

Suggestions for revision or reasons for rejection

This paper analysed an original set of data from Nain (Greenland) spanning between 1806 and 1813. Data were collected by Giesecke a mineralogist who combined his geological activities with meteorological observations (according to the authors). The record is kept at the Royal Society of London.

The aims of the paper are to present to the scientific community this series of daily atmospheric observations, and to compare the mean air temperature of the study period with modern day temperature.

Early instrumental series are indeed limited in Arctic and Sub-Arctic regions, and even short set of data can provide valuable onset of the weather or climatic variability. However, it is important to clearly present the possible bias. Here, authorship is unsure, no location, no instrument, no position of the instrument, no time of readings even the scale is unsure. Authors slightly presented this possible bias.

There are also several lack of transparency. Authors never mentioned if there were missing values in the 1807-1813 record, readers should assume that every day readings were recorded. Comparing a 6 years data with a 30 years normal average should be done carefully. A 30 years normal average is meant to smooth the year to year variability.

Reply. Thank you for your suggestion. We added the following text: The gaps occur in September 1807 and cover 18th–19th for all measurement times, plus 22nd–30th for midday measurements and 21st–30th for evening. The gaps were filled using data from the same days of the year, but from the years 1808–12. These data were used to calculate the differences between noon/evening observations and morning observations—for which data from September 1807 are available. The resulting five-year average differences were added to the morning observation data from the period of September 20–30, 1807. On the other hand, missing data from September 18 and 19 were reconstructed using average values calculated from ten temperature values measured at the same observation time on adjacent days.

Yes, we are aware of this difference in comparisons of 6 against 30 years of observations.

Apparently Giesecke did published a journal of his travel in Greenland, it should be interesting to go through it. Also, Greenland or Danish archives or meteorological repository should be consulted.

Reply. Biographers of Giesecke studied all available information about Giesecke's activity in Greenland also (Monaghan 1993; Jørgensen, 1996; Wyse Jackson 1996; Whittaker 2001), but they write nothing about his meteorological measurements during trips. The irregular measurements during trips are not useful for our analysis due to the large distance from Nuuk, great topographical differentiation, different altitudes and geographical locations, non-standard exposition, etc.

The series presented is conserved at the Royal Society of London, listed as MA for

Meteorological Archives, it was known that this early-instrumental data was there. Moreover, the notice stated that it is a transcription from the originals in Copenhagen for W.C. Trevelyan. This is a second source document, it should be mentioned, it increases the risk of mistake. Readers should be informed. Is the original still in Copenhagen?

Reply. The original manuscript is available in Copenhagen Diamond Library (see below signature). This information was added to the text. Information about possible biases in transcriptions was also mentioned in the text.

Manuscript:

Mineralogisches Reisejournal über Grönland gehalten 1806-1813. (I Nr. 323 a: Tägliche Wetter-Beobachtungen in Godthaab von 1. Nov. 1806 - 16. Aug. 1813; 323 b: Nogle Ord om og til Grønlands Opkomst Hans Kgl. Majest. allerunderdanigst tilegenet; ogsaa paa Tysk.) 9 Bd. Karl Ludwig Giesecke 1761-1833 mineralog (DBL) 1806-1813

Quality control must be done on data. See Slonosky, 2014. Historical and modern data should present a similar distribution shape. See also Ouellet-Bernier et al., 2023, where early-instrumental Moravian data showed dissimilarities with modern data probably due to an instrumental bias.

Reply. Thank you for this suggestion. We wrote more about quality control. See added text below:

In the article, we present an analysis limited to air temperature – the most important variable in every climate analysis. We first verified all transcribed data against the source data. In the next step, these data ~~All source data~~ were quality-controlled first by (i) visual inspection and then (ii) by the method recommended by WMO (Aguilar et al. 2003). ~~and no incorrect or suspect data were found.~~ All sub-daily series of temperature (morning, midday and evening) were analyzed, looking for data exceeding 3–4 SD. We found only a few such cases, all of which we analyzed using air pressure and wind direction (atmospheric circulation) in terms of the probability of occurrence (determining the cause and consistency with the course of the aforementioned meteorological elements). For this purpose, we also used the descriptions written by Giesecke, who regularly indicated high/low values and large day-to-day fluctuations (and explained them, giving the reasons). We did not find any erroneous temperature values. We also calculated the differences between observations taken at noon and in the morning, at noon and in the evening, and in the evening and in the morning. We also checked several values exceeding 3–4 SD, and all of them were deemed correct. We performed a similar test for day-to-day changes and again did not find any changes that aroused doubts. All these methods demonstrated that the data are of good quality and homogeneous. Our comparison with present values (see results part) also support this favourable assessment, as did comparison with parallel observations available for Nuuk for the years 1811–12.

Aguilar, E., Auer, I., Brunet, N., Peterson, T.C., Wieringa, J.: Guidelines on climate metadata and homogenization, WMO/TD No. 1186, pp. 50, 2003.

I do agree with many comments made by referee 2. And most of them were not addressed by the authors in their revision.

-There is a lack of historical context. Moravian missionaries were in Greenland by the end of 18th century. They did perform meteorological activities but did not publish meteorological records. See Vinther et al., 2006 and

https://www.dmi.dk/fileadmin/user_upload/Rapporter/TR/2014/tr14-06.pdf

They published an inventory of meteorological records available from 1784.

-Authors claim to present the longest meteorological series of early 19th century of the Arctic. Can you present other series? How can we verify?

Reply: The history of Moravian missionaries is presented in many papers authored by the team of Gaston Demarée (e.g. Demarée and Ogilvie 2008; Demarée et al. 2020, 2021) and Lüdecke (2005), and recently also by Borm et al. (2021). But more important is that this paper does not present its analysis based on data gathered by Moravian missionaries, and therefore there is no reason to write their history here.

We analyse series conducted by Giesecke, who was not a Moravian missionary. This series (1807–13) for Greenland is not included in either of the inventories you mentioned, and therefore we decided to describe this series as “newly discovered”.

We confirm that, according to our knowledge, this is the longest continuous series for Greenland for beginning of the 19th century (see the mentioned inventories).

Borm, J., Kodzik, J., and Charbit, S.: Producing and communicating natural history in the long 18th century: Moravian observations concerning Greenland’s climate in unpublished sources, *Polar Rec.*, 57, 1–10, <https://doi.org/10.1017/S0032247421000218>, 2021.

Demarée, G. R. and Ogilvie, A. E. J.: The Moravian missionaries at the Labrador coast and their centuries-long contribution to instrumental meteorological observations, *Climatic Change*, 91, 423–450, <https://doi.org/10.1007/s10584-008-9420-2>, 2008.

Demarée, G. R. and Ogilvie, A. E. J.: Missionary Activity in Greenland and in Labrador: The Context for Early Meteorological Observations, in: Jenz, F. and Petterson, C. (Eds.), *Legacies of David Cranz’s ‘Historie von Grönland’ (1765), Christianities in the Trans-Atlantic World*, https://doi.org/10.1007/978-3-030-63998-3_7, 2021.

Demarée, G. R., Ogilvie, A. E. J., and Mailier, P.: Early meteorological observations in Greenland and Labrador in the 18th century: a contribution of the Moravian Brethren, in: *Proc. 35th Int. Symp. on the Okhotsk Sea and Polar Oceans, Mombetsu, Hokkaido, Japan*, 35–38, 2020.

Lüdecke, C.: East meets West. Meteorological observations of the Moravians in Greenland and Labrador since the 18th century, *Hist. Meteorol.*, 2, 123–132, 2005

Title and abstract:

-I don’t think these data should be consider Newly discovered. There are indeed unique or original.

Reply. We find no justification for your assertion: this series is not listed in either of the mentioned inventories, even by the DMI, which is responsible for meteorological measurements in Greenland, so there is no evidence that contradicts the description as “newly discovered”. Of course we agree that this series is unique and original.

-were “supposed to be” carried out by

Reply – No. 100% of measurements were performed by Dr Giesecke (or under his supervision) – see original signature from Diamond Library in Copenhagen, given in our

further reply to your comments; see also photography attached below (it is part of his manuscript kept at the Royal Society in London).

-Possibly the coldest of the past two millennia. This is not your finding. It is in accordance with proxy data that cover the past two millennia.

Reply. Thank you for this suggestion. You are right that we based this statement on other works; therefore, we changed the text to:

„Summarising the obtained results, we can again underline that the first two decades of the 19th century in the study region, in all of Greenland and on average in the Arctic, were, *according to reconstructions based on proxy data (Miller et al. 2010; Werner et al. 2018)* one of the coldest periods in the past two millennia (and possibly the coldest).”

Miller, G. H., Brigham-Grette, J., Alley, R. B., Anderson, L., Bauch, H. A., Douglas, M. S. V., Edwards, M. E., Elias, S. A., Finney, B. P., Fitzpatrick, J. J., Funder, S. V., Herbert, T. D., Hinzman, L. D., Kaufman, D. S., MacDonald, G. M., Polyak, L., Robock, A., Serreze, M. C., Smol, J. P., Spielhagen, R., White, J. W. C., Wolfe, A. P., and Wolfe, E. W.: Temperature and precipitation history of the Arctic, *Quat. Sci. Rev.*, 29, 1679–1715, <https://doi.org/10.1016/j.quascirev.2010.03.001>, 2010.

Warren, R., Bartlome, N. E., Wellinger, N., Franke, J., Hand, R., Brönnimann, S., and Huhtamaa, H.: ClimeApp: data processing tool for monthly, global climate data from the ModE-RA palaeo-reanalysis, 1422 to 2008 CE, *Clim. Past*, 20, 2645–2662, <https://doi.org/10.5194/cp-20-2645-2024>, 2024

-Lines 25-27 : “almost fully consistent”. This sentence is not clear enough. What proxy? Using the same scale ?

Reply. In our view, this sentence is clear. In this sentence, we state that available air temperature reconstructions—whether utilizing proxy data or obtained through modelling—agree to a large extent with instrumental observations.

Introduction:

Lines 70-72 : Can you give example where it was done? Most likely, it is the opposite. Your paper is validating the early-instrumental data with proxy-based reconstructions.

Reply. The text is correct. Instrumental data are used to validate reconstructions that are based on proxy data, not the other way round. The text has been checked by a native speaker to ensure that this relationship is clearly expressed.

Line 77: It is confusing referring to a figure from another paper.

Reply. We do not see nothing wrong in referring readers to the content of other papers, including to figures. We have often done this in another papers, and in other parts of this paper. It is also common practice in the literature.

Line 80: On what is based this definition? Latitude? mean annual temperature? tree line?

Reply. Southern boundary of the Arctic is delimited using climatic criteria, many variables were taken into account and their gradients. For more details see *Atlas Arktiki* (1985) or Przybylak (2016).

Gosudarstvennyy Komitet SSSR po Gidrometeorologii i Kontrolyu Prirodnoy Sredy, & Arctic and Antarctic Research Institute (Ed. A. F. Treshnikov). (1985). *Atlas Arktiki* [Atlas of the Arctic]. Moscow: Main Administration of Geodesy and Cartography under the Council of Ministers of the USSR.

Przybylak, R. (2016), *The Climate of the Arctic* (2nd ed.). Cham: Springer International Publishing.
Series: *Atmospheric and Oceanographic Sciences Library*, Vol. 52.
<https://doi.org/10.1007/978-3-319-21696-6>

Line 81: we ? scientific community or the authors ?

Reply. Scientific community. For clarity we change a little text to:

„For the 1840s and 1850s, ~~we have a continuous series of data is available~~ *available* for Illulisat (Jacobshavn) (Vinther et al., 2006) and probably also for Lichtenau (1843–51) and Neu-Herrnhut (1843–60) according to Table 2 (Lüdecke et al., 2005).”

Lines 85-86: I am not sure it is the place to call out the collection owner

Reply. Thank you for this suggestion. We deleted the last sentence.

Lines 87-90 : State of knowledge only presents one work (Vinther et al., 2006) and your own work.

Reply. We do not agree. The state of knowledge is presented in lines 51-86, where we also give some papers written by Lüdecke (2005), Demarée and Ogilvie (2008), Demarée et al. (2020), Kodzik (2019), Borm et al. (2021), Vinther et al. (2006) and our works also.

Line 92: London archives or the Royal society of London?

Reply. Thank you for this suggestion. We corrected text to:

While searching the *Royal Society archives in London* ~~archives~~ for early instrumental meteorological observations by the Moravian Brothers, we happened upon this series.

Line 93: Moravian Brothers is not correct

Reply. We do not agree that such description is incorrect. Nevertheless, we changed it to Moravian Brethren.

2. Area, data and methods

Line 115: Or he might not be the author. Many scholars visiting Greenland and Labrador were bringing excerpts of meteorological observation made by the Moravian missionaries.

Reply. No. We know for certainty that he is the author of this series of observations. It is clearly stated before the publication of meteorological observations from the years 1811–13, see below.

The formula using the daily minimum and maximum values of temperature only roughly approximate the real daily mean. In half of the world, the mean daily temperature was calculated using extreme temperatures because observations were not done on regular bases, e.g. every 6 or 3 hours per day.

Line 243: greater than the average temperature of the contemporary period.

Reply. Yes. Your proposition was added.

Line 245: you mean the lower monthly average?

Reply. Yes. The sentence was changed to: *On average, in the yearly cycle, the coldest mean monthly temperature occurred in February (-14.4 °C)...*

Line 248: Year-to-year changes you mean standard deviation or the mean difference between each year?

Reply. Mean difference between years. For greater clarity, the sentence was change to: *Mean year-to-year changes between ~~in~~ mean monthly values are clearly most significant in winter...*

Line 312: calm days

Reply. Yes. We clarified the text using your proposition.

Line 314: Might also be related with a change in atmospheric circulation patterns like NAO.

Reply.

Thank you for this suggestion. However, it is not possible because the NAO indexes were clearly negative (between -1 and -1.5 according to reconstructions of the NAO). For more details, see reply to your comment to lines 444-448.

Line 329: climate or weather features? Extreme or daily changes are more of meteorological phenomena

Reply. Here we underline the importance of use of greater resolution of data (i.e. daily data) for more precise analysis of climate. Therefore, we prefer to leave the text as it is.

Line 333: Do you present these sub-daily data because it is what you did in the past or because it will show something specific?

Reply. Both reasons. For example, sub-daily data allow to calculate, for example, diurnal temperature range (DTR), which is a simple but very informative statistic saying much also about the character of weather in the given day.

Lines 407-409: Could be compared with southern regions, subarctic Canada which most likely answer to similar atmospheric circulation patterns. See for examples: Catchpole and

Faurer, 1983; Catchpole and Hanuta, 1989; Catchpole and Ball, 1981; Ball, 1994; Wilson, 1982.

Reply. The Canadian Arctic lies in a different climatic region (Canadian region) than Nuuk (Baffin Bay region) according to *Atlas Arktiki* (1985), see also (Przybylak 2016). These areas differ significantly in character of climate. The Canadian Arctic (in particular sub-Arctic) has a sharp continental climate, while the coast of Greenland has a maritime climate. For this reason, comparison with sub-Arctic Canada is not a good idea.

Gosudarstvennyy Komitet SSSR po Gidrometeorologii i Kontrolyu Prirodnoy Sredy, & Arctic and Antarctic Research Institute (Ed. A. F. Treshnikov). (1985). *Atlas Arktiki* [Atlas of the Arctic]. Moscow: Main Administration of Geodesy and Cartography under the Council of Ministers of the USSR.

Przybylak, R. (2016), *The Climate of the Arctic* (2nd ed.). Cham: Springer International Publishing. Series: Atmospheric and Oceanographic Sciences Library, Vol. 52. <https://doi.org/10.1007/978-3-319-21696-6>

Line 413: Add reference to modern day climatology.

Reply. Thank you for this suggestion. We added one reference: Putnins (1970).

Putnins, P. : The Climate of Greenland. in: S. Orvig (ed.), *Climates of the Polar Regions* (World Survey of Climatology, Vol. 14), p. 3–128, Elsevier Publishing Company, Barking (UK), 1970.

Line 444: unknown or you don't know how to explain it?

Reply. We rephrased the sentence a little. We hope that it is clearer now.

„ *The explanation of these changes is an open question.* ~~unknown.~~”

Lines 444-448: Reference is needed to support this hypothesis. Also, six years of data is quite short, it could be due to change in atmospheric circulation patterns (e.g. AO, NAO, El Niño, etc.)

Reply. Thank you for suggestion. We added the reference (Lea et al. 2014a, b). According to these publications, the glacier (Kangiata Nunaata Sermialo) located to the NE of Nuuk has shown recession of about 10.6 km since the mid-19th century. We checked your proposition and stated that, in the first half of the 19th century, the NAO was slightly below zero (Luterbacher et al. 2002; Trouet et al. 2009; Ortega et al. 2015), while in years 1990–2020, it was slightly above zero (https://climatedataguide.ucar.edu/climate-data/hurrell-north-atlantic-oscillation-nao-index-pc-based?utm_source=chatgpt.com). Such a change in NAO between the two studied periods cannot have caused the changes which we noted in Fig. 11. For this to be possible, the NAO would have had to exhibit positive values in the first half of the 19th century and negative values currently—that is, the reverse of historical reality.

Luterbacher, J., Dietrich, D., Xoplaki, E., Grosjean, M., & Wanner, H. (2002). Reconstruction of sea level pressure fields over the Eastern North Atlantic and Europe back to 1500, *Climate Dynamics*, 18, 545–561.

Trouet, V., Esper, J., Graham, N. E., Baker, A., Scourse, J. D., & Frank, D. C. (2009). Persistent positive North Atlantic Oscillation mode dominated the Medieval Climate Anomaly. *Science*, 324(5923), 78–80. <https://doi.org/10.1126/science.1166349>

Ortega, P., Lehner, F., Swingedouw, D., Masson-Delmotte, V., Raible, C. C., Casado, M., & Yiou, P. (2015).

A model-tested North Atlantic Oscillation reconstruction for the past millennium, *Nature*, 523, 71–74.

Lines 446-447: how do you know it is the wind bringing warmer air, and not just the local temperature that is warmer?

Reply. This is a standard interpretation of Figure 11, which presents results of thermal roses. It is not important whether the air masses coming to Nuuk were of local or regional character.

Line 453: Thermal seasons are interesting.

Reply. Thank you.

Line 518: The decade 1810 is known for the year without summer 1816, which is one of the coldest years in all Northern Hemisphere. It should be mentioned in your interpretation and comparison with other sources that cover the entire decade.

Reply. Thank you for suggestion. We added the following sentence:

It is worth adding that this series includes the year 1816 (called the “year without summer”), which was one of the coldest years in all Northern Hemisphere (due to the Tambora eruption, see Raible et al. 2016).

Raible, C. C., Brönnimann, S., Auchmann, R., Brohan, P., Frölicher, T. L., Graf, H.-F., Jones, P., Luterbacher, J., Muthers, S., Neukom, R., Robock, A., Self, S., Sudrajat, A., Timmreck, C., & Wegmann, M.: Tambora 1815 as a test case for high impact volcanic eruptions: Earth system effects. *Wiley Interdisciplinary Reviews: Climate Change*, 7(4), 569–589. <https://doi.org/10.1002/wcc.407>, 2016

Line 545: See Stein, 2007; Mikkelsen et al., 2018; Perner et al., 2012. A lot of work has been done on marine core from west Greenland.

Reply. Thank you for these references. But neither of these publications provides a reconstruction of temperature made using marine cores.

Only the publication of Stein (2007) contains a temperature reconstruction since 1800. However, in this publication, the temperature reconstruction for West Greenland was taken from Jones and Mann (2004). In turn, Jones and Mann took data after Fischer et al. (1996). This reconstruction is based on stacked ice core oxygen isotope records. Therefore, we added only the last two items to our discussion.

Fisher, D. A., R. M. Koerner, K. Kuiviner, H. B. Clausen, S. J. Johnsen, J.-P. Steffensen, N. Gundestrup, and C. U. Hammer (1996), Inter-comparison of ice core and precipitation records from sites in Canada and Greenland over the last 3500 years and over the last few centuries in detail using EOF techniques, in *Climatic Variations and Forcing Mechanisms of the Last 2000 Years*, NATO ASI Ser., Ser. I, vol. 41, edited by P. D. Jones, R. S. Bradley, and J. Jouzel, pp. 297–328, Springer-Verlag, New York.

Jones, P. D., and Mann M.E.. Climate over past millennia. *Rev. Geophys.*, 42, No. 2, RG2002, doi:10.1029/2003RG000143, 2004.

Lines 674-678: Indeed proxy-reconstruction have limits and bias, and so instrumental data, it should be mentioned, and interpretation should be done carefully. As you have no information on the source, instrumental, location, etc. bias are possible.

Reply. Of course we agree with your opinion, but please note that here we write generally about instrumental observations (not only about the series analysed herein). This statement about the advantage of instrumental observations over from proxy data was added at the suggestion of one of the reviewers of the present manuscript.

Line 685: Editorial comment might not be appropriate.

Reply. Thank you for suggestion. We deleted the last sentence.

Acknowledgements: Have you asked anybody from Greenland, university or archives about the implication of local Inuit communities?

Reply. No. However, we believe that the community of that time deserves to be recognised, as it was their involvement in assisting with the meteorological observations can be assumed with high certainty.