Clim. Past Discuss., 9, C1977–C1987, 2013
www.clim-past-discuss.net/9/C1977/2013/

Climate of the Past Discussions

Interactive comment on "NGRIP temperature reconstruction from 10 to 120 kyr b2k" *by* P. Kindler et al.

Anonymous Referee #1

Received and published: 13 September 2013

1- SUMMARY AND GENERAL COMMENTS:

Kindler et al. present the first continuous quantitative temperature reconstruction covering the beginning of the Holocene back to 120 ka inferred from the Greenlandic NorthGRIP ice core. Their study is based on a compilation of published and new air δ15N measurements combined with firn densification modelling. They provide insights on the effect of air trapping processes in the firn on the attenuation of the measured δ15N. They confirm previous studies evidencing issues with the accumulation rate estimate given by the glaciological NorthGRIP age scale. Finally, their new temperature reconstruction enables them to investigate the δ18Oice-surface temperature relationship over the last glacial period. The continuous quantitative temperature reconstruction for the NorthGRIP ice core represents an interesting and a useful result for the paleocli-

mate community working on the last glacial period. It benefits from the fact that it is based on one single paleothermometry method. Also, it addresses important issues in ice core science about past estimates of surface climatic conditions in Greenland. The authors certainly did their best to argument their study. However, many aspects of the paper need improvements and clarifications. In my opinion, the manuscript is not suitable for publication in his current form and requires major revisions before it can be published in Climate of the Past.

I have general comments on the form of the paper. First, many sentences need to be rephrased for better English and should also be shortened. The authors should keep the structure of the sentences as simple as possible. Indeed, the manuscript is hard to read and to follow in its present form. The authors should also be careful to not use colloquial expressions. Second, the current manuscript is too long. Some sections have excessive details. Too much information leads to the blurring of the main findings and makes it difficult to extract the key results. Related to this last point, an effort should also be put on highlighting what is novel in the study. The authors also have to rethink what is the key information and thus what information to prioritise.

To give more consistency to the paper, a better link should be done between the different aspects of the study. Indeed, the different sections of the discussion look a bit decoupled one to the other for now and I would like to see in the introduction a few sentences explaining why it is of interest to investigate those three particular issues. As for the content of the paper, my main concern is related to the discussion that the authors proposed on the δ18Oice-temperature sensitivity. I understand that such a discussion is a logical outcome when having a quantitative surface temperature reconstruction. However I don't think that they provide any outstanding results about it. I would suggest the authors to re-think about section 3.3.1 to shorten and clarify it and to simplify Figure 6. Previous studies already suggested an effect of obliquity and ice-sheet on the temporal δ18Oice/temperature slope mainly via the seasonality of the precipitation and/or moisture source (Denton et al., 2005; Masson-Delmotte et

al., 2005; Fluckiger et al., 2008). Also I am not convinced about the authors' statement about the significance of the lag between α variations and obliquity increases during the course of the glacial period. If the authors want to keep this section they have to make a stronger case of what they propose and the novelty of their results compared to previous published studies.

I detail below some specific comments and technical corrections that should be taken into account by the authors when preparing the revised version.

2- SPECIFIC COMMENTS:

P4100: I find the introduction too long and too general. It should be reduced by half at least and it should be more focused on better highlighting the relevance of the study carried out. A lot of the information has been already given in many previous papers. You should just refer to the original and key papers. For example: (i) the first paragraph could be summed up in one sentence only, (ii) the paragraphs on the mechanisms attached to DO events can be shortened a lot as well and (iii) I do not think that a full paragraph on AIM events is necessary. But in the mean time, it misses to introduce clearly what are the goals of your study. A more focused introduction will help to better highlight why your particular study is of interest. For example I am very surprised that you do not mention in the introduction why it is important to constrain the surface temperature changes and accumulation rates but also the current limits i.e. sensitivity of water isotopes to temperature changes in Greenland, the reason why one needs alternative approach to water isotopes for quantifying temperature changes, the δ15N damping in the firn... More focused and precise background information in the introduction would also help to go much more to the point in the rest of the paper and to better link the different sections of the paper which I found a bit disconnected one to other in the current form of the paper as previously mentioned.

P4104: I suggest naming the section "Methods and data" instead of "Method" The introduction of the Method part should be a section on its own (from line 19, P4104

to line 23, P4105) I would suggest the following titles for the sub sections 2.1. Paleothermometry method based on air δ15N measurements 2.2. Published and new δ15N measurements 2.3. Strategy for surface temperature reconstruction

P4106: You should shorten paragraph 2.1 by replacing the text describing the published/new datasets with a table.

P4109: Line 9: I don't understand why you put the discussion of the δ18Oice-temperature relationship in two sub sections of the "3.3 accumulation rate" section. You should have a section "3.4. δ18Oice-temperature relationship" with two sub sections 3.4.1 and 3.4.2. Line 10: the title is to generic, change it for something like "NorthGRIP surface temperature reconstruction"

Section 3.3.1. Too many details are given in this section. You need to shorten the text Remove the first sentence of the paragraph and start directly with "the temperature evolution for the transition...."and refer to Figure 2 at the end of this sentence.

Line 16: do you have an explanation why the model would create bumps at around 80 ka and 100 ka in the δ15N and thus in the temperature reconstruction while they are not seen in the δ18Oice signal? I guess this is due to the tuned accumulation rate since it shows those two bumps on Figure 4 but what could induce those accumulation rate variations? This sentence could actually be part of the previous section when you discuss the fact that the tuning is not perfect over DO 16, 17 etc... you could also mentioned to which extend and level of details your temperature reconstruction can be discussed and interpreted.

P4112: Section 3.2. You need to state more clearly what is the purpose of this section (e.g. the fact that you are testing two hypotheses and tell that you use the Spahni et al. model from the start. What is the key message at the end of this section? What are the implications of these modelling results on your surface temperature reconstruction? All need to be stated in a clear way.

Line 4: the two paragraphs should be moved out of this section and put in the section where you describe your strategy to reconstruct the surface temperature and examples of deviations due to the use of two different methods (you give them with DO 25 and DO 11) should be attached to illustrate this later point.

P4113: From Line 12: you need to be more concise. You should state from the beginning of this paragraph that you are using the Spahni et al. model, it arrives too late (line 19) in the current manuscript.

3- STYLISTIC AND TYPOGRAPHICAL COMMENTS

P4100: Line 1: NEW measurements of δ15N have been performed covering the time period from the beginning of the Holocene to Dansgaard-Oeschger (DO) event 8. Line 3: remove "are now able to" Line 7: "...δ15N measurements COMBINED WITH a firn densification..." Line 8: "the detected temperature rises at THE ONSET OF DO events..." Line 10: "...by the NorthGRIP ss09sea06bm..." Line 11: you should quantify (e.g. "by up to XX %) instead of using "significantly" Line 14: remove the two last sentences and replace by: We evidence an anti-correlation between the variations of the δ18Oice sensitivity to temperature (referred as α) and obliquity in agreement with a simple Rayleigh distillation model. Finally, we suggest that α is also influenced by the Northern Hemisphere ice sheet volume.

P4101: Line 5: replace "generally" by "at least" Line 12: add references at the end of this sentence

P4104: Line 19: replace the sentence by "To reconstruct the surface temperature evolution at the NorthGRIP site, we combine air δ15N measurements with simulations performed with a firn densification and heat diffusion model..." Line 23: this sentence needs to be rewrite. For here as for some other parts in the manuscript, try and keep the sentences simple and short (one idea per sentence).

P4105: Lines 3-5: avoid using "one finds" Line 9: add a reference such as Landais et

al. QSR 2006 at the end of the sentence.

P4106: Shorten this paragraph as in term of methodology it has been described in previous papers already. Line 2: replace data by dataset Line 19: editing problem as the ‰ sign does not appear Line 22: editing problem as the ‰ sign does not appear

P4107: The uncertainty of $\pm$3°C associated with the temperature estimate has to be mentioned in this section rather than in the Result section Line 3: "...the NorthGRIP ss09sea06bm..." Line 5: replace the sentence starting by "the ss09sea06bm..." by "the ss09sea06bm timescale is the most appropriate since it is the only age scale with accumulation rate reconstructions over the entire studied time period" Line 7: avoid the "when one...", they are too many in the manuscript. Line 13: editing problem as the ‰ sign does not appear Line 14: editing problem as the ‰ sign does not appear Line 19: "three steps are followed to infer the NorthGRIP surface temperature ..." instead of "the temperature reconstruction is divided into three steps" Line 26: editing problem as the ‰ sign does not appear

P4108: Line 2: "the delta age is significantly underestimated in some parts": can you quantify please? Line 10: editing problem as the ‰ sign does not appear Line 16: remove the sentence "the adjusted accumulation..." since you mention it later in the text Line 25: remove "is able to" and thus put a S to "reproduceS" Line 26: the sentence "A mismatch....25" should be moved at the end of the paragraph. Do you have an explanation for why you still cannot get a good agreement? You should also refer to Figure 2 at the end of this sentence.

P4109: Line 20: change the sentence by "to define the temperature amplitude of a DO event we specify the onset and the end of the event based on the following criteria. The DO event onset corresponds to the difference quotient...found by Huber et al. (2006b)

P4110: Rephrase paragraph starting line 5 Line 23: avoid expression such as "some sort of plateau"

P4111: Rephrase the sentence starting at line 3 Line 5: remove the sentence starting with “this feature...” and only refer to Figure 2. Line 9 : “not manifest ANY OBVIOUS long-term warming...” Sentences from Line 9 to Line 17 (finishing with “...NEEM site”): Be more concise and refer to the work of Jonkers et al and Guillevic et al in two sentences max. Line 16: “...as Guillevic et al. (2013) found ALSO a slight...” Line 21: this entire paragraph needs to be shortened and re written. Line 19: you should precise the type of proxies those studies are using (eg, water isotopes, dust, chemistry...) Line 24: remove the sentence starting with “However, ...” and replace by something along those lines :” we cannot observe such a rapid temperature increase in our reconstruction for two reasons:...” The entire section 3.2 is too long and needs to be shortened.

P4112: Line 19: “high resolution data”: you should precise what type of data (i.e. water isotopes, dust, chemistry, ...) Line 23: remove the sentence starting with “However, ...reconstruction” and replace by: “ we cannot observe such rapid temperature increases in our records for two reasons (i)...and (ii)...” And attached your two reasons given from line 24 at the end of the sentences.

P4113: Line 4: change the sentence as such “THE ATTENUATION EFFECT ON THE GAS SIGNAL DURING THE ENCLOSURE PROCESS AT THE BOTTOM OF THE FIRN is included neither in the Schwander nor the Goujon model (Schwander et al., 1997; Goujon et al., 2003). TO OUR KNOWLEDGE, ONLY GRACHEV AND SEVERINGHAUS (2005) HAVE STUDIED SUCH AN EFFECT ON δ15N VARIATIONS AND THUS ON SURFACE TEMPERATURE RECONSTRUCTION.

Lines 6-11: Remove the entire paragraph

P4119: 3.3.1. d18Oice-temperature relationship: this section should not be under the accumulation section, it should be a different section such as: 3.4. δ18Oice-temperature relationship Line 10: editing problem with the ‰ Line 14: rewrite this sentence. For example: “By considering the same 38ka to 65 ka time interval as in Huber et al. the deduced XX gradient is in line the XX deduced from the later study.

Line 15: editing problem with the ‰ Line 16: editing problem with the ‰

P4120: Line 1: rephrase the sentence starting by “This effect is incorporated...”

P4121: Line 13: the imprint of obliquity in the source-site temperature gradient has been evidenced in the d-excess measurements performed in both Antarctica and Greenland ice core (ref)

P4124: Line 7: write “this is supported QUALITATIVELY by a simple...”

The last sentence needs to be shortened. I suggest writing something along those lines: “Associated with the NorthGRIP δ18Oice profile, our reconstructed temperature provide useful constraints for future investigations on the α parameter based on water isotope modelling aiming at better quantifying in particular, the respective influences of obliquity on the source-site temperature gradient, and the ice sheet volume.”

P4114: Line 13: move this sentence to the caption of Figure 3. Line 17: move also this sentence to the caption of Figure 3. Line 15: memove the sentence starting with “The reason...”

P4115 “Section 3.3. Accumulation rate” Line 24: you already wrote this sentence in a previous section.

P4116: Line 16: state more clearly what you want to test about the accumulation rate estimate. Line 19: a mean SURFACE temperature Line 25: present day SURFACE CLIMATIC conditions, similar at line 28. Line 26: the sentence starting with “in general” could be removed.

P4117: Line 1: cut the sentence starting with “therefore” in two. Line 7: rewrite this sentence. The paragraph starting with this sentence and the paragraph started at line 24 don’t really provide any new results compared to previous studies so I think you could greatly reduce it. Line 25: “this” instead of “that”

P4118: You need to state clearly what you are trying to test in this paragraph Line 6: do

you mean “an indirect proxy for accumulation rate changes”? please can you precise. Lines 20 and 23: update the ref : Veres et al 2013-09-06

P4119: âĂć Section 3.3.1: δ18Oice-temperature relationship The authors should define “$\Delta\delta$18O sea” and refer to Bintanja et al. (2005) but should remove the sentence starting line 5 with “For this...” Line 10: sentence starting with “as there...” can be removed. Line 14: the sentence has to be re-written Line 18:”...compared to the PRESENT-DAY slope is...” Line 22: write “previously discussed (REF)” instead of including the references in the sentences. Line 25: the entire paragraph is long and difficult to follow. Try to shorten and clarify, it is difficult to get what extra information your study provides compared to previous published work.

P4123: Line 5: the first two sentences of the conclusions should be removed and replaced by: “We present for the first time a continuous temperature reconstruction for the whole glacial period (10 to 120 kyrs) based on new and published δ15N measurements performed on the trapped air of the NorthGRIP ice core. In line with previous studies, we find surface temperature rises from +5 to +16.5 °C at the onset of abrupt events (references).

Line 13: remove the sentences from “Stadials....” to “... (H4, H5, H6)” and replace by: “No particularly cold temperatures characterise stadials associated with Heinrich events and a long term warming of about one to three degrees is observed during the Heinrich-stadials 4, 5 and 6 of MIS3”

Line 26: remove the sentence “As also...” and replace by: “This further emphasises the fact that the D-J ice flow model partly overestimates the NG accumulation rate (all references of the sentence here).”

4- REFERENCES:

There is an editing problem which is probably not the responsibility of the authors but still should be mentioned: Pages numbers of the CPD manuscript have been added at

the end of each reference in the list.

5- FIGURES

General comments: -You should also try and shorten the caption of the figures. -Editing problem with the ‰ sign in captions of the figures.

Here is a suggestion of what could be done for the caption of Figure 4.

“Fig. 4. Top graph: Accumulation rate from the ss09sea06bm timescale (blue line, ADD A REF), reduced accumulation rate used for the temperature reconstruction. Middle graph: modelled delta depth with original accumulation rate (blue) and reduced accumulation rate (red), delta depth measurements (green). Bottom graph: same with modelled delta age. Periods characterised by a significant reduction of the accumulation rate and lacking of empirical delta age and delta depth constraints are indicated in shaded grey bars.

âĂćFigure 1: I suggest putting the data points at the front and the model curves at the back. It will help the model-data comparison.

âĂć Figure 2: Line 5: “Capron et al. 2010b, a” should be “Capron et al. 2010a, b”

âĂć Figure 3: The x axis should be below the graph b as well. You should highlight the start of the abrupt temperature change in both panels with a vertical line crossing the x axis at 0 years. I suggest putting the data points at the front and the model curves at the back. It will help the model-data comparison. Line 7: the sentence starting with “According to...” can be removed as it is also stated in the main text.

âĂć Figure 4 . a, b, c instead of top graph, middle graph and bottom graph

âĂćFigure 5. The grey and blue shaded areas are missing in the description of the caption. Replace “transformed to” by “displayed on” To make it clearer, you should precise “MODELLED Δage” for the orange line

âĂćFigure 6. Use “δ18Oice corr” instead of repeating “corrected for the ....Jouzel et

al. (2003)" Line 3: remove "single" Line before the last " respecTively" What are the arrows showing? I am confused by the respective changes in slope of the red and the blue curves. It needs to be clarify.

References:

Denton, G. H., Alley, R. B., Comer, G. C., and Broecker,W. S.: The role of seasonality in abrupt climate change George, Quaternary Sci. Rev., 24, 1159–1182, 2005.

Flückiger, J., Knutti, R., White, J.W. C., and Renssen, H.: Modeled seasonality of glacial abrupt climate events, Clim. Dynam. 31, 633–645, 2008.

Landais, A., Barnola, J.-M., Kawamura, K., Caillon, N., Delmotte, M., Van Ommen, T., Dreyfus, G., Jouzel, J., Masson-Delmotte, V., Minster, B., Freitag, J., Leuenberger, M., Schwander, J., Huber, C., Etheridge, D., and Morgan, V.: Firn-air δ15N in modern polar sites and glacial-interglacial ice: a model-data mismatch during glacial periods in Antarctica?, Quaternary Sci. Rev., 25, 49–62, doi:10.1016/j.quascirev.2005.06.007, 2006.

Masson-Delmotte, V., Jouzel, J., Landais, A., Stievenard, M., Johnsen, S. J., White, J.W. C., Sveinbjornsdottir, A., and Fuhrer, K.: Deuterium excess reveals millennial and orbital scale fluctuations of Greenland moisture origin, Science, 309, 118–121, 2005a.

Interactive comment on Clim. Past Discuss., 9, 4099, 2013.