

Reply to Reviewer 1 (Olivier Planchon, 19 Mar 2026).

13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?

YES - Thank you for making the following few minor corrections :

Figures 2, 3, 4, 5. Please add axis titles.

Reply. Thank you for this suggestion. We added the titles to the axis of Fig. 5 and changed the captions to figures 2–4 for greater clarity.

This paper is placed in the context of numerous other publications dealing with the study of climatic conditions during the Little Ice Age in Western and Central Europe, by means of the combined analysis of dendrochronological data and documentary sources. The major interest of the results obtained is to confirm, on the territory of present-day Poland, the complexity of the climatic history at that time. The authors clearly show the existence of multi-year oscillations, both thermal and pluviometric, and sometimes contradict, in a very relevant way, the notion of the Little Ice Age as it is usually understood. Interannual climate variability is therefore highlighted, modulated according to the seasons. Seasonality seems to me, in this article, to be one of the most interesting points, because the authors highlight a continental character of the climate more accentuated than nowadays. Continentality is more rarely studied than the mere temporal evolution of temperature, which makes this point particularly interesting to study and develop, perhaps for a possible follow-up to this article? Many "continentality indices" have been developed for more than a century to quantify continentality using various parameters. Perhaps it would be relevant to use some of them for studies of palaeoclimatic reconstructions?

Reply. Thank you very much for your good opinion of our work.

Thank you also for a very good suggestion. We added the following texts

(i) to the methods section:

The climate continentality of Poland was calculated using Gorczyński's index of thermal continentality using the following formula (Gorczynski 1920; Kożuchowski and Marciniak 1985):

$$K = (1.7 \times A / \sin \varphi) - 20.4$$

where K is the continentality index in %, A is the annual temperature amplitude, and φ is the geographical latitude. Annual temperature amplitude was calculated using mean summer and winter temperatures, as only seasonal temperatures were reconstructed for the 16th century. Also, Warsaw's latitude (52.23°N) was used for calculations.

(ii) to the results section:

The annual temperature range (summer minus winter) in Poland in the 16th century was significantly greater (by about 3 °C) than it is at present, indicating that climate continentality was also greater. According to Gorczyński's index of thermal continentality, that difference reached about 6%.

(iii) to the list of references

Gorczynski, L.: Sur le calcul du degré du continentalisme et son application dans la climatologie. Geografiska Annaler, 2, 324–331, 1920.

Kożuchowski, K., and Marciniak, K.: Zmiany kontynentalizmu termicznego klimatu Polski, Wiadomości IMGW, 1985.

Two other questions for the authors:

- Among the documentary sources used, did the authors have in hand information concerning possible links between weather / climate conditions and agricultural activities, for example harvest dates and/or indications of yields and damage to certain crops?

Reply. Yes, but information is sparse. There is no regular data about harvest dates. The fundamental problem is that economic sources from the 16th-century Poland are usually tax records. These do not contain variable charges that might depend on the size of the grain harvest, but are fixed and unchanging, regardless of the harvest's size. It is therefore difficult to find sources that would indicate the size of the harvest in individual years. There is some potential value in analysing the prices of various goods, including grain. Such price lists have been compiled for, for example, Gdańsk and Wrocław. However, in this case, many factors influence prices, such as inflation, administrative price controls, and significant price fluctuations over a few days. Research in this area is rather risky. It is certainly possible to some extent, but it requires a great deal of painstaking research, checking price lists in existing studies – which, as in the case of Gdańsk, date from before 1939 – and developing a suitable method that would allow the actual correlations between the weather and price movements to be demonstrated. In this case, a great deal of work is still needed to make sense of the data.

- At that time, did the administration of the Hanseatic city of Danzig carry out systematic observations of the winter freeze-up of its port and gulf, like its "colleagues" in Riga?

Reply. Unfortunately not. Only fragmentary information exists for the port of Elbląg (near Gdańsk). It is possible to show the number of days for which shipping traffic was closed, but only for some years. For example, ships did not operate for 173 days in the winter of 1585/86; for 143 days in the winter of 1596/97; and for 136 days in the winter of 1599/1600. There are data for Elbląg for some years in the 17th century as well. Thus, it could be assumed that extremely severe and severe winters led to the suspension of shipping for 152 to 173 days, or about 5 months or more in the mentioned years.

Thank you very much for your useful suggestions and comments, which have significantly improved the quality of our paper.

Reply to Reviewer 2 (Anonymous Referee #2, 06 Apr 2026)

Dear Authors,

The paper 'Climate variability in Poland (Central Europe) in the 16th century based on multiproxy data' fits the scope of *Climate of the Past*.

A few comments are provided to enhance the manuscript:

It would be important to add a few sentences about the effects of proximity to the sea in the North and of continentality in the South, and to cross-reference them with the mentioned air temperature differences.

Reply: the following text was added to section 4:

One of the most important reasons for this variability is the increasing continentalization of the climate in Poland, which is progressing from west to east (Kozuchowski and Marciniak, 1985) and is caused by the decreasing influence of oceanic masses flowing eastwards from the Atlantic, particularly in winter. The influence of the Baltic Sea on the climate of Poland extends only several dozen kilometres inland, mainly along the coast in north-western Poland. The mentioned maritime air masses bring warming to Poland in winter and cooling in summer.

Kozuchowski, K. and Marciniak, K.: Zmiany kontynentalizmu termicznego klimatu Polski, Wiadomości IMGW, 1985.

This variation does not significantly affect the temperature differences between the 16th and 20th centuries, because the same climatic factors operated similarly in both periods.

Lines 62 – 65: Add references.

Reply. Thank you for this suggestion. We added the following supplement to the text, with some of the most important synthesis papers: (*Grove 1988; Hughes and Diaz 1994; White et al. 2018, and references therein*)

Grove, J. M.: *The Little Ice Age*, Methuen & Co., London, 498 pp., ISBN 0-416-31540-2, 1988.

Hughes, M. K., & Diaz, H. F. (Eds.): *The Medieval Warm Period*. Dordrecht: Springer Netherlands. <https://doi.org/10.1007/978-94-011-1186-7>, 1994.

White, S., Pfister, C., & Mauelshagen, F. (Eds.): *The Palgrave Handbook of Climate History*. London: Palgrave Macmillan. <https://doi.org/10.1057/978-1-137-43020-5>; ISBN: 978-1-137-43019-9, 2018.

Lines 100 – 103: Add references.

Reply. We added the link to the project: <https://extremeweather.umk.pl/pages/funding/?lang=en>

Line 111: Add references.

Reply: Thank you for this suggestion. We added the following references: Przybylak et al. (2005); Przybylak (2011, 2016).

Przybylak, R.: Changes in Poland's climate over the last millennium, *Czas. Geogr.*, 82, 23–48, 2011.

Przybylak, R.: Poland's Climate in the Last Millennium, in: *Oxford Research Encyclopedia, Climate Science*, Oxford

University Press, USA, <https://doi.org/10.1093/acrefore/9780190228620.013.2>, 2016.

Przybylak, R., Majorowicz, J., Wójcik, G., Zielski, A., Chorążyczewski, W., Marciniak, K., Nowosad, W., Oliński, P., and Syta, K.: Temperature changes in Poland from the 16th to the 20th centuries, *Int. J. Climatol.*, 25, 773–791, <https://doi.org/10.1002/joc.1149>, 2005.

Lines 484 – 486: This sentence is unclear, and it would need additional data and references to support arguments. Is this statement valid for Central Europe? How about other regions in Europe with very different climates (e.g. Southern Europe or Western Europe)?

Reply. Thank you for these suggestions. For greater clarity, we changed the sentence as follows:

Thus, it seems very probable that the winter temperature should also be used to ~~for~~ representing annual temperature in some parts of Europe, particularly in central Europe, instead of the more usual use of summer temperature for this purpose (see Ljungqvist, 2010).

Line 634: Explain and add references/data to support arguments, particularly when comparing Poland to other geographical areas.

Reply. Thank you for this suggestion. For greater clarity, we added the following references: Hernández-Almeida et al. (2017); Valler et al. (2024). The text was also slightly modified; see below:

On the other hand, summer temperature reconstructions are ambiguous (Hernández-Almeida et al., 2017; Valler et al. 2024). A reconstruction based on documentary evidence does not indicate a temperature drop in the second half of the 16th century, except for the decade 1561–70 (Fig. 5), whereas a chironomid-based reconstruction of August temperature does (Fig. 10G). Additionally, a global palaeo-reanalysis reveals a cooling at this time (Fig. 11, Fig. S1). The lower accuracy of information on weather conditions in historical sources for the last three decades of the 16th century, compared to the earlier period (Fig. 2), may be one of the reasons for the uncertainty of summer temperature reconstruction based on the documentary evidence.

Do the documentary sources mention the impacts of climate deterioration? It would be interesting to include a few examples/transcripts to highlight the impacts, such as on farming/crops or freeze-thaw cycles.

Reply. We constructed a new Table (Table S2) to supplement, with six such examples.

Include an image of one of the documentary sources for context and illustration purposes.

Reply. Thank you for this suggestion. One example of a documentary source was included in the supplement (Fig. S1).

Best wishes,

Reviewer

Thank you very much for all your constructive comments and suggestions, which definitely helped us to improve our article.