Response to reviewers' comments on
"Atlantic Water flow through Fram Strait to the Arctic Ocean measured by repeated glider transects" by Vår Dundas and Ilker Fer.

Dear reviewers,

Thank you both for reading our manuscript so thoroughly and for your insightful input, which helped us improve the manuscript. We have addressed your comments and suggestions carefully. Please find our point-to-point response below. Specific changes made to the text are given in italics, and line numbers refer to the updated manuscript. The final revised version of the manuscript with all changes tracked has also been submitted with this response.

Sincerely,
Vår Dundas and Ilker Fer

Response to anonymous reviewer #1:

Thank you for reading our manuscript so thoroughly and for all your comments – your input and suggestions helped improve our manuscript. We hope you will both find that we have addressed your comments satisfactorily.

The manuscript presents repeated glider transects on the western slope of Svalbard in 2020-2022. From these transects, volume transport is estimated of the West Spitsbergen, the Front Current and the recirculation branches in Fram Strait at different seasons. Some episodes of anomalous volume transport are analyzed in more details within case studies to suggest process mechanisms behind the variability of the volume transport. The results of this manuscript, although not so novel, highlight how gliders can be used to complement mooring lines and hydrographic transects. This manuscript can then have a significant impact when it comes to planning of future fieldwork. The manuscript is well written, and the methodology seems robust. The figures are clear and self-explanatory. This manuscript should be accepted for publication after some minor revisions.

We are very happy to read that our manuscript has been well received. We thank the reviewer for their encouraging and constructive feedback.

My main comment regarding the manuscript concerns the description of the case study. I find those very interesting; however, I think it would be valuable to be able to add some statistics about the wind. How often do we see these northerly/southerly winds? How representative are the observations over a longer time? A time series of wind over the last 20 years for example, with quantification of the different events will be useful, and some statistics could then be provided on how often the different cases are expected to occur.

Re.: Thank you for pointing this out. We agree that adding more statistics about the wind would be valuable. Further analysis on this also aligns well with our response to the second reviewer, who made recommendations to make the case study analysis more robust. In response to your comment, we extracted the wind stress from ERA5 for 1979-2024 at hourly resolution over the same area as used in the case study (0°E-12°E and 77.25°N +/- 0.75°N). We include the following figures in the appendix, along with some amendments to the main text, as indicated below. We use 7-day rolling averages for the wind stress analysis because the duration of the two case studies is seven and ten days.

The wind stress conditions during the two case studies presented are relatively common over this section. The temporal maximum northward and southward stresses during the case studies discussed in section 3.4, i.e., cases S9 and S22 are 0.14 and -0.31 N m^{-2}, respectively, based on the 7-day rolling average wind stress averaged over 0°E-12°E and 77.25°N +/- 0.75° (Fig. 1 below). These limits are indicated by the orange and blue horizontal lines in Fig. 1. Strong wind events exceeding these thresholds typically occur several times per year in the 7-day rolling average (case S9: usually between 2 and 15 times per year, case S22: 1-12 times per year). These case studies thus do not represent rare, extreme conditions, but atmospheric forcing events that are typically expected each year.

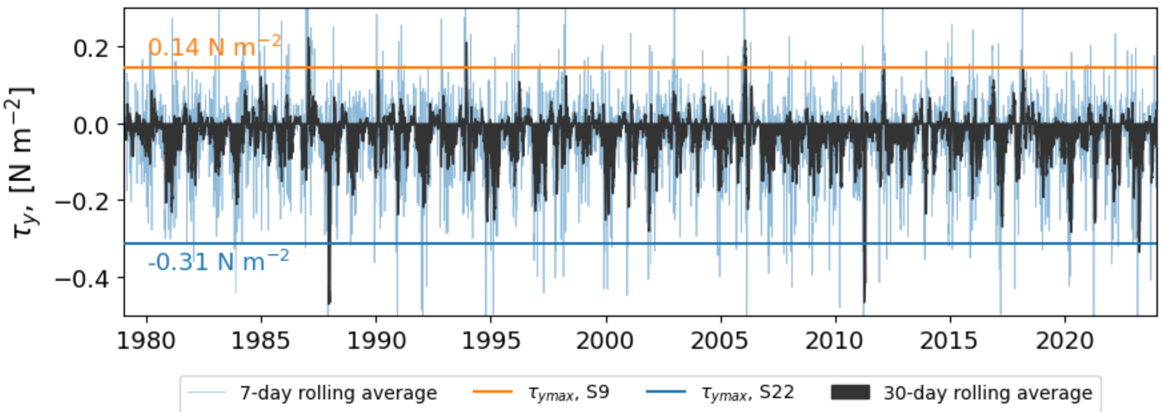

Figure 1. Time series of surface wind stress from ERA5 averaged over 0°E-12°E and 77.25°N +/- 0.75°. 7-day (light blue) and 30-day (black) rolling averages. The maximum northward stress during Case S9 (orange) and southward stress during Case S22 (blue) are included (based on 7-day means).

The maximum southward wind stress during Case S22 is well within the 5th percentile of the distribution of the time series of minimum 7-day averaged wind stress across the target section. The northward wind stress during Case S9 is marginally within the 95th percentile of the analogous maximum wind stress. Figure 2 is based on only the months covered by the glider missions (August through February), and a plot using the full time series from 1979-2024, is very similar.

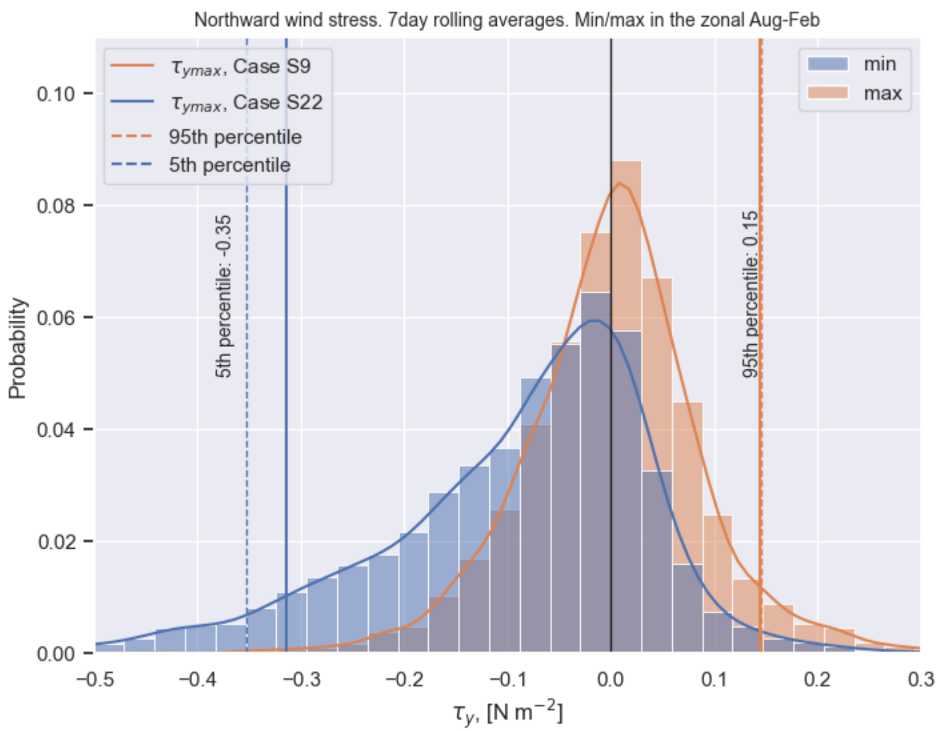

Figure 2. Distribution of minimum and maximum meridional surface wind stress across the target section for each 7-day rolling window averaged over 77.25°N+/-0.75°. The 5th percentile of the minimum wind stress (dashed blue) and the 95th percentile of the maximum wind stress (dashed orange) are indicated.

The wind stress curl, which can induce vertical oceanic motion, is nearly zero across the full section during Case S9, whereas during Case S22, the mean wind stress curl is roughly 1.5×10^{-6} Nm^{-3}. This is well within the 99th percentile of the zonally average wind wind-stress curl in this region, but higher than the 95th percentile (Fig. 3). The wind stress curl during case S22 is thus higher than expected values. This means that the glider mission captures a period of particularly strong wind stress curl.

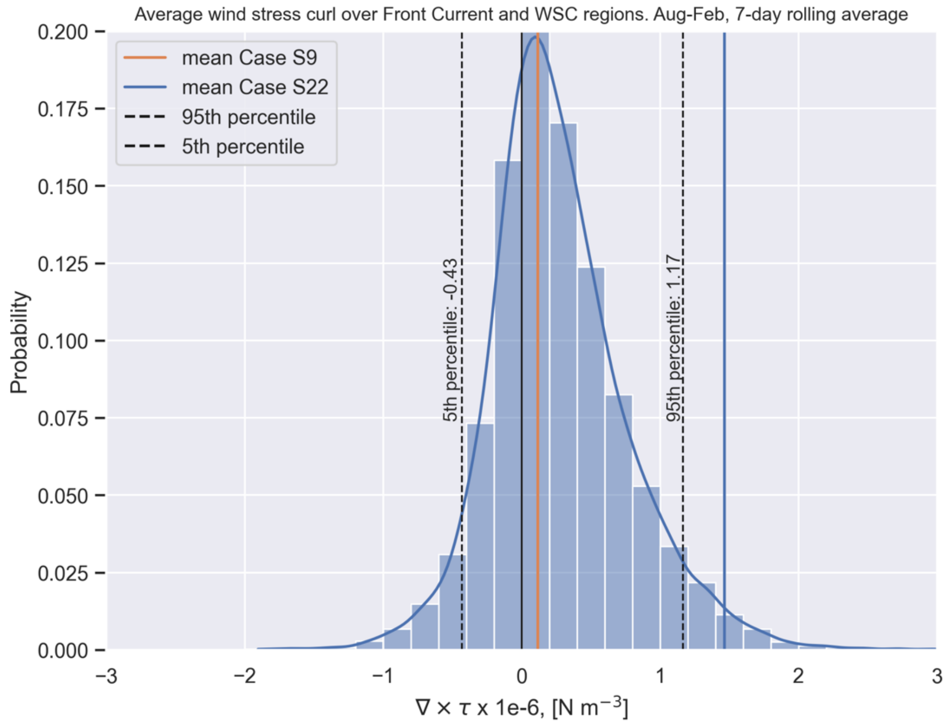

Figure 3. Distribution of the 7-day rolling averaged wind stress curl horizontally averaged over the Front Current and WSC regions (6°E − 12°E, 77.25°N ± 0.75°). The mean wind stress curl during the cases S9 and S22 and the distribution's 5th and 95th percentiles are included

We have added the following lines to section 3.4 to specify these aspects.

Lines 363-369: *"The wind stress conditions during these two cases are not rare in a long-term perspective (Fig. A4). An analysis of wind stress extracted from ERA5 during 1979–2024 and averaged over our analysis section within 7-day-long overlapping windows shows that northward wind stress values exceeding the maximum during case S9 occur 2−15 times each year. Similarly, values of southward wind stress stronger than the maximum southward stress during case S22 occur 1−12 times each year. The maximum stress values during the two case studies are within the 5th and 95th percentiles of the maximum absolute wind stress for each 7-day-long window between 1979 and 2024 (Fig. A4b). The cases highlighted are thus not extreme conditions in terms of maximum wind stress but represent atmospheric forcing that may be expected to occur several times each year."*

We amended further (Lines 370-372): "*Unlike the wind stress, while the September 2021 case (S9) was within the typical expected values of wind stress curl (horizontally averaged over the Front Current and WSC regions: 6°E − 12°E, 77.25°N ± 0.75°), the average wind stress curl during section 22 in December 2022 was stronger than the 95th percentile (Fig. A4c)."*

Minor comments:

Figure 1: Please move the inset with the small maps, so that we can see the entire coastline of Svalbard. That will help the reader to find out where the study is localized.

Re.: In the revised manuscript, we have updated the figure so that nearly the full coast of Svalbard is visible.

Figure 3: what are the light blue dots? They are the same for both panels, but it is not indicated what they represent.

Re.: We have updated the caption (Fig. 4 in the updated manuscript) as follows to make this clear: *"The light blue markers in the background show the data from the full transect and are the same in both panels for reference."*

Figure 7: Very nice figure! Would it be possible though to add some scale for volume transport? Or has it been normalized? Also, for guiding the reader I would suggest indicating clearly which sections are autumn and which ones are winter.

Re.: Thank you! We agree that a scale is necessary. We have included a scale and highlighted fall and winter as you suggest (also in response to the second reviewer's comment).

We have updated this part of the caption as follows: "A scale of volume transport is indicated in the lower left corner of each row. The scales differ because the height of the panels is determined by the total duration of the mission, not the number of sections during the mission. […] Autumn and winter are indicated by the blue and orange background shading."

44: 'Foot of the shelf slope': do you mean the shelf rise? Maybe rather use that terminology.

Re.: Updated as suggested.

103-104: why is there so much variability in the duration of a transect?

Re.: The larger end of the variability is mainly due to the location of deployment and recovery of gliders.

However, we acknowledge that this is not the best way to indicate the duration of the transect. We have therefore estimated the average time it takes from the start to end of each section but only using those sections that cover more than 80% of the target section. Based on this, the average duration for the glider to sample the target section is 23 days (based on 15 sections). Sampling the WSC and the Front Current region takes on average 9 days (based on 21 sections).

We have clarified the text as follows (Lines 109-112): *"The average duration for the glider to sample the target section is 23 days (based on the 15 sections with > 80% coverage of the target section). Sampling the WSC and the Front Current region takes on average 9 days (based on 21 sections with > 80% coverage). The main reason that not all sections cover the full target section is because of the opportunistic deployment and recovery location of the gliders."*

143: I would suggest deleting 'To investigate … glider data'

Re.: Deleted as suggested.

216-217: how is the 'velocity-weighted mean temperature' defined? As far as I can see it is not defined in the manuscript.

Re.: We now defined it as (Lines 130-133): "*Velocity-weighted temperature and salinity are defined as:*

$Y = sum(v_g(x,z)y(x,z)\Delta x\Delta z)/sum(y(x,z)\Delta x\Delta z)$,

where Y is the velocity-weighted temperature or salinity, $v_g(x,z)$ is the velocity field, y(x,z) is the temperature or salinity field, and Δx (Δz) is the horizontal (vertical) resolution of the gridded data."

234-237: In general, the uncertainties inherent to the methodology are not shown in the study. They should be explained somewhere, as they could potentially explain some of the patterns that are observed.

Re.: Agreed. Our group in Bergen has conducted similar studies where the uncertainties on transport estimates using glider data were carefully estimated and described, e.g., Kolås et al. (2020) and Kolås et al. (2024).

We have added the following to quantify this uncertainty (Lines 216-224): "*Some uncertainty in the transport estimates arises from the methodology used to prepare the glider data for analysis. Uncertainties on transport estimates using similar analysis of glider data have been carefully estimated and described earlier (Kolås et al. 2020; Kolås et al. 2024). Their objective mapping, gridding and transport calculations are similar to those presented here. Conservative estimates of the uncertainty in transport calculations of AW in the boundary current north of Svalbard from Seaglider sections were 0.1 to 0.2 Sv (Kolås et al., 2020), and less than 0.1 Sv in the Barents Sea (Kolås et al., 2024). This is much less than the variability quantified by the standard deviation in our results (e.g. Tables 2 and 3, and the shading in Fig. 6) and is typically less than 0.1 standard deviation. Added uncertainties include those arising from filling the missing edges of the sections (quantified above) and those arising from using surface geostrophic currents from the altimeter instead of DAC from the glider (quantified in section 2.2).*"

References: Kolås, E. H., Koenig, Z., Fer, I., Nilsen, F., & Marnela, M. (2020). Structure and transport of Atlantic Water north of Svalbard from observations in summer and fall 2018. Journal of Geophysical Research: Oceans, 125, e2020JC016174. https://doi.org/10.1029/2020JC016174

Kolas, E. H., Baumann, T. M., Skogseth, R., Koenig, Z., & Fer, I. (2024). Circulation and hydrography in the northwestern Barents Sea: Insights from recent observations and historical data (1950–2022). *Journal of Geophysical Research: Oceans*, *129*, e2023JC020211. https://doi.org/10.1029/2023JC020211

240: Could it also be that the AW has not been lost, but that rather the gliders resolve better the branches thanks to their high resolution?

Re.: Thank you for pointing out this alternative explanation. While it is plausible that gliders resolve the branches better, it is highly unlikely that all of the 2.3 Sv higher transport estimate relative to the mooring array can be explained by this. Transport estimates from the mooring array at 79°N can be considered the "golden standard" for the WSC transport and has been monitored for several decades with some confidence. Substantially narrow and high-speed currents are required to increase the transport from 3 to 5.3 Sv. Furthermore, it is well established that there is recirculation of AW in Fram Strait and a substantial fraction of this is expected to occur between the glider transect and 79°N (based on mooring observations and numerical modelling). We therefore retain our explanation as the main hypothesis for the difference between the glider-based and mooring-based transport estimates. We now also mention the alternative possibility as you suggested. We revised as (Lines 288-292):
"Assuming our limited observations are representative of a longer-term average, the large difference between our estimates of total Q_{AW} (WSC region and Front Current region: 2.7 Sv + 2.6 Sv = 5.3 Sv) and the mooring-based transport (3 Sv, Beszczynska-Möller et al., 2012), further

implies that approximately 2 Sv of AW must have been lost to recirculation between 77°15' and 79°N. This agrees with the recirculation estimate by Marnela et al. (2013). A fraction of the discrepancy could also be due to high-resolution measurements from gliders resolving the branches better relative to the mooring array."

292-293: What happens when considering the volume transport of both the WSC and the Front current together? Does the volume transport shows less variability and become more stable?

Re.: The grey bars in the background of Figure 5a shows the total transport, which is not more stable. While the total transport varies between roughly 3 and 9.5 Sv, the northward WSC and Front Current varies between roughly 0.5-5 Sv and 1-7 Sv, respectively. The total range is, i.e., roughly 6.5 Sv, the WSC range is 4.5 Sv, and the Front Current's range is 6Sv.

293: Is there any lag for this co-variability? The co-variability could be quantified better.

Re.: We do not conduct a thorough lagged correlation analysis because the number of sections (i.e., data points) is not sufficient to obtain significant results. The irregular temporal spacing of the data also makes us hesitant to apply a lagged correlation analysis. We have amended the text to clarify this (Lines 344-345): *"Limited to only 7-8 data points with irregular temporal spacing per mission, we cannot confidently quantify the amplitude and lag of co-variability."*

Response to Rebecca McPherson (reviewer #2)

Thank you for reading our manuscript so thoroughly and for all your comments – your input and suggestions helped improve the structure and content of our manuscript.

We hope you will both find that we have addressed your comments satisfactorily.

General Comments

This manuscript presents novel estimates of Atlantic Water (AW) transport across a zonal section in the Nordic Seas, using high-resolution glider measurements collected between 2020 and 2022. The use of gliders to provide enhanced vertical and horizontal spatial resolution—beyond what is achievable with traditional mooring arrays—is a valuable contribution to the field. The finding that transport estimates for both northward and recirculating AW generally align with existing mooring data, while providing new insights into the lateral variability of the West Spitsbergen Current (WSC) and the Norwegian Atlantic Front Current, is particularly noteworthy.

The manuscript is very well-written, generally logically structured, and provides a compelling narrative. The clarity of the prose is impressive and makes for an engaging read.

We are very happy to read that our manuscript has been well received. We thank the reviewer for her motivating and constructive feedback.

Major Comments

This concerns the structure of the results and the discussion. While the writing is generally of high quality, the presentation of results and discussion (specifically in Sections 3.2 and 3.4) would benefit from tighter organization. Currently, there is a tendency to jump between different results, themes and figures, which can obscure the main and interesting findings. It means it is also unclear why you show certain figure panels as you leave them to much later in the section to discuss, after introducing new figures, so they have lost their relevance. Though this often occurs when results and discussion sections are combined, it can be easily remedied by some restructuring and clearer linking sentences between paragraphs. I suggest ensuring that figures are discussed comprehensively and restructuring the sections so that each paragraph builds towards a central result, using clear linking sentences to connect the current, almost sporadic results, into a more cohesive argument.

We agree that the structure of the results and discussion could be improved. When preparing the revised version, we aimed to reorganize the results and discussion so that the results are presented in a more logical order, improving the flow of the text. We have been attentive to how we introduce the figures and strive to focus on one result and its discussion at the time.

As this restructuring required relocating and re-sectioning several paragraphs, we refer to the track-changed version of the manuscript for the overview of changes made in response to this comment. The tracked version is submitted with our final response.

This second point is about strengthening the wind forcing analysis (section 3.4). The case study examining the relationship between wind forcing and AW transport is very interesting but the current approach, which relies on two specific examples of northwards and southwards wind forcing, could be made more robust. I suggest the authors consider inverting their analysis - instead of considering the two examples of different wind forcing and seeing what that corresponds to in the transports, could you instead identify periods of anomalously high/low transport and produce a composite map of the corresponding wind forcing. This 'reversed' approach would more definitively establish the role and dominance of the atmospheric forcing on AW transports and strengthen the evidence for the proposed mechanisms.

Re.: Thank you for this suggestion. We agree that a more robust analysis can be conducted using composites rather than two specific events. To follow up on this, we have estimated the 90^{th} and 10^{th} percentiles of the maximum volume transport for all sections and created composites based on these sections. Each composite has three sections, as shown in Figure 1 below. Sections 9 and 22, which are the basis of the case study, are highlighted according to the legend. Note that section 22, collected when the WSC and Front Current are weak, and the wind stress is strongly southward, has marginally stronger volume transport to be included in the "10th percentile" composite, but is within the 20th percentile (recall that this distribution is made up of only 22 data points).

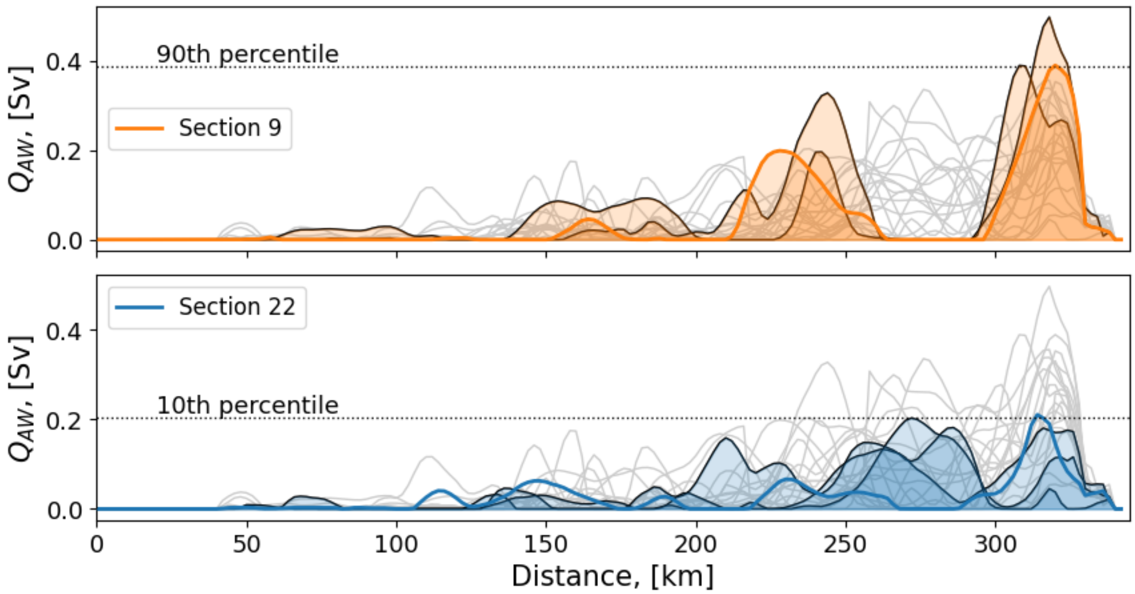

Figure 4. Volume transport of AW across the target section with maximum transport stronger than the 90th percentile of the maximum of all sections (filled orange) and less than the 10th percentile (filled blue). All sections are shown in gray. The sections used in the case study are indicated in thick orange (section 9) and blue (section 22) lines.

The wind stress in the 90th percentile composite agrees well with the case study (Figure 2, middle panel). The wind stress has a strong northwestward component, which can contribute to coastal Ekman transport and the enhanced WSC through barotropic adjustment. This composite transport is consistent with the single event, showing a clear separation between the WSC and a strong Front Current, supporting the Section 9 observation robustly.

The wind stress in the 10th percentile composite (Figure 2, left panel) has notably different characteristics than the wind stress during the case study of Section 22 when the WSC was relatively weak. The main takeaway from this composite is that when the maximum transport is weak, the overall wind stress field also appears to be particularly weak.

However, we note that in this composite, we have considered the maximum transport over the full transect. When we only consider the maximum transport in the Front Current region (200-300 km horizontal distance on our target transect), the sections with the weakest Front Current correspond to a strong southward wind stress field (Figure 2, right panel). This supports our argument that Ekman divergence lifts the isopycnals that support the Front Current, thereby reducing its volume transport.

Based on the limited data set with a small number of sections, we cannot conclusively identify a seasonal variability in the magnitude of transport. The three sections with large volume transport are in September, October and November, while the sections with small transport are in September, November, and January.

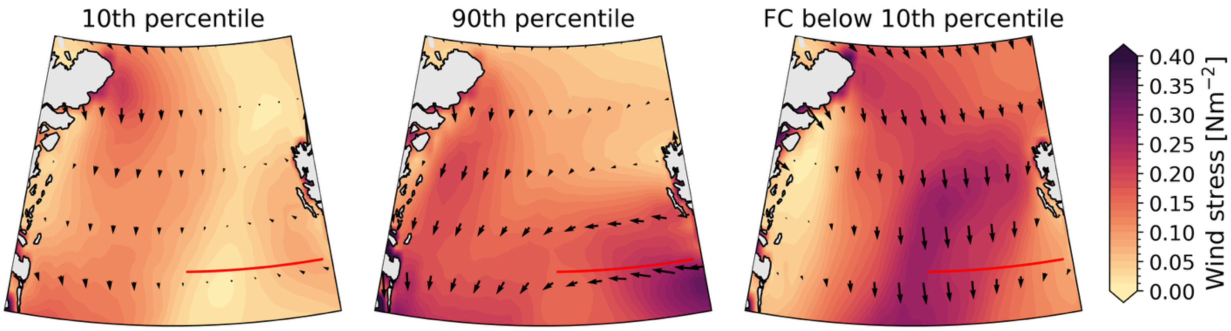

Figure 5. The average wind stress during the three sections of the 10th and 90th percentile composites and the three sections when the Front Current is weaker than the 10th percentile of maximum Front Current (FC) transport.

This composite analysis yields credibility to the conclusion regarding strong WSC. The patterns relating to a weakened WSC are not systematic, but weak transport within the Front Current corresponds to strong southward wind stress.

In the revised version, we emphasize these findings by amending the following text:

Lines 382-386: "*While limited in sample size by 22 sections, a more robust conclusion can be attempted based on a composite analysis using sections with weak Front Current transport. We select the sections with $Q_{AW,\ max}$ within the Front Current less than its 10th percentile over all sections. The average wind stress field during these three sections has a dominant southward component (not shown), supporting a relationship between the southward wind stress and the Front Current strength. Note that the significance of this composite is limited by the sample size of three out of 22 sections.*"

Lines 390-393: "*Similarly to cases of weak Front Current transport, a composite can be made of the wind stress field during strong WSC transport. We detect three sections when $Q_{AW,\ max}$ in the WSC was larger than its 90th percentile over all sections. The average wind stress field during these three sections has a clear northwestward component (not shown).*"

Specific Comments

Line 11: 'resolve spatial variability', as mooring arrays do capture temporal variability better than gliders.

Re.: Changed as suggested.

Figure 1: is it still fair to call the northern extent of the WSC (north of 80°N) the WSC? Or more accurately is it the Svalbard Branch? As you have already named the Yermak Branch separately.

Also consider adding a line where the AWI moorings at ~79°N are, as you reference them and the Beszczynska-Müller et al., (2012) volume transport estimates a lot.

Re.: Agreed. We have changed the corresponding WSC label to "Svalbard Branch" and added the mooring locations at 78°50'N.

Line 25: 'detailed horizontal structure'

Re.: Changed as suggested.

Line 56: Tie the two points about the WSC core and the more northern transports together – does this imply that the WSC core is solely responsible for the transports measured on the southern slope of the Yermak Plateau?

Re.: We have updated this sentence to clarify (Lines 55-59): *"[...], and the remaining can be considered to contribute to the recirculation and the Yermak branch. Consistently, further north, at roughly 80°N after the circulation branches separate (Fig. 1a), year-round observations from moorings on the southern slope of the Yermak Plateau show an average AW transport of 1.1 ± 0.2 Sv with a maximum in autumn (1.4 ± 0.2 Sv), and a minimum in summer (0.8 ± 0.1 Sv, Fer et al., 2023)."*

Line 62 - 63: I think the main issue is not the scarcity of data (there are multiple cruises to Fram Strait each year from myriad institutions and all tend to take hydrographic profiles) but that the data is generally summer-focused and therefore not a good representation of annual variability (this is also where the novelty of your glider measurements lies). So gliders not only fill the spatial gap but also in the months where ships don't generally sample.

Re.: Thank you for emphasizing this point. We have updated this sentence to clarify (Lines 64-65): *"Ship-based hydrographic and current sections help address these questions, but such data are generally collected during summer, and therefore not a good representation of annual variability."*

Line 88 – what months do you define as autumn and winter? What happens to the data you collect in July and August (which are arguably summer months)?

Re.: We keep each section intact in the autumn and winter estimates. Sections that end before 15th of November are defined as autumn, and sections starting after 15th of November are defined as winter. Sections that include the 15th of November are assigned to autumn or winter, depending on when most of the data points in the section were collected. This yields roughly the same number of sections in each season.

Sections that contain data from both August and September are assigned to autumn. One short section that only collected data from August is disregarded in the seasonal analysis. The figure below shows the distribution of data throughout the year.

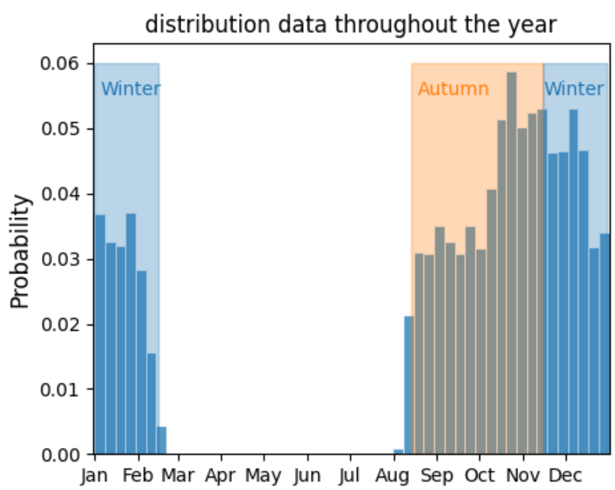

Figure 6. Seasonal distribution of data collected by the gliders. The periods defined as autumn (orange) and winter (blue) are indicated.

We clarify our choices and definitions as (Lines 126-128): "*In season-specific calculations, autumn and winter are defined as the parts of a mission before or after 15 November. To keep a section intact, if it includes 15 November, the section is assigned to the season it contains the* *most observations from. One section exclusively contains data from August and is thus disregarded from season-specific estimates."*

Regarding the data collected in July: Deployments were made from a ship of opportunity at locations close to the target section that were also convenient for the ship's cruise plan. For example, in August 2021 (mission 2), the deployment was near 79°N, 0°E, and the glider arrived at the offshore end of the target section on 14 Aug, after 11 days. For mission 3, starting in Jul 2022, the deployment was near 79°N, 8°E. The glider arrived at 5°E (i.e., the middle of the target section) on 7 August and proceeded onshore. Because this section was partial, it was excluded from the analysis. The target section from the onshore end started on 17 August.

We aim to include as much of the collected data in the analysis as possible, but because of these deployment constraints, we disregard a period at the beginning of all sections. The longest such period was during the last glider mission, which started in July. Therefore, the data collected in July is not included in the analysis.

We amended the text (Lines 85-88): *"Deployments were made from a ship of opportunity at locations close to the target section that were also convenient for the ship's cruise plan. As a result, there is a period during which the glider is in transit toward the target section at the beginning, or toward the recovery location at the end of each mission."*

And lines 93-95: "*We only use the profiles from the target section in our analysis and exclude the periods when the gliders were in transit. The transit period to the target section was longest, approximately two weeks, during mission 3."*

Line 105 – is this a typical way to define a glider section? It seems overly confusing to split it into distance and then longitude, especially as you refer to distances throughout the rest of the paper (i.e., the lateral boundaries separating the cores). If this is standard practice, can you add a line that says so. Else make it clearer from the beginning why you are doing this as it is not clear.

Re.: Our description was unfortunately confusing. We have used "distance" and "longitude" interchangeably here. Basically, our gridding is based on horizontal distance (equivalent to longitude for this zonal section). However, because the boundary current is strongly guided by topography and the shelf-break, gridding of the profiles east of 300 km (roughly 10°E) requires special treatment. We simply move the position of these profiles along bathymetry to the corresponding isobath on the target section, and then use distance for gridding. This is a typical way of gridding glider data in the presence of boundary currents.

We updated these lines to make this clearer (Lines 115-118): *"Gridding is based on distance. East of 300 km (~10°E, ~1600 m isobath), however, currents are strongly influenced by the steep bathymetry near the continental shelf break. Profiles collected in this region are assigned to their corresponding isobaths and distance on the target section before gridding. This is a typical method when gliders are advected by boundary currents that are guided by topography."*

Line 130: what is the horizontal resolution of this product?

Re.: The global resolution is 0.125°x0.125° (User manual of https://doi.org/10.48670/moi-00148). We have added this information (Lines 145-147): *"Outside this period, depth-averaged currents from the glider agree well with surface geostrophic currents from the gridded altimeter product (Global Ocean Gridded L4 Sea Surface Heights And Derived Variables Reprocessed 1993 Ongoing, 2024, horizontal resolution 0.125°) calculated from the slope of the absolute dynamic height using a geostrophic balance (Fig. A1).*"

Line 141: you handled this comparison between glider velocities and surface altimetry well – it is well described and makes sense. Can you give a percentage of the difference using each method, like Mork and Skageth (2010) (i.e., their 15%)? You don't have to show the figure but a number would be very helpful for context.

Re.: When comparing the mean absolute values of glider-based velocities and satellite altimetry-based velocity estimates in the WSC and Front Current regions, the glider-based estimate is 4% less than the surface altimetry estimate (excluding sections 7 through 10).

We revised as (Lines 154-156): "*Excluding the first half of Mission 2 (sections 7 through 10) with erroneous DAC estimates, the absolute depth-averaged current estimated by the gliders is, on average, 4% weaker than the satellite altimetry estimates."*

Section 2.4 – it is a shame that it wasn't possible to identify the two cores in every section – I had hoped this would be a major advantage of using gliders and moving away from the fixed boundaries that moorings assume. However, you can still resolve the horizontal scales much better so at least the estimates using these fixed boundaries are more accurate. Good progress.

Re.: Thank you for this constructive comment. No action taken.

Figure 3 – be more specific about what the light blue markers actually are in the caption (not just that they remain the same in both panels).

Re.: We have updated the caption (Fig. 4 in the revised manuscript) to read: *"The light blue markers in the background show the data from the full transect and are the same in both panels for reference.*"

Section 3. These two paragraphs before 3.1 should be re-written/removed – they are specific results that don't fit in this introductory part, and seem unrelated when written in this way. Start with Line 199 (In the following…) and outline what you are going to describe in the upcoming section. Keep the specific (and seemingly randomly chosen) numbers to their relevant section (i.e., maximum temperatures and salinities can be moved to 3.1 when discussing the standard deviation from the mean state). The seasonal cycle of wind stress (Line 200 – 205) also needs some context – move it to the subsection where you link the transport variability to wind forcing.

Re.: We have restructured these paragraphs as suggested:

The description of maximum temperature, salinity and currents is moved (Lines 252-256): *"Atlantic Water is present […] Front Current regions (Fig. 4).*"

The description of the wind stress is moved to section 2.3 (Lines 168-172): *"During the mission years (2020-2022), the wind stress across […] and 2024 is* -0.04 ± 0.07 *N* m^{-2}*."*

Line 210 – what is the standard deviation/width of the WSC? How much does it laterally vary?

Re.: Estimating the width and variability of the WSC was one of our initial goals, but it proved difficult to estimate in an objective and robust way due to the frequent merging of the current cores. We tried, among other methods, Gaussian fitting and applying velocity thresholds to identify the core position and width; however, we found that too many subjective choices had to be made and thus we have not included these estimates in the manuscript.

In response to your question, however, we have conducted a simplified estimate based on the AW volume transport. Figure 4 below is analogous to Figure 1 but shows all sections with max Q east of 275 km larger than the 60th percentile in orange (upper panel). We limit this estimate to east of 275 km to only select sections with distinct WSC and Front Current cores. In the lower panel, the average of these filled orange sections is shown.

Based on the mean Q in the lower panel, we arrive at these estimates of the WSC core:

- Mean width: 28km
- Standard deviation of the width: 7 km
- Standard deviation of the western boundary: 7km
- Standard deviation of the eastern boundary: 0km

We have summarized this result in the revised version (Lines 236-242): "*Intermittent merging of the current cores makes it difficult to apply an objective and robust method to delineate the cores. A simplified estimate of the WSC core width can be made based on the northward volume transport. We consider the vertically integrated volume transport of each section (i.e., Q as a function of zonal distance) and estimate its maximum value east of 275 km in each section, Q_{max}. We limit the estimate to the east of 275 km to only select sections with distinct WSC and Front Current cores. We then compute the average northward volume transport across all sections with Q_{max} greater than the 60th percentile. The zonal extent of the region with transport exceeding this threshold gives a representative estimate of the WSC width, 28 ± 7 km. The standard deviation is due to variability at the western boundary.*"

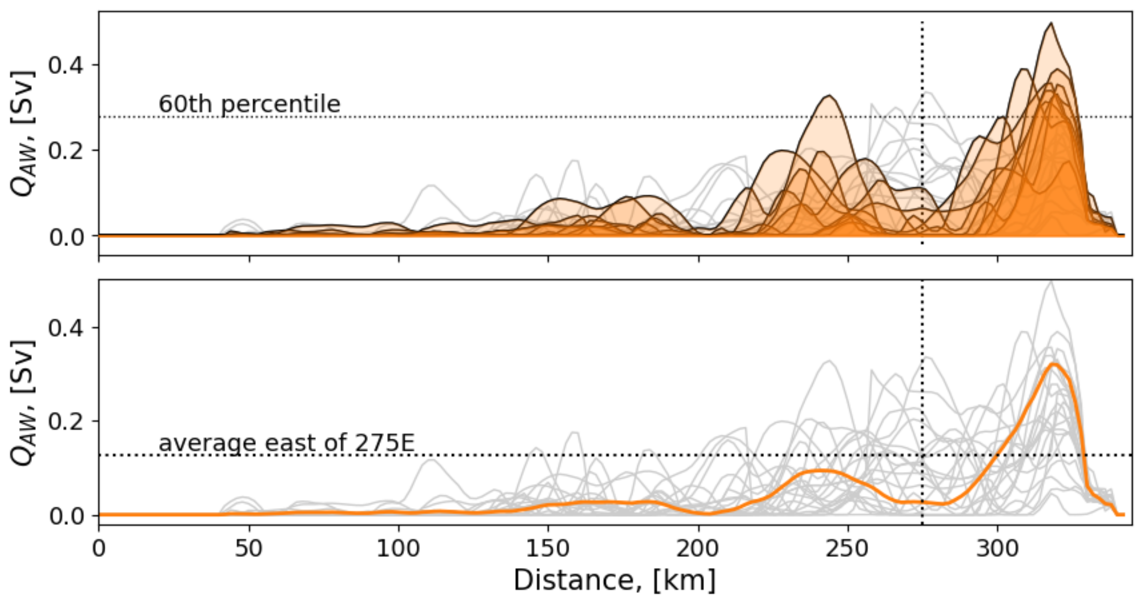

Figure 7. All sections with max Q east of 275 km larger than the 60th percentile (dashed black horizontal line) in filled orange (upper panel) and their average (orange, lower panel). The volume transports of all sections are included (thin grey lines). The vertical dashed lines indicate 275 km east, and the horizontal dashed line in the lower panel indicates the average Q east of 275 km.

Line 213 – are the mean hydrographic properties also distinct between branches like the velocities? Warmer temperatures in the WSC? Salinities? Not just seasonal (such as described in Table 2) but as a mean section. You start this in Line 221 – move it up here so the mean sections are described together, and elaborate on the differences between the two currents hydrographically.

Re.: We have restructured and added these details as suggested. Lines 244-246 are added to include the average hydrography values: "*The velocity-weighted average temperature (Eq. 1) within the WSC is more than 1°C warmer than within the Front Current region (4.1°C vs. 2.8°C, Fig. 3). The velocity-weighted average salinity is 35.156 g kg^{-1} within the WSC and 35.146 g kg^{-1} within the Front Current.*"

We have also added these values to Fig. 3 with the following update to the legend: "*Average Θ – SA values of a) the Recirculation region within the northward and southward current domains, and b) within the WSC and Front Current regions are indicated according to the legend.*"

Line 239: not actually identical – use a different word.

Re.: Agreed. The sentence now reads (Lines 316-318): *"While the mean net transport of the WSC and Front Current are comparable (within 0.1 standard deviation, Table 3), some sections have significantly larger near-instantaneous northward Q_{AW} in the Front Current, e.g. in January 2022 and the second half of August to September 2022 (∼ 2 times the average, Fig. 6a)."*

Line 239 – 240 - 'mean transports are typically comparable', some sections show 'near-instantaneous' large QAW (to make it clearer than one is from the total mean and the other more of a snapshot), and give some quantitative evidence (e.g., XX%/Sv higher than the mean during the two example time periods).

Re.: These lines are updated as indicated in the response to the previous comment.

Line 238 – where does the 5.3 Sv come from? This is the total AW across the whole section? Make this clearer, and perhaps even include it in the table.

Re.: 5.3 Sv is simply Q_{AW} within the Front Current region + the Q_{AW} within the WSC region (2.6Sv+2.7Sv=5.3Sv). We have now specified this (Lines 288-289): *"[…] estimates of total Q_{AW} (WSC region and Front Current region: 2.7 Sv + 2.6 Sv = 5.3 Sv) […]"*

Figure 6. Only include the relevant contours (the blue/orange/red) for each panel (i.e., the WSC shouldn't have the blue southwards contour line)

Re.: We agree and have updated the figure as suggested. This part of the caption now reads: "*The black contours indicate volume transport of 2 Sv a) southward and b) northward in the recirculation region, and c) net in the WSC and Front Current region.*"

Figure 7. This would benefit from having some kind of coloured bands representing the seasons across the panels. As it stands, the figure is great but hard to interpret when looking at seasonal variability (the dates on the left hand side are useful but colours would really simplify what you count as autumn or winter). Also add a grid to the panels b and c so it's easier to read values and compare sections.

Re.: Thank you for this suggestion. We have highlighted fall and winter as you suggest with orange (fall) and blue (winter) backgrounds in the panels.

Line 278 – remove or reword the 'in agreement with Beszczynska-Müller et al., (2012)' as it makes it sound like they also found anomalously higher transports in 2020 and 2022 – emphasise that it's the seasonal difference observed. However, this also contradicts your point which says that no seasonal cycle was observed in the WSC core by Beszczynska-Müller et al., (2012) so clarify this.

Re.: Thank you for pointing this out, it helped us be more precise and correct in our referencing to these details. We agree that these aspects should be clearer. The conclusions found by Beszczynska-Müller et al., (2012) are that

1) In their defined WSC core (roughly east of 8°E; note that their transect is further north than ours), the northward volume flux was 1.3+0.1 Sv of AW warmer than 2°C, with no seasonal variability.
2) In their defined offshore WSC branch (roughly 5°E-8°E), the long-term mean was 5+0.4 Sv, with a strong seasonal variability.

We have updated the following lines to make these distinctions clear (Lines 52-55):

"At the Fram Strait mooring array, the average (1997–2010) northward volume transport of water warmer than 2°C is 3.0 ± 0.2 Sv (Sverdrup, 1 Sv ≡ 10x6 $m^3 s^{-1}$), showing a strong seasonal signal with summer averages approximately doubling in late autumn and winter due to

variability within their defined offshore WSC branch (Beszczynska-Möller et al., 2012). Out of these 3 Sv, 1.3 ± 0.1 Sv is carried in the WSC core (Beszczynska-Möller et al., 2012).

And (Lines 312-315): "*This seasonality agrees with the seasonality within the offshore WSC branch in Beszczynska-Möller et al. (2012) but disagrees with the lack of observed seasonality within their main WSC core. This partial agreement could be fortuitous and due to lateral adjustments in current characteristics or interannual variability. For example, during mission 2, the AW transport in the WSC was relatively high during both crossings in autumn, and low in January."*

And further (Lines 318-321)*: "The lack of seasonal variability within the core defined by Beszczynska-Möller et al. (2012) implies that the near-zero Q_{AW} estimates within the WSC in our data (e.g., January and September 2022) likely occur because the core is displaced out of the zone selected for this branch and potentially merged with the Front Current, or temporarily suppressed."*

Line 289 – this is a very interesting point (that velocity dominates AW changes in the FC and temperature in the WSC) – can you make it slightly more quantitative/results-based or give more examples with numbers? Right now, it reads like speculation and would benefit from another sentence or 2 to strengthen it.

Re.: Thank you for pointing this out, we agree that this aspect can be strengthened. We have estimated R^2 for the Q_{AW} and area of AW for the WSC and Front Current regions as well as values describing the isopycnal depth and WSC velocity during the discussed sections 11 and 12.

The two paragraphs describing this are updated as follows (Lines 325-341): *"A reduced amount of water warm and saline enough to be considered AW could also explain the sections of low AW volume transport. However, the area of AW present in the WSC region remains relatively stable throughout the glider sections and there is no correlation with Q_{AW} (R^2 = 0.01, excluding section 14 as it did not cover the WSC and Front Current regions). Conversely, in the Front Current region, the cross-sectional area of AW does co-vary with the AW volume transport (R^2 = 0.7, excluding section 14). This suggests that the volume of AW limits Q_{AW} in the Front Current region but not in the WSC region. The current speed is thus the remaining factor that can control the AW transport in the WSC region. If this is the case, we would expect a large AW area to yield high Q_{AW} in the Front Current but not in the WSC unless the currents are also strong. Two examples with anomalously weak Q_{AW} in the WSC region but large Q_{AW} in the Front Current region are sections 12 and 13 (Figs. 6a and 7a). During these sections, the σ_0 = 27.97 isopycnal is deep and relatively flat (630 ± 50m and 600 ± 95m vs. 490 ± 120m and 380 ± 95m for case study sections 9 and 22 discussed below), sustaining a large volume of AW in both the Front Current* *and WSC regions. However, the average WSC velocities are low (section 12: 5 cm s^{-1} and section 13: 2 cm s^{-1}), and the large area of warm water thus does not translate into high Q_{AW} in the WSC.*

While the divide between the Front Current and WSC regions at 300 km appears to be a robust choice (Fig. 3 and Fig. 7), these two current cores do occasionally merge (e.g., sections 2, 5, 12) and shift (e.g., sections 13 and 17, Fig. 7). This contributes to the apparent fluctuation between strong Q_{AW} in the Front Current and the WSC during some instances. We thus note that a larger sample size would be necessary to make a more confident conclusion regarding this possible distinction in limiting factors of Q_{AW} (area of AW vs. current speed) in the WSC and the Front Current."

Section 3.3. There needs to be some mention that it is mostly autumn and winter that are sampled here so spring and summer (thus the whole seasonal cycle) cannot be fully quantified. A definition of each season would also be helpful here (see my earlier comment) as there are sections taken in July/August. I assume that there are not enough repeated sections in these months to say something of statistical significance?

Re.: Indeed, we should emphasize that the seasonal cycle cannot be fully quantified. In response to your earlier comment, we have already clarified the definition of each season. Here, we have added lines 309-310 to emphasize the lack of sections in spring and summer: *"Note that the full seasonal cycle cannot be resolved as the gliders mostly sampled autumn and winter, and lack sections in spring and summer.*"

Line 296. -297. This is both a results and discussion section so add some discussion to this result. Is this expected?

Re.: We have expanded on these results as follows (Lines 346-353): "*Considering observed and modeled mean circulation in this region (e.g., Hattermann et al., 2016; Beszczynska-Möller et al., 2012; Wekerle et al., 2017; Hofmann et al., 2021) where the main recirculation occurs west of 0°E, it is surprising that the southward component dominates as far east as in our defined recirculation region (~ 0°E − 6°E). The main exception is in November and December 2021, when there is a strong (> 4 Sv) northward transport of RAW also in the recirculation region. This variability in direction of the RAW transport is likely not influenced by the position of the Front Current, as its average position and region of high standard deviation are well away from the boundary between the Recirculation and Front Current regions (Fig. 3a,b). It thus indicates relatively large variability in the circulation pattern between the northward AW branches and the southward East Greenland Current."*

Section 3.4. Are you assuming an instantaneous response in the AW transport to the wind forcing?

Re.: Yes, we are relating the wind forcing during the time it took the glider to cross the Front Current and WSC regions. We specify this on lines 358-362: *"We expect that the effect of wind stress on the WSC through coastal Ekman transport can happen quickly (< day). The response time is likely longer (day to week) for the effect of Ekman pumping/lifting of the isopycnals supporting the Front Current. In comparison, the average duration to cover the WSC and Front Current region is 9 days, and the WSC region alone is approximately 3 days. During the case studies, the wind field is averaged over 7 days (S22) and 10 days (S9)."*

In this section, better separate the discussion about two wind anomalies – it is sometimes hard to tell if you are discussing the northward or southward wind forcing.

Re.: We have rewritten this section to keep the two case studies more separate. We refer to the track-changed version of the updated manuscript for an overview of these changes.

Line 331 – not just northwards transports are presented here

Re.: Correct. We have rewritten this sentence as follows (Lines 406-407): *"We present transport estimates of warm Atlantic Water (AW) and Recirculating Atlantic Water (RAW) across a zonal transect at 77°15'N based on repeated ocean glider sections."*