

Clim. Past Discuss., referee comment RC1
<https://doi.org/10.5194/cp-2021-30-RC1>, 2021
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Comment on cp-2021-30

Anonymous Referee #1

Referee comment on "CHELSA-TraCE21k – high-resolution (1□km) downscaled transient temperature and precipitation data since the Last Glacial Maximum" by Dirk Nikolaus Karger et al., Clim. Past Discuss., <https://doi.org/10.5194/cp-2021-30-RC1>, 2021

Review of "CHELSA-TraCE21k v1.0. Downscaled transient temperature and precipitation data since the last glacial maximum" by Karger and others

Summary

The manuscript describes an approach to produce high-resolution climate data by downscaling the output of a long simulation of a general circulation model using additional data sources. Most of the text is rather technical, a description of the downscaling process and validation of the resulting temperature and precipitation data. The paper ends with a potential use case of the produced dataset, the application to a problem in paleo-biology.

General comments

Overall, I appreciate the manuscript as an interesting contribution to facilitate paleo modelling work, which relies on high resolution past climate data. In my view, however, there is a number of severe shortcomings in the paper that need to be addressed before it can be published.

My first question was if the manuscript is well placed in the context of CP. The manuscript largely reads like a model description paper and may be better placed in a journal specialised for such content (e.g. GMD). The comments I will raise further on will not depend on this decision. But I will suggest revisions that bring out the modelling aspect even more, asking for further details that are currently lacking.

The manuscript is giving a good overview of 'what' is done, but has severe shortcomings in explaining 'why' and 'how'. I believe there is need to improve on describing the motivation for most of the decisions and clarifying the details of the processes (see specific comments below). The use of symbols is confusing and inconsistent and should be

improved. The aim should be to put interested readers in the position to understand and reproduce the work that has been done. Additional figures/illustrations may help to achieve that.

There may be a conceptual problem with the reconstruction of past surface elevations for glaciated regions. It is not clear to me why past sea surface elevation (i.e. global sea-level) is needed to correct the elevation (l109). The surface elevation of a glaciated region is the result of changing ice thickness and changing bedrock elevation. Neither of these changes is related (linearly) to sea-level changes. A better explanation is needed to justify the presented approach.

The same applies to the coupling with temperature, which appears to modify the elevation estimate. Again, this is not well motivated and described.

Specific comments

Abstract

l12 Suggest to start a new sentence after (ICE6G) and lay out in simple terms what the temperature coupling entails. This has not become clear to me throughout the manuscript. The amount of ice at a certain place is not determined solely by local temperature, if that is what is happening here.

l13 At this stage the reader will not know what CCSM3-TrCE21k and CHELSA stand for. This requires a bit more explanation already in the abstract.

l16 Here the species distribution is described as a validation of the dataset, while later it is an application of the forcing data. Which one is it?

l31 It is not clear to me how satellite data can be used to 'bridge the gap between the coarse GCM output and the high resolution needed'. The two sources are distinct and have their own biases. Can you explain?

l43 'ice shields' --> 'ice sheets'. Correct this also in the rest of the manuscript.

l43 'along the poles' --> 'in polar regions'

l58 How does a simulation that starts at 21k-BP with 100 yr time steps come out at

1990?

I59 Isn't paleo-orography an *input* to the downscaling procedure? Here it looks like an output.

I62 It would be useful to distinguish between the model (CCSM3), the specific simulation (TraCE-21k) and the output of that model for a specific simulation (CCSM3 TraCE-21k).

I69 Should add here that the model is run with a fixed topography (which one? PD, LGM) and fixed land-sea mask (if that is so). Is the fixed land-sea mask not a problem for the downscaling? How does your process deal with regions that change from land to ocean with deglacial sea-level rise?

I73 What does the acronym CHELSA stand for?

I76 Explain what GPCC stands for.

I78 ICE-7G appears to be available since 2018. Can you explain why you are using ICE6G? What is the difference between ICE6G and ICE6G_C and why did you chose the 'C' variant?

I78 Same point as above, is ICE6G_C the model the simulation or the data?

I80 To my knowledge ICE6G is not a dynamic ice sheet model and does not explicitly model changes in ice thickness.

I82 Topography update is every 500 years, but according to I57 climate updates every 100 years. How do you deal with this issue?

I85 It could be useful to explain here or elsewhere that the given extent mask is not necessarily in agreement with ICE6G at LGM. When is LGM defined in Ehlers et al., (2011). Is there a possible temporal mismatch with ICE6G?

I88 What year do you assign to this dataset, what does 'current' mean specifically?

I94 What does 'derived' mean. What is different and what is the same compared to the original CHELSA V1.2. Again, is CHELSA V1.2 the algorithm (as stated here) or the dataset originating from it?

I96 Why is GMTED2010 not described as input data in section 2? It should.

I98 Why is the Miller data not described as an input dataset in section 2? It should.

I100 Could state here that the details 1-4 are described in the following sub-sections. It would be useful to describe the overall process in a flow diagram or other schematic to make it easier to understand the different steps. Add motivation at every step why things are done the way they are and how in detail.

I102-104 It seems that this part still belongs to the general intro section 3 assuming that 3.1 is only about orography.

I105 Explain what the purpose of combining Ehlers and ICE6G is. Motivate this by laying out your assumptions (do you trust Ehlers more than ICE6G in terms of accuracy?). What does Ehlers give you that ICE6G doesn't and vice versa? It may be useful to illustrate the whole process with a figure for one or several example location. Maybe a cross section through the margin of an ice sheet?

I106 Explain the choice and significance of taking 100 samples? How many samples are left (on average, max) after removing the outliers. Is ICE6G distributed at 1 degree resolution? If so mention it in section 2.2. If not, why work at that resolution?

I106 Not clear what "extracted the height of the glacier plus the surface elevation" means. Maybe 'height of the glacier' is ice thickness? Or is it height as in surface height? Is e_{t}^{ice} the surface elevation or the surface elevation + glacier height?

I107 What does the subscript 't' stand for?

I107 Explain why these points are omitted. What is the reason for further extracting the point locations on the boundaries?

I108 What does 'DEM' stand for and what is the data source for it?

I109 Is 'past sea surface elevation' from Miller? Explain why this correction to sea-level is needed. As mentioned in the general comments, I don't understand why this is done and suspect a conceptual problem. Please explain this.

I116 What does subscript 'c' stand for.

I have tried to give exhaustive comments on page 4 to show the level of detail that is in my mind required to make this a useful description. Similar comments could be made in the sections that follow.

I120 Explain up front why the B-spline interpolation is needed and what the main ideas of the iterative approach are.

I131 What is this 'change factor'? Explain what it serves for in the approach.

I131 What time period is $\text{tas}_{\text{cur}}^{\text{mod}}$ averaged over? Why do you resample to 0.5 degree resolution?

I138 What is the significance of levels 26 and 20. What pressure/altitude do they represent?

I146 The main ideas of that temperature coupling process have to be explained. What assumptions go into that approach? How is temperature assumed to modify orography?

I155 Where does 'glacial melt' come from in this approach?

I166 What process is assumed to modify orography?

I195 in I184 the grid is described to have 4km resolution. Why the change to 3km?

l225 text here appears to be repeated in l227.

Figure 1

Suggest to (additionally) show anomalies relative to the present day. For now, it is difficult to make out clear differences in these plots.
Suggest to show the present day reference temperature field for comparison.

The '-' in 22k-BP should be removed. It reads like a minus sign.

Is this a perceptually uniform colour map? If not, consider using one (e.g. <https://www.nature.com/articles/s41467-020-19160-7>)

Figure 2

Results should be shown relative to a long-term average rather than one year (1990). If this is the case, what period is the data averaged over?

l288 Motivate why it is needed to project the data to another map? Details like projection parameters can be presented elsewhere (table, appendix).

l290-294 What is the underlying physical assumption for the 1/0 assignment? Clarify.

l314 Is the strong correlation maybe related to the fact that the data was bias corrected to a similar product? How do you explain such impressive match?

l334 'idiosyncratic' Strange choice of word. Reformulate?

Figure 5

The strong mismatch at LGM could suggest that the lapse rate correction plays out in an unexpected way. It should be checked if that mismatch arises from climate model bias, lapse rate corrections or the bias corrections that are applied in the process.

l344 It is not clear to me how glacier extent is meant to validate the downscaling process. It may serve to validate ICE6G and may reveal a mismatch between ICE6G and Dyke, but

that is not really at stake here. Could you explain how that comparison can constrain your approach? How does unmodified ICE6G compare to Dyke. Is that improved with your modifications?

I360 This section comes with unexpected new concepts and models (GLM, KISSMig) that were not introduced before. After going through the technicalities of the sections before, this is a steep change of register. In the abstract this part is introduced as another aspect of the model validation, while here it is written as a use case for the produced dataset. In either case, I suggest this part has to be better linked with the rest of the paper or, maybe better, extended and conceived as a separate paper.

I381 Why is yet another projection needed in this case? Motivate.

I418 What trends are to be preserved? Clarify. Reference to (Hempel et al., 2013) is probably better placed in the description in section 3.2.