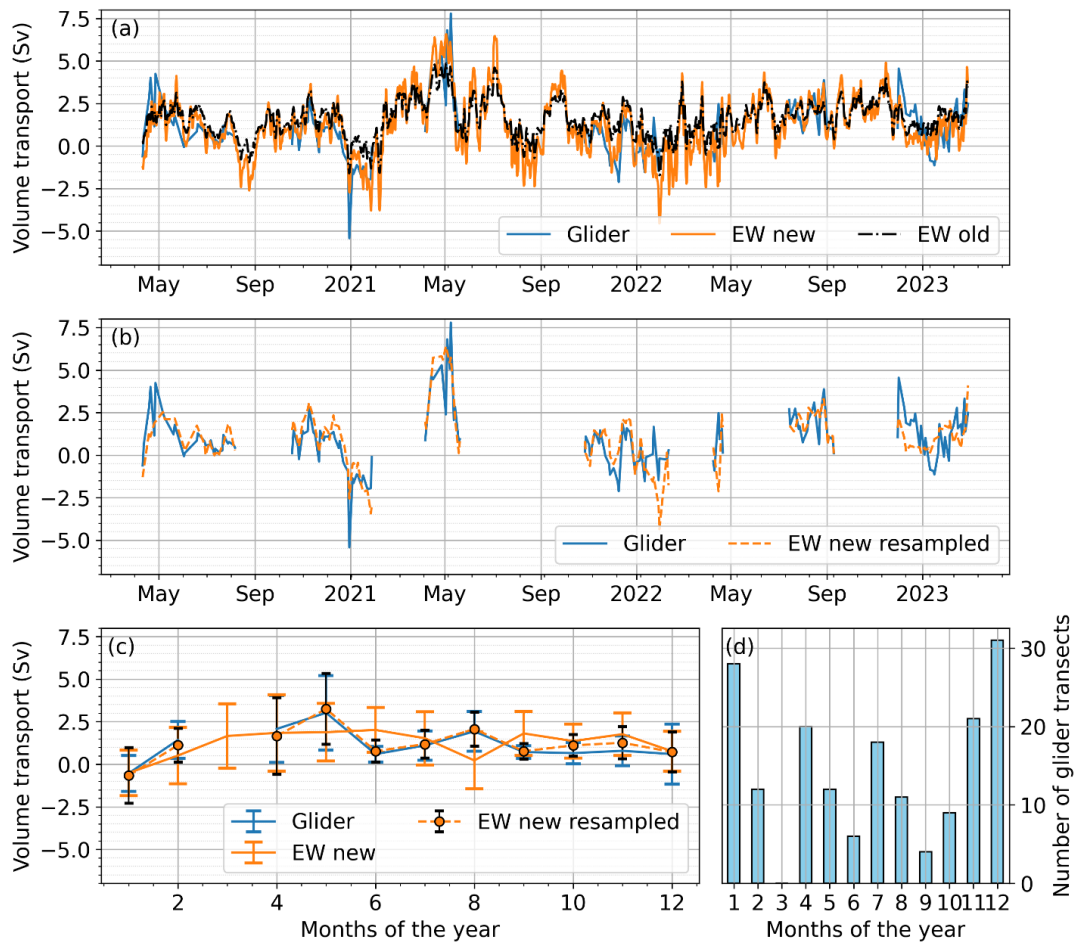


Figure 1: a) Time series of volume transport for the upper 1000 m derived from meridional velocity section based on glider transects (blue line), the new eastern wedge reconstruction (EW new, orange line), the old eastern wedge reconstruction (EW old, black dotted line). (b) Transport time series of the new approach averaged  $\pm 1$  day on the time step of the glider observations (EW new resampled, orange dashed line). Glider transport are shown in blue again for reference. (c) Monthly mean seasonal cycle for glider (blue line), the new eastern wedge reconstruction (EW new, orange line) and the resampled new eastern wedge reconstruction (EW new resampled, orange dashed line). The error bars mark  $\pm 1$  standard deviation. (d) Number of glider transects per month of the year.

The Discussion reads like a conclusion, and much of what should be included in the Discussion is throughout. Currently, the paper ends abruptly and the “why should you employ this method” is missing.

Thank you for highlighting that the manuscript does not clearly convey the benefits of the new methodology. We are revising the discussion to emphasise why this approach should be employed. The main advantages are:

- 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.

Line by line comments:

Line 13: What is European temperature? Temperature of Europe?

We are editing the entire introduction section and this phrase is no longer part of it.

Line 15: Does order one mean “first order”? Can the authors clarify what they mean by this sentence?

Thanks for highlighting. We are editing the text for clarity.

Line 31: Presumably some of the observational difficulty in this region stems from ship traffic. Has there been any effort to integrate commercial shipping data?

No, there has been no effort to integrate commercial shipping data into our observations for this region.

Line 31-32: I would suggest putting part about RTADCP into methods and add abbreviation definition

Thank you for pointing this out. We are editing the manuscript accordingly.

Line 40: Perhaps change “amassed” to “completed”?

We are editing the entire introduction section and this phrase is no longer part of it.

Line 41: The reader needs more information on Fraser et al method without having to chase it down themselves.

Thank you for highlighting. As mentioned above we are adding further information about the methodology in the supplementary information.

Line 56: Please stay consistent with “Seaglider” or “glider”.

Thank you for pointing this out. We are editing the manuscript accordingly.

Line 69-70: Can you expand on this with how? I can see it is discussed below, but the how should come in the first sentence.

Thank you for your comment. Unfortunately, it is not entirely clear to us what the reviewer is referring to. The sentence in question introduces the methodology by Fraser et al. (2022), and the detailed explanation of how this method works is provided in the subsequent section.

Line 70: The sentences “glider transects are invariably affected by the ocean velocity field and hence follow irregular and inconsistent trajectories. The different transects do not correspond spatially and do not in general have the same cross-sectional area” are a bit too close to Fraser et al. 2022: “However, glider transects are invariably affected by the ocean velocity field and hence follow irregular and inconsistent trajectories. As a result, different transects do not correspond spatially and, due to the variability in slope shape and steepness at different locations, do not in general have the same cross-sectional area.”

As mentioned above, this study builds on the dataset and methodology presented in Houpert et al. (2020) and Fraser et al. (2022). Given the continuity in approach, some textual overlap in the methods section is unavoidable. However, we are reviewing the manuscript carefully to ensure that all reused descriptions are necessary, appropriately cited, and clearly contextualised within the scope of this study.

Line 76: Can you expand on what you mean by the correct isobath? Is this equivalent to essentially depth binning

Thank you for pointing out that this section lacked clarity. We are revising the text to better explain that data from individual glider transects are allocated to coordinates along the standard transect that share the same isobath.

Figure 1b : Please make the font larger.

Figure 1b: The black cross hatching is very difficult to see.

Figure 1b: What do the green triangles, blue boxes, and red circles represent? Please be explicit.

Figure 1a: Please remove the abbreviations if they are not mentioned.

Figure 1a: This panel is missing the 'A'.

Thank you for your five suggestions regarding Figure 1. We are revising Figure 1 and its caption for completeness, clarity, and consistency.

Line 104: What does “generally very high” mean? Please be explicit.

Thank you for highlighting the need for greater clarity. At EB1, 78% of CTD data and 89% of current meter data were successfully recovered. At WB1 and WB2, 85% of CTD data were recovered, along with over 99% of current meter data at WB1 and 97% at WB2. We are adding these details to the manuscript.

Line 107-108: This statement is redundant with the introduction and can likely be removed.

We used the RTADCP to correct the GLORYS12V1 output. We are editing the paragraph for clarity.

Line 105: Typo- “Gap filling”.

Thank you for pointing this out. We are correcting the typo.

Figure 2: If you are going to include cruise IDs, those cruises need to be listed somewhere. Perhaps a table in the supplemental?

Figure 2: Please increase the font size.

Thank you for your two suggestions regarding Figure 2. We are revising Figure 2 and its caption for completeness, clarity, and consistency.

Line 109: Do you mean “auxiliary data”?

Thank you for pointing this out. We are correcting the section title accordingly.

Figure 2: Does the y-axis represent a fixed pressure? Why does this differ from the black lines when they are supposed to be the same variable?

The black lines represent the actual instrument depth over time, while the shading shows interpolated fields on a regular depth grid. Both appear in the same plot. Please note that we are converting pressure to depth for consistency across all figures in the manuscript.

Figure 3: Please define EOF in the caption.

Thank you for your suggestions. We are revising Figure 3 and caption for completeness, clarity and consistency.

Line 119-121: I appreciate the comparison of this “new” method to the previous method.

Thank you.

Line 125-126: I would suggest you contrast your method with the previously utilized method of Brandt.

Thank you for the suggestion. Brandt et al. (2014, 2016, 2021) use a combination of moored and ship-based observations to estimate the transport of the Atlantic Equatorial Undercurrent. Instead of standard EOF patterns, they apply HEOF (Hilbert Empirical Orthogonal Function) patterns to better capture the vertical displacement of the current core. In our study, we evaluate both EOF and HEOF approaches with similar results and choose to use EOF patterns for simplicity. We are adding further explanation in the text to clarify this choice.

Figure 4: This is a very nice figure.

Thank you.

Figure 4: Is ‘ADCP’ ‘RTADCP’? Please be consistent .

Thank you for your suggestions. We are revising Figure 3 and caption for completeness, clarity and consistency.

Lines 138-139: Please expand on this EOF analysis more.

Thank you for indicating that more information is needed for clarity. We are moving this part into the data and method section and are adding additional information about HEOF accordingly.

Line 144: Should GLORYS2v12 be GLORYS2v1?

Thank you for pointing this out. For simplicity we are referring to the ocean reanalysis now as GLORYS throughout the manuscript and introduce the version in the data and method sections accordingly..

Equations 1 and 2: Shouldn’t this whole section be in a better-defined methods section?

Thank you for highlighting this point. Section 3 on transport calculations is now being incorporated into the data and methods section for clarity and consistency.

Lines 149-154: Can you add significance tests to these correlations to further validate the approach?

Thank you for this suggestion. All regression results are statistically significant, and we are adding the corresponding details to the manuscript for clarity.

Line 158-159: Can Section 3 be restructured so that “the volume, heat and freshwater transports are then calculated from the reconstructed eastern wedge velocity and hydrography sections using Equations 3-5” immediately precedes these calculations?

Thank you for your suggestions. We are revising the section accordingly.

Line 157-158: It does not look like that reconstructed data is present in Fig 4b? Did you mean above 1000 m?

The reconstructed data below 1000 m is included; however, it may appear absent because the temporal mean velocities at EB1 below this depth are close to zero.

Line 157-158: What are the upper and lower bounds of depth bins?

Thank you for highlighting a lack of clarity here. As mentioned in Section 2.2, all mooring data are vertically gridded onto a regular 20-dbar grid. We are adding this information to the section describing the new eastern wedge reconstruction for clarity.

Section 3.2: Much of this section could better fit in a proper Discussion section.

Section 3.2 describes the previously published methodology used to reconstruct the eastern wedge velocity section as presented in Houpert et al. (2020) and Fraser et al. (2022). We have retained this description because the approach is used for comparison purposes and remains relevant, particularly since the new methodology incorporates certain elements of the original method.

Lines 193-195: I find these sentences unnecessary, but that is personal preference.

Thank you for your feedback. As part of the revised structure, we are splitting the results section into two parts for clarity. We are keeping these sentences because they help introduce the organisation of the section, and we are editing them for improved clarity.

Figure 5b: Please fix formatting of the legend so it does not cover part of the figure.

Figure 5: Please differentiate between a and b in the legend.

Figure 5: Somewhere, please mention/explain the glider data gaps.

Figure 5: Can you put a and b y-axes on the same scale?

Figure 5: Maybe chose different colours to make it more obvious when glider data is missing?



Thank you for your 5 suggestions regarding Figure 5. We are revising Figure 5, caption and text for completeness, clarity and consistency.

Figure 6: This is a nice figure.

Thank you.

Line 185: Can you provide the reference density and specific heat capacity?

Thank you for pointing this out. We are editing the manuscript accordingly.

Line 208: Can you please expand on the bias correction?

Of course. A bottom-mounted Acoustic Doppler Current Profiler (RTADCP) was deployed in the ESC core in 2014, but only eight months of data were recovered; later deployments failed due to damage, likely from fishing (Houpert et al., 2020). To compensate, Houpert et al. (2020) used GLORYS12V1 meridional velocity fields, which captured variability but underestimated flow strength by about +7.6 cm/s. They corrected this bias by applying a uniform offset of +7.6 cm/s at the RTADCP location (57.1°N, 9.3°W, upper 750 m). We are adding these details to the data and methods section for clarity.

Lines 242-249: Comparisons between Fraser et al and this study should be better integrated.

Thank you for highlighting this point. We are adding a paragraph in the discussion section that compares the previous methodology with the new approach.

Lines 251-255: The discussion does not need to begin with a recap of the study. This is redundant and would be better fitted as a single sentence in the start of the conclusion.

Thank you for highlighting. As part of the revision, we are restructuring the entire manuscript and are introducing separate sections for discussion and conclusion to improve clarity and readability.

Figure 7: Please specify what red and blue shading are in the caption.

Thank you for pointing this out. We are editing the manuscript accordingly.

Line 263-264: Throughout, the authors will make statements like: “. . .declining northward transport in the mid basin was counteracted by decreasing southward flow at the western boundary” but it would be good to have a figure showing these type of spatial trends.

Thank you for this suggestion. We are adding a table in the supplementary information listing the trends fitted to the different transport estimates.

Lines 269-270: If the ESC is “disproportionally important for poleward heat and freshwater fluxes”, it should be discussed more, and its importance should be brought up earlier in the paper. Is this from the literature or a finding?

Thank you for highlighting this point. The statement refers to findings from previous studies (Clark et al., 2022; Daly et al., 2024), which emphasise the importance of the ESC for on-shelf heat and freshwater transports. The term “disproportionally” reflects its relatively small transport compared to the NAC in the Rockall Trough; however, NAC transport in this region does not significantly affect European shelf exchanges, whereas the ESC does. We are editing the sentence for clarity.