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The Cryosphere Discussions

Interactive comment on "Drivers for Atlantic-origin waters abutting Greenland" *by* Laura C. Gillard et al.

Anonymous Referee #1

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General Comments

Using a combination of eddy-permitting and eddy-resolving ocean model simulations, the transport of warm waters through from the Greenland Shelf through the troughs towards marine terminating glaciers is examined. The manuscript contains interesting and important analysis geared toward understanding: the influence of meltwater, storms and model resolution on heat transport through the troughs. In the present form the manuscript has too many somewhat disparate sections, the progression between which is not obvious. The manuscript could be made a welcome contribution to the literature if a) the less relevant sections are removed, b) the connection/progression between sections and their contribution to the goals of the manuscript are made clearer and c) the sections of greater potential that remain are strengthened with a modest

amount of additional analysis.

Specific comments.

Page 3, lines 10-15. The following questions (6 of them) are quite cumbersome and without any logical progression or structure. This negatively impacts the flow of the rest of the manuscript. For example (5) and (6) are sub questions of (1). It is not necessary to state (2), as their significance is implied by the nature of the study. In question (3) it is not clear what is meant by 'this'. In (1) does 'to the coast' mean 'through the troughs' or 'to the shelf edge'? Is it not possible to capture the essence of the research with three questions? For example: 1. What is the mean and variability of heat flux through the troughs around Greenland? 2. What are the processes that drive this variability of flux? 3. How is heat flux through the troughs affected by ocean resolution?

Section 2.1 Model Evaluation. As discussed in the manuscript, there were some noticeable changes in temperature between 2004-2016. The extent that the model captures these changes will affect the interpretation of the results. The authors should include some evaluation of the model's ability to capture observed temperature changes in the western SPG.

Section 2.1/Section 2.2.2. Could the authors clarify/ state that Bamber et al. (2012) encompasses melt water from Greenland's marine terminating glaciers (as the terminology changes somewhat throughout the manuscript). What is the time period for the monthly Bamber et al. data? In addition, could they make it clear that in the model, the ocean does not affect GrIS melting as the melting is prescribed and non-interactive.

Section 2.2.3. Page 5, line 10. 'such as temperature and wind speeds'. Do the authors mean only temperature and wind speed? Why not specific humidity which will affect latent heat flux and the other atmospheric forcing fields?

Section 3. 1. This section on 'The HighRes vs LowREs experiment' is problematic in that it has no connection with the rest of the paper. I suggest it is removed. The results

section (3.1) contains more of a literature review than an analysis of new results. In addition, a large amount of Section 3.1 is a description of the resolution changes and a relatively small amount is on the impact on the circulation. With regard to HighRes vs LowRes, are not the changes in on shore heat flux (as in Fig. 6) of more relevance to the manuscript than EKE changes?

Page 9, line 7. 'Significant'. By what measure of significance.

Section 3.2.2 Fig. 5a and 5b. There are two peaks in the DB seasonal cycle. August coincides with warmer surface waters. The later December peak coincides with the peak in the Irminger Water. The August-December lag corresponds to the advection time from when the water was last near the surface in Irminger Sea. The lack of a summer peak at MB, suggests seasonality is dominated by the subsurface warm layer.

Page 10, line 25. Re: Straneo et al. 2011. Is the Atlantic Water warmer during winter in the model? If so, why does on shore heat flux not increase during the winter? As with all of these plots, it would be nice to see the seasonal cycle of temperature across the section to determine if Fig. 5 reflects seasonality in temperature or volume transports.

Section 3.3. In this section there is a comparison of HighRes vs LowRes. If the authors quantify the comparison (correlation, RMSE), it will provide some justification for the locations at which LowRes can and can not be used instead of HighRes in the sensitivity experiments (Sections 3.4 and 3.5). With this in mind, I recommend removing lowResDoubleMelt from 3.3 and making Section 3.3 about HighRes vs LowRes only.

Fig. 6. It is quite difficult to get a picture of how important the fluctuation component is due to the different scales. Would it be possible to plot 'total' transport on the left hand side and 'mean' transport on the right hand side on the same scale?

Section 3.4. In discussing the mechanism whereby melting increases the temperature of the lower layer of the trough x-section, it is possible to include some sense of spatial scale over which one might expect the increase melt to influence the circulation? For

example, this could be done by comparing maps of on shore velocity in the lower layers. The authors appear to be saying an increase in melt increases the local THC and thus the onshore transport of heat. Is there any signal of circulation change outside the MB troughs?

Section 3.5. Why are the authors only looking at HG in this section? I suggest the authors should a) do all, b) do none or c) justify why their selection of sites.

In this section the authors discuss changes in on shore/ off shore heat transport with storms/ no storms. Rather than look at EKE, it seems that an appropriate figure would be Figure 4 for the storms and nostorms simulations. This way, strengthening / weakening of the inflow/outflow transport paths would be more clearly seen.

Section 3.6. The authors may wish to consider if this section is necessary. I would suggest that for it to be a helpful contribution to the manuscript it needs to be more quantitative. For example, Fig 9. suggests a very small fraction of warm water at MVB is from north of Fram Strait. A lot is south of Denmark Strait and nearly all of it is in the Atlantic Sector South of 79N. It would be helpful to know the % of particles in Fig. 9a that have come around Cape Farewell and the % that have come through, Denmark Strait and Fram Strait.

Technical

Page 1, Line 10. 'the north-west coast and south-east coast respond. . .' » 'Ocean temperatures near the north-west coast and south-east coast respond. . .'

Page 2. Line 10 'Mass balance has been persistently negative' needs rephrasing. 'The annual mass balance has been persistently negative' or 'the mass of the GrIS have been declining since..'

Fig. 2 Caption » 'Our model resolves larger scale processes that occur along the coastline, AND therefore, injects the meltwater from the GrIS at the first ocean'

Page Line 4, 30. It would be clearer to say 'The models used in this study, do not have

an iceberg module and so only include river and tundra runoff (∼46 % of the total)...' otherwise it hints that this is a difference between HighRes and LowRes in Section 3.3

Equation 1). LHS should have '(t)' after 'HeatFluxeddy'. Specify what is denoted by the overbar.

Page 9, Line 5. It did not increase for 5 years.» 'The MVBNT, MVBCT and MVBST heat transport increased between 2009 and 2010 and persisted in an anomalously high state for 5 years.'

Page 10, line 30. Some sections look quite small: How many model grid points across is the SBST section?

Fig. 4 – Please add 'N' and 'S' to the appropriate end of each panel to aid the reader. Also Figure 7.

Section 3.2.6. Can the authors make it clear when they are referring to SBST and when they are referring to 79NG.

Page 11, line 21. 'arrival of warm waters from the WGC' » 'arrival of warm Irminger Water from the subduction area in the Irminger Sea'

Page 16, line 22. 'Warm waters are replaced by sources from...'» 'Instead the predominant sources of warm water are from Fram Strait...'.

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