- **Please note that the reviewer comments are posted in Black, responses posted in Red, and our revisions to the text posted in Blue.**

- The authors present a modelling reconstruction of the northern branch of the Patagonian Ice Sheet (PIS) during the last deglaciation, precisely from the last glacial maximum (LGM) to 10 ka ago. The ice-flow model ISSM is used for this purpose. The exercise makes use of various glacial climatologies to reconstruct the glacial state of the ice sheet and of a transient climatology (TraCE-21ka) to simulate the early stage of the deglaciation. The results are then compared with reconstructions available for that region (PATICE - Davies et al., 2020). Ice-climate interactions, sensitivity on the employed climate model, and goodness of the model results are then discussed.
- The work is novel and very appealing, as it is the first modelling work trying to delucidate the deglaciation history of a region of the PIS that unfortunately still presents a lot of uncertainty. The manuscript is well written, well organised ad the methodology is mostly sound.

We would like to thank the reviewer and appreciate the thorough comments, especially those involving the role of GIA during the deglaciation of the PIS. We apologize for any confusion that was presented in our first draft, but as we describe below, we did prescribe GIA in our numerical simulations and account for its influence during the deglaciation.

- Still, I am very surprised that no Glacial Isostatic Adjustment (GIA) is taken into account in their simulations.

Apologies, but it seems we have introduced some confusion in our original draft.

We account for the GIA modeled time series of bedrock and geoid from Caron et al., 2018 (Global GIA model for the last glacial cycle (-122 to PD)). We include 3 physical components: 1) Bedrock vertical motion 2.) Eustatic sea level 3.) Geoid changes. This is represented by the figure below (Figure S1), showing the transiently evolving relative sea-level changes prescribed in our model simulations across the last deglaciation. The prescribed RSL is on par with a study that the reviewer cited below (i.e. Troch et al., 2022) who use isolation basins to reconstruct RSL across the last deglaciation.

The time series we use to prescribe GIA is from the model average of an ensemble of GIA forward model estimations from Caron et al., 2018.

Given this, and to add clarity to our original text, we adjust lines 156-163. We also would be happy to supply the figure below in a supplement to our manuscript:

"To account for the influence of glacial isostatic adjustment (GIA), we prescribe a transiently evolving reconstruction of relative sea level from a global GIA model of the last glacial cycle from Caron et al. (2018). This includes 3 physical components: 1) Bedrock vertical motion 2.) Eustatic sea level, and 3.) Geoid changes. The time series we use to prescribe GIA is from the model average of an ensemble of GIA forward model estimations from Caron et al., 2018. The prescribed GIA is in good agreement (Figure S1) with a reconstruction of relative sea-level change from an isolation basin in central Patagonia (Troch et al., 2022). This methodology has been applied in recent modelling following Cuzzone et al. (2019) and Briner et al. (2020)."

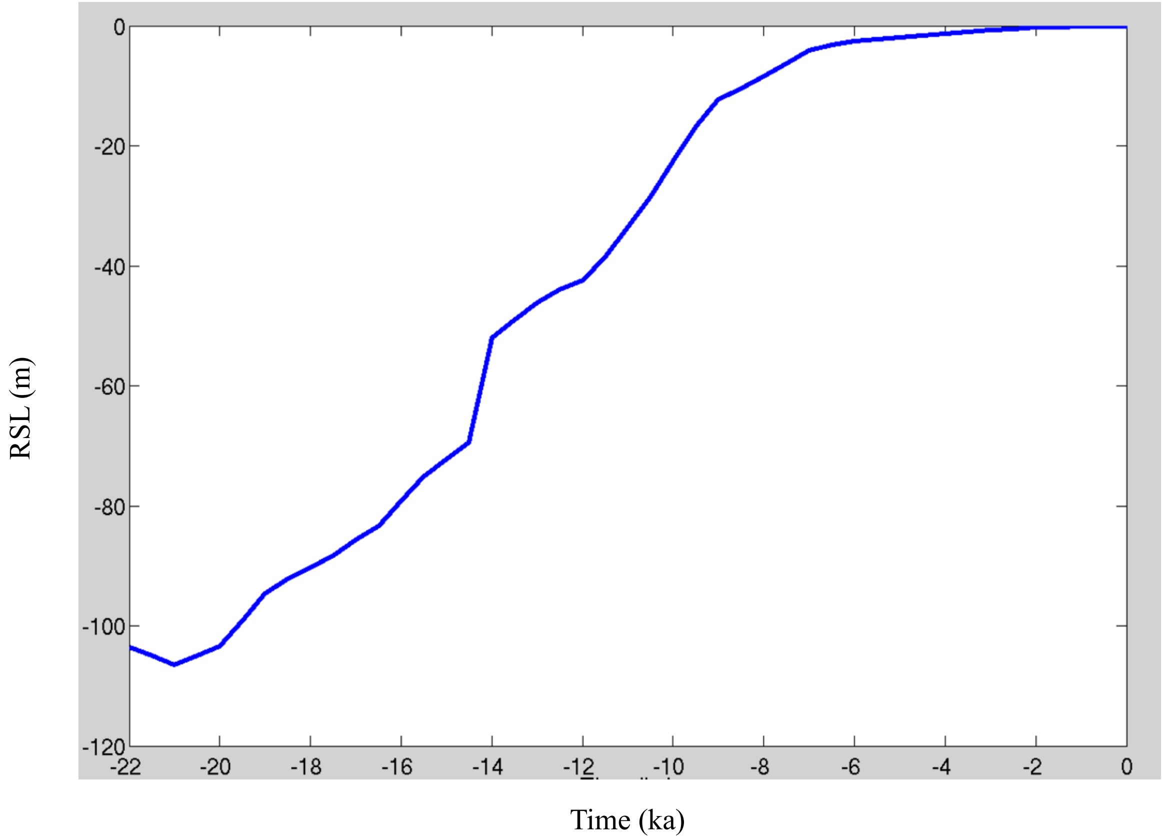


Figure S1: The time dependent prescribed relative sea level change area averaged across our model domain. The relative sea-level change consists of 1) Bedrock vertical motion, 2.) Eustatic sea level change, and 3.) Geoid changes from Caron et al., 2018 across the last deglaciation.

Limitations section:

We acknowledge that there is no 2-way coupling between the ice and solid-earth in our model currently. For these simulations GIA is prescribed following what was stated above. While the simulated ice history in our experiments is influenced by time varying GIA, the simulated ice changes that occur in our model do not feedback onto GIA. The ice history for Patagonia incorporated into the Caron et al. (2018) ensemble is from Ivins et al. (2011). Therefore, the prescribed GIA response across our domain does not perfectly match our simulated ice history. One can also acknowledge that the model of Caron et al. (2018) is not perfect. The global mantle from Caron et al. (2018) does not exhibit regional low viscosity that is attributable to Patagonia (Personal Communication with Lambert Caron). Therefore, current rates of deformation are likely underestimated by the model.

These are limitations of our model when it comes to GIA. However, given the reasonable agreement of the prescribed GIA and what others have found through direct observations (cited in the reviewer comments), we think our model includes an adequate treatment of the influence of GIA on the simulated ice history. We hope that this helps to clarify that we do indeed account for GIA in our model simulations.

To further address the reviewer comment, we have added a limitations section (see Discussion 4.3).

“Currently ISSM is undergoing model developments to include a full treatment of solid earth-ice and sea-level feedbacks (Adhikari et a., 2016). Therefore, at this time, there is no coupling between the ice sheet and solid earth. Instead, we prescribed GIA from a global GIA model of the last glacial cycle from Caron et al. (2018). While this model reasonably estimates GIA across the PIS over the last deglaciation, our simulated ice history does not feedback onto GIA. The ice history for Patagonia incorporated into the Caron et al. (2018) ensemble is from Ivins et al. (2011). Therefore, the prescribed GIA response across our domain does not perfectly match our simulated ice history. Additionally, the global mantle from Caron et al. (2018) does not exhibit regional low viscosity that is attributable to Patagonia and therefore, current rates of deformation are likely underestimated by the model. By not simulating the 2-way coupled ice and solid-earth interactions, we could be missing some feedbacks between our simulated ice history and the solid earth that may modulate the deglaciation across this region. Despite this limitation however, our prescribed GIA from Caron et al. (2018) is reasonable when compared with reconstructed deglacial GIA in Patagonia (Troch et al., 2022), giving confidence that the simulations are capturing the regional influence of GIA on the deglacial ice history. "

- It is very well known that the chilean coastal region presents a unique tectonic setting promoting fast response of solid earth to ice mass changes (e.g. Richter et al., 2016, Troch et al., 2022, …). In fact, the thin lithosphere combined with a low upper mantle viscosity and current fast ice retreat leads to extraordinary high uplift rates there. These are found today near the Southern Patagonia Icefield (~4 cm/a) (Lange et al., 2014; Dietrich et al., 2010), for instance, where the current uplift is mostly due to the ice unload after the Little Ice Age. Yet, strong GIA signals are also found for the last deglaciation/early-middle Holocene in:
    - Larenas Bay (48°S, between modern Northern and Southern Patagonia Icefields), which rebounded isostatically by almost 100 m between 16-8 ka ago, with a rate of 1.3 cm/yr (Troch et al., 2022), and most of it occurring before 14 ka ago;
    - Northern Patagonia Icefield, where GIA rates of 1.5-3.4 cm/a were found for the past ~8 ka (Bourgois et al., 2016);
    - More to the south, in the Strait of Magellan, with uplift rates of 0.5 cm/a for the last 13 ka (Rios et al., 2020).
- It is true that data of uplift rates for the last deglaciation/early Holocene, especially in northern Chile, is somehow lacking. However, new relative sea level (RSL) reconstructions along the southcentral chilean coast (18°S - 44°S, Garrett et al., 2020) reveal interesting informations. Regions where tectonic deformation is associated with the subduction of the Nazca Plate beneath the South American Plate may have experienced uplift rates even higher than 1 m/ka during the mid Holocene (such as Isla Santa María and Isla Mocha). Other regions, such as the southern area of Bío Bío, Valdivia and Arauco, show a sea level highstand of 6-8 m around 8-7 ka ago compared to the present, suggesting a clear local response of solid Earth to the ice unload. This is confirmed by the agreement between such RSL data and GIA model simulations (ICE-5G and ICE-6G), suggesting that the isostatic uplift has a primary control in changes in RSL in these regions (Garrett et al., 2020). This is also in agreement with strong uplift rates (1.5 ± 0.3 m/ka) found in Isla Santa María during MIS3 (Jara-Muñoz and Melnick, 2015), and those found in the region south of the Arauco Peninsula (0.5 m/ka) during the Holocene (Stefer et al. 2010). All these areas are close to the northern branch of the PIS (35°-43°S), therefore it is very likely that the isostatic rebound had a crucial role also in the evolution of the PIS.

- The lack of a clear response of the lithosphere to the ice unload during the deglaciation might well affect the results presented in this paper. In fact, the exclusion of an isostatic rebound due to ice melt might partly explain why the area modelled after 16 ka is well below the reconstructions from PATICE: the modelled surface elevation might be too low to sustain the existence of an extensive ice field for increasing Holocene temperature. This is somehow - although indirectly - shown in the sensitivity experiment, where a constant, LGM precipitation (higher than today) is applied to the whole Holocene. In this test, we see that even a small variation in the precipitation might strongly affect the retreat in terms of timing and deglaciation rate. This is because - here -

a higher winter accumulation rate helps to sustain the presence of glaciers even with warmer temperatures. Still, a delayed retreat could also be the result of an uplifted topography, which ensures temperature lapse rate near the glacier surfaces to decrease more rapidly. It would be interesting to see if the authors can reproduce similar results in the retreat either by reducing the tropospheric lapse rate (i.e. making the atmosphere cool more rapidly at increasing elevations) or by considering a synthetic higher topography (+50 m, +100 m, for example) for specific deglaciation times. Therefore, the deglaciation history might not be only defined by the applied paleo climatology, but also by climatology/topography effects that are not taken into account for the moment due to the lack in the GIA treatment. In such a case the whole discussion on climate-ice sensitivity as described in the manuscript risks becoming pointless. Put it in another words, it might be that the simulation experiment with a higher precipitation set for the whole deglaciation matches better the geological reconstructions, but for the wrong reasons.

- I understand the authors justify this deficiency as ISSM is currently lacking a GIA solver (even though they claim it's under development), and that they have already successfully applied a similar model configuration - with only relative sea level changes - in previous work in Greenland (Cuzzone et al., 2019 and Briner et al., 2020). However, to me this lack represents a big flaw in the work presented here, as I would expect that GIA has a clear primary control on the evolution of the PIS during the last deglaciation.

We think that we have adequately addressed the above comments with the clarification and addition of new text. However, we would kindly push back a bit on the notion raised by the reviewer that GIA has a primary control on the evolution of the PIS during the last deglaciation. GIA is a response to the ice history changes and not a forcing (Climate changes are a forcing). Therefore, GIA cannot be a primary control on the evolution of the PIS. With that said, GIA can modulate the response of the PIS. GIA can influence local to regional scale elevation-mass balance feedbacks, and in turn enhance or dampen ice change. The reviewer cites many great papers discussing current and past reconstructions of GIA across Patagonia. Uplift rates during the deglaciation are on the order of cm/yr. Over time, this may have some impact on mass balance through time. However, the surface mass balance is on the order of m/yr, which is the primary control on the ice history during the deglaciation.

- Finally, the glacial outline from PATICE (Davies et al., 2020) is really uncertain in the northern part of the domain (in fact only very few radiocarbon dates were taken in the Lake district). It might be that the PIS was covering a region further north than what is presented here, as suggested by previous work (Rabassa & Clapperton 1990, Garret et al., 2020). In that case the reconstruction from Trace-21ka would not be sufficient to cover those areas and the whole discussion comparing different climate model outputs and comparing model results to the reconstructed ice retreat during the deglaciation becomes sterile. Therefore, I suggest to clearly discuss the uncertainties in the glacial reconstruction of the northern boundaries before comparing them to the model simulations.

We appreciate the reviewer highlighting the existing limitations of the terrestrial reconstruction. For this matter, we modified the text in the discussion section as it follows:

"The PATICE dataset (Davies et al., 2020) serves as the best available reconstruction of ice margin change for the PIS across the last deglaciation. This state-of-the-art compilation provides an empirical reconstruction of the configuration of the PIS as isochrones every 5ka, from 35 ka to present, based on detailed geomorphological data and available geochronological evidence. Because geochronological constraints on past PIS change are limited, the PATICE reconstruction assigns qualitative confidence to its reconstructed ice margins. Where there is agreement between geochronological and geomorphological (i.e., moraines) indicators of past ice margin history, high confidence is assigned. Where geomorphological evidence suggests the existence of past ice margins, but lacks a geochronological constraint, medium confidence is assigned. Lastly, low confidence is assigned where there is a lack of any indicators of past ice sheet extent, where the ice limits result in interpolated interpretations from immediately adjacent moraines from valleys that have been mapped and dated. Across the CLD, the LGM ice extent is well constrained by geologic proxies particularly in the west and southwest (Figure 1). The moraines that constrain the piedmont ice lobes that formed along the western boundary are now presently lakes and have reasonable age control (Denton et al., 1999; Moreno et al., 1999; Lowell et al., 1995), giving confidence to the LGM ice margin limits. Beyond this region, age control is sparse along the western boundary for the timing of LGM ice extent, but the existence of well-defined moraines along lakes in the northern CLD are assumed to be in sync with those moraines deposited to the south (Denton et al., 1999). However, low confidence remains in the geologic reconstruction of the LGM ice boundary along the eastern margin where little to none chronological constraints are available. In general, deglaciation from the maximum LGM ice extent begins between 18 – 19 ka (Davies et al., 2020), however, poor age control and lack of geomorphic indicators make it difficult to constrain the ice extent across this region during the deglaciation. For instance, a single cosmogenic nuclide surface exposure date retrieved from the Nahuel Huapi moraine yielded an age of ~31.4 ka (Zech et al., 2017). While it is assumed that the ice limit behaved similarly both to the west and east, the limited existing data prevents a comprehensive understanding of the ice extent at the northeastern margin. This induces the highest level of uncertainty in the reconstruction and hinders our data model comparison. Therefore, we rely on the PATICE dataset interpolated isochrones (low confidence) for this northeastern region as the state-of-the-art reconstruction."

Regarding the comparison with previous reconstructions, we argue that in fact, the PATICE reconstruction resulted in a slightly larger ice sheet extent (up to ~12%) compared to the previous state-of-the-art reconstruction (Coronato and Rabassa, 2011). Davies et al. (2020) indicate that the PATICE reconstruction is in agreement with previously published datasets, either geomorphological (Caldenius, 1932; Mercer, 1968, 1976; Coronato and Rabassa, 2011; Harrison and Glasser, 2011) or modeling studies (Hulton et al., 2002). However, when considering the Rabassa and Claperton (1990) reconstruction, it is noticeable that the northern extent of the ice sheet is in fact outside of the Patagonia region. We therefore, rely on the PATICE reconstruction for several reasons: a) it constitutes the state-of-the-art reconstruction up to date, b) relies on an extensive dataset of regional chronological constraints, c) it is consistent with topographic boundaries and geomorphological evidence, being physically plausible for ice flow dynamics. Moreover, previous developed reconstructions predate the extensive geochronological dataset currently available.

- In summary, I am afraid I cannot recommend the publication of this work in The Cryosphere until the lack of a GIA treatment in the model is either exhaustively discussed, or it is taken into account presenting a new set of simulations from the same ISSM model, when the GIA module becomes available, or from another ice-flow model which already computes the interactions between the solid Earth and the ice sheet.

We think that we have addressed the reviewer comments and clarified that we indeed account for GIA in our model simulations.

- Here I note down specific comments:
- Line 71: please describe how the SWW position and strength changed during the last deglaciation with more details.

We added this line (67): During the LGM and last deglaciation, the position, strength, and extent of the SWW varied latitudinally, migrating southward during warmer intervals and northward during cooler intervals, ultimately altering overall ice sheet mass balance (Mercer, 1972; Denton et al., 1999; Lamy et al., 2010; Kilian and Lamy, 2012; Boex et al., 2013).

- Line 85: what do you mean by “climate?”

Changed “climate” to “precipitation”

- Line 113-115: This is already written some lines above. Please rephrase to avoid repetitions.

We adjusted line 96 to read: “To advance our understanding of last glacial and deglacial ice behavior across the CLD, we use a numerical ice sheet model to simulate the LGM ice geometry forced by an ensemble of climate boundary conditions from PMIP4 models (Kageyama et al., 2021). “

- Line 145: how is N calculated?

We have added text:

“Here $N = g(\rho_i H + \rho_w Z_b)$, where g is gravity, H is ice thickness, ρ_I is the density of ice, ρ_w is the density of water, and Z_b is bedrock elevation following Cuffey and Paterson (2010). “

- Lines 156-161: this paragraph about the missing GIA model definitely needs further development. See my main comments above.

Please see the comments, discussion, and added text above.

- Lines 228-229: why not simulating calving at the ice-lake interface too? Could you apply the von mises stress law also there?

We have removed lines 218-229 and instead added this text and more to the Discussion (limitations) section:

“Across most of our domain, there is evidence for an advance of piedmont glaciers across glacial outwash during the LGM, which formed the physical boundary for some of the existing terminal moraines around the lakes within the CLD (Bentley, 1996; Bentley, 1997). The formation of ice-contact proglacial lakes likely occurred as a function of deglacial warming and ice retreat Bentley (1996). Where there were proglacial lakes along the westward ice front in the CLD, evidence suggests that ice was grounded during the LGM (Lago Puyehue; Heirman et al., 2011). During deglaciation, iceberg calving into the proglacial lakes may have occurred (Bentley 1996,1997; Davies et al., 2020), with evidence suggesting that local topography and calving may have controlled the spatially irregular timing of abandonment from the terminal moraines surrounding the proglacial lakes (Bentley, 1997). Recent glacier modelling (Sutherland et al., 2020) suggests that inclusion of ice-lake interactions can have large impacts on the magnitude and rate of simulated ice front retreat, as ice-lake interactions promote greater ice velocities, ice flux to the grounding line, and surface lowering. However, because the inclusion of ice-lake interactions is relatively novel for numerical ice flow modeling (Sutherland et al., 2020; Quiquet et al., 2021; Hinck et al., 2022), we choose to not model the evolution and influence of proglacial lakes on the deglaciation across this model domain. Given this limitation, our simulated magnitude and rate of ice retreat at the onset of deglaciation may be underestimated, especially when looking at local deglaciation along these proglacial lakes. Although we do not think that these processes would greatly influence our conclusions regarding the role of climate on the evolution of the PIS is the CLD region and the simulated ice retreat history, future work is required to assess the influence of proglacial lakes in this region.”

- Line 248: please change “grounded” to “tidewater”.

Completed

- Line 276: MIROC has drier winter conditions only in the southern part of the domain, Please correct.

Completed but please note we removed the PMIP analysis based off of Reviewer 2 comments.

- Line 399-413: I don't see the point of this sensitivity test. Yes, the experiment might be interesting to see the effect of the increased precipitation in the retreat. But what do we learn from this? Does this mean that the reconstructed precipitation is wrong? Or could this be related (also) to the missing uplift upon ice unload in your experiments? Please, discuss this further and think about other possible sensitivity tests about atmospheric lapse rate/synthetic elevation (see paragraph above).

To the GIA point, we have addressed this above and in the text.

The point of this sensitivity test follows from literature cited in our paper indicating the role of the SWW on driving changes in the hydrologic budget across the PIS and its impact on ice history. Recent ice modelling suggests the critical role of precipitation in modulating the size and extent of portions of the PIS (Muir et al., 2023; Martin et al., 2022; Leger et al., 2021). What we learn: We find that modest changes in precipitation can impact ice retreat, as we describe in the text here and the discussion section. We are very limited in understanding past climate, especially when it comes to precipitation. Few data exist reconstructing past precipitation, and that data is spatially limited. Secondly, we are limited by the fact that we only have 1 transient climate model simulation of the last deglaciation. This sensitivity test therefore raises is an important finding and signals a need for better reconstructions of past climate, including precipitation. If modest changes in precipitation can alter the surface mass balance enough to modulate ice retreat that is being driven by deglacial warming, then in order to better compare models and data in the future we also require better constraints on past climate. It is not our goal, nor did we seek, to evaluate "whether the reconstructed precipitation is wrong?"

We have added some text to the discussion section lines 532-534:

"Prior numerical ice flow modelling has indicated that precipitation played a critical role in controlling the extent of paleoglaciers of the PIS (Muir et al., 2023; Leger et al., 2021) and can modulate the retreat/advance during past intervals (Martin et al., 2022)."

Additionally, following Reviewer 2 comments we have performed 2 more sensitivity tests with different precipitation forcings. We kindly point Reviewer 1 to our response to Reviewer 2, Likewise, following Reviewer 2 comments, 3G. These simulations reinforce our conclusions regarding the ability of precipitation to modulate the pace and magnitude of deglacial ice retreat.

We have also added more text and analysis of the TraCE-21ka simulated climate as it realyes to the SWW (Please see response to Reviewer 2 section 2A). Here we have bolstered our discussion with comparison of the simulated TraCE-21ka climatology against paleoclimate reconstructions from the CLD.

- Line 450 onwards: I am missing at least a large paragraph concerning the model limitations, such as lacking GIA effect, lake-terminating calving, …, and their possible influence in the results.

Thank you. We have now added a new limitation section in the Discussion section.

"4.3 Limitations

Currently ISSM is undergoing model developments to include a full treatment of solid earth-ice and sea-level feedbacks (Adhikari et a., 2016). Therefore, at this time, there is no coupling between the ice sheet and solid earth. Instead, we prescribed GIA from a global GIA model of the last glacial cycle from Caron et al. (2018). While this model reasonably estimates GIA across the PIS over the last deglaciation, our simulated ice history does not feedback onto GIA. The ice history for Patagonia incorporated into the Caron et al. (2018) ensemble is from Ivins et al. 2011. Therefore, the prescribed GIA response across our domain does not perfectly match our simulated ice history. Additionally, the global mantle from Caron et al. (2018) does not exhibit regional low viscosity that is attributable to Patagonia and therefore, current rates of deformation are likely underestimated by the model. By not simulating the 2-way coupled ice and solid-earth interactions, we could be missing some feedbacks between our simulated ice history and the solid earth that may modulate the deglaciation across this region. Despite this limitation however, our prescribed GIA from Caron et al. (2018) is reasonable when compared with reconstructed deglacial GIA in Patagonia (Troch et al., 2022), giving confidence that our simulation is capturing the regional influence of GIA on the simulated ice history.

Across most of our domain, there is evidence for an advance of piedmont glaciers across glacial outwash during the LGM, which formed the physical boundary for some of the existing terminal moraines around the lakes within the CLD (Bentley, 1996; Bentley, 1997). The formation of ice-contact proglacial lakes likely occurred as a function of deglacial warming and ice retreat Bentley (1996). Where there were proglacial lakes along the westward ice front in the CLD, evidence suggests that ice was grounded during the LGM (Lago Puyehue; Heirman et al., 2011). During deglaciation, iceberg calving into the proglacial lakes may have occurred (Bentley 1996,1997; Davies et al., 2020), with evidence suggesting that local topography and calving may have controlled the spatially irregular timing of abandonment from the terminal moraines surrounding the proglacial lakes (Bentley, 1997). Recent glacier modelling (Sutherland et al., 2020) suggests that inclusion of ice-lake interactions may have large impacts on the magnitude and rate of simulated ice front retreat, as ice-lake interactions promote greater ice velocities, ice flux to the grounding line, and surface lowering. However, across our region Heirman et al. (2011) indicate that is not well constrained how the proglacial lakes in the CLD may have influenced local deglaciation, and more geomorphic data is needed. Therefore, because the inclusion of ice-lake interactions is relatively novel for numerical ice flow modeling (Sutherland et al., 2020; Quiquet et al., 2021; Hinck et al., 2022), we choose to not model the evolution and influence of proglacial lakes on the deglaciation across this model domain. Given this limitation, our simulated magnitude and rate of ice retreat at the onset of deglaciation may be underestimated, especially when looking at local deglaciation along these proglacial lakes. Although we do not think that these processes would greatly influence our conclusions regarding the role of climate on the evolution of the PIS is the CLD region and the simulated ice retreat history, future work is required to assess the influence of proglacial lakes in this region."

- Line 478: why did you choose this “small sample” of PMIP4 climatologies? Why these models, precisely?

Please note that based off of Reviewer 2 comments, we have removed the PMIP4 analysis. We now focus on the TraCE-21ka LGM and last deglaciation experiments and have added 2 additional sensitivity tests as described above and in our response to Reviewer 2 (section 3G).

- Lines 528: again, could not this be related to the missing regional uplift too?

As described above GIA is prescribed in our model simulations.

- Lines 557-565: I suggest to work on these conclusions as they are only partly corroborated by your sensitivity test.

Given that we do indeed include GIA in our simulations and after clarifying in text, we think our original conclusions stand.

Figures:

- Figure 1, figure 2: it would be helpful to add some reference locations to the map (e.g. gulf of Ancud, Seno de Reloncaví, …) and lat/lon.

We have added this to Figure 2.

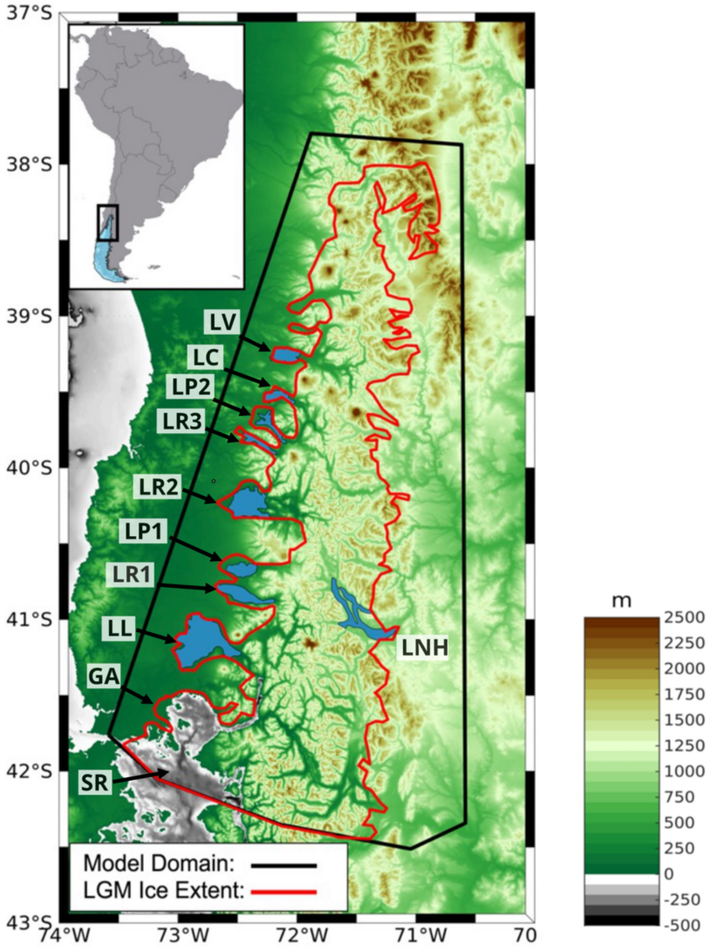


Figure 1. Bedrock topography for our study area (meters). Our model domain (shown as the black line), encompasses the reconstructed LGM ice limit (shown in red) from PATICE (Davies et al., 2020). Present day lakes are shown in blue, with abbreviated names as: SR (Seno de Reloncaví), GA (Golfo de Ancud), LL **(Lago Llanquihue), LR1 (Lago Rupanco)**, LP1 (Lago Puyehue), LR2 (Lago Ranco), LR3 (Lago Riñihue), LP2 (Lago Panguipulli), LC (Lago Calafquén), LV (Lago Villarica), LNH (Lago Nahuel Huapi).

- Figure 3: I would like to see a further discussion about the reasons that explain the main differences between the PMIP4 models (model parametrisations, …) or at least citing some papers that point to that.

We do not think the burden is on us to discuss the differences in the model parameterizations as work is still being done to evaluate these models, and the role of each models' individual parameterizations on the results is often not evaluated in detail. Main goals of the PMIP experiments are captured by Kageyama et al., 2017 (See Section 2). Often large model differences can be down to differences in climate sensitivity, which may be related to things such as cloud feedbacks. We can add the citation from Brierley et al., 2020, which has some text about possible reasons for differences in simulated climate.

Additionally, we have removed the discussion of the PMIP4 simulations per Reviewer 2 comments, and instead focused on more TraCE-21ka sensitivity experiments and last deglacial experiments.

Citation: Masa Kageyama, Samuel Albani, Pascale Braconnot, Sandy Harrison, Peter Hopcroft, et al.. The PMIP4 contribution to CMIP6 – Part 4: Scientific objectives and experimental design of the PMIP4- CMIP6 Last Glacial Maximum experiments and PMIP4 sensitivity experiments. Geoscientific Model Development Discussions, Copernicus Publ, 2017, 10 (11), pp.4035-4055. ff10.5194/gmd-10-4035-2017ff. ffhal-02328464f

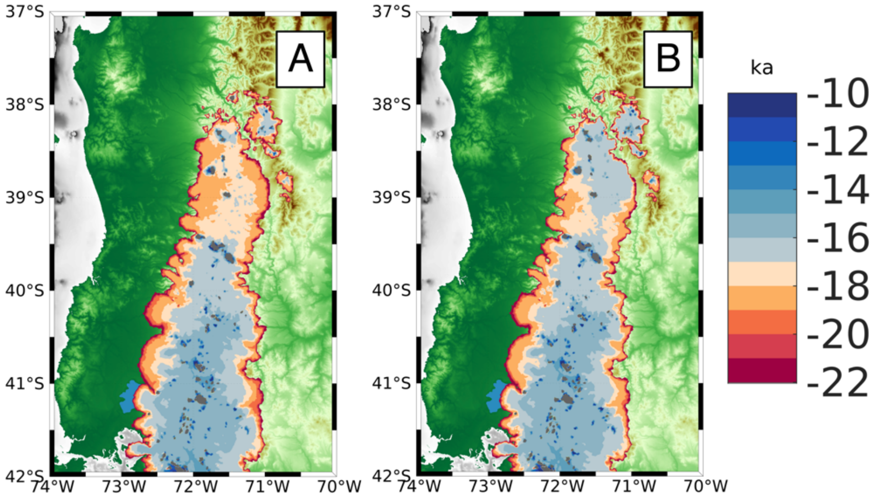
Brierley, C. M., Zhao, A., Harrison, S. P., Braconnot, P., Williams, C. J. R., Thornalley, D. J. R., Shi, X., Peterschmitt, J.-Y., Ohgaito, R., Kaufman, D. S., Kageyama, M., Hargreaves, J. C., Erb, M. P., Emile-Geay, J., D'Agostino, R., Chandan, D., Carré, M., Bartlein, P. J., Zheng, W., Zhang, Z., Zhang, Q., Yang, H., Volodin, E. M., Tomas, R. A., Routson, C., Peltier, W. R., Otto-Bliesner, B., Morozova, P. A., McKay, N. P., Lohmann, G., Legrande, A. N., Guo, C., Cao, J., Brady, E., Annan, J. D., and Abe-Ouchi, A.: Large-scale features and evaluation of the PMIP4-CMIP6 *midHolocene* simulations, Clim. Past, 16, 1847–1872, https://doi.org/10.5194/cp-16-1847-2020, 2020.

- Figure 6: why not plotting the same figure with respect to the glaciated area and comparing it to PATICE reconstruction? It could be also interesting to plot the same figure, but separately for the northern and southern parts of the domain (e.g. north and south of 40°S) since climatologies present a strong latitudinal pattern.

We have removed the discussion of the PMIP4 simulations per Reviewer 2 comments, and instead focused on more TraCE-21ka sensitivity experiments and last deglacial experiments.

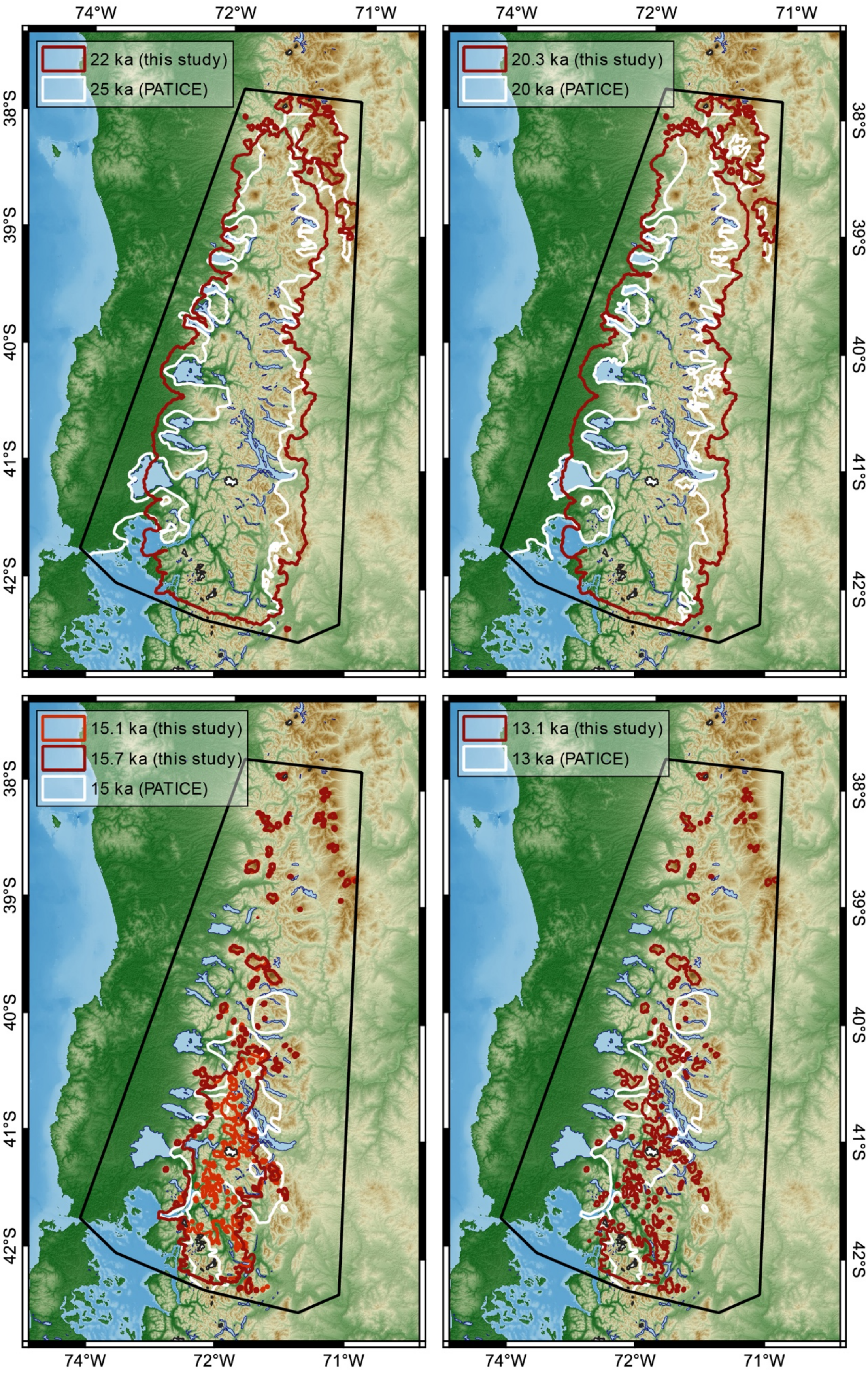
- Figure 7: please choose a different color scale as ice lost from the LGM to 17 ka ago is very difficult to see.

We have changed the colors and hope this is better visually. We note however, that following Reviewer 2 we have changed up the format and will only show Figure A below. In our sensitivity test section (3.2.2) we have added 3 more panels showing the difference in simulated deglaciation age between our standard run (Figure A below) and 3 new simulations that test the sensitivity of ice retreat to precipitation scenarios. We would direct Reviewer 1 to our response to Reviewer 2 (section 3G).



- 10: please use different colours for the simulated outlines (orange, red?) otherwise they can be used with the topography.

Below is an example of new colormaps for the figure. We hope you find this easier to read.


74°W
72°W
71°W
38°S
39°S
40°S
41°S
42°S
22 ka (this study)
25 ka (PATICE)
20.3 ka (this study)
20 ka (PATICE)
15.1 ka (this study)
15.7 ka (this study)
15 ka (PATICE)
13.1 ka (this study)
13 ka (PATICE)

References:

Bourgois, J., et al., 2016. Geomorphic records along the general Carrera (Chile)-Buenos Aires (Argentina) glacial lake(46°-48°S), climate inferences, and glacial rebound for the past 7-9 ka. J. Geol.124, 27e53. https://doi.org/ 10.1086/684252.

Briner et al., 2020, Rate of mass loss from the Greenland Ice Sheet will exceed Holocene values this century. 2020. Nature, 6, 70–74, https://doi.org/10.1038/s41586-020-2742-6.

Cuzzone et al., 2019, The impact of model resolution on the simulated Holocene retreat of the southwestern Greenland ice sheet using the Ice Sheet System Model (ISSM). 2019. The Cryosphere, 13, 879–893, https://doi.org/10.5194/ tc-13-879-2019.

Davies et al., 2020. The evolution of the Patagonian Ice Sheet from 35 ka to the present day (PATICE). Earth Sci. Rev. 204, 103152. https://doi.org/10.1016/j.earscirev.2020.103152.

Dietrich, R., et al. "Rapid crustal uplift in Patagonia due to enhanced ice loss." Earth and Planetary Science Letters 289.1-2 (2010): 22-29.

Jara-Mu~noz, J., Melnick, D., 2015. Unravelling sea-level variations and tectonic uplift in wave-built marine terraces, Santa María Island, Chile. Quat. Res. 83, 216e228

Lange, H., et al. "Observed crustal uplift near the Southern Patagonian Icefield constrains improved viscoelastic Earth models." Geophysical Research Letters 41.3 (2014): 805-812.

Rabassa, Jorge, and Chalmers M. Clapperton. "Quaternary glaciations of the southern Andes." Quaternary Science Reviews 9.2-3 (1990): 153-174.

Richter, A., et al., 2016. Crustal deformation across the southern patagonian icefield observed by GNSS. Earth Planet Sci. Lett. 452, 206e215. https://doi.org/10.1016/j.epsl.2016.07.042.

Ríos, F., et al., 2020. Environmental and coastline changes controlling Holocene carbon accumulation rates in fjords of the western Strait of Magellan region. Continent. Shelf Res. 199, 104101. https://doi.org/10.1016/j.csr.2020.104101

Stefer, S., et a., 2010. Forearc uplift rates deduced from sediment cores of two coastal lakes in south-central Chile.
Tectonophysics 495, 129e143.

Troch, Matthias, et al. "Glacial isostatic adjustment near the center of the former Patagonian Ice Sheet (48° S) during the last 16.5 kyr." Quaternary Science Reviews 277 (2022): 107346.