We highly appreciate helpful comments and suggestions by Reviewer #1. In the following, the comments by Reviewer #1 are underlined and our responses to the comments are in normal characters. Modifications to the text are shown in quotation marks with bold characters indicating newly added text, and normal characters indicating text that was already present in the previous version. The line numbering is referenced to the original copy of the manuscript.

Interactive comment on "Arctic Ocean outflow and glacier–ocean interaction modify water over the

Wandel Sea shelf, northeast Greenland" by Igor A. Dmitrenko et al., Anonymous Referee #1

Review of Dmitrenko et al. "Arctic Ocean outflow and glacier-ocean interaction modify water over the Wandel Sea shelf, northeast Greenland"

Summary: the paper investigates water masses and water column structures based on CTD profiles collected in 2015, and aims at identifying relevant processes and interactions between the different local and advected water masses. The study region is very remote, and largely unexplored, and the spring sampling campaign resulted in a quite unique dataset. While the main conclusions of this paper appear plausible, I find that text and figures need to be improved to convincingly present the main points. In the current form, the text is not easy to follow and could be significantly improved, in particular the introduction and parts of the results and discussion. Some of the figures are very busy, and require a tedious amount of time to identify the relevant details as mentioned in the text. Overall, I find that the paper presents very interesting data and summarizes four plausible main findings at the end of the paper, but requires some major improvements in text and figures to convincingly guide the reader through the paper.

Below please find some general comments as well as more specific recommendations.

1. Introduction: I suggest that the introduction should better introduce the study region and better highlight the significance of the presented scientific aspects. I imagine that most readers are not familiar with the Wandel Sea, and more details may be needed to provide the background necessary to understand the region's relevance as is discussed in the text. Parameters such as area/width of the shelf, depth, bathymetry... How does this shelf compare with other Arctic shelves or is the Wandel Sea rather a glacial inlet or so rather than a shelf? From the maps provided in the paper, I don't get a sufficient idea of the relevance of this region beyond the local scale. However, since the aim is clearly to connect the region with upstream and downstream conditions as well, a more comprehensive introduction might help. A stronger formulation of scientific objectives is needed, rather than to "...investigate the vertical CTD profiles..." (lines 66-67).

The introduction was substantially edited to address questions pointed out by Reviewer #1. The following text was introduced:

1. Second paragraph of introduction, to line 46: "***The Wandel Sea is predominantly covered by landfast multiyear sea ice all year around, and only the interior of fjords may become ice free during late summer (Figure 2b)***."

2. Last two sentences of the second paragraph of introduction, after reference to *Palmer et al.*, 2010 and *Rinne et al.*, 2011, line 49 "***In general, the Wandel Sea is rather a glacial inlet than a shelf sea. It is comprised by several fjords open to the continental slope (Figure 2b). The landfast ice edge in Figure 2b roughly marks the Wandel Sea continental shelf break located in about 35-45 km from the fjord mouths. The bathymetry of the Wandel Sea shelf and upper continental slope is poorly known***."

3. Third paragraph of introduction, after reference to de Steur et al., 2009, line 58: "The coastal branch of the Pacific water flow along the southeast coast of Greenland was reported based on observations [***e.g., Bacon et al., 2002; Sutherland and Pickart, 2008; Sutherland et al. 2009] and numerical simulations [Hu and Myers, 2013; Aksenov et al., 2016]. However, the pathways of the low salinity Pacific water along the northeast coast of Greenland are debatable***.".

4. The following text was introduced after line 61, reference to Figure 1: "***The interaction of warm Atlantic Water with tidewater glacier outlets along the southeast coast of Greenland results in ocean-driven glacier melting. This generates additional fresh water flux contributing to the regional fresh water budget [e.g., Straneo et al., 20011, 2012; Sutherland and Straneo, 2012; Inall et al., 2014]. For the Wandel Sea shelf, the efficiency of the glacier-ocean interaction is not assessed because of the unknown oceanographic conditions at the glacier-ocean interface***.".

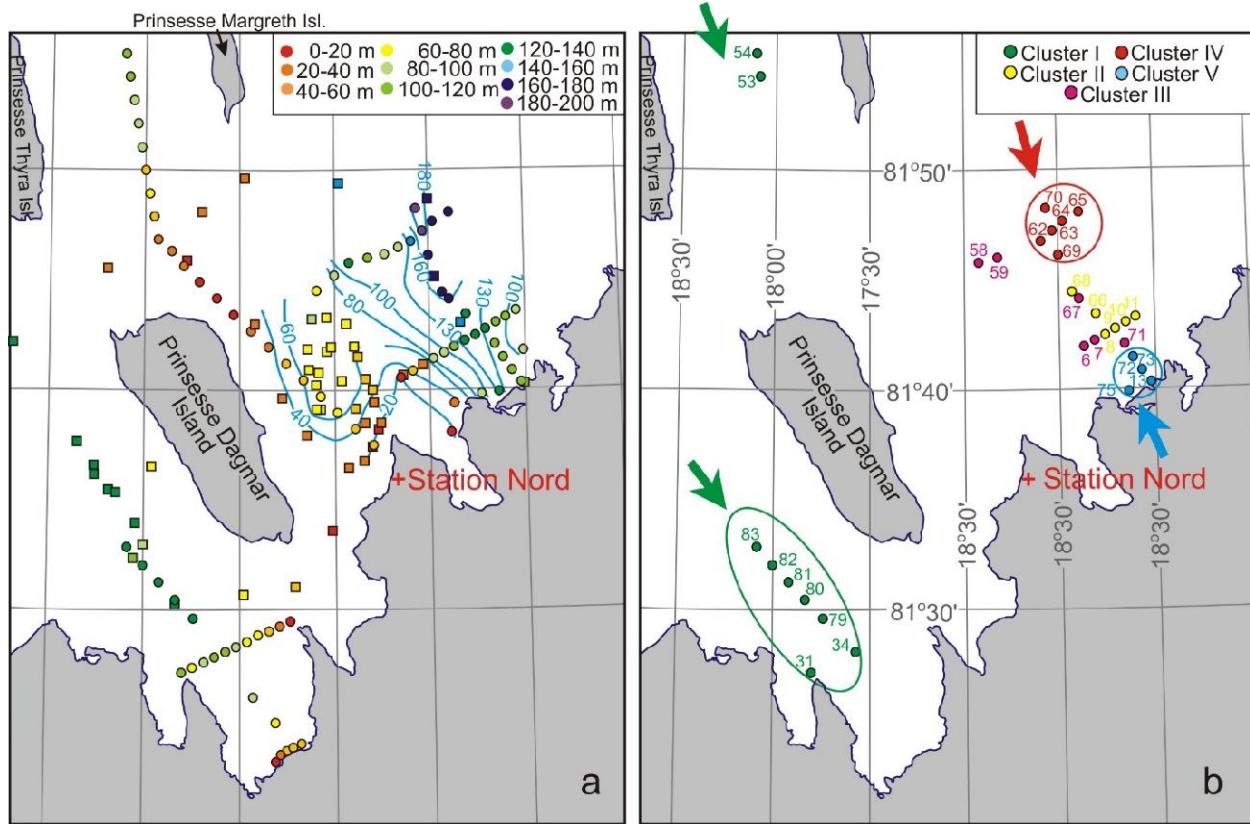
5. Sentence in lines 63-66 was modified as follows: "*This paper is focused on analysis of the first-ever conductivity-temperature-depth (CTD) observations on the Wandel Sea shelf collected from the landfast ice in April-May 2015* **(Figure 3) to put this region in the context of upstream, downstream and local conditions with a special focus on the Arctic Ocean outflow and ocean-glacier interaction***.".

6. Sentence in lines 66-67 was updated: "*Our objectives were to investigate the principal features of vertical profiles of salinity and temperature taken over the shelf regions deeper than 100 m* **for tracing the water origin and local modifications***.".

2. Results: the results are difficult to follow. In particular the clustering is somewhat confusing and not obvious why this is done. Perhaps a better organization into subchapters might help, with section titles that help the orientation. The introductory sentence for the clustering is given in lines 197-199, but may be better before the clusters are introduced. Are all 5 clusters needed for the paper or could the paper do with less for a better overview? There are 5 clusters and 3 regions defined and I wonder if this is necessary. From the map I cannot distinguish between an outer shelf and a mid-shelf region (regions 1 and 2), but perhaps I am just confused by the terminology that is more commonly used for larger shelves. What is the connection between the two regions that are summarized in cluster 1? Perhaps Figure 7 might be better placed at the beginning of the cluster presentation rather than at the end.

Responding this comment by Reviewer #1, we:

1. Reorganised subchapters, with new subsection titles that help the orientation as "***3.1. Water mass structure***", "***3.2. CTD clustering***", "***3.2.1. Methods of CTD clustering***" and "***3.2.2. Description of clusters***";

2. Removed reference to regions from both text and figures;
3. Removed the terminology that is more commonly used for larger shelves such as outer shelf, mid-shelf and inner shelf;
4. Reduced the description of clusters I and II in subsection 3.2.2 to focus on the key clusters IV and V – lines 204-208 and 216-219 were omitted;
5. Moved upfront to Figure 4b the cluster presentation in Figure 7.

New Figure 4

The two regions summarized in cluster I were ice-free during the preceding summers that results in a relatively warm Halostad for the open water cluster I. This explanation is provided in cluster description. Only two clusters are discussed in this manuscript, but for the comprehensive analysis all profiles >100 m depth were processed, clustered and described. Regions were completely omitted.

3. Ocean glacier interaction subchapter: Would an estimate of glacial melt due to glacier-warm water interaction be not as interesting as calculating salinity differences considering the high interest in Ocean-glacier interaction?

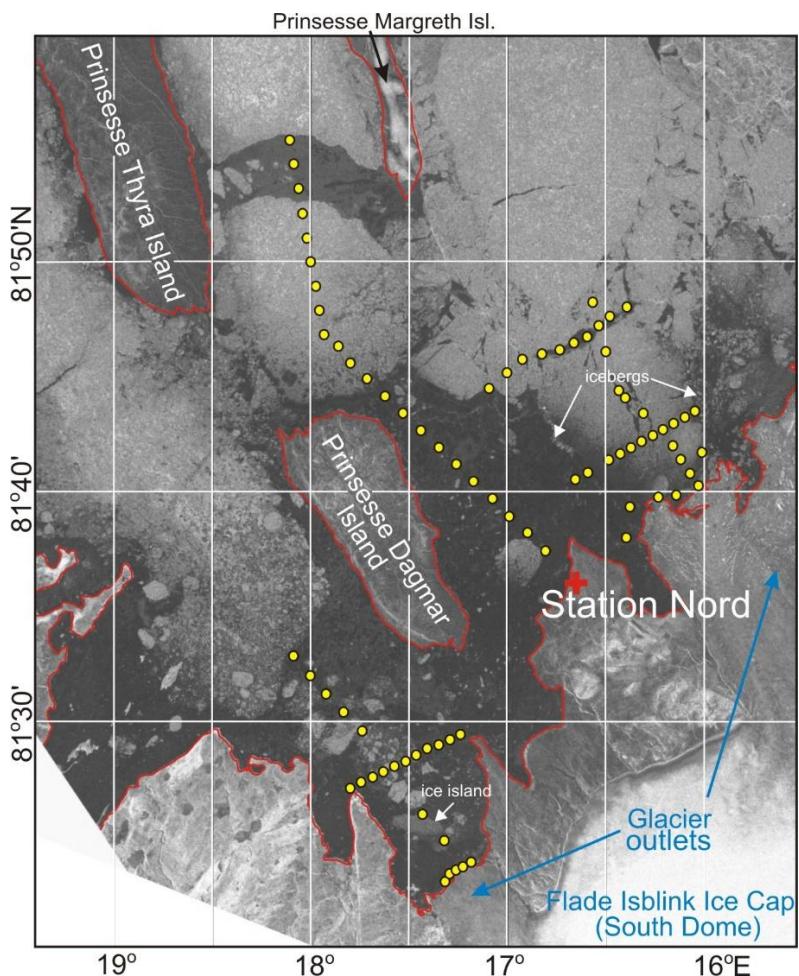
Yes, it would. However, we have no information on the time scale of the ocean-glacier interaction. Without time dimension, we cannot estimate heat fluxes and associated melt rate.

4. L389: Upwelling over the continental slope: Seems random. What kind of upwelling, was upwelling documented before, and where is the Wandel Sea continental slope with respect to your study region?

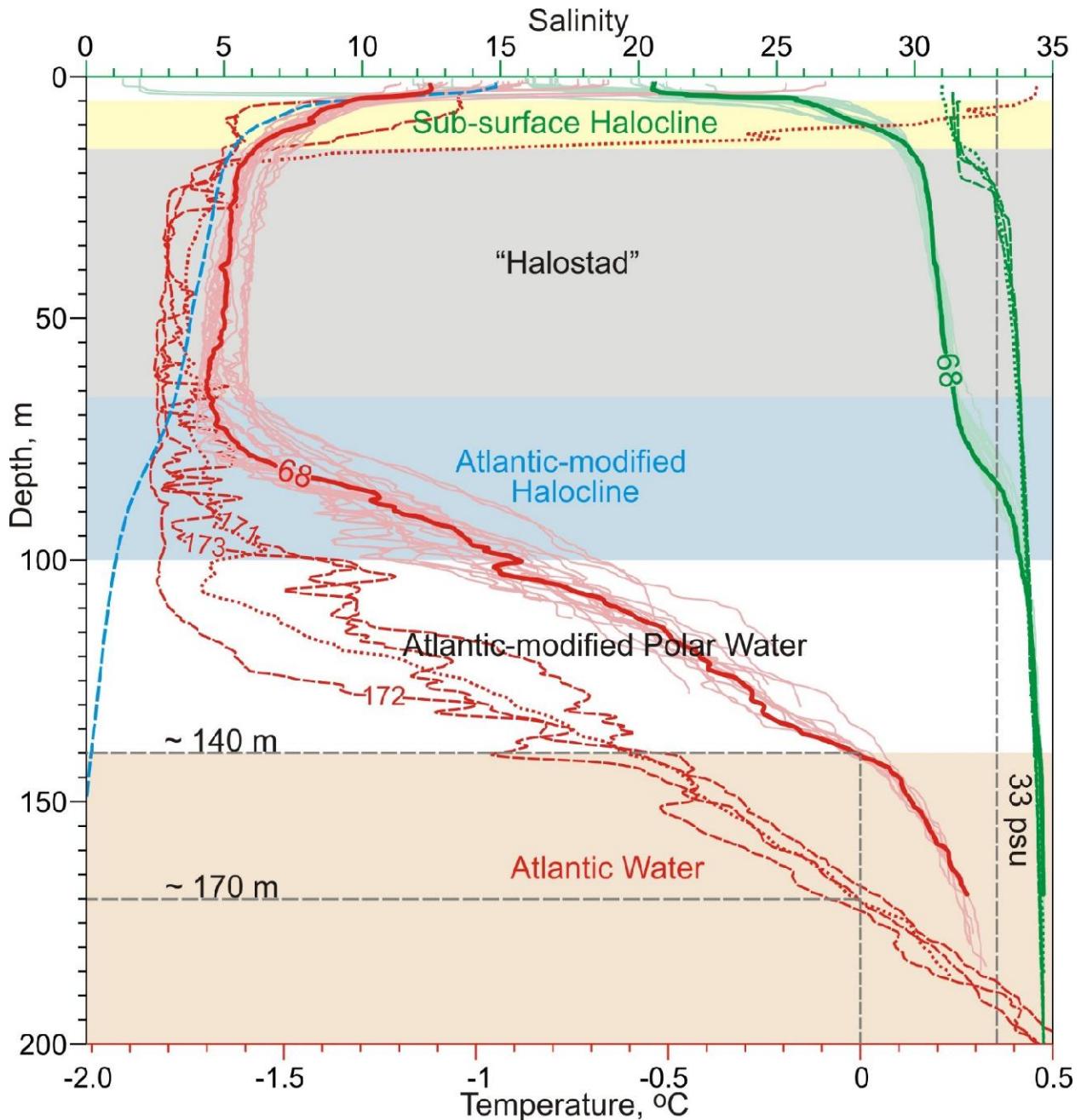
The upwelling was hypothetically suggested to explain the difference between the on-shelf and off-shelf water mass structure. This is pointed out in lines 407-408: "*Hypothetically, the wind-driven upwelling of the Atlantic-modified PrW and AW over the continental slope can result in uplift of the water masses over the outer shelf.*". There are no instrumental observations of upwelling in this area. We specify position of the continental slope after line 48 as follows: "***The landfast ice edge in Figure 2b roughly marks the Wandel Sea continental shelf break located in about 35-45 km from the fjord mouths***.".

Figures:

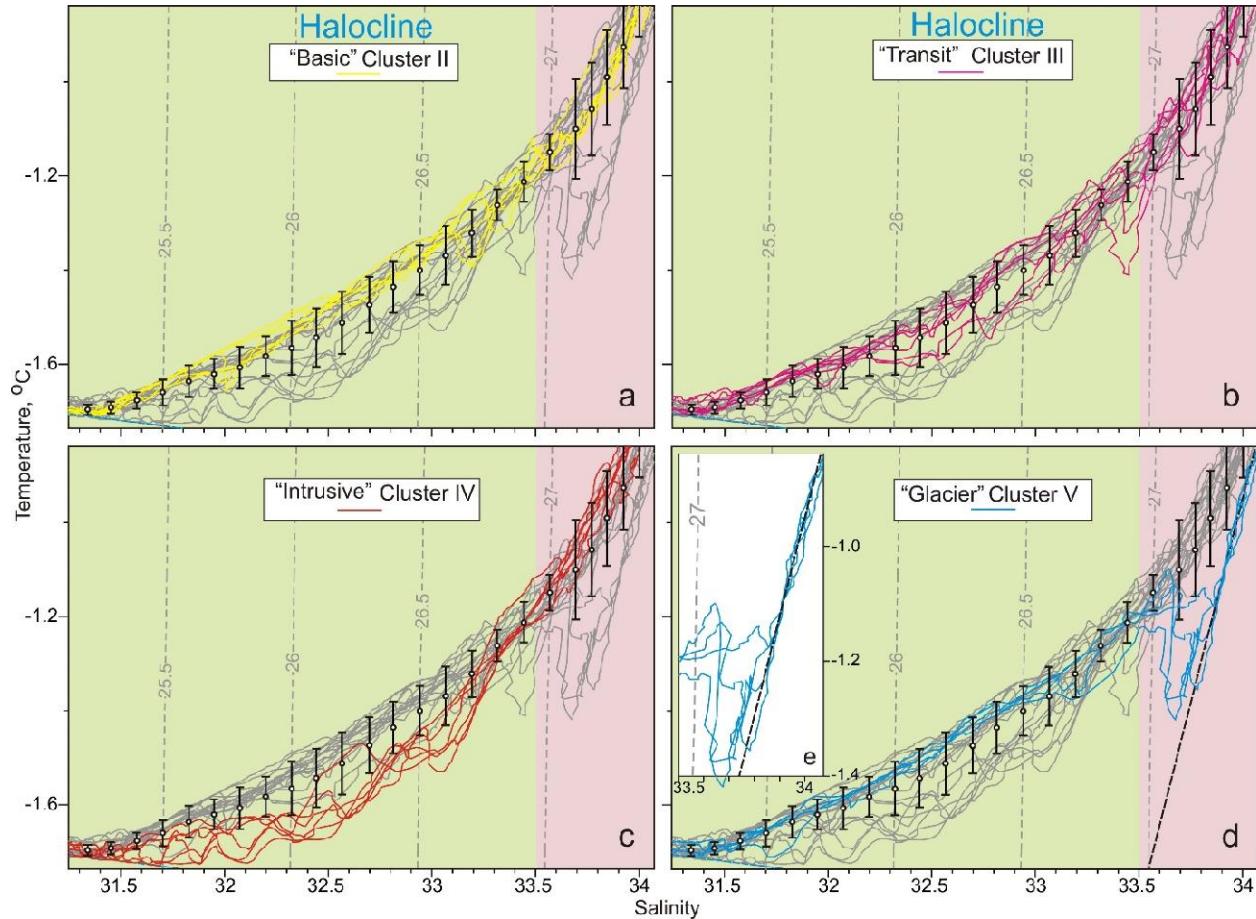
5. Map: A map showing topography and stations on a regional scale might help to put the region into a better context. Figure 1 is good to have for the large-scale circulation, Figure 2 shows where glacier and polynyas are located, Fig.3 shows the ice conditions during the survey, but the reader has no idea what the greater region looks like, i.e. where is the continental slope that is mentioned in the text. Shelf-slope interaction is one focus of the paper, but not clear to me where this takes place.

We specified position of the continental slope in introduction as follows: "***The landfast ice edge in Figure 2b roughly marks the Wandel Sea continental shelf break located in about 35-45 km from the fjord mouths***.". Figure 3 was modified to focus on ice conditions. The bottom topography was moved to new Figure 4a, and Figure 4b shows stations >100 m depth and CTD clusters.

New Figure 3

6. Fig4: In my opinion this figure is too busy. There are too many lines in there with colors that are not immediately distinguishable. I would strongly suggest to try to make this more user-friendly. Perhaps only show mean profiles rather than the whole bundle, or remove those profiles that are not absolutely necessary. Understanding this figure requires multiple readings of the captions which distracts from the text. Same problem with some of the other figures.

To simplify this new Figure 5, we shaded the whole bundle of profiles and highlighted only the typical profile for station #68 from the "basic" cluster II.

New Figure 5

7. Fig5: Somehow the different dashed lines are confusing and by the time I read through the caption to identify what the different lines indicate I forgot what the figure is supposed to tell us. Could this be made more user-friendly? Also, the box refers to Fig6, not Fig 5.

We modified Figure 5b (new Figure 6b) to differentiate clusters II-V only by colors. In general, Figure 6b is intended to provide only the general overview on clusters over the extended temperature and salinity range. In contrast, new Figure 7 gives more detailed view for the halocline layer. Moreover, we divided Figure 7 to four different panels showing TS curves for each cluster separately as was recommended by Reviewer #2. The figure reference number for the box in Figure 6b was fixed.

New Figure 7

8. Fig7: How are the clusters related to regions? That part seems confusing. Is there a continental slope that can be displayed in this figure to show where potential interaction with ambient waters could take place?

We removed reference to regions from the text and figures to avoid confusions. Figure 7 was moved upfront as recommended and comprised the new Figure 4b (see above). The continental slope is out of the Figure 4b spatial scale. However, we specify position of the continental slope after line 48 as follows: "***The landfast ice edge in Figure 2b roughly marks the Wandel Sea continental shelf break located in about 35-45 km from the fjord mouths***".

9. Fig8: I would suggest to reduce the information displayed to a minimum. A paper that requires a detailed study of each figure caption in order to understand the figures quickly becomes unattractive for the readers. Perhaps show either the mean or just the 21 April profile. Details or differences between the two are not discussed in the text anyway...

We removed the 21 April CDOM profile from Figure 8.

Minor comments:

10. L89-92: Locations are not shown in a map, therefore it is not clear where these stations are and why they are used

We roughly identify this location in Figure 1. The figure caption was modified accordingly adding the following text: "***The blue dot roughly identifies location where CTD profiles were collected in the Beaufort Sea***. ".

11. L91: "meridian" is not needed

Modified as requested in line 91.

12. L136-138: were those the "normal" ice conditions?

We modified this text in lines 136-138 as follows: "*During the field campaign this region was covered with a mix of first year (~1.2 m thick) and multiyear sea ice (~3 m thick), with icebergs and an ice island frozen within the fast ice (Figure 3)* **that corresponds to the typical ice conditions over this area.".**

13. L141: as a result of ice melt and glacier runoff. Can you provide more details at least qualitatively which of the two is more important?

We make reference to Bendtsen et al. [2017] (***Bendtsen, J., J. Mortensen, K. Lennert, J. K. Ehn, W. Boone, V. Galindo, Y. Hu, I. A. Dmitrenko, S. A. Kirillov, K. K. Kjeldsen, Y. Kristoffersen, D. G. Barber, and S. Rysgaard (2017), Sea ice breakup and marine melt of a retreating tidewater outlet glacier in northeast Greenland (81°N), Sci. Rep., 7, 4941, doi: 10.1038/s41598-017-05089-3***) to clarify this point.

14. L167: dotted line is very difficult to see

We make the dotted lines thicker in Figure 4 (see new Figure 5 above).

15. L171: this sentence kind of downgrades your analysis, perhaps mention why it is still worthwhile to do here...

We modified this sentence in lines 170-172 as follows: "*We note, however, that the synoptic, seasonal and interannual variability can be significant [e.g., Falck et al., 2005] making it difficult to interpret the snapshot data from the Wandel Sea continental slope*, **while this analysis appears important and plausible**.".

16. L175: ...were subdivided into clusters... Why? I think an explanation is needed here on why the data are subdivided and what one is hoping to learn from this

We introduced new sentence after line 176 as follows: "***The clustering was conducted to assess the origin of water masses, and to identify the shelf-slope and ocean-glacier interactions***.".

17. L283: "water dynamics"... I would just say "currents are too weak"

Changed as requested, line 283.

18. L289: insignificant sub glacier freshwater discharge. Is it really insignificant? It sounds more important when you talk about it earlier...

We have no evidence of surface freshening along the glacier termination during winter (e.g., Figure 8).

19. L298: heat conduction into the glacier: are there more details regarding this subject, or papers that deal with this? Seems a bit random there...

We have no information on the vertical temperature profile in the glacier. So, any assumptions on the rate of the heat conduction into the glacier are very speculative.

20. L337: 4.2 interaction with ambient water from the continental slope... interaction of what? Incomplete title...

We modified this title to: "*Shelf water interaction with ambient water from the continental slope*".

21. L404: is pers. communication from a co-author the correct referencing?

This reference was changed to "*Kirillov, S., I. Dmitrenko, S. Rysgaard, D. Babb, L. T. Pedersen, J. Ehn, J. Bendtsen, and D. Barber (2017), Storm-induced water dynamics and thermohaline structure at the tidewater Flade Isblink Glacier outlet to the Wandel Sea (NE Greenland), Ocean Sci. Discuss., doi: 10.5194/os-2017-60.*".