

Interactive comment on “The early Spörer Minimum – a period of extraordinary climate and socio-economic changes in Western and Central Europe” by Chantal Camenisch et al.

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Summary

The discussion paper titled "The early Spörer Minimum - a period of extraordinary climate and socio-economic changes in Western and Central Europe" submitted to Climate of the Past by Camenisch et al. aims to provide an end-to-end analysis of the interconnected histories of climate and society during a the winter-cold decade 1430-1440 in Northwestern and Central Europe. The authors provide evidence of climatic anomaly for this period based on multi-proxy and multi-site climate archives and from an ensemble of global climate simulations; they provide evidence on economic and social disturbances during and after this period based on documentary sources.

Assessment

This paper address relevant scientific questions within the scope of CP. It presents a novel combination of existing climate and historical data; bringing the historical socioeconomic data into a climate context and to the readership of CP is relevant. The conclusions drawn from the combination of the different data sources should be better substantiated, the manuscript could benefit from more careful statistical statements and rigorous application of significance level choice and evaluation. The literature cited is plentiful but appropriate, the abstract summarizes the paper well, but suffers from inconclusive statements; also the title should be improved. At several places, more information (that is in the SOM or "not shown") needs to be provided.

The presentation is well structured, the language is fluent, but it lacks precision. Mathematical symbols in the appendix are poorly typed and chosen. All figures are of insufficient quality for publication. I don't see much value in figs 1, 4b, 6, 7, and 9 in the main manuscript. The SOM is lacking a title and summary.

Recommendation

For scope, novelty and relevance I recommend to accept this paper. For accuracy, precision, language, figures, and conclusiveness the paper needs to be revised thoroughly.

Detailed comments

Page 1 Title: as the short comment states, please reconsider your terminology with "Spörer Minimum" and early SPM; I would suggest also to find more distinct names for the period 1300 to 1700 versus the early part of this, esp 1430-1440. The geographical name is not correct; your region of investigation is rather Northwestern and Central than Western and Central Europe

Authors: The list of authors is very long, although this study is not presenting original research but rather relies on data/simulations that have already been published. Why

is there such a long author list, and have all contributed to the manuscript? I suggest to move some to the acknowledgment section and clarify their contribution, if not directly related to research design, data production, analysis and writing of the paper.

l 38: not everyone might understand end-to-end, neither is your understanding necessarily the same as for people from other backgrounds. This should be defined.

Page 2

ll 4-6: consequence ... in order to be prepared. I did not see this chain of causation substantiated in the main text.

ll 7f: "Climate model simulations show .. internal variability" You demonstrate that it is *not* volcanic activity, and conclude then that this must be internal, but there could be other external forcings. (see below) Also, the climate model simulations look at cold winters, not that specific decade.

ll 8f: You do not test the hypothesis formally and don't conclude anything on this hypothesis later. I suggest to delete this sentence.

ll 12: "affected the socioeconomic system". Did all of them have effects, this is speculative

ll 12f: "cold resulted from forcing" imprecise; maybe the coldness can be attributed to forcing?

ll 14: "in the background" wrong "in"

ll 17: "include" and "inter alia" is redundant

ll 19: "negative" is a valuation, which should be avoided

ll 20: "all of which provoked", needs cautionary "may have", not all impacts provoke measures

ll 28f: "climatic and documentary" sources. These sources should not be connected by

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"and", as one points to an analysis tool or discipline and the other to a material. Rather than "climatic archive" we have archives that record aspects of climate ...

Il 30: "devastating" avoid valuation

Page 3

Il 1: "more descriptive" is too general, be precise

Il 6: "punctuated" by

Il 8: "substantially" this is not substantiated or quantified

Il 9: "devastating" valuation

Il 13-15f: "low temperatures could destroy the winter seed" .. "combined with no or almost no snow cover". But your analysis does not include winter precipitation! This statement should have a reference.

Il 15 "usually had an effect". Citation needed.

Il 19 "*with* regard to"

Il 20 "and other" is too imprecise. The many societal changes that the paper later recounts should be mentioned. Otherwise, this sentence gives the impression that climate is the better understood, or more important driver of societal reactions.

Il 23 wording "replace crop failure", do you mean "recover from" or "mitigate"?

Il 29, 32f: "SPM was a period of rather cold" versus "only the Maunder Minimum was a coherent cold phase". This conflict should be resolved.

Page 4

Il 3: "major cooling happens after 1450" what is the relevance of this?

Il 3. "Taken at face value," colloquial

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Il 4: "contradict" I don't see evidence for contradiction yet, since above, you argue that there are "other" impacts at work, too

Il 11: "dramatic change". Is not seen, it is one period of many with changes, has no long-lasting consequences

Il 28: "very moist early LIA". I don't see this in fig 2

Il 29: "context of entire millennium". Elaborate on Büntgen and Ammans findings and provide this context.

Il 30ff: "is rather diagnostic for" needs citation.

Page 5

Il 1: "Summers in the early SPM (1421–1450)". Previously, the early SPM was defined as 1431-1440 ???

Il 2: "see supporting". Where shown in supporting material?

Il 15-18: high seasonality could also indicate hot summer and normal winter, or medium cold winter and medium hot summer. Be clearer everywhere about your definition of high seasonality in combination with cold winter.

Il 19: "Figure 3 shows". I don't see this (see figure comments) well enough.

Il 20ff: Why do you show this in a figure if your data base is insufficient? A simple statement would be enough.

Il 31f: HIST and CNTRL are explained but not the "con" postfix used in the figure. Please elaborate on these four simulations

Page 6 Il 2: "in land use" Which land use scenario do you use? In PMIP both the KK10 and HYDE are available and have very different land use forcings for your time period (see Fig 3a in Kaplan et al. 2011). A discussion on this should be included, also on the potential external forcing effect of land use (e.g. widespread deforestation by

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the 15th century in Central Europe). This may well be one of the "other" external (and anthropogenic) drivers of cold spells.

Il 6.: I see no relevance in the 31-year filtered data series. Remove.

Il 7: "There are large uncertainties". In what quantities? Are they related to natural variability, or to uncertainties in parameter estimation, or to subgrid or other not resolved processes?

Il 14: "models simulate an average decrease" provide reference

Il 30: reference fig S2; better: Show the ensemble average and range, and the CESM runs you analyse later for Tjja, Tdjf and seasonality in a new figure in the main text. leave S2 with the details of all models in the SOM

Il 32ff: Provide results from a statistical test on the significance of the observed differences.

Il 34: if 56% of years with large seasonality coincide with very cold winter, then 44 % should correspond to very warm summers. This seems not significant to me (but you could provide results from a test here.)

Page 7

Il 3: "external forcing does not affect modelled seasonality in Europe". Better: TSI, volcanic and GHG forcing do not affect ... (Land use is not considered, see discussion above). Can this statement be upheld without the statistical tests required earlier in this paragraph?

Il 6: "cold winter decades". It is not discussed how robust this analysis is, the figure S3 should be referenced, what is the motivation for the choice "5 out of 10" and "cooler than mean-1 sigma" and the 600 year baseline? It is expected that in a normal distribution 2 out of 10 are cooler than 1 sigma, could you provide a more objective (reference!) analysis of the clustering of successively cold winters or many winters within a decade?

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Il 8f: "years with strong seasonality show anomalously cold winters in Europe". By definition, as seasonality is not independent of cold winter temperature. Why show annual mean in Fig 6? Rather show seasonality. Why show at all, as the spatial finding (colder on land in winter) is easily report in text and the figure has not added value.

Il 17: "seasonality ... shows ... a reduction in seasonality after an eruption". No, in figure 7, the seasonality anomaly *after* the eruption is close to zero. Only *at* the eruption, seasonality is visibly (but is this significant) reduced. I don't see any significance in the seasonality trends shown in Fig 7, could you report this more objectively?

Il 21: "periods of frequent volcanic eruptions" You analysed not frequent eruptions, but the 10 strongest eruptions, without considering frequency ...

Il 24: "strongly" provide reference.

Il 25: "collapse" is a loaded word, considered biased by many historians, try to rephrase.

page 8

Il 1: "attributed" climate impacts cannot be attributed to a model!

Il 3: why "mainly"? What else?

Il 5: "Monocausal explanations are never sufficient" commonplace statement

Il 6: "reasons for these climate impacts" unclear. Reasons for the impact that climate had on society? or other reasons for impacts that are also interpreted as climatic?

Il 11: "could be drunk" citation needed.

Il 12: "winters during the 1430s" which ones exactly?

Il 14 "From 1424 to 1433 two flood and five drought years occurred," What is the long-term expected frequency of floods and droughts?

Il 20: "problems" too general. What kind?

Il 22f: "This temperature and precipitation pattern is also indicated by the models (see Fig. 6)". It is not valid to compare the coldest winters within the 600 year climate simulation with the historic winters in early SPM. Also, flood and precipitation is not comparable, neither are drought and temperature. Frequency and mean values are incomparable. This needs to be worked out in more detail, or Figure 6 can simply be removed.

Il 22 "the models". Only one model result is shown

Il 25 "several years" which ones precisely?

Il 34: "area of Berne" provide year.

Page 9

Il 8: the "North" might be unknown to non-English.

Il 9: what is "sweet wine"?

Il 16: cite Hungarian National Archives, not undefined acronym HNA

Il 19: "Europe's population sank to its lowest levels"

Page 10

Il 10: "organised" in what year?

Il 11: "Thus". Conjunction misused.

Pag 11

Il 6: "were known" are known?

Il 7: "as a reaction to the continuous rainfall" needs citation

Il 13: the uncapitalized word "gypsy" is wrong here, the capitalized version Gypsy associated with ethnic or racial slur and is to be avoided. Prefer "Romani", or at least use "then called" / "derogatorily termed" when using the word "Gypsy"

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Il 14: "purely negative" is not precise and objective wording, rephrase.

Il 24f: "several wars aggravated the already tense situation". The authors make it sound, as if the social situation aggravated the root-causal climatic situation. I don't believe they want to convey this interpretation, but this needs to be sorted out. I believe that the authors want to say that climate stress aggravates the situation for already vulnerable societies. That way, the root cause is the social situation, and the trigger or aggravation comes from the climate impact (as clearly shown on page 12 Il 6).

Page 12

Il 17: "did not escalate into a demographic repeat" the demographic depression 1430 was the only one (as stated before by the authors). What is meant by this statement?

Il 24f: "Mutually reinforcing" sound like "circular arguments", maybe rephrase.

Il 25- next page: The relevance of herring for the period 1430-1440 is not demonstrated. The section is interesting but not relevant and could be removed.

Page 13

Il 15ff: "This strong increase in the seasonality of temperature suggests that, despite normal climatic conditions in the growing seasons, terrestrial ecosystem productivity was substantially decreased during this decade." This has not been conclusively shown.

Il 19: "caused by internal natural variability in the climate system rather than external forcing". This has not been shown, as land use was not considered and the evidence concentrated on ruling out volcanic forcing.

Il 27: "restrictions on the brewing of beer." This has not been shown

Il 32: " This period demonstrates .. a multitude of factors are needed". From the evidence presented, this cannot be concluded.

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Page 14

Il 1: "threatening" is valuation, not objective.

Il 6: "Western", better Northwestern

Il 16: Style of equation poor. Choice of variable names, T1, T2 sxy nx, ny, syz non-standard. Typography not helpful for understanding. Use subscripts, proper roman/upright versus italic symbols, better weighted font sizes in equation. Avoid accent above x,y to denote mean (a bar would be more standard). A point is not a multiplication dot!

Il 17: Symbols don't match those in equation, see above.

Il 22: see above, poor equation style. zscores is not explained

Figure 1

Not needed.

Figure 2

Graphical resolution of figure is poor. Please add (short) author information to legend, such that it is more easily seen when records from the same author appear in multiple panels. Adjust font to match the style of the journal

Figure 3

Most important figure, also requires major overhaul.

- adjust font to match the style of the journal - use consistent font sizes - add seasonality diagnostic to facilitate comparison - consider decadal moving average to provide smoother picture (and less visual clutter) - improve graphical representation of eSPM - annotate LIA and SPM periods - add markers for volcanic eruptions - add author and geographic information to legend - for 40 decades/observations, a p-value of $1-1/40 = .975$ (i.e. approx 3 sigma) is appropriate to detect "anomalous" cold/hot periods (Thom-



son 1990), so extend color range to $\sigma = 3$; the current choice highlights even small (1 σ) excursions that are expected to be realized in 32% of the observations

Reconsider the entire figure with respect to the main conclusions the reader should draw from it. Give the important parts (1430-1440) more room and contrast, help by providing seasonality diagnostics.

Figure 4

- part a) could be moved to SOM, at better resolution and consistent font - part b) is irrelevant and should be removed

Figure 5

The rightmost panel is not legible. gray and blue (CTL) cannot be seen. There is a mismatch between the CTRL and CTL acronyms in figure and text. Postfix "con" is not explained (it should be conditional), PDF (probability density function) is not explained either.

- adjust font to match the style of the journal - use consistent font sizes and font colors
- avoid duplication of data from HIST in rightmost panel

Figure 6

- not needed here, move to SOM - adjust font to match the style of the journal - use consistent font sizes and font colors - poor graphical resolution - abbreviations temp and precip are inconsistent with text - units are missing from color backgrounds - do not use divergent color map for temperature - consider relative anomaly instead of absolute anomaly - poor color choice in P anomaly: red (more) and blue (less) contrast with common perception of red (hot, dry) with blue (cold, wet); especially, since blue in precip mean plot indicates wetness.

Figure 7

- Move to SOM - adjust font to match the style of the journal - use consistent font

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sizes and font colors - poor graphical resolution - motivate 10-90% confidence shading
- highlight CESM results.

Figure 9

- adjust font to match the style of the journal - use consistent font sizes and font colors
- poor graphical resolution

It is difficult to relate the dates to the values. The positioning of year labels along the x-axis is unclear; vertical grid lines would guide the eye, or choosing the bar plot for salt with small gaps between bars.

The y-scale is inappropriate. Percentage deviations should be presented on a logarithmic scale, such that doubling (200%) and halving (50%) have equal distance to the reference. The reference should have a horizontal line.

The eSPM decade should be visually marked.

Extreme events could be annotated if historical accounts are provided by the authors.

References

Kaplan, J. O., Krumhardt, K. M., Ellis, E. C., Ruddiman, W. F., Lemmen, C., Goldewijk, K. K. (2011). Holocene carbon emissions as a result of anthropogenic land cover change. *Holocene*, 21(5).

Thomson, D. J. (1990). Time series analysis of Holocene climate data. *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences*, 330(1615), 601-616. ISO 690

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