

Review of a manuscript for *Climate of the Past*

How precipitation intermittency sets an optimal sampling distance for temperature reconstructions from Antarctic ice cores by T. Munch et al.

Overall:

In this manuscript the authors present a theoretical/modelling framework for establishing the optimal spatial network of ice cores that maximizes the correlation of the derived composite annual series with the target air temperature series. The authors use the output of the past millennium ECHAM5/MPIOM simulation with isotopic tracers as the only data source for their study. Using Antarctica as a target region, they demonstrate that in the framework of the considered model, the optimal ice core network for reconstructing the temperature in a target location should cover the area of 500-1000 km to minimize the noise effects of precipitation intermittence on the T-d18O relationship.

The authors made a number of serious simplifying assumptions in their approach/analysis, such as anisotropic decorrelation scale, linear dependence of d18O in precipitation on condensation temperature and a condensation temperature on 2m air temperature, etc. However, these limitations are clearly presented in the text.

The paper is generally clearly written and results are well presented. I therefore consider the manuscript deserves to be published after some moderate modifications according to the comments provided below.

Major comments:

My major comment concerns the presentation of the sampling procedure in 2.3.2-2.3.3, which I have found not very straightforward to comprehend. One should admit I have spent quite some time trying to understand the actual details behind the technique, though this difficulty could of course be quite individual. The grip of understanding came later, while reading "Results", yet some questions still remain. A number of minor questions that emerged while reading the manuscript, could therefore be a result of my unclear understanding of the basics of the proposed method.

I would like to note also that sometimes the discussion around/use of terms like "target site" or "local site" may appear confusing, same as the actual dimension of the core network being discussed. May be some simplification/clarification of 2.3. can improve the readability?

In general, with respect to the sampling strategy, the question is why the authors initiated the procedure with these concentric rings used for spatial sampling, instead of just random seeding of the "sampling locations", calculating the metrics of interest and then ordering them according to the distances between the locations? It sounds way more straightforward to comprehend than via introducing these circular sampling areas with an increment of an arbitrary choice.

Also, as a suggestion for the future work, it would be highly useful to test the concept of this method on a different model with enabled stable water isotopes in precipitation in order to see how different the results/inference can be. Testing on the existing ice core network can be fairly problematic due to all the deficiencies (both in the available ice core and instrumental data) mentioned throughout the text.

Minor comments (the manuscript text shown italics)

Line 112: “...*define consecutive rings around this site with a 250 km radial width...*”

Here you refer to these concentric rings with a radius increment of 250 km, used for delimitation of the sampling regions, do I get it right? May be it needs to be specified already here. Can you also provide any rationale behind the value of 250 km?

Line 118: “*Finally, we report the mean correlation for every ring combination by averaging across all correlations of the analysed grid-cell combinations.*” Is this averaging based on the distance between the locations, or just everything? How then the distance-based value is calculated?

Line 119: “...for sampling N locations from the model field depending on the distances between the locations.” See my previous comment. If everything is averaged out, how the distance based sorting/ranking is implemented?

Line 136: “(-78.47 S)». No need in “-” before the latitude value if “S” is explicitly indicated.

Line 184: “...*depend on the specific simulated climate state or result...*”

It would be meaningful to add that it also includes the actual model used and the stable water isotope scheme applied in the model

Line 212: “...*maximum average correlation is to sample one location from the innermost ring and the second location from the fifth ring*”

this is not entirely apparent as both maxima in Fig 6 seem to be found on the “5th ring”.

Line 255:” For a conceptual model of the sampling correlation structure, we focus on three processes that influence...”. It is probably would be more relevant to write about focusing on three OF the processes that has an influence, as other processes are discarded in this conceptual model and this is mentioned in the text.

Line 280:”*When fixing one location to the target site and varying the distance from the target site of the second location...*”

This sentence appears again somewhat confusing to me. Do you actually average over "three" locations here or only two? You refer to fixing the core to the target site (first core), and then refer to the "second site". What then denotes "distance of first core " in the figures (like Fig 6)?

Line 307: “*Our results which we obtained from analysing the climate model data and substantiated with our conceptual model provide guidance on where to drill N = 1,2,3 or more ice cores, or from which locations...*”

This statement is not entirely correct, the presented results tell about the relative distances (dimensions) of the core network optimal for the model, rather than point to specific locations that need to be derived via modelling for every target region.

Line 311: *“However, it is unclear whether these results can be one-to-one transferred to the real world, since they might depend on dynamical processes in the atmosphere which could differ between climate states or depend on initial conditions.”* Consider adding “...or unaccounted model deficiencies”

Line 328: *“we expect the optimal spatial configuration to be more dependent on the study region”* ... and very likely on the GCMiso model used in the analysis.

Line 331: *“We thus need to create an isotope record that”* Consider adding “As a proof of concept”

Line 352: *...we expect similar results to hold for other parts of Antarctica, and potentially also for other large-scale ice-coring regions such as Greenland”*

One can add that this is conditional on a simplified assumption of a nearly anisotropic exponential decorrelation scale length to be valid

Figure 3: Why the correlation value for a cell at approximately 70 S and 20E stands out?

Figure 6: The caption is somewhat confusing. Is the "target site" also to be sampled or not? If this is the case, should this be a 3-dimensional case or not?

Figure 7: what is “Rank” on y-axis? Ranking according to the maximum correlation attained? It should than be mentioned explicitly.

Figure B1, caption.

“Note that the plots (a) and (c) are based on the same parameters and therefore identical”.

Why and where they are identical? This is not evident from the plots.