For Anonymous referee #1

We thank this Reviewer for thoughtful and constructive comments on our manuscript. We appreciate the time s/he invested in the review. We believe that our revised manuscript addresses all the comments. In this regard, we have revised and rewritten a few sections such as Abstract, method, results, discussion and conclusion in the revised manuscript. We thought it useful to point out its detailed revisions (lines and sections) in the reply to your comments. Below (highlighted in blue and magenta) is an itemized response to the different issues raised in the review.

Turbulent dissipation from AMAZOMIX off the Amazon shelf along internal tides paths

Fabius Kouogang et al.

The measurements include single microstructure profiles at a variety of stations inside and outside of a modelled tidal beam on the slope near the mouth of the Amazon River.

There are also 25 CTD stations and ship-based ADCP. The authors have tried to examine the difference in turbulence levels in- and outside of this tidal beam. They have mainly examined their ship-based sections with a few stations per section. In my view, the sparse data makes their task very difficult. Many statements in the manuscript are unsupported by the figures: *e.g., mixing is higher in the tidal beams, mixing is higher where tidal energy is higher, mixing is higher with low Ri, mixing is higher where internal tide rays cross, and so on.* While it is possible these are true statements, the chosen approach has not delivered a clear result.

Perhaps a way forward is to do some more averaging and establish 5 averaging areas. These are in the tidal beam: (1) slope, (2) offshore, and (3) internal solitary wave station. And outside the tidal beam: (4) slope and (5) offshore. So rather than make sections, the authors should make scatter plots like Fig 7 but using data from these groups and outside the surface and bottom boundary layers (SBL and BBL) and see if they can find something that is actually related to the dissipation. For example, find all the stations in the beam and calculate mean epsilon. Is this higher than stations out of the beam based on the model? Maybe compare (1) and (4) and also compare (2) and (5). Compare (1, 2, 3) vs (4-5). And so on. Scatter plots could be based on observed tidal amplitudes, current speed, lateral gradients of density or velocity.

R: Thank you for your feedback.
We have implemented your suggested approach, which yielded clear and useful results. While we selected particularly informative stations, we found the "IN" and "OUT" tidal beam classification unsuitable because the so-called "OUT" stations are actually located within a channel, and their limited number prevented meaningful analysis.
Instead, we focused the analysis on 3 distinct paths based on modeled M2 baroclinic tidal flux: 2 high tidal energy (HTE) and 1 low tidal energy (LTE) paths. We established five averaging regions along these paths:

HTE paths: (1) slope, (2) offshore, and (3) internal solitary wave station

LTE path: (4) slope and (5) offshore

We have subsequently regenerated the scatter plots using midwater data of these groups (below the maximum of [XLD, MLD] and above the bottom boundary layer). These analyses are presented and explained in Section 3.2.3 (lines 355-396) and Figure 10 and 11 of the revised manuscript, with the results shown below:

"

3.2.3 Competitive processes to generate mixing

Our aim in this subsection is to associate midwater mixing events with either baroclinic tidal currents or time-averaged (mean) currents. To achieve this, we map depth-integrated and maximum values of station-averaged ε and plot all ε values on a (time-mean shear , tidal shear) diagram across five regions (A_s, A_o, A_{isw}, E_s, and E_o; Figs. 10 and 11). These regions are selected to contrast slope and open-ocean dynamics, with data included from the HTE and LTE transects. All data are collected from below the wind-influenced surface layer (defined as the maximum of XLD or MLD; see subsection 2.2.1) and above the friction-dominated bottom boundary layer ($H_{BB}L$; defined in subsection 2.2.1).

Mixing hotspots (ε = [10^{-6}, 10^{-7}] W kg^{-1}; magenta and red circles in Fig. 11 and Fig. 10) are observed under strong vertical baroclinic shear ([10^{-4}, 10^{-5}] s^{-2}), driven by either tidal or time-mean currents.

On the slope (A^s and E^s), high ε values in A_s are associated with stronger than (magenta, red, and grey stars in Fig. 11a correspond to ≈ 10-4 > ≈ 10^{-5}), indicating that tidal shear explains ~60% of high ε values (Table A3, Appendix C). Similarly, in E_s, moderate ε values (yellow and grey stars in Fig. 11d) are primarily driven by tidal shear, which accounts for ~60% of the observed mixing (Table A3, Appendix C).

In the open ocean (A_o, E_o, and A_{isw}), moderate ε values in A_o and E_o are found when is nearly equal to (yellow, red, and grey stars in Fig. 11b and 11e correspond to ≈ ≈ 10^{-4} s^{-2}), suggesting tidal and time-mean shear each contribute ~50% to mixing (Table A3, Appendix C). An exception is observed in A_{isw}, where high ε values coincide with slightly stronger tidal shear (red and grey stars in Fig. 11c correspond to ≈ 2 x ≈ 2 x 10^{-4} s^{-2}), suggesting that tidal shear explains ~60 % of mixing hotspots (Table A3, Appendix C).

These results suggest that mixing on the slope is slightly dominated by ITs, while offshore mixing is equally balanced by mean circulation and ITs. However, exceptions exist in the open ocean, particularly at stations A_{isw} and , where tidal shear contributes ~60% and ~30% to mixing, respectively. The mixing at is attributed to NBC. A key question remains: why does A_{isw} exhibit strong IT-driven mixing ~230 km from IT generation sites, with mixing hotspots observed at various depths throughout the water column? To address this, we employ ray-tracing techniques to investigate potential IT propagation paths.

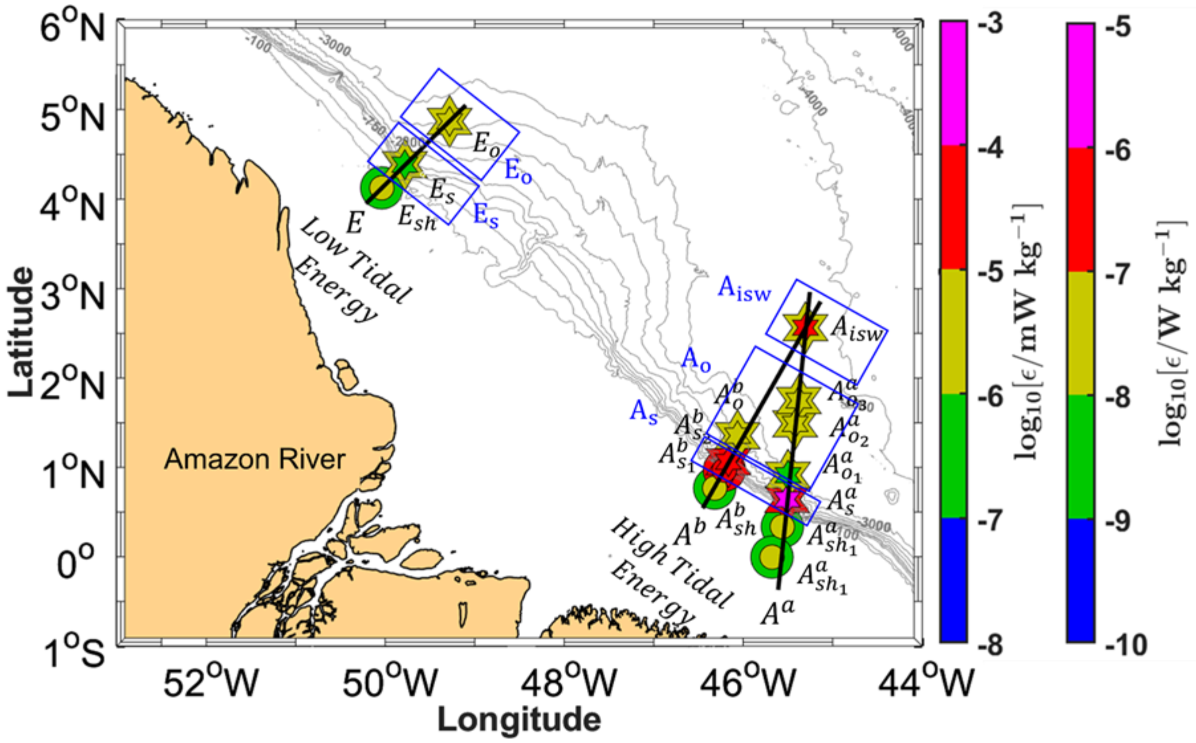

Figure 10: Depth-integrated (in mW kg[-1], logarithmic scale) and maximum values (in W kg[-1], logarithmic scale) of station-averaged dissipation rates (ε) from VMP measurements during the AMAZOMIX 2021 cruise. Solid black lines depict transects (, , and E) along high tidal energy (HTE) and low tidal energy (LTE) paths. Data are from below the wind-influenced surface layer and above the friction-dominated bottom boundary layer. Colored circles and stars represent short and long stations, respectively. Small and large colored circles indicate depth-integrated and maximum values of ε, respectively, with ranges shown by the color bar. Similarly, small and large colored stars indicate depth-integrated and maximum values of ε, respectively, with ranges shown by the color bar. Stations are grouped into five areas: A_s (and), A_o (, , , and), A_{isw} (A_{isw}), E_s (E_s), and E_o (E_o). The five blue boxes indicate these defined areas. Subscripts denote locations: "s" for slope (A_s), "o" for offshore (A_o and E_o), and "isw" for ISW regions (A_{isw}).

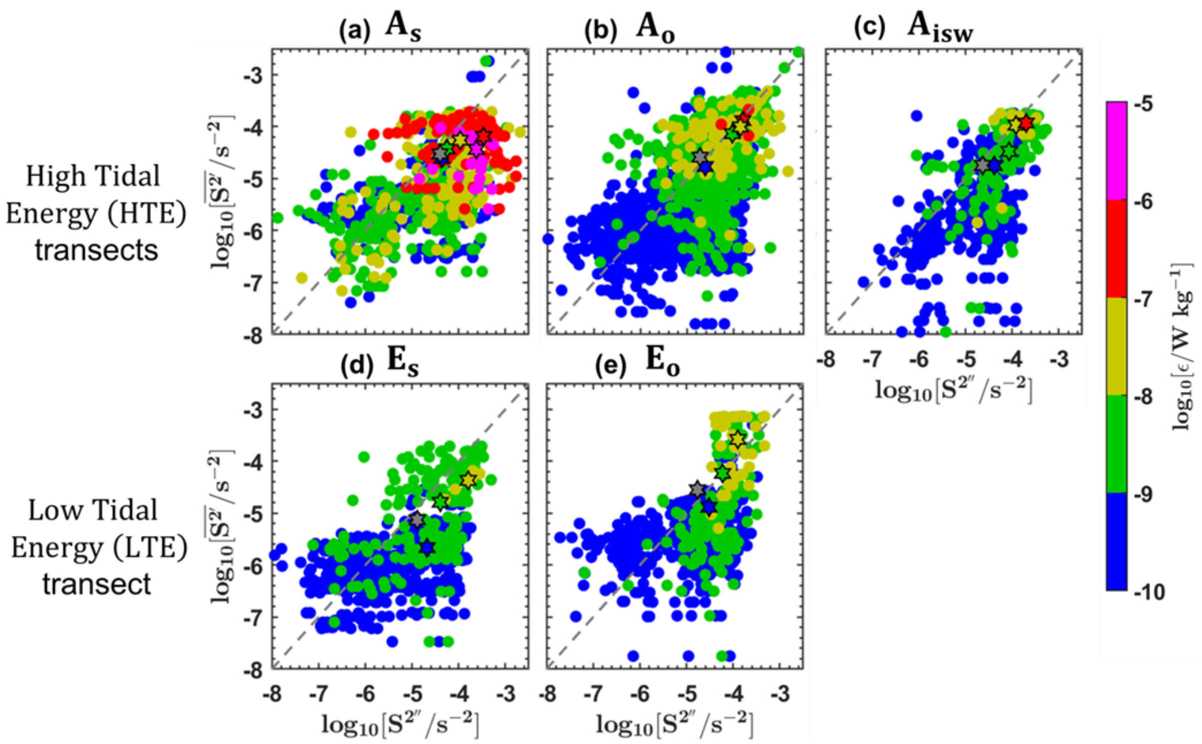

Figure 11: Dissipation rates (ε, in W kg^{-1}, logarithmic scale), measured below the wind-influenced surface layer (max [XLD, MLD]) and above the friction-dominated BBL (H_{BBL}), plotted as a function of the mean baroclinic vertical shear squared (, in s^{-2}, logarithmic scale) and semi-diurnal baroclinic vertical shear squared (, in s-2, logarithmic scale). Data are from defined areas: (a) A_s (and), (b) A_o (, , , and), (c) A_{isw} (A_{isw}), (d) E_s (E_s), and (e) E_o (E_o). ε are represented by colored circles, with their ranges indicated on the color bar. Each panel also includes vertical shear averages for specific ε ranges ([10^{-6}], [10^{-7}], [10^{-8}], [10^{-9}], and [10^{-10}] W kg^{-1}), depicted as colored stars with black edges, grey stars with black edges represents the vertical shear averaged across all ε values. Dashed grey lines are included for comparison.

"

This is a complicated region with a strong mean flow, fronts, eddies, strong river outflow, and strong tides. So it will be a difficult task to come up with a simple explanation based on 25 stations over a wide area.

In other words, summary Fig 9 is not well supported but could be true. So there could be 5 groups of stations with sufficient averaging, arranged in a logical manner as opposed to 25 stations somehwat randomly named on 5 transects again without fully logical naming with limited statistics. I have suggested one approach above but the authors could come up with something else.

R: Thanks for your comments.

This region exhibits complex dynamics involving multiple interacting processes. Rather than analyzing stations individually, we have opted to separate the contributions of mean currents and tidal currents at each station.

Additionally, to better support our analyses and results, we have revised the summary figure (see below Figure RC1.1).

The sites/transects and stations names were systematically re-named and re-organized by location. Each site received a unique identifier based on its position along the HTE and LTE paths. Stations were categorized by site and region: superscripts 'a' and 'b' denoted stations at sites A^a and A^b, respectively, while subscripts indicated location—'sh' for shelf, 's' for slope, 'o' for offshore/open ocean, and 'isw' for ISW regions. This structured naming system ensured clear identification and logical grouping of stations for consistent data analysis. This naming system is corrected through the revised manuscript and reported below:

"

Appendix A

The AMAZOMIX measurement sites and stations were systematically named and organized by location. Each site received a unique identifier based on its position along the HTE and LTE paths. Stations were categorized by site and region: superscripts "a" and "b" denoted stations at sites and , respectively, while subscripts indicated location–"sh" for shelf, "s" for slope, "o" for offshore/open ocean, and "isw" for ISW regions (Table A1). This structured naming system ensured clear identification and logical grouping of stations for consistent data analysis.

Table A1: The naming system of the AMAZOMIX cruise measurement sites and stations.

Paths / Transects	**Sites**	**Stations**							
		Shelf		**Slope**		**Offshore/Open ocean**			**ISWs**
High Tidal Energy (HTE) paths	A^a	$A^a_{sh_1}$	$A^a_{sh_2}$	A^a_s		$A^a_{o_1}$	$A^a_{o_2}$	$A^a_{o_3}$	A_{isw}
	A^b	A^b_{sh}		$A^b_{s_1}$	$A^b_{s_2}$	A^b_o			
Low Tidal Energy (LTE) path	E	E_{sh}		E_s		E_o			-

“

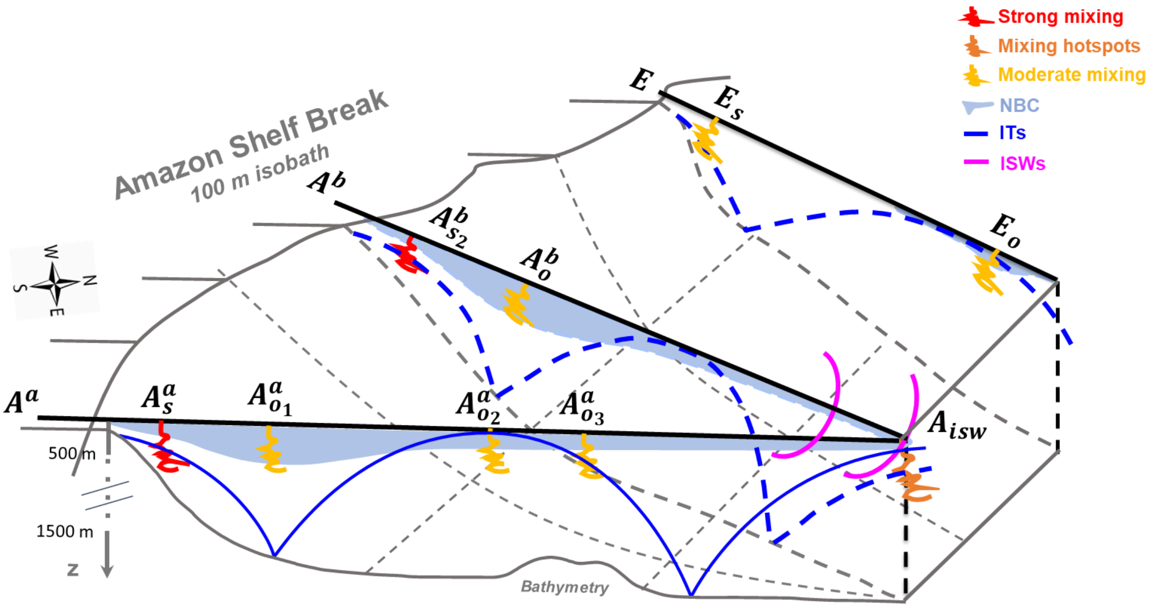

Figure RC1.1: Summary diagram illustrating the key processes driving mixing across the HTE paths (A^a and A^b) and LTE path (E) off the Amazon shelf . At IT generation sites (stations A^a_s, $A^b_{s_2}$, and E_s), mixing is generally stronger (red zigzags), except at E_s, where it is moderated (yellow zigzags). At these generation sites, ITs contribute ~60% of the mixing, exceeding the contribution of the mean circulation (NBC). Away from generation sites in the open ocean (e.g., A^b_o , $A^a_{o_1}$, and E_o; yellow zigzags), mixing decreases but remains substantial, driven by nearly equal contributions from ITs and mean circulation. A key observation is the increased mixing ~230 km from the generation sites, forming a hotspot at A_{isw} (orange zigzags). This coincides with: the surfacing of IT rays (blue lines) from two distinct generation sites on the HTE paths, the vanishing of the NBC (sky-blue shaded areas), and the presence of ISWs (magenta lines). These observations suggest that constructive interference of IT rays may generate ISWs, amplifying mixing at A_{isw}.
‘‘

There is a lot of extraneous material in this manuscript. Basically everything in the paper that does not support Fig 9 should be eliminated from the paper. Fig 9 should be presented much earlier. Perhaps as Fig 1b. The current Fig 1b-c could be moved later.

R: Thanks for your remarks.
While the dataset is extensive, this paper serves as the foundational study for the Amazomix database and will provide a reference framework for future research. To this end, we have allocated a dedicated portion of the database for subsequent studies.
In line with this objective, we have reorganized the summary figure as mentioned earlier. Additionally, we have split Figure 1 (of revised manuscript) into two separate figures (shown below; Figure RC1.2-3) to improve clarity and presentation.

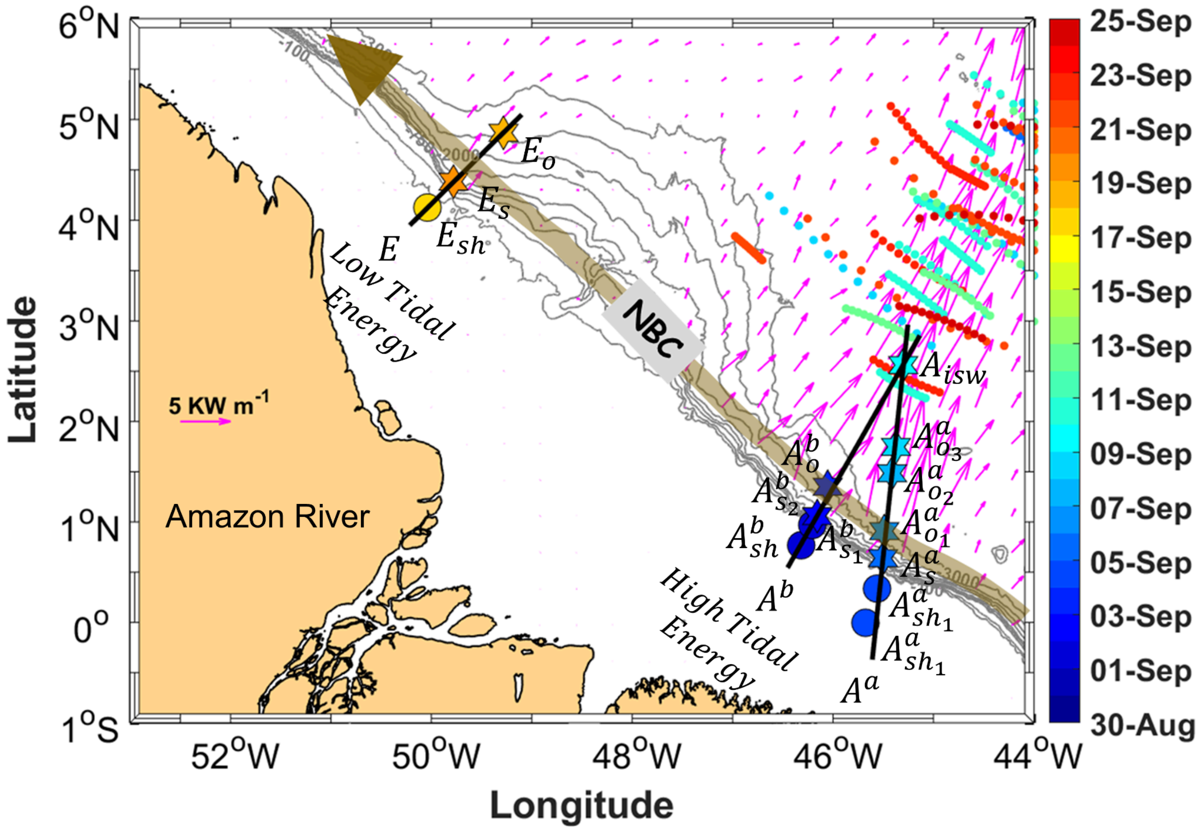

Figure RC1.2: Map of a part of the AMAZOMIX 2021 cruise off the Amazon shelf, showing bathymetric contours (100 m, 750 m, 2000 m, and 3000 m isobaths) in gray. Magenta arrows show the 25-hour mean depth-integrated baroclinic IT energy flux (September 2015, from the NEMO model) originating from IT generation sites (A^a, A^b, and E) along the shelf break. Solid black lines depict transects (A^a, A^b, and E) defined on the high tidal energy (HTE) and low tidal energy (LTE) paths. The solid brown line represents the NBC pathways, illustrating background circulation. Shattered colored lines highlight ISW signatures. Colored circles and stars indicate short and long CTD-O_2/L-S-ADCP stations, respectively, with the corresponding sampling dates represented by the color bar. The superscripts 'a' and 'b' on station names correspond to sites A^a and A^b, respectively. The subscripts 'sh', 's', 'o', and 'isw' indicate station locations: shelf ($A^a_{sh_1}$, $A^a_{sh_2}$, A^b_{sh}, and E_{sh}), slope (A^a_s, $A^b_{s_1}$, $A^b_{s_2}$, and E_s), open ocean ($A^a_{o_1}$, $A^a_{o_2}$, $A^a_{o_3}$, A^b_o, and E_o), and ISW regions (A_{isw}) for sites A^a, A^b and E, respectively.

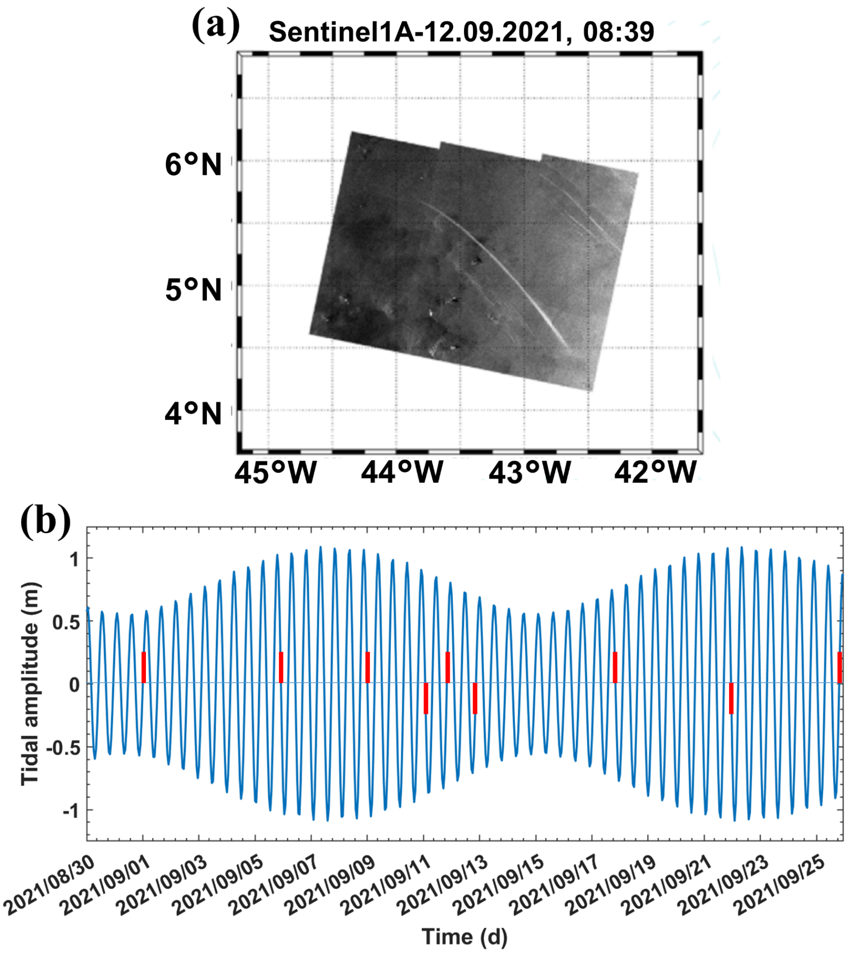

Figure RC1.3 *: a) 1A Sentinel image acquired on 12th September 2021, showing ISW signatures. b) Tidal (M2 and S2) amplitude of the currents (at -45.5°W, 1°N) derived from the FES2014 model (Lyard et al., 2014). ISW signature dates are marked by red bars.*

"

If the manuscript emphasizes internal tide-related mixing, then the focus should likely be on mid water. BBL and SBL mixing could be related to other processes and will cloud relationships between internal tide shear/strain and dissipation. Strain = d(displacement)/dz. Shear and strain are related to turbulence as shown by Gregg (1989) and papers that follow.

R: Thanks for your comments.
We have focused our analyses on midwater mixing (i.e., below maximum of [XLD, MLD] and above the bottom boundary layer). This approach is detailed in previous responses and further clarified in the revised manuscript (Subsection 2.2.1, lines 155-165; Subsection 3.2.3, lines 355-396;)

In this revision, the microstructure methods have been updated nicely and closely follow community standards.

R: Thanks

The summary compares the observed turbulence to a wide variety of measurements around the world. I would be interested in a more narrow view. There are other papers related to this AmazonMix project. Do the results in this manuscript help us to understand any of the previous finding from previous AmazonMix papers?

R: Thanks for your remarks
A direct comparison with previous studies from the AMAZOMIX project was not possible, as this represents the first published work in the series. However, several companion papers are currently in preparation or under submission, some of which have been cited in this study (e.g., Mhamdi et al., in preparation; Dossa et al., to be submitted this year).

The appendix is 23 figures and zero text. This is one relatively major example, which leads me to believe that the first author has not received appropriate guidance from the senior authors of this manuscript. There are further examples. The senior authors should see such obvious organizational issues and get them fixed before submitting a revised manuscript to a journal. I raised a similar point in the previous review with seemingly limited success.

R: Thanks for your comments
We acknowledge the extensive supplementary materials. To facilitate future research, we have allocated a dedicated portion of this database for subsequent publications.
We have added the additional supporting information into appendices in lines 549-588 of revised manuscript and reported below.
The manuscript is currently under collaborative review by senior scientists together with the first author.
"

Appendix A

The AMAZOMIX measurement sites and stations were systematically named and organized by location. Each site received a unique identifier based on its position along the HTE and LTE paths. Stations were categorized by site and region: superscripts "a" and "b" denoted stations at sites and , respectively, while subscripts indicated location–"sh" for shelf, "s" for slope, "o" for offshore/open ocean, and "isw" for ISW regions (Table A1). This structured naming system ensured clear identification and logical grouping of stations for consistent data analysis.

Table A1: The naming system of the AMAZOMIX cruise measurement sites and stations.

<table>
<tr><th rowspan="2">Paths / Transects</th><th rowspan="2">Sites</th><th colspan="8">Stations</th></tr>
<tr><th colspan="2">Shelf</th><th colspan="2">Slope</th><th colspan="3">Offshore/Open ocean</th><th>ISWs</th></tr>
<tr><td rowspan="2">High Tidal Energy (HTE) paths</td><td>A^a</td><td>$A^a_{sh_1}$</td><td>$A^a_{sh_2}$</td><td colspan="2">A^a_s</td><td>$A^a_{o_1}$</td><td>$A^a_{o_2}$</td><td>$A^a_{o_3}$</td><td rowspan="2">A_{isw}</td></tr>
<tr><td>A^b</td><td colspan="2">A^b_{sh}</td><td>$A^b_{s_1}$</td><td>$A^b_{s_2}$</td><td colspan="3">A^b_o</td></tr>
<tr><td>Low Tidal Energy</td><td>E</td><td colspan="2">E_{sh}</td><td colspan="2">E_s</td><td colspan="3">E_o</td><td>-</td></tr>
</table>

(LTE) path					

Appendix B

To relate each mixing event with either tidal or mean (time-averaged) currents along the HTE transects (and) and the LTE transect (E), we quantify the relative contributions of mean and semi-diurnal baroclinic vertical shear squared at transect stations (see Table A2).

Table A2: *miXing Layer Depth (XLD), Mixed Layer Depth (MLD), Contribution (mean and standard deviation) of the Semi-diurnal (CSBS), and Mean Baroclinic (CMBS) Shear to total baroclinic shear.*

Stations	**XLD (m)**	**MLD (m)**	**CSBS (mean ± SD) (%)**	**CMBS (mean ± SD) (%)**
	27	25.0	-	-
	20	5.0	-	-
	57	17.8	66.2 ± 0.3	33.8 ± 0.3
	46	22.5	36.7 ± 3.7	63.3 ± 3.7
	23	44.5	-	-
	29	21.0	-	-
	26	32.5	60.0 ± 4.0	40.0 ± 4.0
	104	15.5	47.6 ± 4.9	52.4 ± 4.9
	75	11.3	56.6 ± 3.3	43.4 ± 3.3
	82	12.3	59.1 ± 3.4	40.9 ± 3.4
A_{isw}	97	12.3	63.6 ± 4.8	36.4 ± 4.8
E_{sh}	45	1.0	-	-
E_o	73	1.8	56.6 ± 3.9	43.4 ± 3.9
E_s	53	1.0	60.2 ± 2.8	39.8 ± 2.8

SD = Standard Deviation

Appendix C

Following subsection 2.2.2, we examined the cross-shelf component of baroclinic tidal currents to investigate IT amplitude (current strength) and shear instability around the pycnocline (70–180 m depth; see Table A3). Additionally, the along-shelf component of mean baroclinic currents (MBC) was analyzed to evaluate the strength of the mean flow and its associated shear instability in the upper 200 m (see Table A3).

__Table A3:__ Strength of baroclinic tidal and mean baroclinic currents.

Stations	***IT amplitudes (cm s-1; maximum)***	***Estimated number of IT eigenmodes***	***IT vertical shears (s-2 x 10-4; maximum)***	***MBC velocities (cm s-1; maximum)***	***MBC vertical shear (s-2 x 10^{-4}; maximum)***
	35	*6-7*	*5.5*	*90*	*1.2*
	15	*4-5*	*2.5*	*98*	*1.7*
	45	*6-7*	*7.7*	*30*	*0.7*
	25	*4*	*2.0*	*90*	*1.2*
	40	*3*	*7.6*	*67*	*1.2*
	25	*3*	*3.3*	*69*	*1.3*
Aisw	*40*	*4.5*	*5.0*	*71*	*1.1*
Eo	*15*	*4*	*3.5*	*43*	*2.7*
Es	*20*	*4*	*1.2*	*28*	*0.8*

“

Figures and captions on the same page are usual.

R: Thanks for your remark.
We have reorganized the figures to appear on the same page as their corresponding captions for improved readability and clarity.

The first lines in paragraphs on adjacent lines have an indent. Or skip a line and paragraphs can be left justified.
R: Thanks for your remark.
We have reformatted the opening lines of each paragraph to improve document structure and readability.

Maybe try running the text through some AI grammar checker. It's ok as is, but could be better.

R: Thanks for your comment.
We have reviewed the manuscript using AI-powered grammar checking tools to ensure linguistic accuracy and clarity.

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Comment by line

Fig 1c - tidal height of what and where?

R: Thanks for your comments.
We have revised the caption in Figure 2 of the revised manuscript, as presented below:
"

b) Tidal (M2 and S2) amplitude of the currents (at -45.5°W, 1°N) derived from the FES2014 model (Lyard et al 2014).

"

16- reserve "significant" for statistically significant and just drop significant and your sentence is still ok

R: Thanks for your comments.
Throughout the revised manuscript, we have systematically replaced non-technical uses of "significant" with alternative terms, reserving "significant" exclusively for cases of statistical significance.

30 - there is not further mention of parameterizations in this manuscript. Delete this sentence.
R: Thanks for your comments.
We have removed the sentence from the revised manuscript.

68 - units: 30% not 30[space]%. Still some funny units here and there- e.g., m.s-1 Check each figure.

R: Thanks for your comments.
We have revised units throughout the revised manuscript.

73 - The introduction is still a bit diffuse. There's a lot of info which seems good to know but it's unclear where the manuscript is going with all this info. I would favor a more narrow focus on this region and previous AmzonMix papers. Some more specific information on what was found in Bertrand (2021), what gaps that left, and how this manuscript fills those gaps. This can be short but it seems to be missing or maybe not clearly stated. Maybe it's something like: "The Amazon plume is highly variable with boundary currents, eddies, and internal tides. Bertrand showed something about mixing. However, he didn't really talk about internal tides. We show internal tides and nonlinear solitary waves produceda lot of mixing. So there are implications for some other things." There are other AmazonMix papers. How does this paper expand on/explain gaps in thoise papers?

R: Thanks for your comments.
This study represents the first peer-reviewed analysis of AMAZOMIX data, with particular emphasis on mixing induced by internal tidal waves. The work of Bertrand et al. (2021) just provides a valuable mission report containing raw VMP measurements. Their work: (1) has not been peer-reviewed, (2) presents uncalibrated data, and (3) lacks complete station coverage in its preliminary plots.

We have accordingly revised the Introduction section (lines 33-69), as presented below:

“

Turbulent mixing in the ocean is essential for sustaining thermohaline and meridional overturning circulation and for maintaining the global ocean energy budget (Kunze, 2017; Koch-Larrouy et al., 2010). It regulates climate by controlling heat and carbon transport and providing nutrients for photosynthesis (Huthnance, 1995; Munk & Wunsch, 1998). Mixing effects are often reflected in step-like density features, indicating homogeneous regions (Koch-Larrouy et al., 2015; Bouruet-Aubertot et al., 2018). Ocean mixing can be driven by processes like current shear (Rainville and Pinkel, 2006; Whalen et al., 2012; Miles, 1961), river plumes (Ruault et al., 2020), fronts (Geyer, 1995), overturns (Thorpe, 2018; Munk & Wunsch, 1998), and tides (Zhao et al., 2012).

Barotropic tides interacting with sharp topography generate internal tides (ITs), strong internal waves at tidal frequencies and harmonics (Zhao et al., 2016). ITs can create strong vertical displacements of up to tens of meters (Garrett & Kunze, 2007) and may propagate offshore. As they propagate, ITs can interact with topography, stratification, waves, currents, and eddies (Whalen et al., 2012; Bordois, 2015; Ivey et al., 2020; Inall et al., 2021), leading to complex offshore mixing (Gill, 1982). ITs can also destabilize, break, and dissipate locally (Zhao et al., 2016), and their intensity and path can change due to environmental factors, potentially generating nonlinear Internal Solitary Waves (ISWs; Jackson et al., 2012).

These processes are prominent in the Amazon River-Ocean Continuum (AROC) in the western tropical Atlantic. This dynamic region, shaped by interactions between currents, eddies, the Amazon River plume, and internal waves, drives complex circulation and vertical mixing. The North Brazil Current (NBC), the region’s dominant western boundary current, flows northwest along the coast (Fig. 1), with velocities of ~1.2 m s^{-1} and a vertical extent of up to 100 m, transporting warm, saline waters from the South Atlantic (Barnier et al., 2001). The NBC influences the Amazon plume’s dispersal and contributes to mesoscale eddy formation (Johns et al., 1998; Bourlès et al., 1999; Neto & Silva, 2014). The Amazon plume shows strong seasonal variability, extending up to 1500 km offshore during the rainy season (May–July) and retreating to under 500 km during the dry season (September–November; Coles et al., 2013).

At the Amazon shelf break, internal waves, such as ITs and ISWs, are generated, propagate, and dissipate. These waves have been observed through in situ measurements (Brandt et al., 2002) and SAR satellite imagery (Magalhães et al., 2016). Recently, de Macedo et al. (2023) used MODIS images to identify frequent mode-1 ISWs originating from two IT generation sites (and ; Figs. 1, 2a, and 2b), with wavelengths ranging from 72 to 128 km. These ISWs appeared where Tchilibou et al. (2022) predicted IT energy dissipation using numerical modeling. Their findings suggest that ~30% of M_2 IT energy dissipates near generation sites (, , and E; Fig. 1), corresponding to higher-mode ITs, while lower-mode ITs propagate offshore, where they dissipate and enhance mixing. Offshore mixing may result from shear instabilities driven by interactions between currents, eddies, the Amazon plume, ITs, and coupled processes (e.g., wave-wave, wave-current, or plume-wave interactions). However, no direct dissipation measurements have been made in this region to quantify IT-driven mixing.

To address this, the AMAZOMIX cruise (Bertrand et al., 2021) was conducted to investigate IT-driven mixing off the Amazon shelf. Microstructure and hydrographic measurements were collected at repeated stations over an M_2 tidal cycle (~12.42 hrs), providing dissipation estimates and insights into associated processes. Stations were positioned along contrasting IT paths, such as high tidal energy (HTE) paths (sites and ; Fig. 1) and low

tidal energy (LTE) path (site E; Fig. 1), enabling dissipation quantification in varying tidal regimes. The AMAZOMIX dataset provides a unique opportunity to assess the role of ITs in mixing within the AROC region.
“

75 - "Direct microstructure measurements of temperature, salinity and velocity were conducted..." Does this mean the instrument was equipped with fast thermistors, microconductivity probes, and shear probes? And are you going to talk about all these?

R: Thanks for your comments.
The measurement system incorporated three key sensors: fast-response thermistors, micro conductivity probes, and shear probes. We have simply rewritten this sentence (lines 65-66) in revised manuscript, as shown below:
“
Microstructure and hydrographic measurements were collected at repeated stations over an M2 tidal cycle (~12.42 hrs), providing dissipation estimates and insights into associated processes.
“

Fig 1- this is really about the worst naming of CTD stations I have ever seen in decades as a scientist. It is slightly better than completely random. Some stations increase onshore and some offshore. Sometimes they do both on the same transect. The letters do not all increase northward.

If you feel the need to retain this because you are attached to the cruise naming convention and previous papers, maybe you could add a supplement with this station naming and provide something logical so that a reasonable reader can follow along without having to look at Fig 1a literally all the time.

R: Thanks for your comments and suggestions.
We have implemented a standardized naming system for all stations, as detailed in previous responses. This structured approach enables clear identification and logical grouping of stations, ensuring consistency throughout our data analysis. The updated station names are presented below.

“

Appendix A

The AMAZOMIX measurement sites and stations were systematically named and organized by location. Each site received a unique identifier based on its position along the HTE and LTE paths. Stations were categorized by site and region: superscripts "a" and "b" denoted stations at sites and , respectively, while subscripts indicated location–"sh" for shelf, "s" for slope, "o" for offshore/open ocean, and "isw" for ISW regions (Table A1). This structured naming system ensured clear identification and logical grouping of stations for consistent data analysis.

Table A1: The naming system of the AMAZOMIX cruise measurement sites and stations.

Paths / Transects	**Sites**	**Stations**			
		Shelf	**Slope**	**Offshore/Open ocean**	**ISWs**

<table>
<tr><td rowspan="2">**High Tidal Energy (HTE) paths**</td><td>A^a</td><td>$A^a_{sh_1}$</td><td>$A^a_{sh_2}$</td><td colspan="2">A^a_s</td><td>$A^a_{o_1}$</td><td>$A^a_{o_2}$</td><td>$A^a_{o_3}$</td><td rowspan="2">A_{isw}</td></tr>
<tr><td>A^b</td><td colspan="2">A^b_{sh}</td><td>$A^b_{s_1}$</td><td>$A^b_{s_2}$</td><td colspan="3">A^b_o</td></tr>
<tr><td>**Low Tidal Energy (LTE) path**</td><td>E</td><td colspan="2">E_{sh}</td><td colspan="2">E_s</td><td colspan="3">E_o</td><td>-</td></tr>
</table>

"

This constant work is extremely distracting and seriously detracts from the manuscript. See line 258, for example, where XLD is noted as deeper than MLD except at stations S8, S10, and S25. S8 and S10 are neighboring stations near the slope in the south and S25 is way off to the north in deep water. Every sentence requires similar parsing. This is a simple example.

R: Thanks for your comments and suggestions.
We have systematically revised sentence structures throughout the manuscript to ensure consistent grammatical parsing and improved readability. This comprehensive editing approach maintains technical precision while enhancing clarity across all sections.

Here is a longer example from the discussion: "Stations were located in the most energetic regions of IT, specifically at sites Aa, Ab, and D, covering stations S2 to S14, as identified in previous studies (Magalhaes et al., 2016; Tchilibou et al., 2022; Assene et al., 2024). Stations S19 to S21 were positioned in less energetic IT generation areas at site E, while stations S24 and S25 were located outside the influence of the IT fields (site G). Stations were distributed across different areas, including the shelf (e.g., S4, S9, and S19), the shelf-break (e.g., S3, S6, and S10), and the open ocean (e.g., S14, S24, and S20)." It's complicated and does not have to be.

R: Thanks for your remarks.
We have accordingly revised the discussion section (lines 429-545) in the revised manuscript.

105 - what was done with the pre- and post-cruise calibrations?

R: Thanks for your remarks.
Pre- and post-cruise CTD-O_2 calibrations were conducted to ensure accurate dissolved oxygen measurements during the survey. This is now specified in lines 105-106 of the revised manuscript, as shown below:
"

The 24 Hz CTD-O2 sensors were calibrated before and after the cruise to ensure accurate dissolved oxygen measurements throughout the survey.

"

106 - means?

R: Thanks for your remarks.

we have rewritten the sentence in line 107 of the revised manuscript, as shown below:

"

The temperature, salinity, and oxygen standard deviation between the CTD-O_2 and the bottle samples was 0.003 °C, 0.003 PSU, and 0.05 ml l^{-1}, respectively.

"

107 - lag effects- does this refer to S spikes from mismathed times of T and C?

R: Thanks for your remarks.

Indeed, lag effects can produce salinity spikes due to temporal mismatches between temperature and conductivity measurements..

123 - Great

R: Thanks

151- tracer variance not energy

R: Thanks for your remarks.

We have decided to reorganize this subsection ("the vertical eddy diffusivity coefficient") in the revised manuscript.

152-153 - unclear

R: Thanks for your remarks.

We have decided to reorganize this subsection ("the vertical eddy diffusivity coefficient") in the revised manuscript.

161 - Gregg (2003) showed mixing is dramatcially reduced with decreasing latitude for a given internal wave energy level compared to higher latitudes.

R: Thanks for your remarks.

Yes, of course.

170 - "XLD is specified as the depth where ε drops from its first minimum value." I don't understand this definition.

R: Thanks for your remarks.

Indeed, this definition means that XLD is defined as the depth at which ε decreases from its first minimum value, e.g., 10^{-9} W kg^{-1} at S7.

186 - define along-/across-shore

R: Thanks for your remarks.

We have defined in lines 180-185 of the revised manuscript, as reported below:

"

The baroclinic mean velocities $[\overline{u'}, \overline{v'}]$, calculated to estimate mean circulation along IT paths, are decomposed into along-shore $\overline{u'}_l$ and cross-shore $\overline{u'}_c$ velocities. The overbar denotes the average over the M_2 tidal period. Similarly, the components $[u'', v'']$ are decomposed into along-shelf u''_l and cross-shelf u''_c velocities. The along-shelf velocity component is defined parallel to the 200 m isobath (treated as the coastline), with positive values indicating northwestward flow and negative values indicating southeastward flow. The cross-shelf velocity component is defined perpendicular to the 200 m isobath, with positive values indicating northeastward flow and negative values indicating southwestward flow.

“

188 - alternately?

R: Thanks for your remarks.

Indeed, CTD-O_2 measurements were performed alternately. We have removed the terminal word in line 187 of the revised manuscript, as shown below:

“

The similar processing is applied to the CTD-O_2 data.

“

200 - energy is E, dissipation is epsilon

R: Thanks for your remarks.

We have decided to remove this sentence in the revised manuscript..

204 - "measured bathymetry from CTD-O2"- what?

R: Thanks for your remarks.

Indeed, these represent bathymetry measurements at sampling stations.

We have revised the description in lines 166-188 of the revised manuscript.

206 - In this ratio the N's cancel- I don't understand this. Why N*S? Is S either S or S^2? See line 208.

R: Thanks for your remarks.

The formulation in lines 196-197 of the revised manuscript has been revised as follows:

“

The individual contributions of semi-diurnal ITs and mean circulation are then expressed as follows: $S^{2''}/(\overline{S^{2'}} + S^{2''})$ for tidal contribution and $\overline{S^{2'}}/(\overline{S^{2'}} + S^{2''})$ for mean circulation contribution.

“

225 - combined not glued. Has some ffort been made to avoid discontinuities in the profiles?

R: Thanks for your comments

Specific efforts were made to minimize profile discontinuities in the measurements.

226 - there needs to be some minimal description of this model

R: Thanks for your comments

We have added some minimal description of this model in line 216-225 of the revised manuscript, as reported below:

"

Amazon36 is a specific configuration, specifically designed to cover the western tropical Atlantic from the mouth of the Amazon River to the open sea (see Tchilibou et al., 2022; Assene et al., 2024; for configuration details and model description). The NEMO model's fine horizontal resolution (1/36°) and 75 vertical levels allow for accurate simulation of low-mode ITs generated along the Brazilian shelf break. Key inputs include bathymetric data from the 2020 General Bathymetric Chart of the Oceans, surface forcing from ERA-5 atmospheric reanalysis (Hersbach et al., 2020), and river runoff data from the ISBA (Interaction Sol-Biosphère-Atmosphère; https://www.umr-cnrm.fr/spip.php?article146&lang=en) model. Open boundary conditions were driven by 15 major tidal constituents (M2, S2, N2, K2, 2N2, MU2, NU2, L2, T2, K1, O1, Q1, P1, S1, and M4) and barotropic currents from the FES2014 atlas (Lyard et al., 2021), supplemented by temperature, salinity, and velocity data from the MERCATOR-GLORYS12v1 assimilation product (Lellouche et al., 2018).

"

Fig 3- What is plotted? Two selected profiles about 6 hrs apart to emphasize displacements at each station? Up- and downcasts? This is not necessarily an indication of mixing. A linear wave can displace isopycnals. Displacements can be calculated as (rho - mean rho)/(vertical density gradient) and plotted as a figure with shaded colors. Then you can also calculate strain = d(displacement)/dz which will highlight finer scales and maybe show internal wave propagation along the section

R: Thanks for your comments.
This figure (updated and shown below) in the revised manuscript plots, for long stations, two selected profiles (up-cast and down-cast) separated by 6 hours (half the semi-diurnal tidal period) to highlight station displacements. This sampling interval optimally captures phase reversals of internal tides, facilitating observation of isopycnal vertical displacements (Abyssal recipes II: energetics of tidal and wind mixing - ScienceDirect).
How internal tides propagate and how their vertical displacements can be observed through repeated density profiles (Internal Tide Generation in the Deep Ocean | Semantic Scholar).
These internal tides can contribute to mixing in the ocean, leading to the formation of step-like structures (Abyssal recipes II: energetics of tidal and wind mixing - ScienceDirect).

Figure RC1.4 illustrates two key aspects:

1) The observed isopycnal displacements at 6-hour intervals result from internal wave propagation, specifically through vertical advection (the advective component of wave motion)."

2) The step-like structures, consisting of vertically stacked homogeneous layers, represent clear signatures of mixing. These features result from wave-induced mixing during propagation. Notably, their spatial distribution is heterogeneous across stations, reflecting the localized nature of the mixing processes.

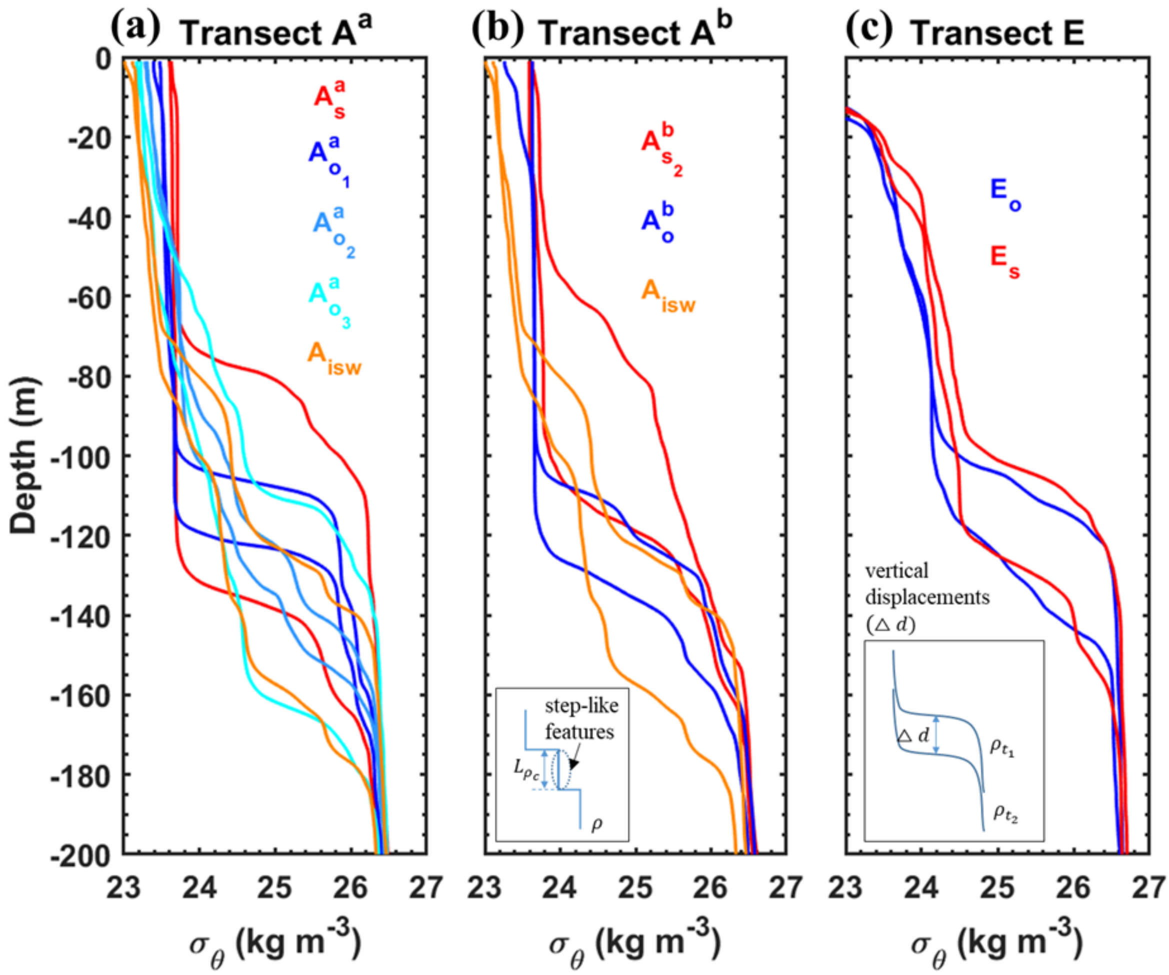

Figure RC1.4: Density profiles (σ_θ, kg m^{-3}) from CTD-O_2 measurements during the AMAZOMIX 2021 cruise along transects: (a) A^a, (b) A^b, and (c) E. For long stations ($A^b_{s_2}$, A^b_o, A^a_s, $A^a_{o_1}$, $A^a_{o_2}$, $A^a_{o_3}$, A_{isw}, E_s, and E_o), two density profiles recorded ~6 hrs apart (half the M_2 tidal period) are shown to highlight step-like structures and vertical isopycnal displacements along the transects. Colored lines represent stations on the slope (red) and open ocean (blue, sky-blue, cyan, and light-orange). The subpanel in panel b depicts a step-like structure, where L_{ρ_c} represents the vertical extent of homogeneous regions and ρ_c denotes the density structure. The subpanel in panel c illustrates vertical displacements (Δd) of density structures, with ρ_{t_1} and ρ_{t_2} representing density structures at times t_1 and t_2, respectively

252-253- Maybe plot these on a different scale than the others.

R: Thanks for your remarks

We have plotted these on a different scale, as shown below (Figure RC1.5):

“

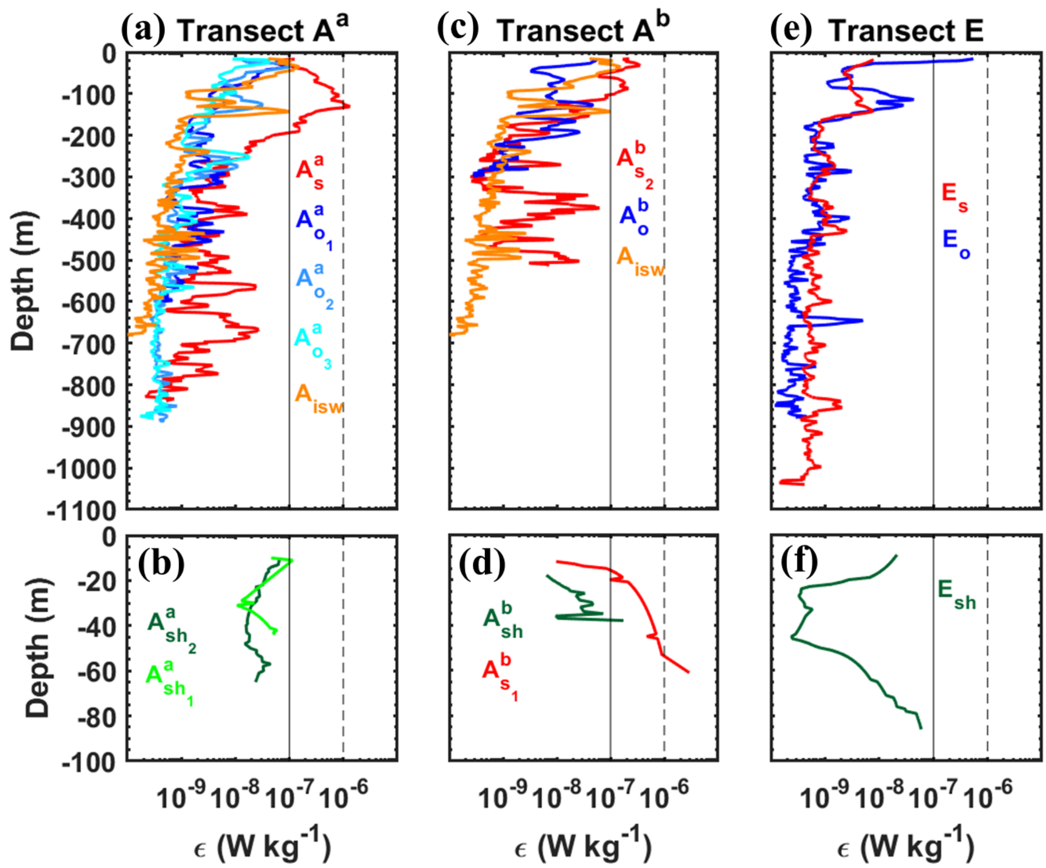

Figure RC1.5: Station-averaged dissipation rate profiles (ε, in W kg[-1], logarithmic scale) from VMP measurements during the AMAZOMIX 2021 cruise along transects: (a)-(b) Aa, (c)-(d) Ab, and (e)-(f) E. Colored lines represent stations on the shelf (green, lime-green), slope (red), and open ocean (blue, sky-blue, cyan, and light-orange). Vertical dashed and solid black lines are included for comparison.

"

256 - diffusivity not mixing coeff

R: Thanks for your remarks

We have updated this subsection in lines 262-280 of the revised manuscript.

258 - "It is important to note that the XLD is typically deeper than the MLD at all stations" but then there is no further mention of XLD or MLD in ths subsection.

R: Thanks for your remarks

We have updated this subsection in lines 262-280 of the revised manuscript..

Fig 4a - what do the symbols mean? Also plotting the max epsilon seemds like it will produce widely varying results. Better to use a depth- and time-mean value over some depth or density ranges.

R: Thanks for your remarks

In this figure, colored circles and stars denote short and long CTD-O_2/LADCP stations, respectively (see caption in Figure 10 of the revised manuscript).

For our analysis, we have decided to use both depth-integrated and depth-maximum values derived from time-averaged dissipation profiles at each station. To isolate tide-induced mixing in the mid-water column, we exclude the surface mixing layer and bottom boundary layer from these calculations. We reported the figure below (Figure RC1.6):

"

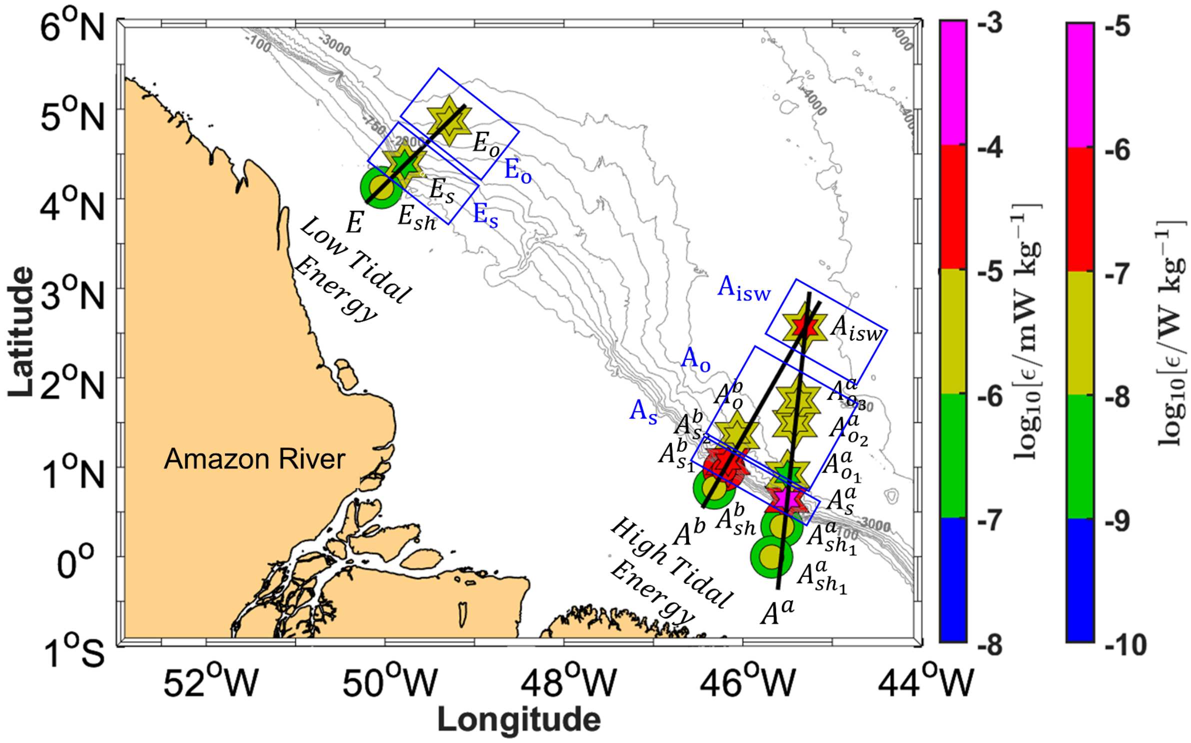

Figure RC1.6: Depth-integrated (in mW kg^{-1}, logarithmic scale) and maximum values (in W kg^{-1}, logarithmic scale) of station-averaged dissipation rates (ε) from VMP measurements during the AMAZOMIX 2021 cruise. Solid black lines depict transects (A^a, A^b, and and E) along high tidal energy (HTE) and low tidal energy (LTE) paths. Data are from below the wind-influenced surface layer and above the friction-dominated bottom boundary layer. Colored circles and stars represent short and long stations, respectively. Small and large colored circles indicate depth-integrated and maximum values of ε, respectively, with ranges shown by the color bar. Similarly, small and large colored stars indicate depth-integrated and maximum values of ε, respectively, with ranges shown by the color bar. Stations are grouped into five areas: A_s (A_s^a and $A_{s_2}^b$), A_o (A_o^b, $A_{o_1}^a$, $A_{o_2}^a$, and $A_{o_3}^a$), A_{isw} (A_{isw}), E_s (E_s), and E_o (E_o). The five blue boxes indicate these defined areas. Subscripts denote locations: 's' for slope (A_s), 'o' for offshore (A_o, and E_o), and 'isw' for ISW regions (A_{isw}).

"

270 - Some stations are plotted in the Appendix and some in the main text. This means after reading this sentence, I have to go to 2 widely separated figures.

R: Thanks for your remarks

We have completely reorganized and removed some materials in the revised manuscript.

Fig A5 - With a 2-day record, the frequency resolution is 1/2 cycles per day. The individual semidiurnal constituents cannot be distinguished and neither can the individual diurnal constituents. A fit of 1 cpd and 2 cpd and 4 cpd is sufficient- my previous review comment was unclear on this point.
R: Thanks for this clarity.

305 - 3-5 tidal modes - are these vertical normal modes? If vertical modes, no info has been provided on the mdal decomposition.
R: Thanks for your remarks
This study did not perform a formal modal decomposition. Instead, we analyzed the vertical structure of baroclinic tidal velocities to identify characteristic mode patterns by examining zero-crossings and amplitude variations (Abyssal Mixing: Where It Is Not in: Journal of Physical Oceanography Volume 26 Issue 10 (1996) ; Internal tides in the ocean - Wunsch - 1975 - Reviews of Geophysics - Wiley Online Library).
The identification criteria were:
Mode 1: Single zero-crossing with opposing velocity directions above/below
Mode 2: Two zero-crossings with two directional reversals
Higher modes: Additional zero-crossings (though typically weaker and less observable)
Thus, modes were classified by their zero-crossing counts (Mode 1 = 1, Mode 2 = 2, etc.).

Fig 6- S^2" in m s-1?
R: Thanks for your remarks
We have revised it in figure 9 of the revised manuscript.

Fig 7 - arrange panels better.
R: Thanks for your remarks
We have thoroughly restructured the revised manuscript, including the removal of some content to improve clarity and focus.

366 and Fig 7- At S10, turbulence appears unrelated to Ri calculated from N^2 and S^2"
R: Thanks for your comments
In this figure, we have added the linear lines representing Richardson numbers (Ri) following the relation $N^2 = Ri \times S^2$, with Ri values of 0.25 and 1.".
We have thoroughly restructured the revised manuscript, including the removal of some content to improve clarity and focus.

Fig 8a - the entire slope appears critical. So up- or downward and offshore beams could be emanating from any location on the slope in this figure. Beams if present would be visible not in the mean velocity (because tides are oscillating) but in the variance. Dissipation appears largest in the upper 100 m where currents are strong. Possibly this is a front at S6 and S10.
R: Thanks for your comments
By comparing ray slopes with topographic slopes using bathymetry from both the NEMO-AMAZON36 model and GEBCO, we not find that the entire slope appears critical in our sensitivity tests (see Figures RC1.7 and RC1.8; with topographic steepness γ). However, these results might vary with different bathymetric products.

This figure 8a displayed total (rather than mean) along- and cross-shore velocities. Indeed, the strongest dissipation occurs in the upper 100 m, may be associated with strong currents and a frontal feature near stations S6 and S10.
In the revised manuscript (Figure 12), we have removed total velocities and focused exclusively on internal tide rays to facilitate comparison with dissipation rates. This approach helps explain the intense mixing hotspot at Aisw, which contrasts with values typically found in the open ocean..

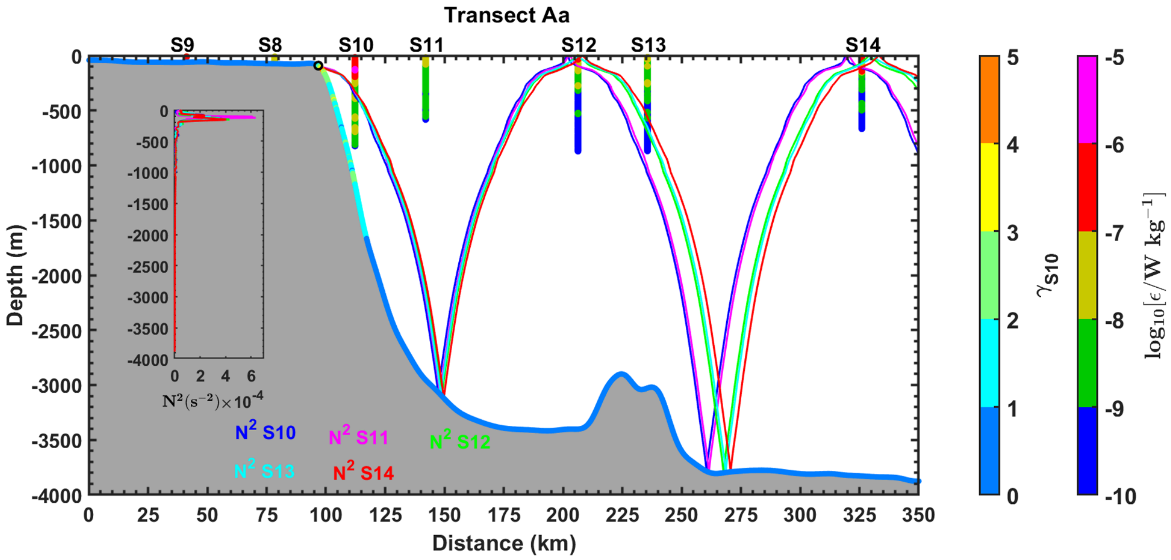

Figure RC1.7: Example of sensitivity tests with different cross-sectional measurements of N^2 along the transect T1 N^2. colors are used to distinguish different cross-shore measurements of N^2 for corresponding stations on T1. Topography steepness (gamma = ray slope / topography slope) for T1 using measured N^2 of S10. Gamma is illustrated by the colored bar (named gamma S10).

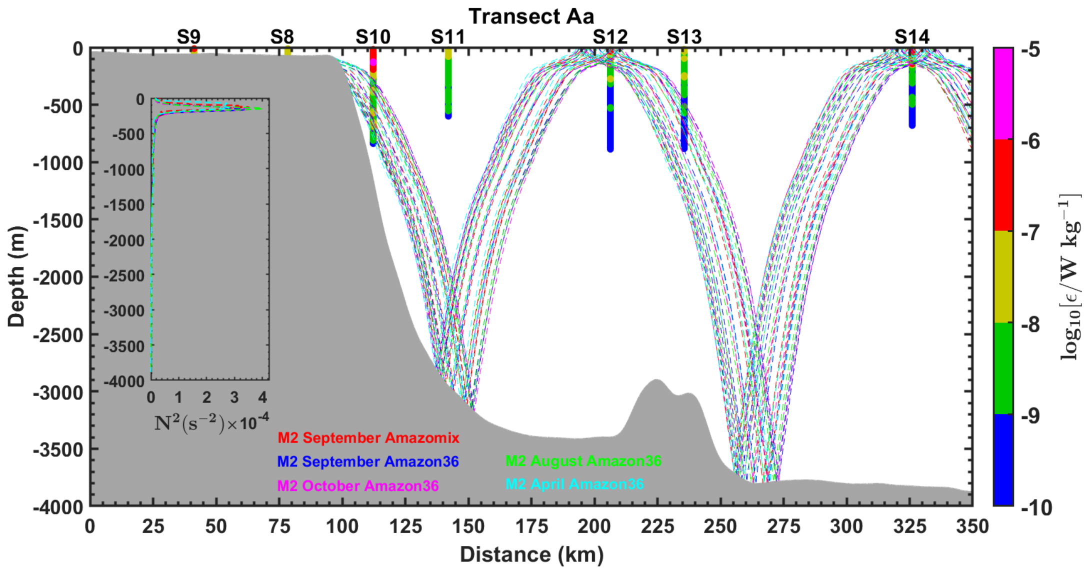

Figure RC1.8: Sensitivity tests of M2 IT ray-tracing along the transects Aa, conducted by varying the location of the critical topography slope. The tests use mean buoyancy frequency squared (N^2, in s^{-2}) obtained from CTD-O_2 data (September 2021) and NEMO-Amazon36 model data (2012-2016). Dashed colored lines represent IT beams calculated for different seasons (April, August, October, and September) and for varying locations of the critical topography slope. Grey areas indicate local topography. Panel also includes dissipation rate profiles (ε, in W kg^{-1}, shown as vertical colored bars on a logarithmic scale) from

413- I think there is little evidence showing elevated turbulence along ray paths. I can't see where interference/interaction between waves along these ray paths occurs.
R: Thanks for your comments
While not explicitly examined in this study, we propose wave-wave interference as the primary mechanism potentially explaining the enhanced hotspots at station A_{isw}. This hypothesis requires verification through future targeted studies.

553- "The most relevant finding of this study was the relative increase in mixing within the pycnocline layer, observed at S14 in the
open ocean, far from the IT generation sites." Agreed. This is a possible focus of the manuscript. Everything in the paper should support this statement. Everything that is unrelated to this statement can be removed.
R: Thanks for your agreement.
We have substantially revised the manuscript to focus exclusively on this central finding, removing all extraneous material to sharpen the study's narrative and conclusions.

561 - I don't understand? - "...with large-amplitude ISWs
exceeding 100 m clearly visible in satellite records..."
R: Thanks for your remarks
We have updated the text in lines 356-358 of the revised manuscript to clarify this point.