**Climate
of the Past**

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Discussions

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Interactive comment on "Climate variability in subarctic area for the last two millennia" *by* Marie Nicolle et al.

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My co-authors and I would like to thank the Anonymous Reviewer #2 for their comments and suggestions on our submitted manuscript. Here, I would like to provide additional details on the Reviewer #2 comments concerning a better rigorous treatment of uncertainty to put the trends and claimed covariabilities between our regional mean records and the instrumental climate index. For a better understanding, language comments are dissociated for the rest of the specific comments.

Specific comments:

- One of the comments of the Reviewer #2 is to be clear when climatic means temperatures". In the update version of the manuscript, "Climatic" was modified where it's

appropriate.

- The Reviewer #2 reports an arbitrary regional grouping of the series. The spatial density of the data set was the first argument to group the series into three regions, but the regional impact of climatic oscillation observed in instrumental data and found the literature allows to justify that this grouping has a currently climatic reality. In fact, one of the main objectives of the paper is to determine the ability of the Arctic 2k database series to reproduce the regional internal variability recorded in the observations data. Maybe this objective is not clearly noticed in the introduction of the paper and we have to insist on that.

- p4L23: Standardization does not change the underlying distribution. It only changes the units. It is used here to compare the proxy series with different units. All the series were individually standardized before calculate each regional mean records.

- The alpha (α) significance level is the probability of rejecting the null hypothesis - data are independent and randomly ordered – and a significant trend exists. The term 'specific' is not really appropriate and it will be removed in the updated version of the manuscript.

- Concerning the software packages used, we propose to add the following sentence into the 2.4 Wavelet analysis section is add in the update version of the manuscript: 'Wavelet analysis were performed with the software R (Team, 2008) using the packages biwavelet (Gouhier et al., 2012).'

- The size of the axes labels on Fig. 2 is increase for a better readability.

- The Reviewer #2 suggest being more specific to explain the difficulty in identifying the Little Ice Age in the Arctic. A paragraph describing the different expressions of the LIA in Arctic will be added to the updated version of the manuscript. A new paragraph will also be added and the same synthesis will be made for the warm period of the MCA, with the update of the Fig. 4.

- It is noticeable that without uncertainties around regional mean records presented in Fig. 3 and Fig. 5, it is impossible to judge the significance of the trends. In the updated version of the manuscript Fig. 3 and Fig. 5, but also Fig. 6, will be modified and the standard deviation curves for the three regional mean records will be added. The addition of the number of records used for each regional mean records and the standard deviation is sufficient to evaluate the uncertainty around regional mean records and so the significance of the trends.

- p9 and 10: Indeed, a p-value of 0.05 is commonly used for a statistical test. If trend detected in the regional mean records are significant at 99% confidence level (p-value < 0.01), it is also true for a 95% confidence level (p-value < 0.05). Given that the 95% confidence level is used for the wavelet analysis, we will change this value to homogenize the new version of the manuscript. Autocorrelation and partial autocorrelation was calculated for the three regional mean records (see Fig.1 below). Results show that Mann-Kendall trend detected are not linked to autocorrelation in the regional mean records generated.

- Concerning the uncertainty estimation for the wavelet analysis, it is included in the statistical test associated. For all local wavelet spectra, the statistical significance of peaks is assessed using Monte Carlo simulation against an appropriate background noise. Autoregressive modeling is used to determine the AR(1) stochastic process for each time series. AR(1) background noise could be either a red noise (AR(1)>0) or a white noise (AR(1)=0). Each AR(1) is calculated before performed wavelet analysis to determine the background noise used. Concerning the cross-wavelet spectrum, detected fluctuations are statistically tested at $\alpha = 0.05$ significance level against a red noise background. All these precision will be added in the 2.4. Wavelet Analysis part of the manuscript.

- In the update version of the manuscript, the part about the link between climatic oscillation (AMO and PDO) and the proxy data will be developed, including the role of sea-ice cover on climate. Especially, a new figure will be added and presents the

similarity between the trends of the AMO index and the sea-ice cover.

Language comments:

All the language mistakes listed by the Anonymous Reviewer #2 were taken into account. Specifically:

- p1L18: replaced 'on many sorts of proxy data' with 'on multiple proxy type records'

- p1L24: replaced 'show relationship' with 'show a relationship'

- p1L31: replaced 'temperature have' with 'temperature has'

- p2L5: added 's' to 'lake sediments'

- p2L7: added 's' to 'temperatures'

- p2L16: replaced the sentence 'The LIA is however characterized by an important spatial and temporal variability expression, particularly visible at more regional scale (e.g. Pages 2k Consortium, 2013).' with 'The LIA is known to have an important spatial and temporal variability, particularly at regional scale (e.g. Pages 2k Consortium, 2013).'

- p2L26: replaced 'led to' with 'were made to'

- p2L32: added 'a' to 'over a large spatial scale'

- p3L2: replaced 'data sets' with 'data set'

- p3L2: removed 'a' to 'A special attention'

- p4L21: replaced 'regional' with 'regionally'

- p5L5: removed 's' to 'trends'

- p5L8: replaced 'with' with 'which'

- p6L1: removed 's' to 'indicates'

- p6L6: replaced 'well-conservation' with 'conservation'

- p6L14: added 's' to 'decomposes'

- p8L3: replaced 'pronounced decreasing trend of temperatures' with 'decreasing temperatures'

- p9L8: removed 'date'

- p9L11: replaced 'seems' with 'appear'

- p9L14: 'removed 'the'

- p9L28: replaced 'to' with 'for'

- p9L29: added 's' to 'regions'

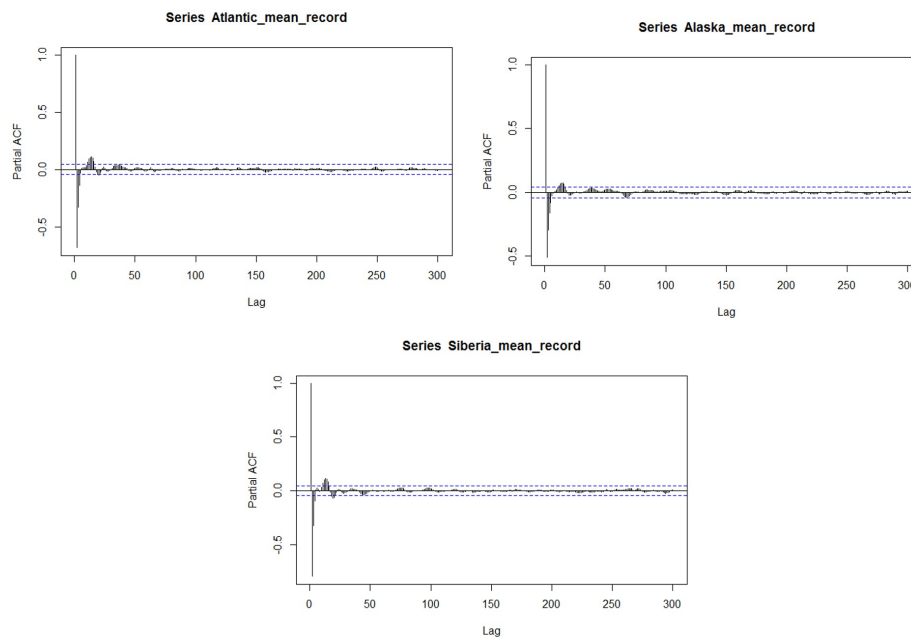- The final paragraph will be entirely corrected.

Fig. 1. Partial autocorrelation calculated for the three regional mean records