

Journal: Climate of the Past

Manuscript ID: egusphere-2023-1143

Title: The climate in Poland (Central Europe) in the first half of the last millennium, revisited

Dear Professor Natalia Piotrowska

Editor, Climate of the Past

We would like to thank you and the anonymous reviewers for providing positive feedback and constructive comments on our manuscript. All comments were carefully considered, and we believe they helped us improve the description of our work. The detailed corrections/modifications are listed below, point by point.

(Note: The changes in the text and the answers to the reviewer's questions/suggestions are marked in red font. We revised the text taking into account all comments and suggestions proposed by the reviewers. All changes have been carefully applied to the text.)

Response to Reviewer No. 2

Review of manuscript "The climate in Poland (Central Europe) in the first half of the last millennium, revisited".

This manuscript investigates climate variability in Poland over the first half of the last millennium, especially over the 15th century. The authors combine previously published climate reconstructions with novel time series from dendrochronological and documentary material. I am especially impressed with the extensive and detailed work on gathering all the documentary evidence (Tables S2 and S3).

ANS: Thank you.

As I do not have expertise in dendrosciences, I will focus mostly on the documentary evidence and the reconstruction created from these data. After taking into consideration the few suggestions pointed out below, I think this manuscript is well suited to EGU sphere.

Major

My major concern is related to the temperature reconstruction based on documentary evidence (lines 112–116 and 235–249, Fig 4.). The authors state that the reconstruction method is "described in a paper by Przybylak et al. (2005) and is therefore omitted here". However, I would strongly suggest including a brief description on the method, as well as adding some critical reflections on the potential biases of historical data. There are few reasons for this:

ANS: Thank you for these suggestions. We added the following passage:

Standard methods used commonly in the historical climatology were utilised for this purpose. Pfister et al. (1994) proposed that, for the following index values: i) +3 and -3 should represent anomalies exceeding 2.0 standard deviations (SD) from the mean of the long-term period, ii) +2/-2 and +1/-1 should represent less extreme conditions, i.e. 1.41–2.00SD and 0.7–1.4SD, respectively, iii) 0 (>-0.7SD – <0.7SD) should represent the average climate of the long-term period or missing data. The above-mentioned criteria were slightly modified by us using results of calibration of documentary evidence with air temperature data from Warsaw for the period 1789–1850 done by Sadowski (1991). As a result, the seasons described in this paper by indices from +3 to -3 fulfil the following criteria:

$$+3 \geq m + 1.5SD$$

$$m + 1.0SD \leq +2 < m + 1.5SD$$

$$m + 0.5SD \leq +1 < m + 1.0SD$$

$$m - 0.5SD < 0 < m + 0.5SD$$

$$m - 1.0SD < -1 \leq m - 0.5SD$$

$$m - 1.5SD < -2 \leq m - 1.0SD$$

$$-3 \leq m - 1.5SD$$

where m is the long-term mean (for calibration period 1789–1850) air temperature from the Warsaw series and SD is the standard deviation of that series. For more details, see Przybylak et al. (2005). The reader should be reminded of the possible biases related to climate reconstruction based on the documentary evidence such as, for example: i) the number of available sources, their quality and discontinuous structure, ii) the subjectivity of the indexation, iii) weaknesses of the reconstruction method used. A detailed overview of the strong points and the drawbacks of documentary data is presented by Brázdil et al. (2005).

We hope that the reconstruction method and documentary data are now more clearly presented.

1) As the documentary evidence presented by Przybylak et al. (2005) covered years 1501–1840, the transformation from the -3,...+3 index values into °C (Przybylak et al. 2005, Tables II and III) was done with a reference period when the documentary and meteorological data overlapped. This is not the case in the current study, as (as far as I understood) reference period 1951–2000 is used for the 1361–1500 reconstruction. Thus, is the method still applicable if the documentary and meteorological series do not overlap?

ANS: In the present paper, as well as in our previous reconstructions published in papers Przybylak et al. (2005) and Przybylak (2011), the same methodology was used. That is why our reconstructions for the entire historical period (including the present reconstruction for the 15th century) are fully homogenised and comparable. Calibration and verification of documentary evidence with meteorological data from Warsaw from the period 1789–1850 was made by Sadowski (1991). Only for this period is documentary evidence available that overlaps with the meteorological data. In the next step, for each index we calculated mean values of seasonal temperatures using the homogenised

temperature series from Warsaw from the period 1779–1999 and using established temperature intervals as shown above to the first point of question, i.e. also covering the reference period 1951–2000 (excluding one year). Nobody is trying to make a calibration and verification procedures based on contemporary documentary evidence and also contemporary meteorological data, which if we understood correctly, the reviewer is proposing. Brázdil et al. (2005) clearly write: “Each kind of documentary proxy data needs to be calibrated against (early) instrumental series and is restricted to specific periods of the year in the same way as natural proxy data.”

In the paper Przybylak et al. (2005), we calculated temperature anomalies between historical periods in reference to the two periods 1789–1850 (early instrumental) and 1901–60. Here, we decided to present the comparison to only more contemporary thermal conditions in Poland (1951–2000) taking into account areally average temperature for Poland calculated based on data from 45–50 weather stations. This reference period was used only to show the change in temperature between historical periods and the contemporary period.

2) The approach described by Przybylak et al. (2005) is based on the assumption that "there were no significant changes in mean temperatures [...] from the 16th to the 19th centuries" and thus "it can be assumed that any changes in temperature variance that occurred were insignificant" (Przybylak et al. 2005, 778). However, can we similarly assume that there were no changes in the mean and/or variance between the periods 1361–1500 and 1951–2000?

Ans: True, we cannot make such an assumption. But we do not need to make this assumption in order to reconstruct temperature for the 15th century. The period 1951–2000 is used only for comparison of reconstructed mean decadal temperature from historical period against the contemporary observed values, in order to show the change in temperature between the two periods.

3) The reconstruction (Fig. 5) indicates that 15th century winters were systemically colder and summers warmer than during the later half of the 20th century, which provides further evidence on the transformation to a more continental climate during this period (lines 326–329). However, I was wondering whether the source material might contribute to the higher occurrence of colder/hotter anomalies as well? It is well established that historical weather descriptions contains bias in the focus of the observer and they emphasise extreme events (see, e.g., Brázdil et al. 2010, "European climate of the past 500 years" Climatic Change 101). The number of available weather descriptions (Fig. 2) and the frequency of extreme events (Table 2) show a similar temporal pattern. Thus, to what degree the increased number of mentioned cold/hot seasons can be explained by increasing source availability, especially because we know that historical records rarely record "average" weather?

Ans: The remark is important. Please note that the pattern of temperature changes between the 15th century and contemporary period is the same as in our reconstructions made for the period 1501–1840 (Fig. 3 in Przybylak et al. 2005). It supports the correctness of our recent reconstruction. You are right, evidently there exists some influence of a different number of weather notes on each reconstruction constructed based on documentary evidence. However, we do not know the scale of that influence. But we know that this influence is greater for the less-extreme events than for highly extreme events. The latter events were usually not missed in the historical sources even if the overall number of them was small (for the reason that you also mentioned). A very good example illustrating this is the analysis of the decades of the 1430s and 1450s. The number of weather notes for winter was about four times smaller in the first decade than in the decade 1450s (Fig. 2), but in both decades the number of extremely cold and very cold winters (indices -3 and -2) was the same (7 cases) (see Fig. 3). As a result, the reconstructed temperatures were also comparable (Fig. 4). Both decades were very

cold, and there is a lot of evidence for the occurrence of both cold periods in many reconstructions based on different proxies, even if averaged for the northern hemisphere or the globe.

4) And last, related to the point above, it would be good to add a table of criteria (i.e. list of typical descriptions/events in the documentary sources) for the -3,...,+3 classification for both seasons. This would be informative for readers who are not familiar with what is considered as "typical" or "extreme" weather over the study area. Moreover, clearly defined classification criteria would help to assess the high frequency of the late 15th century extreme events as well (Table 2).

ANS: Thank you for this suggestion. A new Table (Table S4) was added.

Moderate/minor

Please, provide further information on the meteorological data used, as the referred publication (Kozuchowski and Żmudzka, 2003) is not publicly available. Based on Fig 1, the meteorological data is coming from two stations, from Torun and Kraków?

ANS: The meteorological data from Toruń and Kraków were used only for the calibration and verification procedures needed for the reconstructions of temperature based on dendrochronological data. Kozuchowski and Żmudzka (2003) and Tomczyk (2022) used 45–50 and 40 weather stations to calculate areally averaged temperature for Poland, respectively.

The following sentence was added to the main text for clarity:

These two present mean temperatures for the area of Poland were calculated based on data taken from 45–50 and 40 weather stations, respectively.

Pay attention to terminology "current", "contemporary", and "present" (for example, lines 27, 239, 248, and 324). In many cases more accurate expression would be "latter half of the 20th century" or similar.

ANS: Thank you. The suggestion was introduced to the text.

The manuscript includes quite a lot of additional material from previous publications (e.g., Fig. 10 and the section Summary and discussion. Also the abstract starts by mentioning these materials). Consider introducing these data, for example, in a supplementary table.

ANS: Actually, only Fig. 10 includes data from previous publications. All other documentation is new and is shown for the first time. Figure 10 summarises concisely the course of temperature in Poland in the period 1001–1500, gathering all the existed temperature reconstructions for Poland published since 2010. For this reason, we believe this figure to be very important: it allows direct comparison of the results. Therefore, for the reader's sake, we prefer that the figure be left in the main body of the paper.

Technical

Line 22: Correct "date" as "data"

ANS: Done

Lines 66 and 67: Bold font for the titles.

ANS: Done

Table 1: Verification statistics are missing for Lesser Poland Scots pine and Silver fir.

ANS: Thank you. The verification statistics was added.

Line 149: What are the "extreme thermal conditions" that the moon rings indicate? Extremely cold winters? Please clarify for non-specialist.

ANS: Done

Lines 204 and 206. Winters 1280, 1306, and 1225. For example, in the case of winter 1280, does this mean the winter 1279/80 or 1280/81?

ANS: Done

Line 255 and after. What the identified moon rings indicate? Colder winters?

ANS: Done