We thank Bas de Boer for his thorough review on our paper and for his constructive comments and remarks. We hope that we were able to address them in a satisfactory manner and discuss the modifications we introduced motivated by the main remarks below. Please find all changes and the new or modified figures in the attached manuscript tracked in red. We also included the main changes below each comment in this document (response to reviewer comments in blue, changes to the manuscript in red).

1. Transfer function

As pointed out on line 15, page 5, you have used a transfer function to describe 2 Myr of climate variability, combining the EDC ice core record and LR04 benthic oxygen isotope stack. Please use a couple of sentences to describe this function in the main text.

This information was indeed missing and we now include a short description including the transfer function used (p5 l27-32).

and Raymo (2005) (LR04) or the global surface temperature data set from Snyder (2016). To obtain an "Antarctic" surface temperature record from the far field benthic oxygen isotope stack, the LR04 isotope values are scaled via:

$$LR04_T = -(LR04 - \overline{LR04_{810}})\frac{\sigma(EDC2007)}{\sigma(LR04_{810})} + \overline{EDC2007} - 55 \qquad (1)$$

5

$(LR04_T)$ is the new surface temperature record, $LR04$ is the benthic isotope stack data (time corrected to match the AICC2012 time scale (Bazin et al., 2013; Veres et al., 2013)) and $\overline{LR04_{810}}$ the mean LR04 isotope data for the last 810 kyr, standard deviations of the EDC and $LR04_{810}$ record denoted by $\sigma(EDC2007)$ and $\sigma(LR04_{810})$, mean Dome C surface temperature record is denoted by $\overline{EDC2007}$. The forcing variables (surface temperature T_s, ocean temperature T_o) can then be calculated

2. Description of temperature forcing (eqns. 1 and 2)

The description of the temperature forcing in equations (1) and (2) should be expanded a bit more and made clearer. For example, since you use the temperatures at the LIG, LGM and Pliocene as anomalies, use a _T in the equations and description of the variables in the text below. Also describe all three anomalies below the equation for both surface and ocean temperatures as (for example):
"The ESM anomalies _T$_{s\ ig}$, _T$_{s\ g}$, and _T$_{s\ p}$, represent the LIG, LGM and Pliocene, respectively. Ocean temperatures (eqn. (2)) are defined in the same way."
Secondly, when describing the calculation of the weighting factor w, using the glacial indices, it is unclear how you distinguish between the three states (w$_g$, w$_{ig}$ and w$_p$).
Also, it would be good to have a Figure 2 close by to refer to the GI values over time (instead of places in Figure 5 only). Also, what are the values of GI$_{PD}$ and GI$_{max}$?
Do these vary between the two GI records? Also, why did you not shifted the index to have GI$_{PD}$ = 1 or 0 for example? (since it is an index and can be shifted any way you want, as long as you coherently adapt equations 3-5). I do understand that since you have two GI records, based on Snyder and ice-core/_$_{18}$O records, the differences between the two need to stay intact.

We agree, that the description of the climate forcing should be expanded. To this end we introduce a plot which illustrates how the glacial index is implemented (p.7 new Figure 2). We also correct a mistake in equations 4-6 (p6).

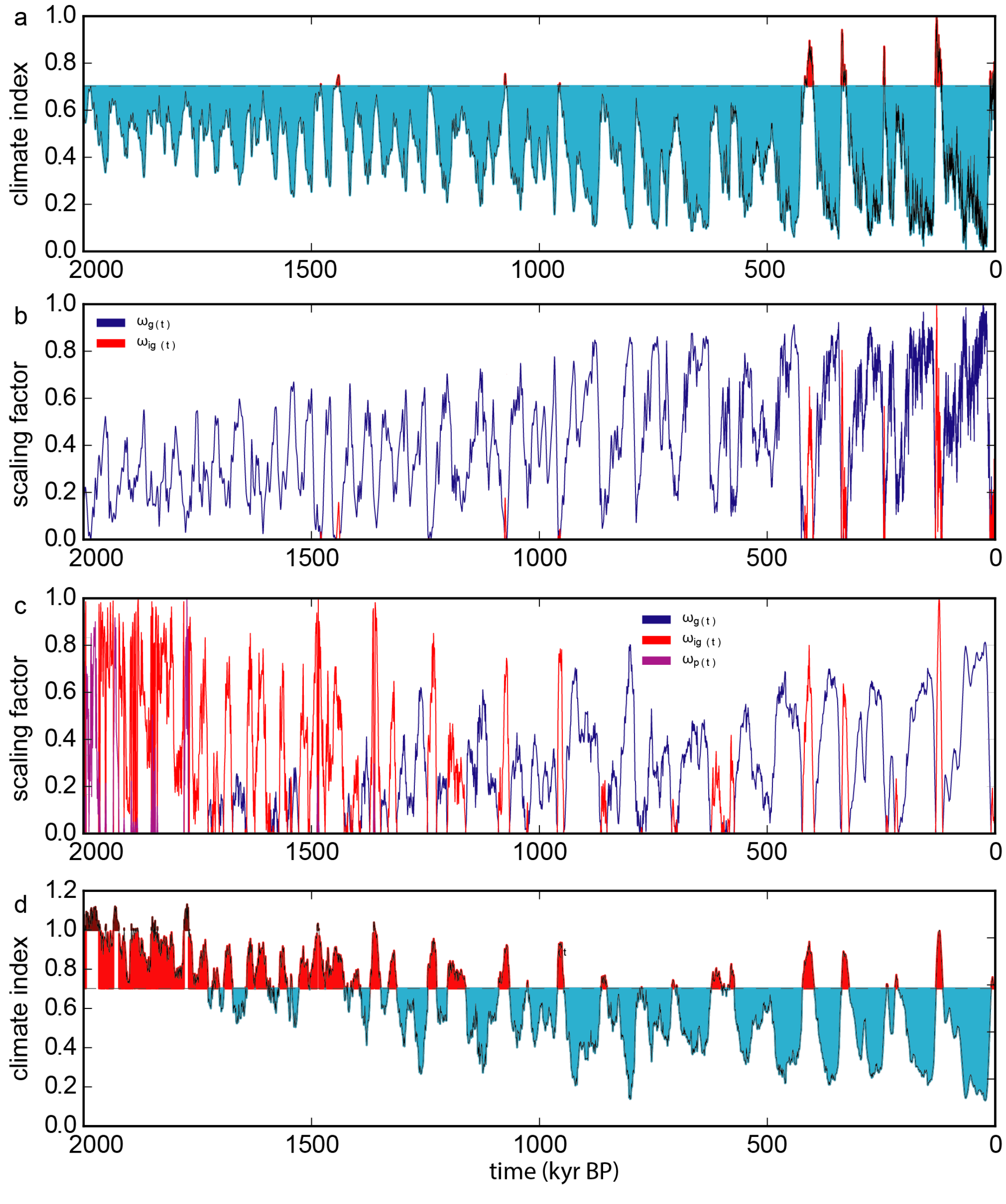

Figure 2. climate index derived from Dome C deuterium record a) and corresponding scaling factors ω_X in b). Times colder than present are shaded in cyan and times warmer than present in red. d) same as as a) but for climate index derived from the Snyder global air temperature record and scaling factors ω_X in c) . Times warmer than the last Interglacial are shaded in dark red.

<u>3. Comparison with PD09 and dB14</u>

As mentioned on line 3, page 10, you shortly explain the type of forcing used in the two other studies. For a good comparison I do think you have to add a bit more explanation on how these two studies derived a transient climate forcing, and use this later

on in your discussion as well. Both studies derive their long-term forcing in temperature and sea level from the LR04 benthic _18O record, although applied in different ways. Also, they both use a weighting index (eqn 6 in PD09, equation 7 in dB14) to prescribe the variation in sub-oceanic melting. This weighting index includes solar variations (through an anomaly at 80S) which mainly controls the waxing and waning of the WAIS (see dB14 supplement figure S4). The large peaks towards lower ice volume are caused by including this insolation anomaly, so take this into account in your comparison/discussion. For more description of the methods, please see Methods section at the end of both papers.
Some more thoughts: It is a bit hard to distinguish individual simulations in Figure 5, but I guess your simulations of the B1-ensemble should be, in terms of timing, compare rather well to both PD09 and dB14 (depending on the sea-level forcing used). As you noted on line 6, page 10.

We agree, that the reader should be able to grasp major differences between the different studies approaches without doing a literature search first. We include a more detailed discussion of the approach in dB14 and P09 and a quick comparison of the main differences in the forcing approach with our study. We put the focus on basal shelf melt as we deem this to be the major difference affecting the simulated ice volume between the studies (p11 l 9-15, p12 l 1-2 & l 5-8.)

One of the main differences in the approach here and the forcing applied in Pollard and DeConto (2009) and de Boer et al. (2014), is the handling of basal melting underneath the ice shelves. This forcing component arguably exerts the strongest influence on grounding line migration of the AIS in interglacials. Our calculation of basal melt rates is very similar to de Boer et al. (2014), with lower differences between assumed peak interglacial and present day uniform ocean temperature. Peak interglacial temperature for ensemble B1 is approximately 2°C warmer than present day and 3°C warmer in B2 (3.7°C in de Boer et al (2014), -1.7°C at present day and +2°C at peak interglacial). Additionally, we increase the sensitivity of the basal melt rate to ocean temperature changes in certain ocean basins (see method section). Pollard and DeConto (2009) prescribe basal melt rates directly, scaling them via the far field benthic isotope record (Lisiecki and Raymo, 2005) and austral summer insolation. Ultimately this scaling leads to larger bulk ice shelf melt rates and smaller melt rates close to the grounding line compared to the ones calculated in our approach.

4. Structure of the ensemble

Based on the variables in Tables 1 and 2 you have a possible ensemble of 12 x 92 members. Please clarify in Section 2.3 how the two ensemble branches are built up. How many members does each have, and which specific experiments did you perform. All possible combinations? Or only a set? Also, in Table 2 the variable cE has only 1 value, so not a variable that you vary within the ensemble? If so, please remove form the table. What are the other settings of the model? Do you intend to include a parameter table? Or are these settings similar to previous simulations with PISM (please refer)?

This is indeed confusingly presented in the manuscript. We now address specifically which ensemble members are mainly analysed in the study (p8, l 8-10 & p9, l 1-4) and changed table 2 (p9) accordingly. Table 2 now provides the two main parameter sets used for all sea level and geothermal heat flux combinations in ensemble B1 and for all geothermal heat flux combinations in B2. We further provide additional parameter combinations simulated in the ensemble but not discussed in the manuscript in the third line of table 2. We hope this clarifies the main scope of the ensemble.

The constituting forcing set for the ensemble consists of four different geothermal heat flux and three sea level data sets, i.e. twelve individual experimental settings. We explore two main parameter sets (P1 and P2) highlighted in table 2. While we do take into account all sea level variations for ensemble B1 (48 individual experiments), we only look at the sea level forcing derived from Lisiecki and Raymo (2005) (LR05) in ensemble B2. We also experimented with other parameter choices based on table 2 (VP) but do cover all individual forcing sets, thus these are not discussed in this study. The ensemble members discussed in this manuscript consist of 8 experiments for each ensemble B1 and B2 with sea level forcing from LR05.

Table 2. Selected ISM parameters for the model ensemble. First and second line show the main parameter sets used in the ensemble (P1 and P2). The third line lists additional parameters tested but not further explored (VP). cH stands for thickness calving limit (in meter), cE is a parameter in the Eigencalving equation. sia_e and ssa_e stand for the so called sia and ssa "enhancement factors", $till_{min}$ and $till_{max}$ modify basal friction in the sliding law. γ_{EAIS} is a dimensionless scaling factor for basal shelf melt for selected East Antarctic ice shelf regions (George V Land, Wilkes Land).

Parameter	sia_e	ssa_e	cH (m)	cE	$till_{min}$	$till_{max}$	γ_{EAIS}
P1	1.0	0.55	**75**	$1 \cdot 10^{17}$	5	30	**10**
P2	1.0	0.55	**150**	$1 \cdot 10^{17}$	5	30	**1**
VP	1.6 ; 1.7 ; 2.0	1.0	100	$1 \cdot 10^{18}$	10	40	5-20

5. Revise Figure 6

In general, I think your figures look really good. I do suggest you add panel labels to all figures (a,b,c, etc.) and use these in the captions. However, the left panel of figure C4 6 is unclear, and I cannot distinguish between the dots or triangles at all. I suggest you create a separate figure from the left panel and the two other panels (the maps). In the new figure 6, make the symbols much bigger and perhaps put the time frames next to each other (LGM, LIG and you could also add the simulated PreInd or PD ice volumes in the middle perhaps?). Please also mention the total number of simulations shown in the plot. Nice to add the values, that should be included again.
In the two panels with the map, please indicate which specific simulations you have used here. Is this a minimum/maximum within the ensemble, or a (sort of) reference simulation that represents the middle/median of the ensemble? Are the lines of LGM, PD and LIG shown in both panels?

Figure 6 is now split into two figures (Figure 7 on p14 and Figure 8 on p15). We hope Figure 8 provides an improved visual aid to the spread of the ensemble, with the main 8 ensemble members highlighted in colour for both B1 and B2.

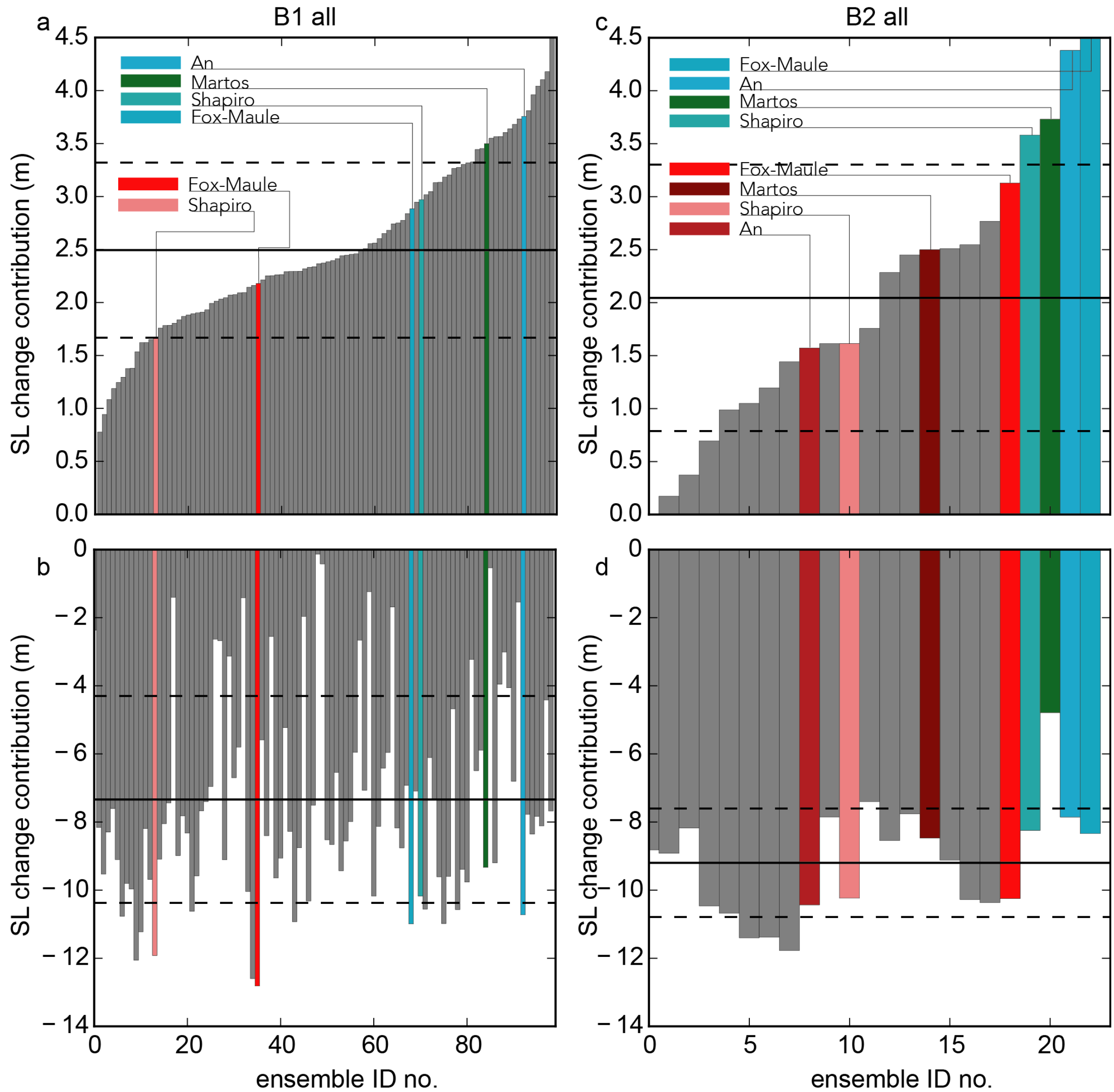

Figure 8. Sea level contribution in the LIG (a/b) and LGM (c/d) for the full ensemble forced with climate index B1 and climate index B2. The ensemble members focused on in this paper are highlighted with colours (P1 red colors, P2 blue/green colors). Horizontal black line depicts the full ensemble mean and the dashed line the standard deviation.

We expanded Figure 7, to illustrate the effects of the different forcing approaches on the spatial configuration of the AIS during the LIG, LGM and PD.

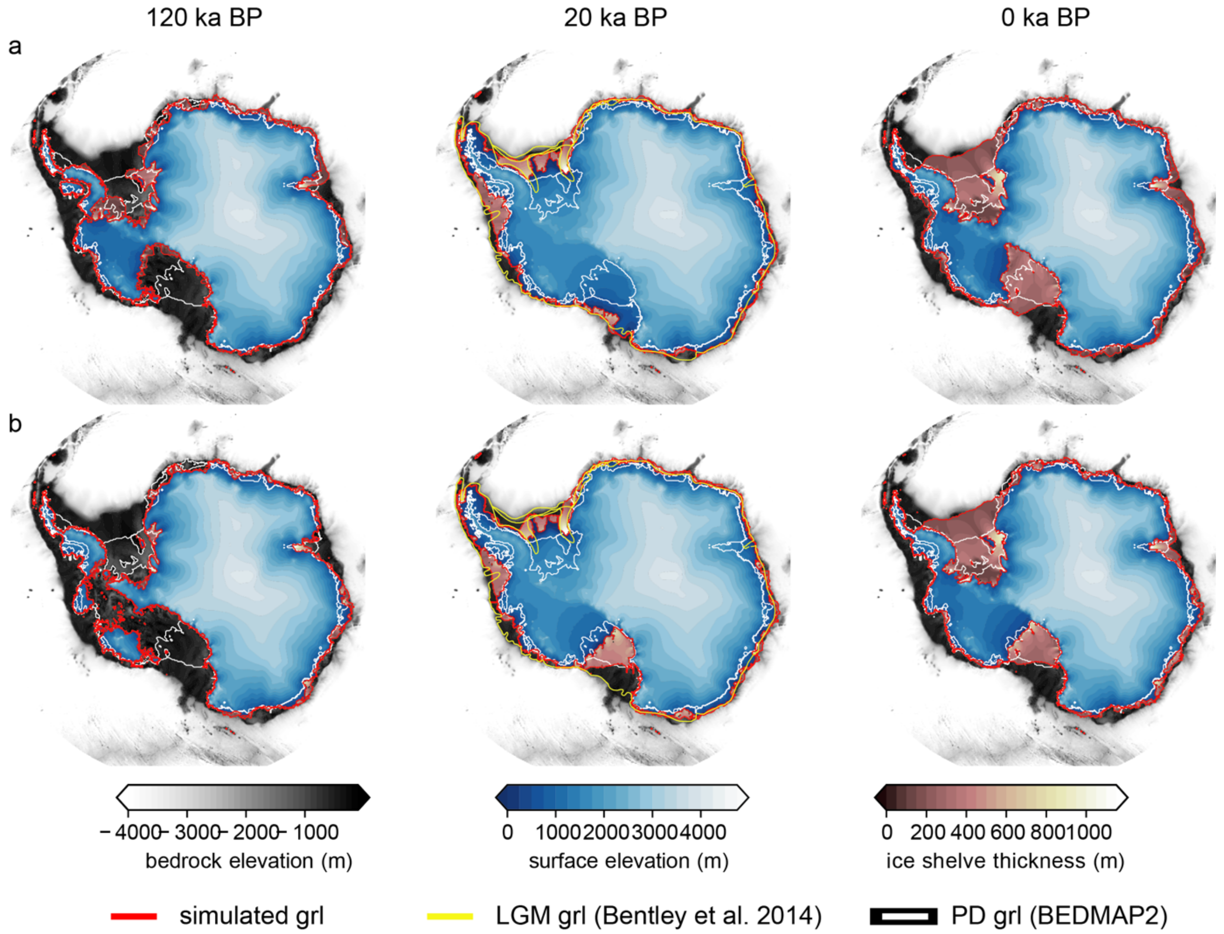

Figure 7. Panel a/b illustrate simulated ice-sheet configurations for the LIG, LGM and PD, respectively. Both simulations are carried out with forcing B1, using a different ice thickness calving limit (a: cH=75 m, b: cH=150 m). Reconstructed grounding line positions for the LGM (Bentley et al., 2014) are depicted in yellow, and both grounding line and ice shelf front from BEDMAP2 (Fretwell et al., 2013) are depicted in white.

6. Revise Figure 9
Also, figure 9 is not really clear for me, took quite some time to get the full picture right. Please indicate for each panel what it shows, i.e. write type of experiment above the labels or ordered in a 4x4 grid. Make the lines of the ice divides thicker. Since you have so many panels, I don't think panel labels are useful here. What is the purpose of the big central panel, just as an overview? It takes away the attention so if it is less important, position it more on the side. Also, make a clearer division between the different sensitivity experiments with using names on top of the figures and put the colour bars at the bottom of the figure. Something like a 4x4 panel, with the x-axis (on top) the four different regions and the y-axis (on the left) the four different GHF datasets used. And then the big panel on the left.

We modified Figure 9 (now Figure 11p19) as suggested.

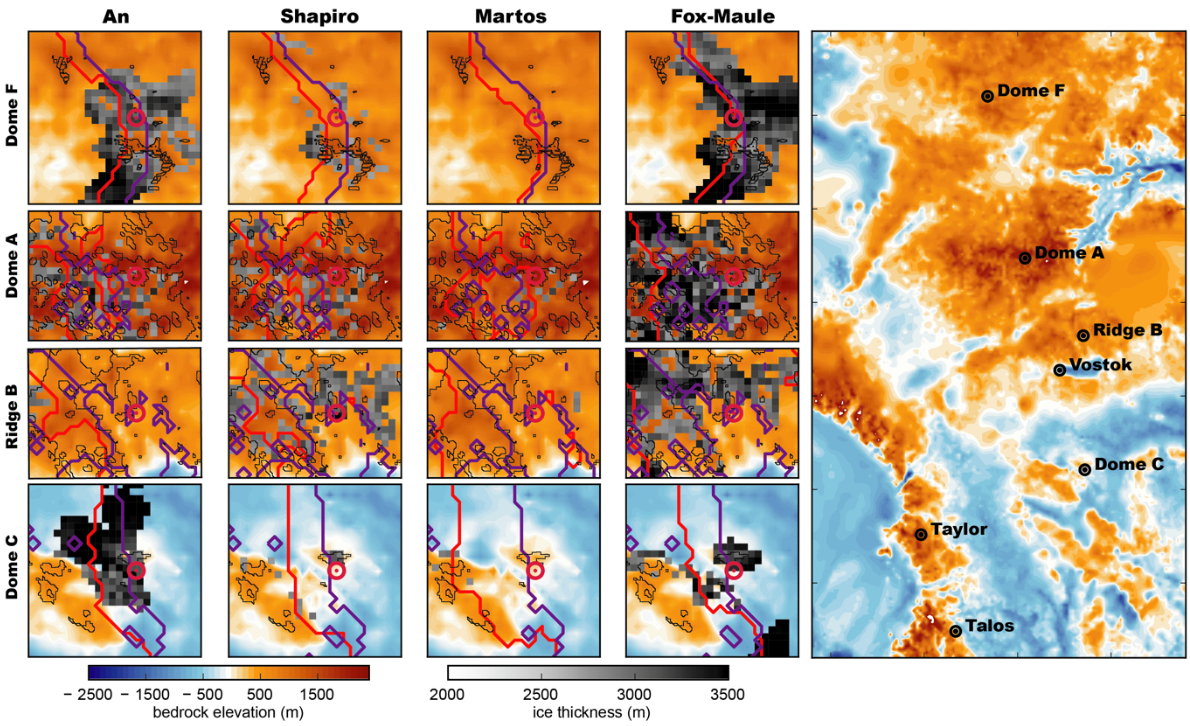

Figure 11. Comparison between regions of Oldest Ice identified in this study and in Van Liefferinge and Pattyn (2013) (Ridge B, Dome A) and Van Liefferinge et al. (2018) (Dome C, Dome Fuji) outlined in black. Regions of oldest ice are defined as grid nodes where ice thickness is larger than 2000 m, basal melting is zero and surface ice velocity slower than 1 m/a (boxes coloured in grayscale). The left matrix columns show magnified sections centred at Dome Fuji, Ridge B and Dome C for identical parameter sets and forcing but different geothermal heat flux (from left An et al. (2015), Shapiro and Ritzwoller (2004), Martos et al. (2017) and Purucker (2013) GHF forcing). The red line in blown up regions depicts simulated present day ice divide (defined as position where surface elevation gradient switches sign), while the dark rose line depicts the present day ice divide as computed from BEDMAP2.

7. Reference list

I have added some minor comments in the reference list, seems to have some issues with the copy from Bibtex (in case you have used latex). Please carefully check your list of references on errors in mainly page numbers and hyperlinks via doi.

This is now corrected.

We thank Bas de Boer for his positive review of our manuscript and hope that the revised manuscript satisfactorily addresses all critical points.