Clim. Past Discuss.,
doi:10.5194/cp-2016-38-AC3, 2016

Climate of the Past Discussions

Interactive comment on "A 413-year tree-ring based April-July minimum temperature reconstruction and its implications on the extreme climate events, northeast China" *by* S. Lyu et al.

S. Lyu et al.

wangxc-cf@nefu.edu.cn

Received and published: 21 July 2016

Response to Anonymous Referee 3:

We are grateful for the anonymous reviewers' valuable comments on the MS. Those comments are all constructive and very helpful for revising and improving our paper, as well as the important guiding signiïňĄcance to our researches. We have enclosed the revised MS based on the reviewers' suggestion. The following are our responses to the reviewers:

Major concerns: 1. It is strange for me to see that radial tree-growth was only correlated to minimum temperature for the period from April to July. I would expect to test a wider

period from e.g April to August or April to September for the reconstruction.

The authors' response: Thank you for this suggestion. We provide an additional Table 1 with these analyses of various month combinations. The highest correlation ($r=0.757$, $p<0.0001$) was found between STD chronology and April-July mean minimum temperature (MMT). It is generally accepted that the sap flow of Korean pine starts from the mid- to late-April, when the activity of cambium starts. April is the early stage of the growing season for Korean pine, and the main growing season is from May to August in our study area. As climate warms in northeastern China, trees could carry out photosynthesis at the early stage of the growing season, higher minimum temperature is conducive to produce more auxin, promote photosynthesis rate and increase the nutrient accumulation. July is the rapid growth period of Pinus koraiensis, which is important for the formation of early wood. We estimate the minimum temperature in April-July (4.96 °C) by lapse rate (0.6 °C 100m-1) along the elevation, which is higher than the sap flow of Korean pine for temperature (4.5 °C) in this region. Besides, if a wider period was added, the temperature variance explained by the STD chronology will decrease sharply. Therefore, we choose a period from April to July for this reconstruction.

2. I do not understand the use of a non linear model to reconstruct the April-July MMT. What is the added-value of this model? Most of the dendroclimatological studies are based on linear models. To my knowledge logarithmic transfer function are not used for climate reconstruction. The authors should explain in detail the reasons why they chose this type of transfer function and the "biological reality" supported by this model.

The authors' response: Comment accepted. At first, both the logarithmic and linear functions are good to build the reconstruction equation, while the variance explained by the logarithmic function is better than linear function. So we choose it in the previous MS. Now, we accepted your suggestion: the transfer function is modified as follows: $Y = 2.987X_t + 4.829$.

3. The comparison between the newly developed reconstruction and other regional and hemispheric reconstructions is not sufïňĄcient and only concerns the last decades (p6, L7-23). This weakness does not allow to have a clear idea about the reliability of the new reconstruction.

The authors' response: Comment accepted. A new comparison of different temperature reconstructions was done. Correlation function coefficients were calculated between our reconstructed temperature series and other temperature reconstructions and northern hemisphere temperature reconstruction. We compared our reconstructed series with two nearby tree-ring based temperature reconstructions: one is from the Dunhua by Li and Wang (2013) and another one is from the Changbai Mountains by Zhu et al. (2009). Two nearby reconstructed temperature series were significantly positively ($r = 0.499^{**}$, $p < 0.01$; $r = 0.454^{**}$, $p < 0.01$) associated with our reconstructed temperature series, respectively. Meanwhile, a significant negative correlation ($r = -0.179^{**}$, $p < 0.01$) between our reconstruction and the northern hemisphere temperature data (D'Arrigo et al., 2006) was also found (Fig. 5).

4. The sections 3.4 and 3.5 respectively dedicated to frost disaster events and to the analysis of periodicities in the newly developed reconstruction are too weak and failed to prove (i) that trees properly recorded extreme events and (ii) to properly demonstrate the impacts of solar cycles on temperatures ïňĆuctuations in north-eastern China.

The authors' response: Comment accepted. We provide an additional Table 3 which is the comparison of extreme events between historical archives and this tree-ring reconstruction. There is a year-by-year comparison between historical archives and the tree-ring reconstruction to prove that trees appear to have recorded extreme events. In addition, in order to properly demonstrate the impacts of solar cycles on temperatures ïňĆuctuations in northeastern China, we offer a comparison between reconstructed April-July temperature series and April-July sunspot numbers as a reference (Fig. 6).

5. I would recommend a strong revision of the results and discussion section as several

statements remain insufïňĄciently demonstrated (see comments below). In addition, I would also recommend a careful revision of the language by a native speaker.

The authors' response: Comment accepted. The results and discussion section were rewritten by a native English speaker.

Minor concerns:

1. P2. L19-22. It would be very valuable for the paper, and especially for readers that are not familiar with recent tree-ring developments, to add a map with the location of the study sites as well as other available chronologies for China.

The authors' response: Comment accepted. A map and a panoramic photo was added to clearly show our study area (Fig. 2).

2. P2. L18-19. "However, tree-ring series were rarely used to reconstruct past climate (especially temperature) in this area because of the exceptional hydrothermal conditions." Could you assess the impact of hydrothermal conditions on radial growth in this region?

The authors' response: Thank you for this suggestion. This region belongs to temperate continental monsoon climate. Records from the nearest meteorological station in Dunhua, the mean annual temperature is 3.3 °C from 1956 to 2013, with July (mean temperature of 20.1 °C) and January (-16.8 °C) being the warmest and the coldest month, respectively. The mean monthly minimum and maximum temperatures are -2.5 and 9.8 °C, respectively. The mean annual total precipitation is 627 mm, the majority (63.1%) of which falls during June-August. The annual frost-free period is approximately 90-110 days. The temperature starts rising in April, and May–June is a comparatively warm and dry period in this region. Although July is the hottest month of the year, moisture limited is no longer a problem because of the ample summer monsoon rainfall. In the growing season, higher temperature can improve photosynthesis rate, accumulate nutrients, thus could be more advantages for tree to form a wider ring. We mention “the exceptional hydrothermal conditions”, it is not too cold or too warm, and is not too dry and wet. So it is not easy to find which factors (temperature or precipitation) is more important to limit tree growth here. Therefore, few climate reconstructions have done here. Our site is nearly located to the upper limit of Korean pine distribution in this Mountain. So it is sensitivity to temperature and appears usable for a temperature reconstruction.

3. P2. L20-25. In my opinion, the necessity for a new reconstruction in this area is insufïňAciently explained. Please consider rephrasing this section.

The authors’ response: Comment accepted. We rephrased this section. However, tree-ring series were rarely used to reconstruct past climate (especially temperature) in this area because of the exceptional hydrothermal conditions. Several temperature-sensitive tree-ring chronologies were developed in Changbai Mountain (e.g., Shao and Wu, 1997; Zhu et al., 2009; Wang et al., 2012; Li and Wang, 2013) and Xiaoxing’an Mountain (Yin et al., 2009; Zhu et al., 2015), but almost no results were obtained for the past 250 years and few reflect low-frequency climate variations. These issues limit our understanding for a longer time scale of climate variations. The existing temperature reconstructions are far from adequate and do not satisfy the demands of scientific research. Therefore, there is a need for more high-quality climate reconstructions that cover longer periods in this region. For this reason, more information of regional past climate variations registered in a long-term tree-ring series is needed, and it is important to understand the impacts of climate change on forest ecosystems and human production activities in northeastern China.

4. P2. "Therefore, our new temperature record not only furthers the tree-ring series in northeastern China and provides new evidence for regional impacts of past climate variability and changes". This sentence is not clear, please consider rephrasing.

The authors’ response: Comment accepted. The sentence was modified as follow: Our new minimum temperature record supplements existing data in northeastern China

and provides a new evidence of past climate variability. There is the potential to better understand future climatic trajectories in northeast China from these data.

5. P2. L25-26 “it is important to understand the longitudinal impacts of the climate change on forest ecosystems and human production activities in northeastern China.” This sentence is very confusing.

The authors’ response: Comment accepted. The sentence was modified as follow: it is important to understand the impacts of climate change on forest ecosystems and the ecosystems services provided to humans in northeastern China.

6. P3. L3. I strongly recommend to add a location map for the study sites.

The authors’ response: Comment accepted. A map and a panoramic photo was added to clearly show our study area (Fig. 2).

7. P3. L20. "Tree-ring samples were obtained from the south slope of Laobai Mountains along an elevational gradient from 950 to 1050 m". It is strange to ïňAnd temperature-sensitive trees at low altitude, far from the timberline, especially on a south-facing slope. Please provide more detail here to explain how minimal temperatures could be a limiting factor at such altitude for tree-growth.

The authors’ response: Thank you for this suggestion. In our study area, the south as the windward slope has more rainfall, so the upper limit of vegetation distribution at southern slopes is higher than that at northern slopes, and the southern slope has some vegetation types which does not exist in northern slopes. In addition, the northeast China is a part of high latitude region. The highest peak of Laobai Mountain rises to 1650 m, which is the third highest peak in northeast China. The vegetation remains predominantly original, and which is occupied by the mixed broadleaved Korean pine forest from 800 to 1050 m and dark conifer forest with Picea jezoensis from 1050 to 1350 m. It is generally accepted that extreme temperature limits tree growth at treeline or at high latitudes forest, especially spring or early summer minimum temperature

(Körner and Paulsen, 2004; Porter et al., 2013; Wilson and Luchman, 2002; Yin et at., 2015). The sampled site was located at higher elevation and close to the upper limit of Korean pine distribution, which may be more sensitive tree growth in relation to temperature (Szeicz and MacDonald, 1995; D'Arrigo et al., 2009; Li et al., 2011; Yu et al., 2011; Flower and Smith, 2012).

8. P3. L31-32. "A standard chronology, which preserves more low frequency signals than other chronologies, was used in the subsequent analyses". Accounting for the detrending method used in this study, the negative exponential curve, it is difïňĄcult to understand why this detrended chronology would preserve more low frequency.

The authors' response: Thank you for this suggestion. ARSTAN (Cook 1985) was used to detrend and standardize cross-dated tree-ring width series into a tree-ring chronology. During this detrending process, to remove biological factors (such as age-related trends) and non-climatic variations and preserve as much low-frequency signal as possible, each ring-width series were fitted with a straight line or negative exponential function. A 67% cubic smoothing spline with a 50% cutoff frequency was further used in a few cases when anomalous growth trends occurred. The detrended data from individual tree cores were then averaged using a bi-weight robust mean to form the standard (STD), residual (RES) and autoregressive (ARS) chronologies (Cook and Kairiukstis, 1990). In addition, we compared RCS (regional curve standardization) chronology and STD chronology. The following figure showed that the RCS chronology and STD chronology display similar patterns of variation at low-frequency. Therefore, STD chronology also preserved more low-frequency signals and was used in the subsequent analyses. As shown in Fig. 3, the amplitude of the STD chronology was larger than RES chronology in low-frequency variability, indicating that STD chronology also preserved more low-frequency signals.

9. P4. L2-3 I am really surprised that EPS could exceed 0.85 with a sample depth of only 5 trees.

The authors' response: Comment accepted. We went to the sampled site again on May 16, 2016 again. A total of 17 cores from 10 living trees were sampled again in the same study area. Then, a total 71 cores from 41 trees was used to develop the chronology. Therefore, the sample depth is better than before since 1630 (EPS>0.8). A generally acceptable threshold of the EPS was consistently greater than 0.85 from AD 1660 to 2015 (eleven trees) (Fig. 4).

10. P4. L17-18 "and the reduction of error test (RE), and product means test (PMT) are the tools used to verify the results". Please provide the coefïňĄcient of efïňĄciency (CE) which is usually used to indicate the signiïňĄcance of the model skill on the verïňĄcation period.

The authors' response: Comment accepted. We have added a rigorous parameter of CE in Table 2.

11. P4. L24-25. "Climate-growth response function analysis showed that the standard chronology was positively correlated with the mean minimum temperatures from January to December in current year". Why did you test such a long period as the growing season is probably limited to April to September?

The authors' response: Comment accepted. Climate-growth response function analysis showed that the STD chronology was positively correlated with the mean minimum temperatures from previous July to current August. We provide an additional Table 1 with these analyses of various month combinations. The highest correlation (r=0.757, p<0.0001) was found between STD chronology and April-July mean minimum temperature (MMT). In addition, we estimate the minimum temperature in April-July (4.96 °C) by lapse rate (0.6 °C Âů100m-1) along the elevation, which is higher than the sap flow of Korean pine for temperature (4.5 °C). Therefore, the April-July minimum temperature plays a crucial important role in limiting the annual radial growth of Korean Pine in Laobai Mountain.

12. P4. L25-26. "This means that cool or warm conditions are favored for the Korean

Pine growth in this area." This sentence is not clear please consider rephrasing.

The authors' response: Comment accepted. The sentence was modified as follow: This also means that warm and wet conditions are suitable for the growth Korean Pine in this area.

13. P5. L2-3. "Second, a crucial growth period of the Korean pine is from April to July." Why only April-July and not April-August or April-September, the periods usually used for reconstructions in these regions? did you test all the possible combinations of regressors? In this case, could you please provide an additional table with these analyses? These analyses are even more crucial as the authors state that "the photosynthesis still occurred during autumn, when it is generally the end of growing season; the lower mean minimum temperature reduced the tree respiration, allowing for more photosynthetic products to be stored, thus creating favorable conditions for subsequent tree growth".

The authors' response: Comment accepted. We provide an additional Table 1 with these analyses of various month combinations. The highest correlation ($r=0.757$, $p<0.0001$) was found between STD chronology and April-July mean minimum temperature (MMT). It is generally accepted that the sap flow of Korean pine starts from the mid- to late-April, when the activity of cambium starts. April is the early stage of the growing season for Korean pine, and the main growing season is from May to August in our study area. As the climate warming in northeastern China, trees could carry out photosynthesis at the early stage of the growing season, higher minimum temperature is conducive to produce more auxin, promote photosynthesis rate and increase the nutrient accumulation. July is the rapid growth period of Pinus koraiensis, which is important for the formation of early wood. We estimate the minimum temperature in April-July (4.96 °C) by lapse rate (0.6 °C 100m-1) along the elevation, which is higher than the sap flow of Korean pine for temperature (4.5 °C) in this region. In addition, if more temperature months were added, the temperature variance explained by the STD chronology will decrease sharply. Therefore, we choose a period from April to July for

this reconstruction.

14. P5. L25-28. "The longest cold period lasted from 1605 to 1681 AD (77 years), with an average temperature of 1.04 °C below the mean value". During most of this period, EPS<0.85, it is thus difïňĄcult to consider the reconstruction as reliable during the ïňĄrst part of the 17th century.

The authors' response: Comment accepted. We went to the sampled site again on May 16, 2016 again. A total of 17 cores from 10 living trees were sampled again in the same study area. Then, a total 71 cores from 41 trees was used to develop the chronology. Therefore, the sample depth is better than before since 1630 (EPS>0.8). A generally acceptable threshold of the EPS was consistently greater than 0.85 from AD 1660 to 2015 (eleven trees) (Fig. 4). Therefore, the latter portion of the 1630-1681period (EPS>0.80) is reliable.

15. P5. L31. "were also consistent with other results of the tree-ring reconstructions in northeastern China (Shao and Wu, 1997; Yin et al., 2009; Wang et al., 2012)". Please provide a ïňĄgure in order to highlight this consistency between reconstructions.

The authors' response: Comment accepted. A map and a panoramic photo was added to clearly show our study area (Fig. 2).

16. P5. L33. "In addition, the two cold periods of 1605-1681 and 1684-1690 were fully consistent with the Maunder minimum (1620-1710), an interval of decreased solar irradiance (Bard et al., 2000)". The Maunder minimum is usually deïňĄned as the coldest period of the LIA that extends from 1645 to 1715.

The authors' response: Comment accepted. The cold period of the new reconstructed series has changed. The sentence was modified as follow: In addition, the two cold periods of 1645-1677 and 1684-1691 were fully consistent with the Maunder minimum (1645-1715), an interval of decreased solar irradiance (Bard et al., 2000)

17. P6. L4-6 "The Little Ice Age in the 17th century and the rapid warming during the

mid-19th and late 20th century in northeastern China had been well recorded in this series, suggesting that this series had a good regional representativeness of temperature variations in northeastern China". This is insufïňĄciently demonstrated, please provide more details here.

The authors' response: Comment accepted. We compared our data series with two nearby tree-ring based temperature reconstruction series from Dunhua by Li and Wang (2013) and Changbai Mountains by Zhu et al. (2009). The two temperature series were significantly positively ($r = 0.499^{**}$, $p < 0.01$; $r = 0.454^{**}$, $p < 0.01$) correlated with our reconstructed temperature series, respectively. Meanwhile, a significant negative correlation ($r = -0.179^{**}$, $p < 0.01$) between our reconstruction and the northern hemisphere temperature data (D'Arrigo et al., 2006) was also found (Fig. 5). The three reconstructed temperature series showed analogous cold/warm variation in mid-19th and late 20th century in northeastern China

18. P6. L12-16. "All of the temperature series exhibited signiïňĄcantly low temperatures during the 1950s-1970s, which coincided with a slight decrease in sun activity from AD 1940-1970 (Beer et al., 2000) (Fig. 5). Another notable feature was that all of the curves showed a sharp increase from 1980, and the peak values appeared in the late 1990s and early 2000s, which was consistent with the reports from the Intergovernmental Panel on Climate Change (IPCC, 2007)" Why did the authors only focus on comparisons for the last decades ? I would expect comparisons between reconstructions for the last 400 hundred years.

The authors' response: Thank you for this suggestion. The tree-ring series were rarely used to reconstruct past climate (especially temperature) in this area because of good hydrothermal conditions. Several temperature-sensitive tree-ring chronologies were developed in the Changbai Mountains (e.g., Shao and Wu, 1997; Zhu et al., 2009; Wang et al., 2012; Li and Wang, 2013) and Xiaoxing'an Mountains (Yin et al., 2009; Zhu et al., 2015), but almost no results were obtained for the period of over 250 years and reflected the low-frequency climate variations, which limit our understanding for a

longer time scale of climate variations. Therefore, we only focus on comparison with the temperature series for the last 200 years especially in recent decades in northeastern China. Fortunately, the northern Hemisphere temperature series (D'Arrigo et al., 2006) and historical documents can make up for this shortcoming a little bit.

19. P6. L18-20. "Additionally, three northeastern temperature reconstruction series showed that some cold/warm years were not analogous due to the differences in the reconstruction parameters (e.g., temperature subdivisions into average temperature, minimum temperature, maximum temperature, etc.) and habitat conditions in different sampling areas". Neither these chronologies nor their relations with climatic variables are presented here. In this context, we should only trust the authors. . ..

The authors' response: Thank you for this suggestion. This sentence is a bit confusing. It was modified as follow: Additionally, the three northeastern temperature reconstruction series showed that some of the cold/warm periods may not be analogous with each other, which could be caused by the differences of the reconstructed temperature variable (that is, mean temperature, minimum temperature, maximum temperature) and the habitat conditions in different sampling areas. Three cold/warm periods were inconsistent with two comparison temperature series which were also found in other nearby tree-ring reconstruction series. The cold period from 1914-1922 was consistent with the results of nearby tree-ring reconstructed temperatures in Changbai Mountains and Xiaoxing'an Mountains (Wang et al., 2012; Zhu et al., 2015). The warm periods from 1795-1807 and 1819-1826 were also consistent with that in Changbai Mountains temperature reconstructions (Wang et al., 2012; Shao et al., 1997).

20. P6. L27-28 "The evidence from historical documents shows that cold damage or frost disaster events have been occurring in Heilongjiang Province since 1675 (Sun et al., 2007)." Here again, I would expect a year-by-year comparison between historical archives and the tree-ring reconstruction, at least for the extreme years detected in both datasets in order to demonstrate unambiguously that tree-rings from Korean pines properly recorded past climatic extremes.

The authors’ response: Comment accepted. We provide an additional Table 3 which is the comparison of extreme events between historical archives and this tree-ring reconstruction.

Once again, thank you very much for your comments and suggestions.

Best Regards,

Shanna Lyu, on behalf of all co-authors

Please also note the supplement to this comment:
http://www.clim-past-discuss.net/cp-2016-38/cp-2016-38-AC3-supplement.pdf

Interactive comment on Clim. Past Discuss., doi:10.5194/cp-2016-38, 2016.

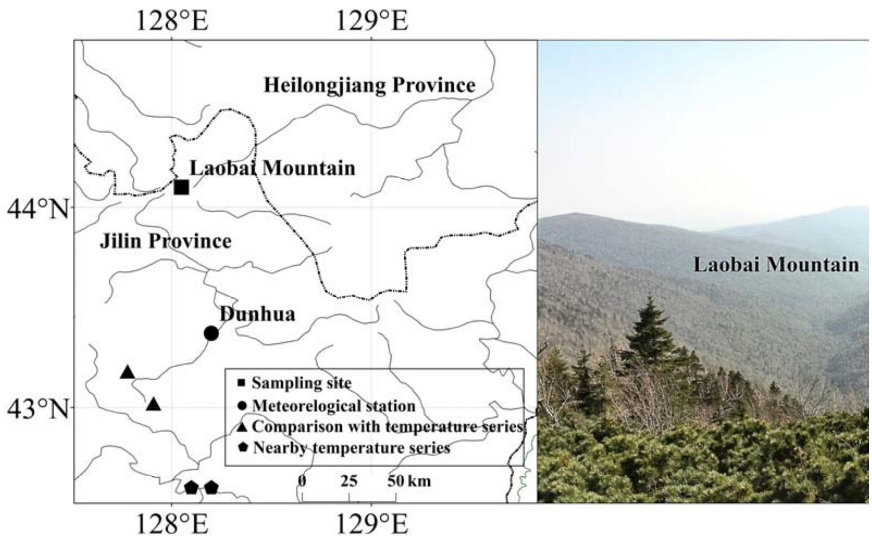


Fig. 2 Map of the sampling site, compared temperature series, nearly tem meteorological station in northeastern China. The photo showed the samp Mountain and the remarkable vertical vegetation distribution along altitude chan

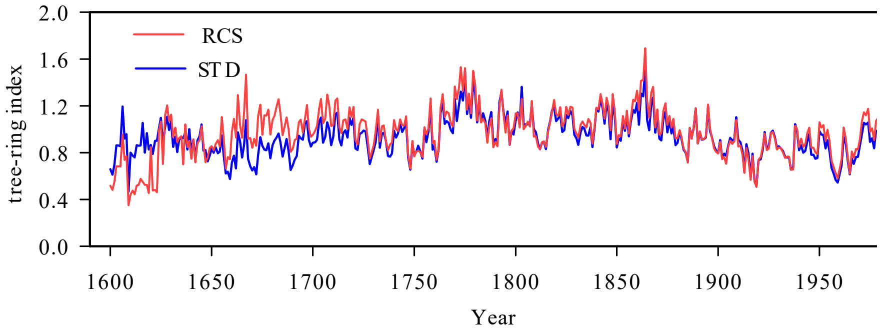


Fig. 3 Comparison of the STD and RCS chronologies in Laobai Mountains

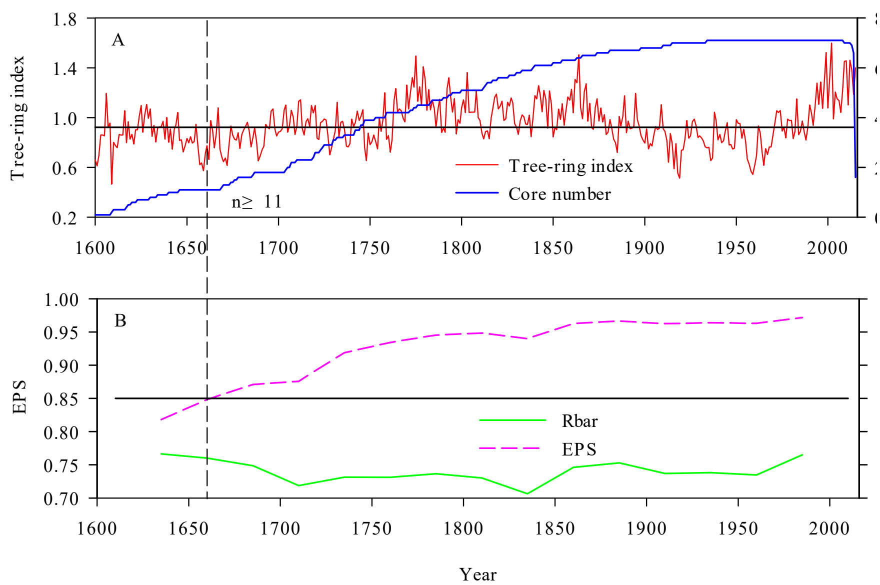
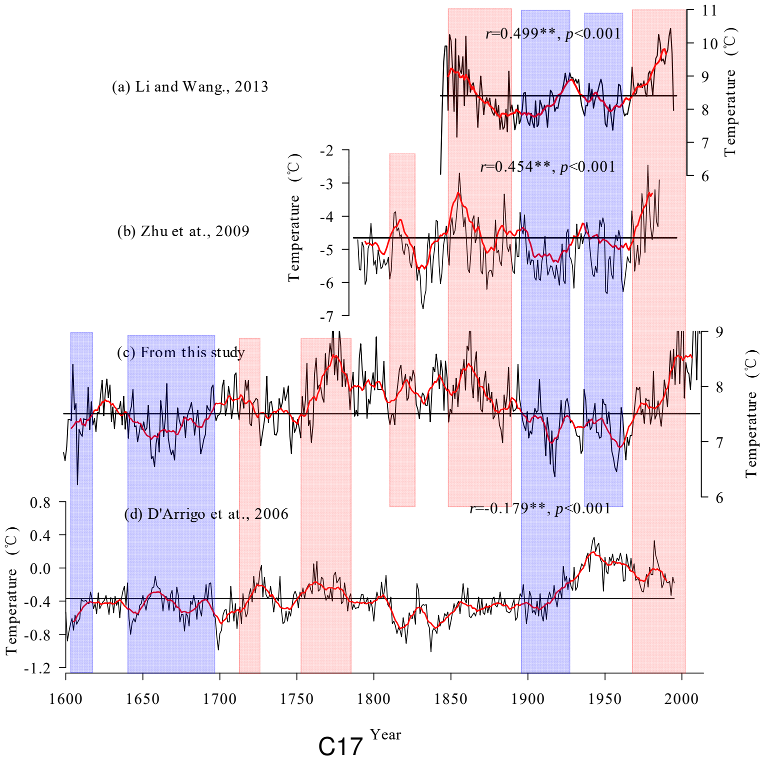


Fig. 4 Variations of (A) the STD chronology and sample depth, and (B) the e

signal (EPS) and average correlation between all series (Rbar) from 1600 to 201



C17

Fig. 5 (a) April-September mean minimum temperature in Dunhu reconstruct

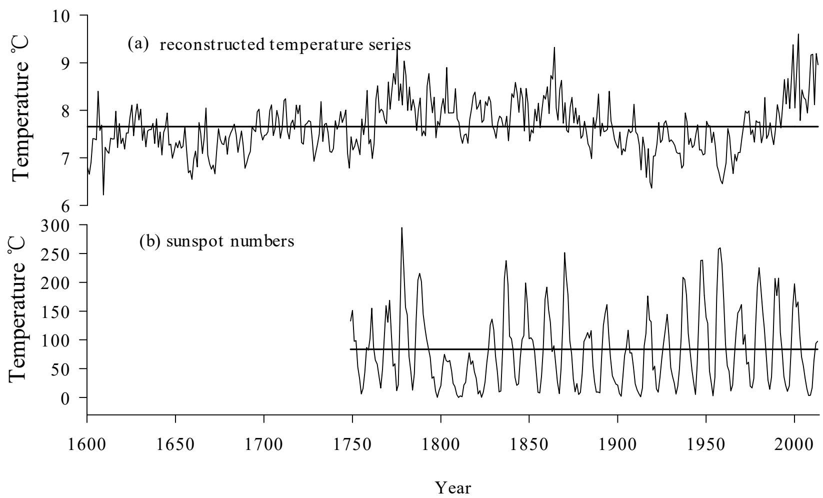


Fig 6. Comparison between the reconstructed April-July temperature series and s

Table 1. Correlation coefficients between the STD chronology and the clima month combinations during the common period of 1956–2013.

Months	T_{mean}	T_{min}	T_{max}
c4-c7	0.577**	0.757**	0.177
c4-c8	0.557**	0.717**	0.183
c4-c9	0.599**	0.726**	0.217
c5-c7	0.556**	0.749**	0.198
c5-c8	0.522**	0.691**	0.198
c5-c9	0.587**	0.709**	0.236
c6-c8	0.447**	0.634**	0.199
c6-c9	0.535**	0.671**	0.241
p7-c8	0.586**	0.682**	0.230

* Significant at the 0.05 level (two-tailed). ** Significant at the 0.01 level (two-tailed).

Table 2. Calibration and verification statistics of the reconstruction equation for of 1956-2013

Calibration	R	R^2	Verification	R	Reduction of Error	Coefficient of efficiency
whole Section （1956-2013）	0.757**	0.573**	-	-	-	-
Front Section (1956-1984)	0.414*	0.171*	Back Section (1985-2013)	0.632**	0.738**	0.446**
Back Section (1985-2013)	0.632**	0.400**	Front Section (1956-1984)	0.414*	0.738**	0.634**

* Significant at the 0.05 level (two-tailed). ** Significant at the 0.01 level (two-t

Table 3. Cold damage or frost disaster events recorded in historical archives of Heilongjiang Province since 1675.

17^{th} century	18^{th} century	19^{th} century	20^{th} century
1675	1730	1800-1801	1901-1903
1682	1746	1812-1813	1909-1915
1689	1749	1830-1832	1917
1699	1748	1878-1879	1920
	1755	1885	1925-1926
	1757		1931-1932
			1934-1936
			1939-1943
			1947
			1950-1969
			1998-1999
			1971-1981