

Review of manuscript “Modelling last glacial cycle ice dynamics in the Alps” by Julien Seguinot, Guillaume Jouvét, Matthias Huss, Martin Funk, Susan Ivy-Ochs and Frank Preusser, Cryosphere Discuss., <https://doi.org/10.5194/tc-2018-8>

General comments

This manuscript describes a model study with the Parallel Ice Sheet Model applied to the last glacier cycle in the Alps. The climate forcing is derived from present day climate of WorldClim and the ERA-Interim reanalysis and time-dependent temperature offsets derived from the Greenland Ice core (GRIP), from Antarctic ice core (EPICA) and Marine sediment core from the Iberian margin (MD01-2444). The study is split in two, in the first part analysis of six model simulations (with and without precipitation scaling) made on a 2 km resolution grid is presented and concluded that out of the three climate forcing records used, the EPICA record gives the most realistic ice volume history during MIS 4 and 2. The second part analyses simulation made with the EPICA forcing record on a 1km grid. The authors draw conclusions about the ice cover, ice flow pattern, ice thickness, LGM ice extent, which in their model is a transient stage with varying timing across their model domain due to glacier dynamics. The manuscript is well organized and clearly written, the missing thing in this study is a discussion of and preferably a sensitivity study of the ice dynamic-model assumptions made. Is the sliding of the ice age ice sheet realistically modelled with pseudo-plastic assumption using the Shallow Shelf approximation? How sensitive are the results to the selected model parameters? It is briefly mentioned once on page 19, line 8, but a thorough analysis of the model sensitivity would strengthen the paper.

Specific comments:

I find missing something that indicates that the times are before present, as in line 5, line 8 and line 16 on page 1 – and elsewhere in the paper it is written (120-0 ka) should you add before present or BP to indicate the time interval?

Could the reason for too large ice volumes when using the GRIP record, as mentioned in lines 13-15 on page 9 be due to Arctic Amplification? Could that have an effect then as it has now? This is also mentioned in line 11 on page 10

Minor comments:

Page 1 line 24 suggest: “have extended well outside their current margins”

Page 2 line 22, could you add a reference and a timing for LGM?

Page 3, line 1, suggest to replace “thus” with “still”

Page 3, line 3 add s to responses

Page 3, line 18, something missing in the sentence, suggest “formulation” after “creep”

Page 4, line 4 suggest to replace “field” with “sheet”

Page 5 figure 1 c) can you add a scale and maybe indication with a box in b) where this extract is from? “from the estimate” (not plural in line 4 of caption),

Line 6 (PDD) is not acronym for surface mass balance, some more explanation is needed here, indicate also, like in the other figures that h) is January and i) is July figures

Page 6 line 6 suggest to replace “of” with “with”

Page 6, line 14, suggest “The climate forcing driving the ice sheet simulations consist spatially of a present-day monthly mean climatology.. “

Page 6 line 15 suggest to delete “s” on corrections

Page 6 line 19 add “mean” after monthly

Page 6 line 22 note, if true (clarify in Figure caption, see comment above) then the reference should be to Fig. 1 i) for summer precipitation

Page 6 line 27 replace “is” with “are”

Page 6, footnote, add a reference for the correct formula for the rigidity and clarify (add something like, the consequence of this error is that the simulations effectively use...)

Delete “in” before “a small” and add a quantification of the small change in the length scale – how small, is it a few percentage?

Page 7, line 2 “shipped with WorldClim” is not clear, please edit, also suggest not to use b for topography, s_{surf} and s_{bed} , or h would be better

Page 7 line 19 add “the” before “oxygen”

Page 7, line 24 “and within a rectangular region ..” is not clear, edit this text

Page 8 add “acceleration of” before gravity, add a reference for the ideal gas constant?

Page 9 line 14-15, see comment above, could this be an example of Arctic amplification?

Page 9 line 19, add “a” before “very” and suggest to turn the sentence around, the EPICA simulations are in a good agreement with the data

Page 9, line 20, followed by first a retreat and then a standstill? replace “blue” with “red”

Page 9, line 21, suggest : The simulations forced by the GRIP palaeo-temperature forcing yield ... (blue curves)”

Page 10, line 2, suggest to add “followed by a rapid retreat”

Page 10, line 3, why state “two or three” in intro the suggestion is either 4 major or 15, is there a reference for 2 or 3?

Page 10, line 10, suggest to replace “lower” with “smaller”

Page 10, line 11, is this due to Arctic Amplification?

Page 10, line 12, suggest to replace “least” with “the smallest”

Page 11, figure 3 caption, what does “cumulative” mean here? Do you mean maximum in each location? clarify what the black line indicates. No solid red line is visible in figures. What is meant with “reasonable”, maybe replace with “realistic”? suggest to replace “cover” with “extent”

Page 11, line 2, suggest to replace “cumulative” with “maximum extent in each area” or something similar

Page 11, line 1-3, how sensitive is the model to different parameters in the applied sliding formulation?

Page 11, line 4-5 “outside this benchmark” clarify if you mean spatially or temporally

Page 11, lines 6-11 is this text better fitted in a discussion section?

Page 12, line 2, suggest to replace “higher” with “larger”

Page 12, line 4, do you mean to refer to Fig. 3?

Page 12, line 29-32 does this text fit better in method section?

Page 13, figure 4 caption, the 200 m surface contours are not clearly visible in the figure, can they be made sharper, or just skipped? Line 3, something like “are shown” is missing. Suggest to replace

“background” with “bedrock”. This is the first time “Natural Earth Data” is mentioned, should that be in the section on the data? Suggest to replace “Gray fields” with “shaded gray area” and “boundaries” with “timing”

Page 15, line 8, replace “was” with “is”

Page 15, line 25 “occurred”

Page 16 figure 5, in figure the color bar is written to indicated maximum surface elevation, but in figure caption the maximum ice thickness, which is correct? The surface elevation contours are not clearly visible. The dark orange color in the figure, that covers the central part of the ice sheet is not (?) in the bar on the left (or is it before 27 ka BP?)

Page 17, line 30 suggest to replace “have” with “could”

Page 18, figure, the 200 m contours are not clearly visible

Page 19, line 7, could you add what the modelled regional ice thickness is, for comparison?

Page 20, add info about the gray areas indicating MIS 4 and 2 “Isolated patches indicate periodic surges from tributary glaciers” needs more explanation and it is not clear what is meant. Does the model simulate periodic surges?

Page 21 line 21, here is a reference for 2 or 3 glaciations (see comment above) but in the intro is only mentioned 4 or 15, suggest to change text to harmonize.

Page 21 line 27, suggest to edit “the study consists of” or start for example like “In this study the model has been applied...”

Page 21 line 28, how important is it that the model has been validated for the Cordilleran ice sheet? Will that support the choices of the sliding model applied in the Alps? I think that it would be valuable for this study to do a sensitivity runs for at least some of the model parameter choices.

Page 22, line 6, add “records” after forcing

Page 22, line 19, why do you add “potentially” here? Isn’t this a firm conclusion from you study?

Page 22, line 20, suggest to replace “higher” with “larger”

Page 22, line 22, same as above, why “potentially” here?

Page 22, line 24, suggest to replace “nevertheless” with “however” or edit the sentence

Page 22, line 26-28, the paper would be able to give stronger conclusions with sensitivity study, suggest to edit the sentence by replace “statements” with “limitations” or “drawbacks” and “last glacier cycle ice dynamics in the Alps” is not easy to read

Page 23, line 2, replace “mode” with “more”

Figures are generally clear and well set up. The surface contours in Figs 4,5 and 6 is not clearly visible in my printout and could maybe become clearer?