In this Author Comment #2 the original comments by Reviewer #2 are written in black while the authors' responses are written in blue.

We thank the reviewer for his/her review and for pointing out to us statements that contradict previously published studies. The major and specific comments raised by the reviewer and our detailed response to each of them are listed below. We note that direct estimates of the transports east and west of Greenland will be carried out in the revision which will fundamentally change the paper's main sermon from using *L* as a proxy for transport (*F*) to using $q=F/L$ as a proxy for the entrainment rate of the surrounding water.

This paper introduced an analysis method, Freshening Length, and applied this to determine the changes of Irminger Current on the both sides of Greenland using SODA reanalysis data.

I have four major concerns/comments for their consideration:

1. Many times the authors stated in the paper that the West Greenland Current (WGC) is a continuation of the Irminger Current. In fact before becoming the WGC, the Irminger Current has merged with East Greenland Current on the east side, referred to as EGC/IC (or EGIC) (e.g., Cuny et al, 2002; Sutherland and Pickart, 2008). I would suggest the authors to improve the introduction with more up-to-date references.

   Sutherland and Pickart, 2008 was referenced in the previous version and the drifter data of Cuny et al. (2002) will be referenced in the revision. The revised version will include a definition of the Irminger Current east of Greenland as the high salinity (S>34.8) current while the EGC is a low salinity (S<34.8) current that flows parallel to the IC along the Greenland shelf while maintaining its low salinity signature. These distinctive characteristics prevail throughout the entire (south-) east coast of Greenland (see Figure 16 of Sutherland and Pickart, 2008). The existence of the EGC will be employed in the revised version to explain the difference in the rates of entrainment of surrounding waters by the IC east and west of Greenland.

2. The author determined the Irminger Current by the maximum salinity at surface. To do that, the authors seem to believe the Irminger Current only contain Irminger Water and this water situates at surface. However, the EGC/IC and WGC contain multiple water masses vertically and the Irminger Water resides away from the surface (~ 500m depth, Pacini et al., 2020). As such, the results shown in the paper can reflect neither the change of Irminger Current nor Irminger Water.

   The various sources that make-up the Irminger Current are not relevant to our sermon. The Current is clearly identifiable by the (local) salinity maximum (S > 34.8, see blue triangles in Figure 2) and the calculations of the Freshening Lengths east and west of Greenland are based solely on the decrease in SSS along it. Both the high SSS of the IC and the freshening (& cooling) along it as it flows around Greenland are its defining characteristics.

3. I am confused by the Freshening Length. The q needs to be better defined. What is the unit of q? m/s? otherwise the equation doesn't make sense as the unit of HU is m^2/s. How to determine the H? The L on the east is 5 times more than the one on

the west. My understanding is that the less L means freshening in a shorter distance or faster freshening in a certain distance, namely the water freshening is 5-time faster on the west than on the east. I am still confused how it can lead to the conclusion that only 20% of Irminger Current contributes to WGC.

The reviewer's concerns in this comment were addressed in Berman et al. (2019) where the underlying theory of Evaporation length was developed. To help the reader grasp the main sermon we will add the following items in the revision: 1) Theoretical details (including a new figure/sketch) that explain the adaptation of the Evaporation Length paradigm; 2) The adaptation of the Evaporation Length to the Freshening Length; 3) A precise definition of *q* as the parameter controlling lateral mixing; 4) The expression used for evaluating *L*.

4. The authors also stated that the amount of Irminger Current supporting the WGC was previously unknow and they determined that only 20% of Irminger Water rounds Cape Farewell using the Freshening Length. First, the authors should be aware of the studies by Le Bras et al. (2018) and Pacini et al. (2020). The former computed the transport of each boundary current in the east of Greenland using the Overturning in the Subpolar North Atlantic Program mooring data, while the latter reported the transports in the west of Greenland using the multiple-year mooring array on the west side. Their results clearly suggested that the most of the boundary currents in east Greenland flow towards the west Greenland with only a few recirculation at Cape Farewell (interacting with Eirik Ridge). How could the authors explain the discrepancy between the main conclusion of this paper and the compelling observations?

   The immediate answer to this dilemma is the different data used in the studies. Our climatological data can be expected to differ from data obtained in particular field campaigns. In the revision the directly calculated values of *F* east and west of Greenland will be combined with the calculated values of *L* to yield estimates of the mixing with the surrounding water (which is much more efficient on the west side). This conclusion is consistent with the qualitative results shown in (old) Fig. 3 where the density of the surface water changes on the west side much more than on the east side. This point will be highlighted in the revised version.

Specific comments:

Line 19. should be Faroe Bank Channel.

Thanks. Will be corrected in the revision

Line 20. The connection is not only with Greenland Sea. I would suggest to say Nordic Seas instead.

Will be corrected in the revision

Line 21. EGC doesn't have to be fresh, particularly in the deep layer it also contributes the dense overflow water.

Our statement follows the claims made in de Stuer et al. (2009) and Dodd et al. (2009). The contradicting views on fresh water in the deep part of the EGC are of no consequence to the statement in our work that deals with the near surface salinity signal.

Line 26-27. What currents are they talking about? I don't see the difference. The currents flow continuously northward in Fig. 1a as well.

This point is irrelevant to the new focus of the revised version that will not include Fig.1 .

Figure 1. The two schematics have some discrepancies which add confusions, e.g. EGC and IC are two separate currents in upper panel, while in the bottom panel they are referred as a single merged current – EGIC (green). Why not just show one up-to-date schematic?

Figure 1b will be eliminated from the revised version

Line 80-85. Mark your study region somewhere in Fig.1 or Fig. 2. Label all of the geographic names that were mentioned in the paper, e.g., Cape Farewell.

Will be corrected as required in the revision.

Line 95-100. How could the mean surface hydrography suggest a cyclonic circulation?

The cyclonic circulation is suggested by the climatological means and by prior sketches of the circulation and not by the surface hydrography. The point will be clarified in the revised version.

Line 140. It IS important… and did you mean Fig. 1?

Thanks for detecting the typos which will be corrected in the revised version.

I suggest to change the subtitle to Discussion and Conclusions.

Right. Suggestion will be implemented in the revised version.

Line 155. Downwelling can flux the saltier water towards the coast in the upper layer, while upwelling can transport the fresher water offshore which may influence the water carried by WGC.

Our scenario results from the fast rate of cooling west of Greenland which is consistent with the notion of subduction but the fast freshening rate there requires an explanation. The point will be clarified in the revised version.

Last paragraph. As I said above, the authors should be aware of the published mooring studies. Also the authors can easily check whether their method works out by using the same SODA reanalysis, e.g., compare the volume transports on the both sides of Greenland.

A new table with direct transport estimates from SODA will be added in the revision.