Dear Editor,

Thank you very much for giving us the opportunity to respond to the reviewers' remarks, suggestions, etc. We are very grateful for all their opinions and suggestions, which were usually very helpful and constructive. All passages where changes in the article have been made are also placed in the text below.

All changes in the text are marked in red fonts. For clarity the reviewers' texts are in black and our answers are in blue. Corrected attached passages are shown in italic.

We would kindly like to inform you that the following alterations have been made to the text regarding the reviewers' comments, suggestions and opinions:

Anonymous Referee #1

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Dear authors, I highly appreciate the approach of combining and complementing available tree-ring width chronologies, written documentary accounts and instrumental data to investigate droughts, i.e. their occurrence, frequency and intensity, in Poland back to ca. 900 CE. An amazing 200 documented drought accounts for the period 1451–1800 were collected and categorized into three classes of severity. In addition, 22 tree-ring width chronologies were used to detect years of extreme low annual growth, so-called negative pointer years, which were attributed to drought events. The extension into the industrial period was done using the Standardized Precipitation Index (SPI) with different seasonal lengths and which was calculated on eight long precipitation records.

Overall, the comprehensive analysis of drought events and duration using existing proxy data is needed, especially under current climate change. However, the amount of statistical approaches applied make the study partly difficult to understand. Moreover, there are several shortcomings in the manuscript regarding the structure and content. Substantial improvements should be made prior to publication and I strongly recommend that the English be revised by a professional service or a native Englishspeaking scientist working in the field.

The entire text was corrected by a native speaker.

General comments

- The title is not reflecting the study very well, maybe include that a multi-proxy approach was used or highlight the main result, for example.

Answer: was changed according to the reviewer's suggestion.

Final title: *Droughts in the area of Poland in recent centuries in the light of multi-proxy data*

- The abstract needs shortening and a clear structure by including a motivation of the study which is followed by data, methods, results and conclusion/significance of the study. The abstract should not be too long and should not include references.

Answer: was shortened and all remarks of the Reviewer were taken into account

Final text of Abstract: *The history of drought occurrence in Poland in the last millennium is poorly known. To improve this knowledge we have conducted a comprehensive analysis using both proxy data (documentary and* *dendrochronological) and instrumental measurements of precipitation. The paper presents the main features of droughts in Poland in recent centuries, including their frequency of occurrence, coverage, duration and intensity. The reconstructions of droughts based on all the mentioned sources of data covered the period 996–2015. Examples of megadroughts were also chosen using documentary evidence, and some of them were described.*

Various documentary sources have been used to identify droughts in the area of Poland in period 1451–1800 and to estimate their intensity, spatial coverage and duration. Twenty-two local chronologies of trees (pine, oak, and fir) from Poland were taken into account for detecting negative pointer years (exceptionally narrow rings). The longest chronology covers the years 996–1986 and was constructed for eastern Pomerania. The delimitation of droughts based on instrumental data (eight long-term precipitation series) was conducted using two independent approaches (Standard Precipitation Index (SPI) calculated for 1-, 3-, and 24-month time scales, and new method proposed by authors). For delimitation of droughts (dry months), the criteria used were those proposed by McKee and modified for the climate conditions of Poland by Łabędzki.

More than one hundred droughts were found in documentary sources in the period 1451–1800, including 17 megadroughts. A greater-than-average number of droughts was observed in the second halves of the 17th century, and of the 18th century in particular. Dendrochronological data confirmed this general tendency in the mentioned period. The clearly greatest number of negative pointer years occurred in the 18th century and then in the period 1451–1500. In the period 996–2015, a total of 758 negative pointer years were recorded.

Analysis of SPI (including its lowest values, i.e. droughts) showed that the long-term frequency of droughts in Poland has been stable in the last two or three centuries. Extreme and severe droughts were most frequent in the coastal part of Poland and in Silesia. Most droughts had a duration of two months (about 60–70%), or 3–4 months (10–20%). Frequencies of droughts with a duration of 5 and more months were lower than 10%. The longest droughts had a duration of 7–8 months. The frequency of droughts of all categories in Poland in the instrumental period 1722–2015 was greatest in winter, while the documentary evidence (1451–1800) rarely mentions droughts in this season. The occurrence of negative pointer years (a good proxy for droughts) was compared with droughts delimited based on documentary and instrumental data. A good correspondence was found between the timing of occurrence of droughts identified using all three kinds of data (sources).

- The introduction needs improvement by 1) removing unnecessary information e.g. reduce p.3, l. 17-20, 2) write in a more precise way e.g. p.2, l.10. “statistical analyses” of what?,

Answer: The Introduction part was corrected and the present version is as below:

The increase in rate ~~in degree~~ of global warming that has been observed in recent decades also influences characteristic changes in the occurrence and intensity of precipitation (IPCC, 2013). Although precipitation totals are slightly greater from year to year in some regions, frequency of precipitation is getting lower, while its intensity is increasing. As a result, breaks between precipitation episodes are getting longer and longer, which significantly favours the occurrence of droughts. The majority of statistical analyses presenting results of frequency and intensity of droughts ~~conducted~~ averaged for the entire world (Dai and Trenberth, 1998; Dai et al., 2004; Dai, 2011a, b, 2013; IPCC, 2013) and its different regions (see, e.g., Held et al., 2005; Alexander et al., 2006; Bartholy and Pongracz, 2007; Łabędzki, 2007; Brázdil et al., 2009; Seneviratne et al., 2012; NAS, 2013; Miles et al., 2015; Osuch et al., 2016; Bąk and Kubiak-Wójcicka, 2017; Brázdil et al. 2018) usually confirm their rising tendencies, in particular in more ~~frequency and intensity of droughts~~ recent decades. On the other hand, ~~However,~~ some authors document that this change for the entire globe is not as ~~big~~ clear as is presented in some of the~~the~~ abovementioned publications and depends among others on the drought metrics used (Sheffield et al., 2012; Greve et al., 2014 and references therein). For example, Sheffield et al. (2012) ~~They~~ argue that overestimation of the rate of change of global droughts is related to the shortcomings (simplifications) of the Palmer Drought Severity Index (PDSI) used for this purpose.

~~Sheffield et al., 2012~~ They write: "The simplicity of the PDSI, which is calculated from a simple water-balance model forced by monthly precipitation and temperature data, makes it an attractive tool in large-scale drought assessments, but may give biased results in the context of climate change." Thus, the reliable estimate of global tendencies in the occurrence and intensity of droughts still needs more research. Nevertheless, a greater or lesser increase in frequency of droughts in many regions ~~global scale~~ has been observed in recent decades. Moreover, climatic models project that this tendency will probably be more common and clear in the future world. ~~also be seen in the entire 21st century.~~ The IPCC (2013) report concludes ~~It is very likely~~ that droughts will be not only more frequent, but also more intense in many regions, but particularly in areas with dry conditions in today's climate ~~(IPCC, 2013)~~. For this reason, the study of drought occurrence and its intensity is very important, in particular when its manifold negative socio-economic consequences are taken into account. Many aspects dealing with drought (definition; kinds – meteorological, agricultural, hydrological, socio-economic; quantitative ways of measurement; socio-economic consequences; etc.) were described recently in many publications (e.g. Wilhite and Glantz, 1985; Tate and Gustard, 2000; Herweijer et al., 2007; Mishra and Singh, 2010; Dai 2011a; Brázdil et al., 2013, 2018; IPCC, 2014; Fragoso et al., 2018; White et al., 2018) and therefore a brief overview is omitted here.

To estimate how unprecedented is the scale of climate drying in recent decades, a longer perspective is needed. Therefore, in recent decades quite a lot of drought reconstructions encompassing almost the entire millennium, or the shorter historical, pre-industrial period, were constructed for different greater or smaller regions (e.g. Inglot, 1968; Piervitali and Colacino, 2001; Cook et al., 2004, 2010, 2015; Herweijer et al., 2007; Pfister et al., 2006; Brewer et al., 2007; Domínguez-Castro et al., 2008, 2010; Woodhouse et al., 2010; Brázdil et al., 2013, 2016, 2018 (see references herein); Dobrovolný et al., 2015; Fragoso et al., 2018; Hanel et al., 2018).

What is the state of knowledge about droughts occurrence and intensity in Poland – the area that is the object of our studies in the paper? It must be said that for the instrumental period, and in particular for the period after World War II, the knowledge is good. Papers have been published analysing: 1) classification of drought types and the development of drought indices (Bąk and Łabędzki, 2002; Łabędzki, 2007; Łabędzki and Kanecka-Geszke, 2009; Tokarczyk, 2013; Łabędzki and Bąk, 2014); 2) tendencies in drought occurrence and intensity (Farat et al., 1998; Magier et al., 2000; Łabędzki, 2007; Kalbarczyk, 2010; Bartczak et al., 2014; Radzka, 2015; Wypych et al., 2015; Bąk and Kubiak-Wójcicka, 2017); 3) monitoring of drought conditions (Łabędzki, 2006; Doroszewski et al., 2008, 2012; Tokarczyk and Szalińska, 2013; IMGW, 2014; ITP, 2014; Łabędzki and Bąk, 2014); and 4) drought hazard assessment for periods when observations are available (Łabędzki, 2009; Tokarczyk and Szalińska, 2014). In recent years the influence of future climate change on the occurrence of droughts in Poland in the 21st century has also been addressed (Liszewska et al., 2012; Osuch et al., 2012, 2016). On the other hand, little is known about drought occurrence in the pre-instrumental and early instrumental periods in Poland. Generally, only one attempt ~~team of researchers under the direction of professor~~

~~Stefan Inglot of Wrocław University was focusing on this issue, in the 1960s. As a result, a first attempted chronology~~ at a chronology of droughts for the 16th to mid-19th century was proposed based on documentary evidence (Inglot, 1968).

Drought is the one of the most stressful factors for trees (Vitas, 2001; Allen et al., 2010; Sohar et al., 2013). The measurement of tree ring widths is one of the ways to study the effect of climate parameters on trees (Zielski et al., 2010). Some factors such as frost or summer drought may have an immediate effect on ring width, whereas other factors, such as winter drought, may have a delayed effect on ring widths. This delayed effect occurs because the meristematic tissues are dormant during the winter months in temperate and cold climates. The effect of different factors is seen as variations in ring size and structure, which change systematically, or vary slowly throughout the life of the tree (Fritts, 1976). The effect of drought on tree rings is observed as narrow rings (Koprowski et al., 2012; Opała, 2015). The relationships are significant enough to reconstruct drought in temperate climate also in cold regions like Finland (Helama and Lindholm, 2003), Sweden (Seftigen et al., 2013) and Czech Republic (Dobrovolný et al., 2015). Therefore, we have assumed that information derived from tree rings can complement the existing knowledge about past droughts in Poland. According to studies by Somorowska (2016), the effect of drought extends from the south-west towards the centre of the country and, in some cases, to the north-east of Poland. Another study suggest that in the future some of the highest probabilities of drought occurrence may be in the central part, with the lowest probability in south-eastern Poland (Diakowska et al., 2018).

Although in the last three decades many climate reconstructions for the last millennium have been conducted for Poland (see Przybylak et al., 2005 or Przybylak, 2016 for a review), droughts were not analysed. Therefore, to fill this important gap we decided to investigate them in a more detailed manner than was done by Inglot's team. Moreover, for this purpose we used more sorts of proxy data (not only documentary but also dendrochronological). The reconstructions of droughts based on all the mentioned sources of data covered the period 996–2015. Thus, the main aim of the paper is to present the main features of drought occurrence, duration and intensity in the area of Poland in this period. Section 2 describes all the kinds of data used and their quality. Section 3 addresses the methods used in this study, including drought indices. Section 4 presents the results of three reconstructions of droughts derived from 1) documentary, 2) instrumental, and 3) dendrochronological data. Examples of megadroughts are also analysed here. The results obtained are discussed in Section 5, and main conclusions in the last section.

and 3) provide more information e.g. p.3, l.21. in which areas is drought the most stressful factor – to only provide a few examples.

Answer: We updated the text with information about areas with the most frequent occurrence of drought in Poland. The following passage was added:

According to studies by Somorowska (2016) the effect of drought extends from the south-west towards the centre of the country and, in some cases, to the north-east of Poland. Another study suggest that in the future some of the highest probabilities of drought occurrence may be in the central part, with the lowest probability in south-eastern Poland (Diakowska et al., 2018).

Also, I was wondering why the authors cite four lines of a publication on l. 18-21? This can be summarized.

Answer: Sorry, but in the mentioned lines there is no citing of publications in any of page in the entire manuscript? It must be a mistake?

- Structure of the Data and Methods chapters needs improvement. A straightforward description of the documentary data is missing. After reading the chapter 2.1, it is not entirely clear what data from whom were used. Maybe start with the summarizing paragraph (p.5, l. 30 – p.6., l.18) and add some (and only) important information from the paragraphs before.

Answer: It seems to us that it is precisely written in the text from which historical sources weather excerpts were taken. The structure of the chapter 2.1 is typical from the historical point of view and therefore we have decided to leave the chapter as it is. At the beginning the published sources are described, divided into different types, and then the archival sources (not published). At the end of the chapter a short summing-up is given. It is rather difficult and in our opinion not appropriate to summarize this not-too-long chapter.

For the dendrochronological data, no information about the quality of the individual tree-ring width chronologies is provided. Information of the number of samples, inter-series correlation, mean segment lengths can be easily added in Table. 1. Information on the sample replication in a tree-ring width chronology is essential to evaluate drought events that were detected during a low replicated time period.

Answer: Table 1 was updated. We provided the information about number of samples, EPS and rbar.tot. In the case of Site 12 the EPS is extremely low; however, the chronologies were not used for climate reconstruction but for detecting negative pointer years. Pointer years confirmed the information from historical sources and show that drought can also affect the trees. It is also worthwhile to note after Buras (2017) that *"EPS is a measure of how well a finite sample of tree-ring data represents an infinite population chronology, but it will not necessarily indicate whether a tree-ring chronology is suitable for climate reconstruction purposes."*

Table 1

Site number	Site name	Time span	Number of samples	EPS	rbar.tot	Species	Source
Region I (Baltic Province)							
Site 1	Koszalin	1782–1987	22	0.899	0.339	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 2	Gdańsk	1762–1986	45	0.887	0.192	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 3	Wolin	1554–1987	23	0.877	0.318	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)

Site 4	Gdańsk	1175–1396	13	0.579	0.388	Oak	Dąbrowski HP, unpublished
Site 5	western Pomerania	996–1986	205	0.907	0.250	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Region II (Masuria-Podlasie Province)							
Site 6	Gołdap	1871–1987	22	0.941	0.472	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 7	Suwałki	1861–1987	19	0.872	0.303	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 8	Hajnówka	1720–1985	19	0.851	0.314	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Region III (Greater Poland-Pomerania Province)							
Site 9	Poznań	1836–1987	17	0.904	0.385	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 10	Zielona Góra	1774–1987	19	0.876	0.330	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 11	Toruń	1714–2015	48	0.886	0.335	Oak	Puchałka et al., 2016 (updated)
Site 12	Tuchola	1249–1490	7	0.054	0.347	Pine	Dąbrowski HP, unpublished
Site 13	Kuyavia-Pomerania	1169–2015	247	0.816	0.195	Pine	Koprowski et al., 2012
Site 14	Chojnice	1100–1468	21	0.688	0.327	Oak	Dąbrowski HP, unpublished
Region IV (Masovia-Podlasie Province)							
Site 15	Warszawa	1690–1985	19	0.850	0.291	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Region V (Silesia Province)							
Site 16	Upper Silesia	1770–2010	80	0.880 (average)	correlation 0.530	Pine and oak	Opała and Mendecki, 2014
Site 17	Wrocław	1727–1987	22	0.870	0.327	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 18	Upper Silesia	1568–2010	178	0.850	correlation 0.510	Pine	Opała, 2015
Region VI (Lesser Poland Province)							
Site 19	Kraków	1792–1986	29	0.906	0.361	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 20	Kosobudy	1782–1989	22	0.937	0.448	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 21	Lesser Poland	1109–2004	238	No data	No data	Pine	Szychowska-Krąpiec, 2010
Site 22	Lesser Poland	1109–2006	560	No data	No data	Fir	Szychowska-Krąpiec, 2010

For the Method chapter, the examples of the individual drought classes in chapter 3.1 are quite long. Please, consider reduction to only 2 to 3 examples and place the remaining examples in the supplementary material.

Answer: the examples of the individual drought classes in chapter 3.1 were significantly reduced according to the reviewer’s suggestion, see tables 3–5 below:

Table 3

Year	Description	Translation	Source

~~1463~~	~~[...] *fuit magnus calor et arditas, ita quod sylvae, nemora et montana incenderentur, ex voragine ignis pro magna parte absumptae*~~	~~[...] there were such great heat and drought that forests, groves and mountain vegetation burned, and were largely destroyed by the fire~~	~~Rocznik wrocławski dawny, MPH, vol. 3, p. 686~~
1473	[...] *caumata et penuriam aquarum, adeo ut perennes aquae verterentur in aridam, et flumina Poloniae principalia ubique fuerunt permeabilia, insignis.* [...] *Fumabant in universis Poloniae regionibus silvae, borrae, arbusta, saltus, irremediabili igne, nec ante rescindi flamma poterat, donec ignis etiam radicem arborum voraret, ex quo ubique fragor ruentium saltuum audiebatur. Apum quoque et alveariorum arbores plurimae deletae, segetes vernales exterminatae siccitate.*	[...] hot weather and a lack of water, to such an extent that the places where there had always been water dried up everywhere, and the main Polish rivers could be crossed everywhere. [...] Forests, woods, thickets and forested hills burnt with fire; there was no way to put it out, and it was impossible to extinguish the flame before the fire even devoured the root of the trees; from here you could hear the clatter of collapsing thickets. Very numerous bee and beekeeping trees were destroyed, and many spring crops were destroyed due to drought.	Długosz, vol. 12, p. 336
1540	[...] *fuit in aestate horrenda siccitas adeo, ut silices, montes et valles quasi igne flagrarent, duravit haec siccitas usque ad hyemem.*	[...] in the summer there was such a terrible drought that the rocks, mountains and valleys were burned down with fire; this drought lasted until winter	Archivum vetus et novum ecclesiae archipresbyteralis Heilsbergensis, in: MHW, vol. 8, p. 597

~~1561~~	~~*Im Julio und Augusto war es sehr dürre und dürre Winde, dass das Wasser sehr austrocknete. Die Oder war klein, dass es keinem Mann gedachte. Viel Brunnen trockneten aus.*~~	~~In July and August there were dry and very dry winds, so that the water completely dried out. The Odra became shallow as it had never been before. Many wells dried up.~~	~~Pol, vol. 4, p. 17~~
~~1575~~	~~*At in Polonia inaudita fere siccitas vere, aestate, autumno et hyeme denique aestivalium segetum, quas arefecerat, penuriam fecit, amnium vero undas adeo minuit, ut iis passim fere privaretur ipsaque Vistula infra Dobrinum multis locis vadabilis fieret, unde nec sal e Russia per Sanum in Vistulam permeari potuit.*~~	~~However, in Poland, a truly unbelievable drought, in summer, autumn and winter, along with spring crops that had dried up, caused poverty[;] the level of the water in rivers had fallen so much that everywhere the rivers almost disappeared, while the Wisła Vistula in many areas below Dobrzyń became quite shallow, and it was not possible to transport any salt from Ruthenia through the San to the Wisła Vistula.~~	~~Orzelski, in: SRP, vol. 22, p. 360~~
1590	*Ist ein sehr heisser truckener Sommer gewesen, also, dass auch die Landflüsse, als der Bober, Queiss, Katzbach, Weida, Olau, Lohe, und andere mehr gänzlich ausgetrucknet. Die Oder ist auch so klein worden, dass man sie an allen Orten durchwatten können.*	The summer was so hot [and] dry that ~~national~~ regional rivers like the Bóbr, the Kwisa, the Kaczawa, the Widawa, the Oława, the Ślęża [Silesia, auth. suppl.] and many others dried up completely. The Odra also became very shallow, so you could cross it anywhere.	Pol, vol. 4, p. 156

	38 Wochen regnete es nicht. Die Flüsse trockneten aus. *Zacken und andere Flüsse trockneten völlig aus* *Der Bober trocknete infolge starker Hitze ganz aus.*	It did not rain for 38 weeks. The rivers dried up. The Kamienna and other rivers dried up completely. The Bóbr dried up completely due to severe drought.	Reinhold, 1846, p. 143 Bergemann, J.G., 1830a, p. 84 Bergemann, J.G. 1830b, vol. 3, p. 85
~~1653~~	~~*In Monath Maii fiel ein dürres Wetter ein, und dauerte biss Ende August. Die alle Bäche vertrockneten, auch Flachs und Gerste verdorrete.*~~	~~In the month of May the dry weather began and lasted until the end of August. All streams dried up, as did flax and barley.~~	~~Gomolcke, p. 53~~
~~1676~~	~~*Tego roku straszne Panowały Susze, że zboża wypalało w polach.*~~	~~That year a terrible drought took place so that crops burnt in the fields.~~	~~Muz. Nar. w Krakowie rps. MNKr. 169, p. 82~~
~~1683~~	~~*Im Jahre 1683 entstand durch die grosse Dürre und den Misswachs eine starke Theuerung und ein fast gäntzlicher Mangel an Getreyde.*~~	~~In 1683, due to the great drought and poor growth [of grain], high prices and almost complete lack of grain prevailed.~~	~~Pisański, Beschreibung der Stadt Johannisburg, p. 96~~
~~1684~~	~~*[...] folgete auf Johanni [24.06.] eine grosse anhaltende Hitze darauf; davon das Erdreich dermassen dürre wurde, dass das Sommer-Getreyde, Flachs, und Grass, gantz zurücke geblieben, das Winter-Korn an vielen Orten überreiffte, ehe es sich gehöriger massen in die*~~	~~The great long-lasting drought arrived on the St. John's Day [24.06.]; the ground became dry, the crops became dry; flax and barley grew very poorly before the proper ear of grain had come out, which caused very high prices […]~~	~~Gomolcke, p. 54~~

	~~*Ahren kaum angesetzet, dahero Theurung entstanden [...]*~~		

Table 4

Year	Description	Translation	Source
1456	*Fuitque anno eodem precipue circa partes nostras, ubi plures sunt agri sabulosi et argillosi, post festa paschalia siccitas magna et usque ad messem continuata. Messis autem tante humiditatis et instabilitatis,*	And that year there was an exceptionally great drought in our area, where there are numerous sandy and loamy soils; it occurred after the Easter holidays and lasted until the harvest. In the harvest period it [the weather] was so wet and unstable [...]	Catalogus abbatum Saganensium, in: Scriptores rerum Silesiacarum, vol. I, p. 340
~~1472~~	~~*Dieser Sommer, von Pfingsten bis auf aller Heiligen, war ganz trocken und warm [...]*~~	~~That summer from Whitsunday to the All Saints Day it was quite dry and warm [...]~~	~~Pol, vol. 2, p. 89~~
1532	*Ein dürrer Sommer. Es regnete in sieben Wochen nicht. Das Getreide und die Weide verdorrete auf den Hügeln ganz aus. In etlichen Dörfern war kein gar Wasser. Auf dem Lande konnte man nicht mahlen. Zu 10. 12. 18. Meilen musste man zur Mühle führen. Die Olau trocknete und dorrete auch aus, und hatte kein Wasser bis auf Bartholomei [24.08].*	Dry summer. It did not rain for seven weeks. The grain and grass on the hillsides dried up. In some places there was almost no water. In the countryside, it was impossible to grind grain. One needed to go 10, 12, 18 miles to reach mills. The Oława River dried up [Silesia, auth. suppl.] and there was no water in it until the Saint Bartholomew's Day [August 24].	Pol, vol. 3, p. 72

~~1585~~	~~*Mensis hic [March] fuit serenissimus usque ad miraculum et siccus*~~	~~That month [March] the weather was fine and it was dry~~	~~Reszka, p. 91~~
~~1637~~	~~*Przy przeważającej w tym miesiącu suszy ogień zniszczył liczne miasta i wsie, widać słabnące plony* [...]~~	~~With the drought that prevailed that month, fire destroyed many cities and villages, we could see the yields failing [...].~~	~~Radziwiłł Albrycht Stanisław, Pamiętnik o dziejach w Polsce, vol. 2 1637–1646, A. Przyboś, R. Żelewski (eds), Warszawa, 1980~~
1665	*Der Sommer des Jahres 1665 wird als ungemein heiss angegehen, und soll es die ganzen Hundstage [10.07.–20.08.] hindurch auch nicht einmal geregnet haben.*	The summer of 1665 was incredibly hot; not even once did it rain – so called "Dog Days".	Wernicke, Gesch. Thorns., vol. 2, p. 321

Table 5

Year	Description	Translation	Source
1461	*Eodem anno fuit estas calidissima et fluvius Odere valde modicus, similiter et alii fluvii.*	That year the summer was the hottest and the water level of the Odra River fell, as did other rivers.	Sigismundi Rosiczii chronica, p. 78.
~~1531~~	~~*Nazajutrz po bitwie pod Obertynem [22.08.] kometa nie dała się iuż tak świetnie widzieć iako przesłey nocy: która ieśli nie porażkę*~~	~~The following day, after the battle of Obertyn [22.08.], the comet did not let itself be seen so well as it had the previous night, which augured~~	~~Bielski, p. 311~~

	~~*Wołoską, tedy suszą podobno znamieniowała; iakoż tego czasu była susza wielka.*~~	~~the defeat of the Vlachs, or drought; And then the drought was really great.~~	
1552	*Den 5 Junii* [...] *nach der Vesper und grosser Dürre kam ein gewünschter Regen, aber mit grossem Wetter*	On June 5 [...] after the evening and after a great drought, came the desired rain with a great storm.	Pol, vol. 3, p. 158.
1661	*Es folgte aber ein dürrer Sommer.*	However, a dry summer came.	Happelius, p. 148.

On page 19, chapter “2.3 Instrumental data” needs to be moved into “2. Data chapter”.

Answer: No. This is just an error. The numbering of the subchapter should be 3.3 and not 2.3 as it is in the original version. We corrected the numbering.

Instead there should be a clearly written paragraph about the detection of the climategrowth relationships of all tree-ring width chronologies, for which period and for what climate variables. Why not use the SPI data for the analysis of the climate response of the trees which would simplify the entire study a lot and at the same time, prove your hypotheses (p.18, l.9)?

Answer: SPI was not taken into account because this parameter results directly from precipitation data.

- Description of the methods lacks detailed and important information. For example, on p. 18, l. 14 “climate monthly precipitation and temperature” were used to evaluate the climate growth relationship. However, only results for precipitation are shown in Fig. 2 and information of the period over which the correlation was done is missing.

Answer: additional information were added in the new Table 6. The information about temperature was also updated (see text below and Table 6).

For each site the climate growth relationships were tested against monthly precipitation and temperature data starting from 1951 and covers maximum time span depending on the length of the chronology (Table 6). Because the time span was too short (for example for Site 2 when chronology covers the years 1951-1986) for some extended analysis going back to previous months, the common period from previous October to current September was taken into account.

Table 6. Climate growth relationships for analysed sites. Only the highest correlation coefficients are presented – with level of significance $p < 0.05$.

Site number	Site name	Analysed period	Highest Pearson correlation coefficient	Months with highest correlation coefficient	Meteorological station	Species	Source
Region I (Baltic Province)							
Site 1	Koszalin	1951–1987	0.378	Sum of precipitation from May to June	Koszalin	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 2	Gdańsk	1951–1986	0.296 (not significant)	Sum of precipitation from June to July	Gdańsk	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 3	Wolin	1951–1987	0.565	Sum of precipitation from June to August	Świnoujście	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 4	Gdańsk	1175–1396	No climate data	No climate data	No climate data	Oak	Dąbrowski HP, unpublished
Site 5	western Pomerania	1951–1986	0.456	Sum of precipitation from June to July	Koszalin	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Region II (Masuria-Podlasie Province)							
Site 6	Gołdap	1951–1987	0.589	Temperature current May	Suwałki	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 7	Suwałki	1951–1987	0.50	Sum of precipitation from June to July	Suwałki	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 8	Hajnówka	1951–1985	0.285	Sum of precipitation from July to August	Białystok	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Region III (Greater Poland-Pomerania Province)							
Site 9	Poznań	1951–1987	0.485	Sum of precipitation from May to July	Poznan	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 10	Zielona Góra	1951–1987	-0.322	Temperature, previous December	Gorzów Wielkopolski	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 11	Toruń	1951–2015	0.334 -0.334	Sum of precipitation from May to June, temperature in June	Toruń	Oak	Puchałka et al., 2016 (updated)
Site 12	Tuchola	1249–1490	No climate data	No climate data	No climate data	Pine	Dąbrowski HP, unpublished
Site 13	Kuyavia-Pomerania	1951–2015	0.443	Sum of precipitation from May to July	Toruń	Pine	Koprowski et al., 2012
Site 14	Chojnice	1100–1468	No climate data	No climate data	No climate data	Oak	Dąbrowski HP, unpublished
Region IV (Masovia-Podlasie Province)							

Site 15	Warszawa	1951–1985	-0.316	Temperature, previous December	Warszawa	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Region V (Silesia Province)							
Site 16	Upper Silesia	1886–1984	>0.4 Precipitation data not presented due to lower statistical significance	Temperature of February and March for pine	Opole, Wrocław, Katowice and Racibórz	Pine and oak	Opała and Mendecki, 2014
Site 17	Wrocław	1951–1987	0.376	Sum of precipitation from May to June,	Wrocław	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 18	Upper Silesia	1568–2010	Only pointer years were analysed			Pine	Opała, 2015
Region VI (Lesser Poland Province)							
Site 19	Kraków	1915–1986	0.324 (not significant)	Temperature in February	Kraków	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 20	Kosobudy	1951–1989	0.314 -0.323	Sum of precipitation from May to July, temperature in June	Lublin and Radawiec	Oak	https://www.ncdc.noaa.gov/ (Ważny, 1990)
Site 21	Lesser Poland	1881-1999	>0.4	Temperature in March	Kraków	Pine	Szychowska-Krąpiec, 2010
Site 22	Lesser Poland	1881-1999	>0.4	Temperature in February	Kraków	Fir	Szychowska-Krąpiec, 2010

- Methodology for the evaluation of the climate-growth relationship is not sufficient. Firstly, it is not clear if the age trend from the individual tree-ring width series is removed and what method was applied. Secondly, it is questionable if daily precipitation data need to be used given 1) that this led the authors to a generalization which might be not true (p.19, l.4) and 2) the description and mention of the droughts in the documentary data are not on daily resolution either. Moreover, I would like to see a comprehensive climate-growth analysis of all tree-ring width chronologies with information of species, Pearson correlation coefficients, period of correlation etc., at least in a Table. This is very important since a publication by Przybylak et al. 2005 used a tree-ring width chronology from pine (Pinus sylvestris) to reconstruct mean January – April air temperature for Poland.

Answer: we added the passage describing detrending methods used by us, see text below

De-trending of the chronology was done with the dplR software (Bunn 2008) using the smoothing spline option, which reflects trends in the chronology better than other options. The ‘‘n-year spline’’ was fixed at two thirds the wavelength of n years (Cook et al. 1990). The residual version of the chronology was built by pre-whitening, performed by fitting an autoregressive model to the data with AIC model selection (Bunn 2008).

Daily data shows more precisely the period of the year which influences tree growth. We used this analysis to prove assumptions about the effect of drought on trees creating narrow rings. For the rest of the comments please see the text below and Table 6.

For each site the climate growth relationships were tested against monthly precipitation and temperature data starting from 1951 and covers maximum time span depending on the length of the chronology (Table 6). Because the time span was too short (for example for Site 2 when chronology covers the years 1951-1986) for some extended analysis going back to previous months, the common period from previous October to current September was taken into account.

- Please avoid repetitions, e.g., on p.19, l.7-11: the two sentences are the same.

Answer: Repeated parts were deleted

- P.19, l.11-16: please rephrase and clarify this entire paragraph since it is not clear what was done and why.

Answer: Paragraph was updated to the following version:

The optimal window of days was revealed to be from May 6 to August 3 for pine with maximal correlation coefficient 0.435, and from April 21 to July 19 for oak with maximal correlation coefficient 0.305.

Anonymous Referee #2

Received and published: 11 July 2019

This article contains a useful review, and assessment, of the occurrence and severity of drought in Poland during the past five centuries using both instrumental data (from the 18th century), historical documentary data and tree-ring width data. As past drought, or hydroclimate in general, in Poland is an under-researched topic, the manuscript is clearly worth publication after revision. The manuscript is in need of some polishing and English language editing but can otherwise, in my opinion, be published.

The entire text was corrected by a native speaker.

That said, I would still recommend the authors to consider a few things:

1) Streamline part of the text, including the Abstract and the Introduction, as especially the Abstract is too long and too detailed.

Answer: was corrected, the first Reviewer also gave the same remarks. For text see reply to the first Reviewer.

Moreover, part of the Introduction does not really well capture the state-of-the-art knowledge of hydroclimatic changes with global warming and the selection of references in the introduction is a bit biased.

Answer: We have introduced some changes to the *Introduction* Section according to the Reviewer's suggestion (for details, please see the text in the reply to the first Reviewer). We hope that now the Introduction presents the real state and is not biased.

2) The translation of narrow tree-rings to dry years/growing seasons are a bit problematic as the response between tree-growth and hydroclimate is non-linear, and not stable over time, and low temperatures may also produce narrow rings. My concern here is mainly that some of the narrow rings during the

climax of the Little Ice Age c. 1570–1710, as well as during some other shorter time intervals, may in some cases be a result of very cold springs and summers. The authors could probably systematically compare the narrow rings with climate information in the documentary sources to rule this possibility out. It is a bit unclear in the present version of the manuscript if this has been done or not. Regarding the non-linear relationship between tree growth and climate, see the discussion and references given in: https://iopscience.iop.org/article/10.1088/1748-9326/ab2c7e

Answer: We are aware of these limitations. Pointer years confirmed the information from historical sources and show that drought can also affect the trees.

3) I would recommend the authors to better include, and cite, the recent scholarship in historical climatology. A good starting point, with ample references, could be the articles in The Palgrave Handbook of Climate History, ed. S White et al (London: Palgrave Macmillan).

Answer: Thank you for this recommendation. According to the Reviewer's suggestion the mentioned publication, which is important for general knowledge about drought occurrence in the world and their environmental and societal consequences, was cited. There is a myriad of publications dealing with the issue of droughts, thus the authors tried to cite the most important of them. To our knowledge the most important publication items dealing with the history of drought occurrence in Poland and central Europe in the last millennium are included in the paper.

Minor comments:

Page 2 (in general): The evidence for increasing droughts in recent decades is weaker, and more controversial, than evident from what the authors write. To a large extent, the results are dependent on which drought metrics is used.

Answer: The remarks of the reviewer were taken into account, the text has been changed and we hope that we have fulfilled the reviewer's expectation, see the Introduction chapter in the reply to the first Reviewer.

It is also questionable, except in some particular regions, if there is any empirical evidence for longer breaks between episodes of precipitation.

Answer: But we wrote (see lines 5-8) that this statement concerns only "... some regions".

The present reviewer has in the past six years worked considerably with hydroclimate and not found support for this in the literature.

Answer: we added one more reference showing the small changes in drought occurrence and the sentence that the issue still needs more research. See again the Introduction chapter in the reply to the first Reviewer.

Page 2, line 5: "The increase in degree of" is a strange formulation here.

Answer: was corrected to: The increase in rate ~~in degree~~ of global warming.

Page 2, line 16: Cite also: Greve P et al 2014 Global assessment of trends in wetting and drying over land Nat. Geosci. 7 716–21

Answer: citation was added.

Page 3, lines 30–33: I guess the authors provide these examples to show that hydroclimate reconstructions also can be obtained for rather cold regions of Europe? It should be made clearer here.

Answer: The text was changed to: *Also in other countries lying near Poland, such as Finland (Helama and Lindholm, 2003), Sweden (Seftigen et al., 2013) and Czech Republic (Dobrovolný et al., 2015) the relationships are significant enough to reconstruct drought.*

Page 12, lines 12–14: It should be better pointed out that some statements about rivers that had dried out certain summers likely are not reliable or that they, at least, are overstatements.

Answer: It seems to us that the information that the reviewer suggest to include in this passage is, in reality, present in the original text, see text below:

Sometimes, and probably in an exaggerated way, sources reported the drying up of smaller rivers.

For this reason, this kind of information was treated by us very carefully.

Section 2.2 and section 3.2: This must be placed in a better dendro research context. In particular, the non-linear relationships between temperature and hydroclimate and tree-growth need to be discussed. I also note that the correlation between the tree-ring records and precipitation is very weak. It is far weaker than in tree-ring chronologies explicitly developed for reconstructing hydroclimate. I think it is important, and fair to the reader, to point out that many of the included tree-ring chronologies have not be developed with that purpose explicitly in mind.

Answer: After the taking into account only narrow rings and precipitation in selected period from daily data the correlation coefficient is 0.79 ($p<0.05$) for pine, and 0.65 ($p<0.05$) for oak.

Page 23, lines 7–10: This part can be shortened as it is not very clear what is meant with that drought has not been "very frequent".

Answer: the passage was shortened according to the Reviewer's suggestion, see below the present version:

Records on drought for historical reconstruction of climate can be found in many different historical sources from Poland. Their number has significantly increased since the mid-15th century, which is why the mid-15th century was adopted as the initial chronological boundary for the reconstruction of the number and intensity of droughts in the Polish territory using documentary evidence.

Page 25, lines 15–16: This is an interesting and potentially important part. Could it also be that there were fewer droughts in the first half of the 17th century in Poland because it also was the coldest part of the Little Ice Age with less evapotranspiration due to lower temperatures?

Answer: According to the reconstruction made by Przybylak et al. (2005) this period had the same winter and summer temperatures as the neighbouring historical periods. Therefore we rather prefer to leave the text as it is.

Page 26, line 31: Very strange formulation. Please, consider revision.

Answer: Text was changed to: *More chronologies in the last 300 years result from existing living trees.*

Section 3.2 and Fig. 7: The low number of dry pointer years in the medieval times is certainly a result of fewer records. This should be pointed out as dry years in the region actually seem to have been more frequent back in medieval times. See, most recently: Scharnweber, T., Heußner, K.-U., Smiljanic, M., Heinrich, I., van der MaatenTheunissen, M., van der Maaten, E., Struwe, T., Buras, A., Wilmking, M., 2019. Removing the no-analogue bias in modern accelerated tree growth leads to stronger medieval drought. Sci. Rep. 9, 2509. https://doi.org/10.1038/s41598-019-39040-5.

Answer: We agree with the Reviewer's opinion and therefore the following text was added:

However the small number of pointer years from 996 to 1200 may be related to the low number of samples. This period is called the "medieval climate anomaly" and reconstruction for northern-central Europe revealed considerably drier conditions for these years (Scharnweber et al., 2019).

Page 33: Try to make changes in drought trends over time clearer to the reader. As it is written now, it is a bit hard to follow this.

Answer: According to the Reviewer's suggestions some changes (see text below) were introduced to the text. We hope that now the passage is more clear for readers.

In winter, extreme droughts do not show any significant changes over time, but it should be emphasised here that they were slightly more frequent in 1951–2000 than in 1851–1900. In spring, moderate droughts prevailed still in the period 1851–1950 (usually 4–6 cases), with a greater frequency in the earlier 50-year period. Both severe and extreme droughts were most frequent (usually 1–3 cases) in both 1851–1900 and, in particular, 1951–2000 (Fig. 10). In summer, there is a clear change in the time pattern of drought occurrence: drought frequency rises in the 20th century (except severe droughts), and in the case of moderate droughts particularly in its second half. ~~The contrast in drought~~ The frequency of extreme droughts is evidently higher in ~~between~~ the 20th century compared to the pre-1900 period. ~~is very clear, primarily in the case of extreme droughts.~~ In autumn, moderate droughts do not show great changes in the last two centuries, while severe and extreme droughts were most frequent in ~~the first and second halves of~~ the 20th century~~, respectively~~ (Fig. 10).

Page 44, lines 18–21: The formulation is unclear and a bit hard to follow.

Answer: the text was rewritten and its final state is:

On the basis of the research presented in this paper, we conclude that severe and extreme droughts ~~of greater importance~~ (indexes -2, -3, respectively) were in fact slightly less frequent, while their occurrence was increasing slightly in the period from the 15th to the 18th century, as previously stated

Page 45, line 7: "T" is missing in "This".

Answer: was corrected

Page 45, line 22: Insects rather than vermin.

Answer: was corrected