Thank you very much for your constructive comments and suggestions. From the comments of both reviewers, it is clear to us that the explanation of the water cycle in the different experiments was not well done. Therefore, we have now included in Section 2.4 a more elaborate explanation of the experimental set-up and the treatment of water and latent heat. The following two paragraphs have been added to the manuscript.

In the CTRL experiment, the freshwater cycle is closed between the atmospheric model ECBilt and the oceanic model component CLIO. In ECBilt, the precipitation (solid and liquid) is computed every 4 hours and the solid precipitation is added to the snow layer. To prevent the model from piling up too much snow in areas with a positive snow mass balance, the height of the snow layer is not allowed to exceed a pre-defined threshold (10 metres). If the snow layer exceeds this threshold, the amount of snow above it (the so-called excess snow) is melted, and is added to the soil moisture (in a bucket model) and routed into the ocean when the maximum, preset soil water holding capacity is exceeded. The heat needed to melt the excess snow on the Northern Hemisphere is computed in the ocean model and taken up from the surface layer of the ocean cells around the Greenland ice sheet homogenously (Fig. 1), which is done in order to account for the effect of floating icebergs, which are not dynamically computed in CTRL. The solid precipitation that is falling on the ice-sheet is given to GRISLI where it is used to calculate the surface mass balance. However, it is not removed from ECBilt because in CTRL the water cycle between ECBilt-CLIO and GRISLI is uncoupled, implying that GRISLI does not provide any freshwater fluxes to ECBilt or CLIO.

In the calving (CALV), the "fresh"freshwater (FWFf) and the "cold"freshwater (FWFc) experiments, the freshwater cycle is closed between ECBilt, CLIO and GRISLI. Therefore, the precipitation given from ECBilt to GRISLI is removed from ECBilt. GRISLI uses the precipitation to calculate the surface mass balance. At the end of one model year it provides ECBilt with the amount of the computed runoff (surface and basal melt) and CLIO with the ice discharge. In ECBilt the runoff is incorporated into the land routing system and distributed to the ocean. The ice discharge in CLIO is either used to generate icebergs (CALV experiment) or melted instantaneously at the ice sheet border (FWFf and FWFc experiments). The ice discharge has to be melted before being supplied to the ocean as a freshwater flux and the treatment of the heat needed to do this differs between the CALV, FWFc and FWFf experiments. In CALV and FWFc, this heat is taken-up from the ocean cell corresponding to the position where the ice discharge is added to the ocean either in the form of an iceberg melt flux (CALV) or in the form of a freshwater flux at the ice sheet margin (FWFc). In FWFf the ice discharge is melted at the ice sheet border without taking up heat, instead the latent heat related to the excess-snow is taken up homogenously around Greenland (FWFf), indentical to the CTRL experiment. This allows us to separate the freshening and the cooling effect of icebergs.

These two paragraphs are now in the section 2.4 (The coupling method and experimental setup) instead of the previous description of the experimental setup.

Reviewer #2 - Specific comments

The details of the various model set ups are not sufficiently well described. In particular I do not understand the details of the CTRL experiment at all. A reference to Roche et al. 2013 is insufficient here as understanding the model set up is crucial to the whole of this manuscript. In particular how are freshwater and latent heat treated in CTRL. The description of the model seems to suggest that no water flux is used yet the text repeatedly hints that there is some water flux.

The experimental set-up has been re-written, please see opening statement.

How does the model compute the surface mass balance?

The ablation is calculated according to the Positive Degree-Day method following Fausto et al. (2009). It uses the monthly downscaled surface temperatures that are computed using the temperatures at the maximum and minimum GRISLI altitude in one ECBilt cell to compute a linear relationship between the altitude and the surface temperature which is then used to correct the ECBilt surface temperature to fit to the corresponding GRISLI cells. The PDD method accounts for refreezing. The SMB is calculated using the total annual snow fall and the ablation rates. The basal melting is parameterized using a fixed rate. This information is now added to the coupling paragraph 2.4:

After one year the monthly surface temperatures and the total amount of snow fall are used are downscaled from the ECBilt to the GRISLI grid and used as input fields calculate the surface mass balance (SMB) that is defined by the accumulation and ablation. To obtain the ablation rates, the Positive Degree-Day (PDD) method of Fausto et al. (2009) is used, which takes into account the dependence of the ice and snow melt rate parameters on temperature as well as the dependence of the refreezing parameter on the altitude. A more detailed description of the coupling between ECBilt – CLIO and GRISLI is given in Roche et al. (2013).

How well do the various ice sheets compare to the observations?

The CTRL ice sheet volume at the end of the 14.000 model years is about one third bigger than currently observed, mainly due to an overestimation of the ice sheet's extent and its thickness. The excessive extent is particularly visible in the northeast and southwest of Greenland where currently no ice exists (see Fig. 1 and updated Fig. 6 in manuscript). The thickness is overestimated in central and northeast Greenland (by up to 1000m) and over North America. It is important to notice that using present-day observations as input fields to force the ice sheet model instead of ECBilt results in an overestimation of the volume of $4x10^{14}m^3$ compared to climatology (Bamber et al., 2001) (Roche et al., 2013). Therefore, dynamically coupling GRISLI to iLOVECLIM results in a 15% overestimation in the ice sheet volume with respect to the computed ice sheet using present-day observations. Both, the overestimated extension and thickness are caused by the SMB that captures the overall pattern of more positive SMB in the south, less in the north and negative at the coast, yet, the positive areas are overestimated (see Fig 2, underneath).

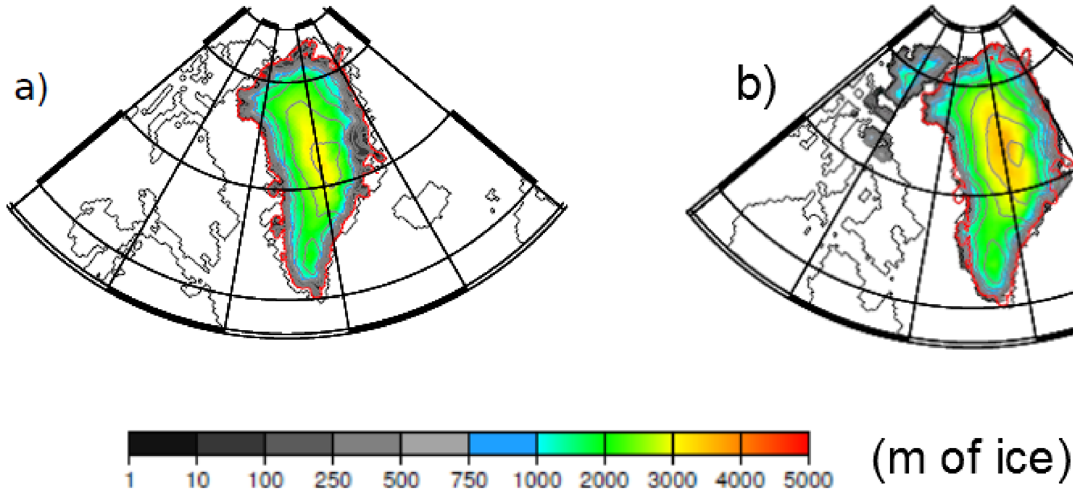

Fig. 1: ice sheet thickness (m); a: observations (Bamber et al., 2001); b: CTRL experiment

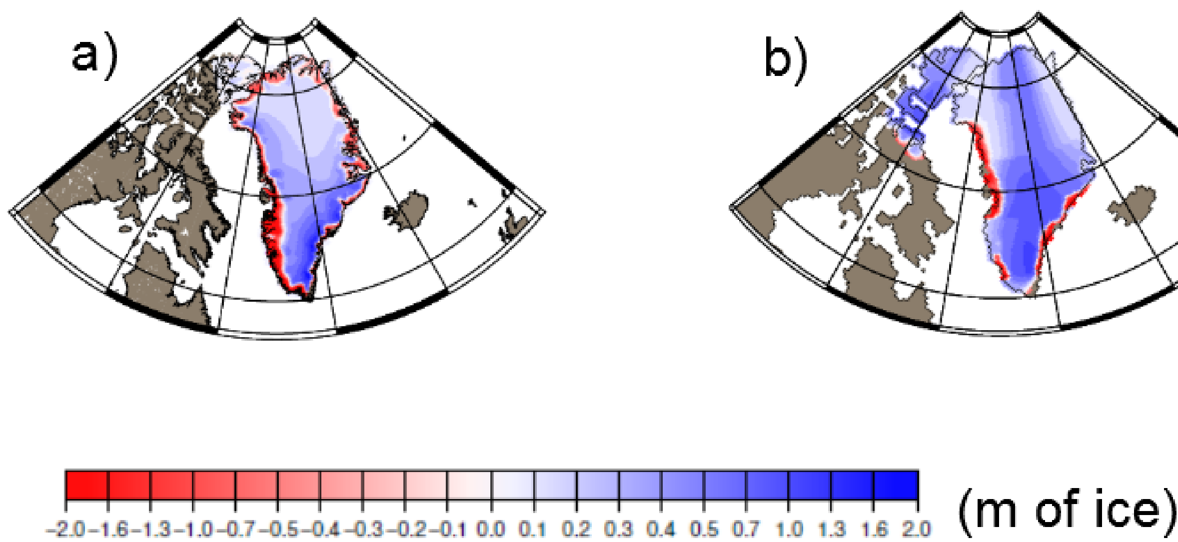

Fig. 2: Surface Mass Balance (m); a: results from the MAR regional climate model at 5km resolution forced by reanalysis (Fettweis et al., 2011); b: CTRL experiment

We added one paragraph summarizing the characteristics of the CTRL ice sheet before Section 3.1 and a few sentences about the SMB and resulting ice sheet of the CALV and FWFc experiments in the corresponding parts of the manuscript:

Before analyzing our results, we shortly want to summarize the main properties of the CTRL ice sheet as presented in Roche et al. (2013).The resulting ice sheet thickness and extent are overestimated with an excess volume of about 1.05 x 10^{15} m^3 compared to observations (Bamber et al., 2011). Comparing the CTRL volume

to the computed volume using present-day observations as input fields to force GRISLI displays that dynamically coupling GRISLI to ECBilt results in an excess ice-sheet volume of $4.4x10^{14}m^3$. The ice sheet (Fig. 6a) extends almost everywhere up to the Greenland coast even at regions that are currently observed ice free. Further, the CTRL ice sheet is too thick in central and northeast Greenland (up to 1000m) and over Devon Island. This can be explained by the overestimation of the positive SMB by GRISLI. The computed SMB captures the overall pattern of positive SMB in south and less in north of Greenland and negative SMB along the coast, yet, GRISLI overestimates the positive SMB resulting in the excessive extension and ice sheet thickness (Fig. 10a). The mean value of the surface mass balance of the CTRL ice sheet of the last 1000yrs is given in Table 3.

Section 3.2:

Overall, the CALV ice sheet is too extensive and thick, as is the CTRL one, but explicitly modelling icebergs decreases the SMB over Northern Greenland and North America (Fig. 10b), which fits better to observations.

Section 3.3.2:
Parameterizing icebergs using the FWFc set-up, further enhances the overestimation of the extension and thickness of the GrIS compared to observations (not shown).

Figures – The blue-green-red colour scheme is, for numerous reasons, an appalling choice and should always be avoided. It is especially useless in most of the figures in this manuscript because there are large areas where the anomalies are near zero, of no interest, yet their colours dominate the figures. The divergent Brewer colour schemes, which go through white, are a far better choice (http://colorbrewer2.org/) and versions of these are available for most plotting software. The figure captions should indicate where the colour schemes are non linear.
Thank you for the suggestion, the figures have been redone

The order of the figures in the text appears to be almost random. For example why are the figures for section 3.3.3 (CALV-FWFc) numbered 5 and 12? Having them on adjacent pages would make it far easier to follow the text and figures without excessive scrolling.
Thanks for this comment, ocean and atmospheric results are now in one figure

Specifics

195-19 – Runoff, does this mean calving? Runoff to me means liquid water flowing off the icesheet, it does not refer to solid ice.
No, it means liquid water runoff. Calving is described before.
Calving occurs whenever the ice thickness at the border of the ice sheet is below 150 meters and the upstream points are not providing enough ice to maintain the height above this threshold. In the iceberg module this mass is used to generate icebergs at the calving site. The ice sheet's runoff (basal and surface melt) is computed at the end of the coupling time step, in our case one year, by calculating the difference in ice sheet …

197-25 – Describe this simluation better. How is water treated in this experiment?

We refer here to our explanation of the water cycle at the start of our reply. We have included two paragraphs on this in Section 2.4

199-24 – I do not have a fig 4(c).
Thank you for pointing this out. You are correct, it should state Fig. 4 a and b instead of c

200-3(on) – please refer to the relevant figures
We have re-written the results section and added the cross reference to the figures, substituted the plot of the sensible heat flux by the geopotential height and added Table 3 that includes the values of the calving flux, ice sheet runoff, surface mass balance and sea ice volume and area.

3.2 Impact of Icebergs on the pre-Industrial climate And The Greenland Ice Sheet:

Including icebergs in the model set-up (CALV experiment) causes a cooler and fresher ocean state east and south of Greenland (Fig. 7a) and consequently an increased sea ice thickness (SIT, Fig. 7b)thereby increasing the surface albedo (Fig.7f) which leads to a cooler atmospheric state (Fig. 7e) compared to CTRL. The changed temperature field is linked to an altered atmospheric circulation pattern (Fig. 7h) with a higher pressure system over Greenland. Due to the northward winds less humidity is transported to the GrIS resulting in a reduced ice sheet thickness over central and east Greenland. Due to the movement of the icebergs, their melt water is distributed away from their calving sites all around the GrIS and reaching up to Svalbard and Iceland (Fig. 5a) with the maximum being released along the coast. In accordance with the icebergs' melt flux, there are decreased sea surface temperatures (SSTs, Fig. 7a) found east and south of the GrIS as a result of the take up of latent heat needed to melt the icebergs (Fig. 5c). But in the Barents Sea and along the coast of North America, the CTRL displays lower SST despite the big iceberg melting rates (Fig. 5a). These differences arise due to the parameterisation of the take up of latent heat used in the CTRL run (Fig. 1), which distributes the excess snow homogeneously all around Greenland. Hence, the SST is altered homogeneously whereas in the CALV experiment the impact on the SST depends on the amount of melt water released by the icebergs. The comparison of Fig. 5c and 5d clearly shows that the parameterisation used in CTRL overestimates the latent heat take up further away from shore, but underestimates it along the coast of Greenland . Additionally, the higher sea surface salinities (SSS) in the CALV set-up in the Baffin and Hudson Bay region (Fig. 7d) indicate that less freshwater is released by the icebergs than is supplied by the land routing system in CTRL, since the amount of freshwater is not defined to be the same in the performed experiments, as it depends on the prevailing climate. A different pattern is seen in the Greenland Sea where the icebergs freshen the ocean's surface due to the major calving sites along the east coast of Greenland and in the Labrador Sea where they cause a decline in SSS as well as a decrease in convection depth (Fig. 7c) whereas in the GIN (Greenland – Iceland – Norwegian) Seas the centre of the deep convection site is shifted northward in the CALV experiment, without a change in convective activity. The strongest impact on sea ice is found along the east coast of Greenland where it becomes thicker due to the lower SST (Fig. 7b). The total sea ice volume is one third higher in CTRL (Table 3) than in CALV due to the thicker sea ice west and north of Greenland (Fig. 7b).

As a consequence of the enhanced sea ice cover and thickness, the surface albedo (ALB) increases in the CALV set-up (Fig. 7f). As less heat is exchanged between the ocean and the atmosphere, the air temperatures over the GIN Seas and central Greenland decrease (Fig. 7e). Less snow fall is found in the CALV set-up (Fig. 7g) owing to the altered pressure system (Fig. 7h). The decrease in accumulation results in a diminution of the ice sheet's height of about 150m in the CALV experiment compared to CTRL (Fig. 6c). In the Arctic on the contrary, the air temperatures are and the amount of snow are increased (Fig. 7e,g), which leads to an increased ice

sheet thickness (Fig. 6c). Overall, the CALV ice sheet is too extensive and thick, as is the CTRL one, but explicitly modelling icebergs decreases the SMB over Northern Greenland and North America (Fig. 10b), which fits better to observations (cf. Roche et al., 2013, Fig. 11c).

From the comparison of the CALV with the CTRL run we conclude that the effect of icebergs on the Northern Hemisphere climate is strongest around the GrIS, reaching into the North Atlantic but decreasing towards Norway. This pattern is not captured by the homogeneous take-up of latent heat in the CTRL run. The effect of icebergs on the ice sheet's development under pre-industrial equilibrium conditions are small (~ 150m) and caused by the local effect of the icebergs on the sea ice thickness.

3.3 Parameterizing Icebergs Using Freshwater Fluxes – How Well Does It Work?

3.3.1 The freshening effect (FWFf – CTRL)

Releasing the calving fluxes instantaneously into the ocean, without forming icebergs, does not alter the climate strongly compared to CTRL. In the FWFf experiment, the calving flux (1,8 10-2SV, table 3) is released instantaneously at the calving sites, consequently freshening the ocean surface but without cooling it, since the FWFf and CTRL set-up share the same parameterisation of homogeneous take-up of latent heat. At the end of the experiments, FWFf and CTRLresult in a very similar ocean and atmospheric state, as well as ice-sheet configuration (not shown). Therefore, the impact of the freshwater fluxes (freshening effect), related to calving under pre-industrial equilibrium conditions, is small.

3.3.2 The freshening and cooling effect (FWFc – CTRL)

Applying the calving fluxes in the form of instantaneous freshwater fluxes that do take up the latent heat needed to melt them at the calving sites both freshens and cools the ocean close to the GrIS margin (Fig 8a). Therefore, they cause warmer and saltier GIN Seas as well as a cooling and freshening in the Davis Strait and Labrador Sea (Fig 8d).

The location of the freshwater fluxes has quite distinct impacts. To the west of Greenland it promotes an increase in sea ice thickness (Fig. 8b) because of the strong freshening. In the GIN Seas however, there is a decrease in sea ice thickness because of the increased SST (Fig. 8a). The freshwater flux released in FWFc (0.026 SV) is confined to the GrIS margin, as is the related cooling effect (Fig. 5d). Therefore, it does not reach the convection site in the Gin Seas which results in a more extensive convection activity and the inflow of relatively warm and saline Atlantic waters that further enhance the sea surface temperature and salinity (Fig. 8a, 8d).

The sea surface temperature, as well as salinity (Fig. 8a, 8d). The freshwater flux along the west coast of Greenland causes a shift of the convection site south of Greenland eastwards (Fig 8c). To the North of Greenland the freshening and cooling effect of released ice flux results in a thicker sea ice. Despite the big differences North of Greenland is the overall sea ice volume and area comparable between CTRL and FWFc (Table 3).

Even though, in Baffin Bay the release of the calving flux and the take up of heat needed to melt it causes lower SST (fig) and consequently increases the sea ice thickness and albedo, the warmer ocean conditions in the GIN Seas cause higher air temperatures over the whole North Atlantic region (FIG). The increase in surface albedo and the related cooling west of Greenland provoke an enhanced high pressure system over the

western GrIS and North America (Fig. 8h) and the opposite effect is seen east of Greenland. Due to the decrease in sea ice in the GIN Seas, the low pressure system transports more humid air to central Greenland. This is reflected in the resulting ice sheet thickness, which over eastern (western) Greenland is up to 300 m increased (decreased) compared to CTRL (Fig. 6f). This is also seen in the surface mass balance (SMB) (Fig. 10a compared to Fig. 10c) and the accumulation (Fig. 10d compared to Fig. 10f).

The comparison of the FWFc with the CTRL experiment shows that the absorption of latent heat from the ocean and the location of the take-up of latent heat have a stronger impact on the climate and consequently on the evolution of the ice sheet than the input of freshwater.

3.3.3. The distribution effect (CALV – FWFc)

Using the calving mass calculated by GRISLI to generate icebergs (as in CALV) instead of applying this mass in the form of direct freshwater fluxes (as in FWFc), has an almost opposite effect on climate and the GrIS. Due to the movement of the bergs and their slow release of melt water, their impact on climate is over a wider area with less water being directly released at the calving sites than in FWFc (Fig. 5c). Therefore, the CALV experiment results in a much fresher and cooler Denmark Strait (Fig. 9a,d) with a reduced convection depth than seen in FWFc (Fig 9c). This is due to the release of melt water in this area by the icebergs, which is not the case for the directly applied freshwater fluxes. In the GIN Seas the decrease in SST and SSS in the CALV run are linked to a spatially smaller deep convection area compared to the FWFc set-up (Fig. 9d). It is interesting to notice that in Baffin Bay the instantaneous release of the calved mass provokes a stronger cooling and freshening than the slow release of melt water by icebergs. Even though they release more freshwater there (Fig. 5c) icebergs take up less heat than the directly released freshwater fluxes (Fig. 5d compared to Fig 5e)..

The thinning of the sea ice thickness west and north of the GrIS and its thickening south east of Greenland in CALV results in a decreased sea ice volume compared to FWFc (Table 3). Moreover, it causes a two-sided response in albedo (Fig. 9f) and the geopotential height, resulting in less precipitation over central Greenland in CALV (Fig. 9g,h). Thus, the air temperature is reduced over the GrIS and increased over the Arctic (Fig.9e). The different effectiveness of direct freshwater fluxes and icebergs leads to different ice sheet geometries at the end of the simulations with a up to 300 metres higher western and lower eastern GrIS in the CALV set-up (Fig. 6e). This is a consequence of the mass balance (Fig. 10f).

From our studies we conclude that the main effect of calving on the climate is due to spatial distribution of the take-up of latent heat absorbed to melt the calved mass. Using local freshwater and latent heat fluxes cause a thicker ice sheet volume and higher melting rates (0.026SV in FWFc compared to 0.017 SV in CALV, Table 3). Therefore, the use of local freshwater and latent heat fluxes does not represent the effect of icebergs well and it strongly underestimates the distribution effect of the icebergs. In our model and under pre-industrial conditions, the FWFf experiment reveals the most similar results to the CALV run (not shown) as it includes the wider spread, parameterised take-up of latent heat and the local freshening.

	Calvflux (GRISLI) (10^{-2} Sv)	Surface Mass Balance (GRISLI) (10^{2} m^{3})	Runoff (GRISLI) (10^{-4} Sv)	Sea Ice Volume (10^{3} km^{3})	Sea Ice Area (10^{12} km^{2})
CTRL	-	-1.7	-	24,69	11,89
CALV	1,7	-0.87	2,1	16,18	11,05
FWFf	1,8	-1.89	3,9	25,09	11,99
FWFc	2,6	-2.2	1,3	24,36	11,76

Table 3: summary of computed ice discharge (CALVFLUX) as calculated in GRISLI, Surface Mass Balance (SMB) of the Greenland ice sheet, runoff as calculated in GRISLI, Sea Ice Volume and area as computed in CLIO; all values plus standard

I do not understand the chain of causality in the description of this experiment. As I see it, Fig 10(a) shows a small change in the albedo in the regions where the sea ice expands, but the largest change >5% is located over the land, indeed the 5% contour seems to trace the model's coast line. The largest SAT cooling is located to the east of this albedo change, almost in the middle of the Denmark Strait, to the north of the largest SST cooling. Over the region of expanded sea ice there is an increase in the snow fall, which peaks nearest the coast, and over the ice sheet itself there is an increase in snow fall that is up stream of the peak cooling. This description does not fit with the explanation of cool SST ! cool SAT ! reduced snowfall. Please can you explain?

We agree that we have not explained this chain of causality clear enough in the first version. In fact, the changes in precipitation pattern are due to changes in the atmospheric circulation. In CALV there is increased high pressure over Greenland and decreased pressure over the North Atlantic, therefore, less humid air coming from the North is transported over the GrIS.

To clarify this to the reader, we have substituted the figure of the sensible heat flux with one of the geopotential height at 850hPa because this better explains the difference in precipitation pattern of the different experiments (please see re-written results section above).

200-17 – what is "excess snow"?

Please see opening statement.

200-14 – The logic in these statements would be clearer if it read something like:

"But in the Barents Sea and along the coast of North America, CTRL displays lower SST than CALV despite the large iceberg melting rates (Fig. 7a). These differences arise from the parameterisation of the take up of latent heat used in CTRL. In CTRL the latent heat is released uniformly across the Atlantic Basin. In CALV, by contrast, the pattern of the latent heat released depends on the melt pattern of the icebergs which is largest near the coasts. CTRL therefore overestimates the latent heat released west of the GIS as well as further away from shore, but underestimates it along the east coast and south of Greenland (Fig. 7a). This leads to the observed cooler SST away from the GIS that are seen in CTRL. "

We have re-written the paragraph as kindly suggested by the reviewer (please see re-written results section above).

But in the Barents Sea and along the coast of North America, the CTRL displays lower SST despite the big iceberg melting rates (Fig. 5a). These differences arise due to the parameterisation of the take up of latent heat used in the CTRL run (Fig. 1), which distributes the excess snow homogeneously all around Greenland. Hence, the SST is altered homogeneously whereas in the CALV experiment the impact on the SST depends on the amount of melt water released by the icebergs. The comparison of Fig. 5c and 5d clearly shows that the parameterisation used in CTRL overestimates the latent heat take up further away from shore, but underestimates it along the coast of Greenland . Additionally, the higher sea surface salinities (SSS) in the CALV set-up in the Baffin and Hudson Bay region (Fig. 7d) indicate that less freshwater is released by the icebergs than is supplied by the land routing system in CTRL, since the amount of freshwater is not defined to be the same in the performed experiments, as it depends on the prevailing climate.

200-22 – Again what is "excess snow"? The description CTRL to me says that there is no liquid water flux to the ocean in CTRL, therefore how can CALV have less of a water flux than CTRL in Baffin Bay?
We have now explained this more clearly in Section 2.4.

201-5 – See previous comments on the interpretation of the snow fall and temperature – why does a temperature drop give a snow fall decrease.
Please see explanation of decreased snow fall above.

202- 6 – thereby should be therefore.
We changed the sentence.

202 – 10, I don't understand this. What does latter refer to? This sentence appears unrelated to the previous one, therefore latter is not a suitable term. This whole paragraph is very confusing.

Perhaps rewrite this paragraph to be structured filling in the ...:
"The location of the freshwater fluxes has quite distinct impacts. To the west of Greenland the freshwater promotes an increase in sea ice thickness (Fig. 5b) because ... . In the GIN Seas, however, there is a decrease in the sea ice thickness (Fig. 8c) because : : :. . Furthermore, the SST and SSS in the GIN Seas are further increased by more extensive convective activity (Fig. 8a, b and d), resulting in an enhanced inflow of relatively warm and saline Atlantic waters and a stronger ocean- to-atmosphere heat flux. South of Greenland the input of the freshwater fluxes lead to a shift of the convection site eastward, with the effect of : : : . To the north east of Greenland the sea ice thickens because..."

However you choose to structure it you need to explain why there is a huge SST and salinity increase in the GIN seas which are counter to what you would expect when you introduce cooling and freshening.
We have re-written the paragraph as kindly suggested by the reviewer.

The location of the freshwater fluxes has quite distinct impacts. To the west of Greenland it promotes an increase in sea ice thickness (Fig. 8b) because of the strong freshening. In the GIN Seas however, there is a decrease in sea ice thickness because of the increased SST (Fig. 8a). The freshwater flux released in FWFc (0.026 SV) is confined to the GrIS margin, as is the related cooling effect (Fig. 5d). Therefore, it does not reach the convection site in the Gin Seas which results in a more extensive convection activity and the inflow of relatively warm and saline Atlantic waters that further enhance the sea surface temperature and salinity (Fig. 8a, 8d).

202-17 on – This paragraph does not make sense. The train of logic is very difficult to follow. Perhaps structure it:

"In Baffin Bay the release of the calving flux and the take up of heat needed to melt it causes lower SST and SSS (Fig. 8a and b). This facilitates the formation of sea ice, thus enhancing the albedo in this region (Fig. 11a). This increase in the sea ice is linked with a decrease in the sensible heat flux between the ocean and the atmosphere (Fig. 11d). Over central and east Greenland we see an increase in the snowfall that is due to : : : . This different accumulation pattern, with more snow over the eastern and less over the western GIS, is shown in the mass balance field (fig 13). This results in ice sheet thickness over eastern (western) Greenland that is up to 300 m higher (lower) compared to CTRL (Fig. 6f) "
We have changed the paragraph as kindly suggested by the reviewer and added the missing information.

Even though, in Baffin Bay the release of the calving flux and the take up of heat needed to melt it causes lower SST (Fig. 9a) and consequently increases the sea ice thickness and albedo (Fig. 8b,f), the warmer ocean conditions in the GIN Seas cause higher air temperatures over the whole North Atlantic region (Fig. 8e). The increase in surface albedo and the related cooling west of Greenland provoke an enhanced high pressure system over the western GrIS and North America (Fig. 8h) and the opposite effect is seen east of Greenland. Due to the decrease in sea ice in the GIN Seas, the low pressure system transports more humid air to central Greenland. This is reflected in the resulting ice sheet thickness, which over eastern (western) Greenland is up to 300 m increased (decreased) compared to CTRL (Fig. 6f). This is also seen in the surface mass balance (SMB) (Fig. 10a compared to Fig. 10c) and the accumulation (Fig. 10d compared to Fig. 10f).

202-21 – If you plot the sensible heat flux for each grid box rather than as a contour plot do you see an increase in the flux over the continent? It looks to me as though the large SHF sits only over the warm SST. It appears to extend over the land areas due to the interpolations that are made when you plot things as contours. For low resolution models, such as loveclim, contour plots can give the appearance of far higher resolution than there actually is. At a T21 resolution much of the structure that you see in the atmospheric fields is most likely the result of the plotting.
We have substituted the plot of the sensible heat flux with one of the geopotential height to better display the reasons of the computed precipitation pattern.

202 – 19 – What does "former" refer to? This statement is somewhat redundant or needs explanation, why is there a reduction in the sensible heat flux?
Thank you, we agree , "former" does not make sense here, we have changed the sentence.

202- 22 – How do large sensible heat fluxes lead to increased snow fall?
This has been changed as we now explain that the atmospheric circulation causes the seen increase in snow fall.

202 – 25 – the logic is weird here. Snowfall changes the mass balance, which in turn changes the ice sheet thickness. The sentence, as structured, implies that the mass balance change is a result of the ice sheet thickness change when it is in fact the other way around.
This indeed gives a wrong impression and has been changed. Thank you.

This is also seen in the surface mass balance (SMB) (Fig. 10a compared to Fig. 10c) and the accumulation (Fig. 10d compared to Fig. 10f).

I'm not even sure that the sensible heat flux is a very useful diagnostic to use. I don't know what we learn from it. Take for example Figure 11. Looking at the SHF field we see large anomalies over Baffin Bay and in the GIN seas. The large GIN seas flux is a manifestation of the warmed SST; it just reflects the warm ocean warming the overlying air. In Baffin Bay, although there is reduced SHF due to the presence of sea ice, the SAT is essentially unchanged, therefore the SHF's effect on the climate is negligible. Thus the effect of the SHF is either obvious or irrelevant. Or am I missing something?
We have substituted the plot of the sensible heat flux with one of the geopotential height to better display the reasons of the computed precipitation pattern.

203 – 6 figs (5) and (12), why aren't the figures next to each other for the reader's ease?
We have re-arranged and re-done the figures so that we now use the suggested brewer scale and we have put the difference of the atmospheric and oceanic output of the experiments in one figure.

204 ***Discussion****. Is the purpose of this section to set the presented results in the wider context of previous literature? If so you need to do this. For each of the previous studies, how are they different to this one? Why are they different? What is the implication?*
We have changed the discussion to better compare our study to the ones previously done, the discussion now reads:

In the presented study the coupling between the ice sheet model GRISLI and the earth system model of intermediate complexity iLOVECLIM and the dynamical iceberg module was further developed. This set-up was used to investigate the impact of icebergs on climate and the ice sheet itself in a fully coupled low resolution model. To model iceberg calving is a complex task as small scale processes are involved, which we cannot expect to be represented with the 40 x 40km resolution of GRISLI. Still, the calculated calving sites fit reasonably well with observations as do the modelled iceberg trajectories. Moreover, we are interested in the impact of the icebergs on the climate and the ice sheet, and especially in the mechanisms behind this impact, which are independent of the model resolution. We have to keep in mind that refreezing of the melt water, as well as splitting up of bergs is not accounted for in our setup. Excluding this latter process probably leads to an underestimation of the spread of the fresh anomaly, but an overestimation of the near-shore freshwater input, as has been reported by Martin and Adcroft (2010) and could explain the less wide spread iceberg melt flux in our simulations compared to theirs. Despite the mentioned shortcomings, this model set-up is a valuable tool to investigate the effect of icebergs on the Northern Hemisphere climate and the GrIS. Especially as the EMIC is coupled to a dynamically computed ice sheet model and therefore changes in calving rates and positions are taken into account. This is of particular interest for the study of past climate changes at relatively long time-scales (centuries to multi-millennia), when also large changes in ice sheet geometries can be expected.

In the prevailing study the resulting climate conditions and ice sheet geometries differ between the experiments even though they were done under pre-industrial conditions where the calving rates are relatively constant and small. The impact of icebergs on the ice sheet's development is thought to be stronger during colder climate conditions with higher calving rates.

So far, icebergs have mostly been parameterised using freshwater fluxes to save computation time. To study the impact of such parameterisations, we compared dynamical included icebergs to freshwater fluxes released at the same locations and according to the same seasonal cycle as the icebergs and found noticeable differences. Icebergs facilitate the formation of sea ice especially in the GIN seas compared to the freshwater fluxes being applied at the calving locations together with homogeneous take-up of latent heat around Greenland. This is comparable to the findings of Jongma et al. (2009) who performed sensitivity studies under pre-industrial conditions, where they investigated the different impact of icebergs compared to homogeneously distributed freshwater fluxes in the Southern Ocean. They found that the effect of icebergs is restricted closer to shore than that of the freshwater fluxes and that the sea ice formation is facilitated by icebergs. Yet, when we apply local freshwater fluxes that cool the ocean locally due to the take-up of latent heat needed to melt, these fluxes are more efficient in producing thicker sea ice than icebergs. This is in agreement with Martin and Adcroft (2010) who investigated the impact of interactively coupled icebergs in an AOGCM and also compared it to directly applied freshwater fluxes. They find a decrease in sea ice thickness almost everywhere around Antarctica besides a few regions when generating icebergs when generating icebergs. Also Hunke and Comeau (2011) investigated the interactions between sea ice and both giant and small icebergs in the Southern Ocean using a stand-alone ocean model with explicitly included icebergs that are moved according to the ocean currents and the atmospheric forcing applied. They revealed that the bergs locally affect the sea ice thickness and area, but conclude that on a global scale these dynamically induced differences are negligible. In our study the effects on sea ice are locally confined, yet, the feedback on the atmosphere and consequently the development of the ice sheet indicates more extensive impact. The CALV experiment is the only one in which the sea ice thickness enhances east and south of Greenland, in all the other runs the sea ice thickness increases only west of it. This different impact on the sea ice and consequently on the atmospheric state results in different ice sheet geometries. In our experiments we find that the effect of icebergs on the climate is due to both the freshening and the cooling effect, as the bergs take up the latent heat from the ocean. These findings coincide with the results of Jongma et al. (2013), who looked at the impact of icebergs on climate during Heinrich events. They show that including icebergs as melt water fluxes and take up of latent heat has a stronger impact on climate than as just melt water fluxes.

The presented coupled model set-up offers a great approach to conduct long term experiments to better understand the role of icebergs and the interactions between the different climate components during abrupt climate changes. This is feasible with the presented model since the computation time for 1,000 model years is about two days in the fully coupled set-up. A useful next step could be to use this model set-up to study Heinrich events in detail, as the crucial question how the icebergs' feedback was on climate under colder and more instable times has not yet been fully addressed.

205 – 3 – present study, not prevailing study. This paragraph is very hard to follow. I have taken the liberty of rewriting it as I understand it. Please note the question in italics in the latter part.

"In the present study the climate conditions and ice sheet geometries do not differ much between the experiments. This is because they were done under pre-industrial conditions where the calving rates are relatively constant and small. However, the impact of icebergs on the ice sheet's geometry is thought to be stronger during colder climate conditions when the calving rates are higher. Moreover, icebergs can also influence the timing of the climate's response during rapid climate changes such as Heinrich Events. Heinrich events are large surges of icebergs released from the Laurentide ice sheet during the last glacial (Hemming et al., 2004), for which widespread evidence has been found in marine sediment cores. Using the same iceberg module coupled to LOVECLIM (Goosse et al., 2010)., Jongma et al. (2013)

mimicked the impact of these Heinrich event by introducing large surges of dynamical icebergs in the model under glacial boundary conditions. They compared this experiment with a run in which an equivalent volume of water was released as liquid freshwater fluxes. They revealed that icebergs that freshen and cool the ocean can cause a faster. climatic response as well as a faster recovery of the system. In a similar experiment Green et al. (2011) investigated the impact of deep-draft icebergs released due to the break-up of the Barents ice sheet collapse during MIS 6 (140 kyr B.P.). Using the global climate model FRUGAL coupled to the iceberg module based on Bigg et al. (1997) they found that the effect of icebergs on the ocean circulation was weaker in the ***beginning of what****?, but lasts over a longer time period* ***than what? When compared to what?.*** *Both studies show that not only the size of the calving fluxes, but also their form – either icebergs or freshwater fluxes – is important. "*

We have deleted this paragraph because it is not directly linked to our results.

205 – 3. If I recall Jongma introduced their freshwater over the area of the Atlantic ocean not just at a few grid points near the edge of Greenland. This point must be emphasised since it could well explain the different conclusions.
Jongma et al., 2009 introduced homogenous freshwater fluxes in the Southern Ocean everywhere South of 55°, we have added this information in the discussion.

Figures
The red-green-blue colour scheme must be changed.
We have re-done the figures using the Brewer color scale as suggested.

Please note in the figure captions where the scale is non-linear.
We have added this information as suggested.

The maps show too great a geographical area, so it is hard to make out the details that are important. You should focus in on the Greenland area – no reference is made to the area outside this so it need not be shown.
We have changed the geographical area to clearer focus on Greenland.

Figure 13 – what are the units of accumulation?
The units are m of ice, as stated next to the color bar.

I appreciate how hard it is to write in a non-native tongue. However, the train of logic in much of the analysis is very hard to follow. Words such as, hence, former, latter, therefore, have very specific meanings which if misused render the text very unclear.