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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.

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Response to Anonymous Referee 2:

Thank you very much for your constructive comments on our manuscript, including major concerns and minor concerns. These comments are very valuable and helpful for revising and improving our MS, which also play an important guiding role in our research. We accepted most of your comments and made correction carefully.

Major concerns: 1. It's impressive that the authors collected 54 cores from 31 trees in the studied area, and all the cores are used and successfully cross dated. The standard tree-ring chronology extended from 1600 to 2013, and lucky enough, EPS>0.85

also starts from 1600 (5 cores). However, the fact is that the core number during 1600-1650 is less than 5 (Fig. 2a). Please check this inconformity. Moreover, the quality of the chronology during around 1670-1710 is low because both EPS and Rbar decrease sharply. For the above reasons, I have to doubt the starting year of the reliable chronology.

The authors' response: Comment accepted. We went to the sampled site again on May 16, 2016. A total of 17 cores from 10 living trees were sampled again near 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).

2. Why do you deal Xt with ln (Y=2.728 ln (Xt)+7.812)? What's the philosophy behind it? I never see such kind of transfer function in dendroclimatology.

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

3. In Fig. 4a, the year to year (high-frequency) variations of the reconstruction and actual April-July MMT didn't match well. The high correlation (0.757) may be caused by similar trends. This is the biggest problem of this manuscript. What's the direct correlation coefïňĄcient between tree rings and April-July minimum temperature? Did you calculate the 1st-difference correlation coefïňĄcient between them? Therefore, the following discussions (especially the extreme cold years in Fig. 4b) are meaningless and unconvincing.

The authors' response: Thank you for this suggestion. As shown in Fig. 3, the amplitude of the STD chronology was larger than RES chronology in low-frequency variability, indicating that STD chronology preserved more low-frequency signals and RES chronology reflected high-frequency signals. The mean sensitivity of the RES chronology was larger than STD chronology, which quantitatively illustrated that the RES chronology exhibits more high-frequency climate information than the STD chronology. In addition, Fig. 1 showed that the significant correlated months between the STD chronology and mean minimum temperature disappeared or poorly correlated for the RES chronology, suggesting that the STD chronology contained minimum temperatures only share low-frequency temperature variability, but not high-frequency temperature variability. Further, the ïňĄrst difference correlation (not shown) between the STD chronology and temperature did not exceed the 95% conïňĄdence level, which confirms that this regressed equation may be better to capture the low-frequency variability rather than high-frequency variability. Besides, the correlation coefïňĄcient between the ïňĄrst-order difference series of the actual and reconstructed values is not signiïňĄcant at the 0.05 level (r=0.12, p>0.05). Therefore, this reconstructed minimum temperature series is more consistent with the observed series at low-frequency variability, which only represents the warm/cold variability at low frequencies in this region.

4. Table 1 indicates that "the autocorrelation order 1" is 0.75, thus except for the current year climatic records, the previous year climatic records should also be included in the climate-radial growth relationship.

The authors' response: Comment accepted. The previous year climatic records have been included in the climate-radial growth relationship. Months from the previous July to current August were selected for the analysis of the relationship between climatic factors and Korean pine growth (Fig. 1).

5. When you do the climate-radial growth relationship analysis, current November and December shouldn't be considered. Because the annual frost-free period in the studied area is approximately 90-110 days (page 3, line 17), which means the growth season is very short. So the tree-ring width almost stops expansion in November and December. If you consider these months, please give convincing reasons. The explanation in line

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5-7 in page 5 is not suitable.

The authors' response: Comment accepted. We have rephrased this section of climate-radial growth relationship. Climate-growth response function analysis showed that the STD chronology was positively correlated with the mean minimum temperatures from the previous July to current August (Fig. 1). Relationships between the STD and RES chronologies and monthly climate data in Dunhua were shown in Fig. 1. Results showed that temperatures were more crucial to Korean pine growth compared with precipitation. In contrast, the correlation coefficients between Korean pine chronologies and mean minimum temperature were positive and higher than those for maximum and mean temperature. The significant correlation months between STD chronology and mean minimum temperature disappeared or poorly correlated for the RES chronology. This indicated that the STD chronology just recorded the minimum temperature signals in low frequency, but not high frequency temperature variability. In addition, different month combinations were also considered. The best-correlated three temperature months were then selected for temperature reconstruction (Table 1). The highest correlation coefficient ($r=0.757$, $p<0.0001$) was found between STD chronology and April-July mean minimum temperature (MMT). 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). Moreover, Tmax, Tmean and Tmin during the observed period of 1956-2013 shown in Fig. 5 illustrated the similar inter-annual variations, while the increase trend of Tmin is much higher than Tmean and Tmax, especially after 1976. This phenomenon is consistent with Karl et al. (1993), Ren et al. (1998) and Tang et al. (2005), which suggested that the global warming over past decades is mostly owing to the faster rise of night or minimum temperatures and the warming in northeastern China is like that. Based on the correlation between the STD chronology and the climate data, we found that compared to the maximum temperature and mean temperature, the minimum temperature (especially for April-July) plays a more important role in limiting the annual radial growth of Korean Pine in Laobai Mountain. This also means that warm and wet conditions are suitable for Korean Pine growth in this area. This may result from two reasons: First, the sampled site was located at higher elevation close to the upper limit of Korean pine distribution, which may have caused 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). In early growing season, higher mean minimum temperature can defense frost damage, thus is more conducive to form a wider ring (Wu, 1990; Akkemik, 2000; Makinen et al., 2003). In addition, higher nighttime temperature could promote the tree respiration and enhance the physiological activity, thereby producing more auxin, promoting cell enlargement, and forming a wider ring in the growing season (Fritts et al., 1976). 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. Therefore, Korean pine tree-ring width is positively correlated with temperature. Second, a crucial growth period of the Korean pine is from April to July. During this period, the temperature could have direct effects on photosynthesis rate, cambium activity, and respiration efficiency, etc., all of which affect tree-ring width (Li et al., 2000; Yu et al., 2011).

6. Theoretically, it's unreasonable to compare this temperature reconstruction (April-July) with the October temperature by Yin et al. (2009), and the February-April temperature in Changbai Mountains (Zhu et al., 2009) (Fig. 5), which was inïňĆuenced by the East Asian Winter Monsoon.

The authors' response: Comment accepted. The temperature series by Yin et al. (2009) was removed from this comparison, but the series by Zhu et al. (2009) was keep because the two sites are close and both contain April, and the most important one is that they show very similar variation patterns. The reconstructed temperature series of Changbai Mountains (Zhu et al., 2009) was significantly positively ($r = 0.454^{**}$, $p < 0.01$) correlation. Therefore, it seems reasonable to compare this temperature reconstruction (April-July) with the February-April temperature in Changbai Mountains (Zhu et al., 2009). In addition, we provide an additional Table 1 with these analyses of various month combinations. It was showed that the photosynthesis still occurred during autumn in our study site, 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 (Gao et al., 2011; Wang et al., 2011). Thus, it's reasonable to compare this temperature reconstruction (April-July) with the October temperature by Yin et al. (2009).

7. What's your deïňĄnition of Little Ice Age (LIA)? According to the general C2CPD Interactive Comment Printer-friendly version Discussion paper deïňĄnition of LIA, the period before 1850 of this reconstruction belongs to LIA. Except for the temperature during 1605-1681 was very low, the other periods before 1850 was not so cold. Furthermore, the comparison with Northern Hemisphere temperature (NHT) (Fig. 5) is not so good. NHT (Wilson et al., 2007) showed evident increasing trend since around 1810, while this temperature reconstruction doesn't show such direct warming trend. The temperatures during most time of 19th even had opposite phase to NHT.

The authors' response: Thank you for this suggestion. 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. 6). It was widely believed that the Little Ice Age in China has three cold periods, that was the 15th century, the 17th century and the 19th century (Wang et al., 2003). The first period was relatively less obvious, and the second period was most obvious of all but different in when it begins and ends, however, the third period has some regional differences (e.g. the southern China was obvious and the northeast region and Sinkiang were the opposite) (Wang et al., 1998; Wang et al., 2003). The third Little Ice Age in 19th century was not obvious in our reconstruction, which was consistent with Wu et al. (1998) and Wang et al. (1998), and which also lead to the bad matching with Northern Hemisphere temperature. In addition, the climate was warm for the late 18th and early 19th in Heilongjiang Province (Gong et al., 1979). While the LIA is a genereal convention for a certain period, we do not think we should expect perfect phasing across regions and seasons of reconstruction. It might be that northeastern China has occasionally experienced significant departures from global trends.

8. CE is a more rigorous parameter than RE in split-period calibration and veriïňĄcation analyses, please offer this parameter in table.

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

Minor concerns: 1. A map showing the general location of sample site and meteorological station is useful in helping the readers get an intuitive understanding of this work.

The authors' response: Comment accepted. A map and a landscape photo was added to clearly show our study area. Details see Fig. 2.

2. The general information of the sampled species in this manuscript should be given. It will be helpful for the understanding the following climate-growth relationships.

The authors' response: Comment accepted. The general information of the sampled species has been added to the MS. Five tree species were cored in this area, but only Korean pine (Pinus koraiensis) cores were used in this study. Korean pine is a sun-loving plant (shade tolerant when it is young) and has shallow roots, widely distribute on well-drained wet mountain slopes close to the subalpine timberline where the brown forest soil is covered.

3. Detailed information of sampling site (e.g. longitude, latitude, main vegetation types) is needed.

The authors' response: Comment accepted. The detailed information of sampling site was added into the MS. The study area is located at Laobai Mountain (128°03' E, 44°06' N) , the boundary zone between Jilin and Heilongjiang provinces, and is also an ecotone between the Changbai and Xiaoxing'an Mountain. Laobai Mt. is the third highest peak in northeastern China and rises to 1650 m above sea level (a.s.l.). Almost no inhabitants live in or near the Mountain, so the forest ecosystem is preserved very well and the native vegetation remains predominantly intact (Fig. 1). Five forest vegetation types from temperate to frigid change with the altitude increase, which is Quercus mongolica broad-leaved forest below 800 m a.s.l., the mixed broadleaved Korean pine forest from 800 to 1050 m, dark conifer forest with Picea jezoensis from 1050 to 1350 m, Betula ermanii forest between 1350 and 1640 m, and Pinus pumila forest and subalpine meadow above 1640 m. Plant species is a transition from Changbai Mountain to Xiaoxing'an Mountain. Five tree species were cored in this area, but only Korean pine (Pinus koraiensis) cores were used in this study. Korean pine is a sun-loving plant and has shallow roots, widely distribute on well-drained wet mountain slopes close to the subalpine timberline where the brown forest soil is covered. The vegetation of this area is mixed broadleaved Korean pine forest dominated by Pinus koraiensis, Picea jezoensis and Abies nephrolepis as well as broadleaf tree species, such as Juglans mandshurica, Fraxinus mandshurica and Acer mono (Bu et al., 2003).

4. I don't agree that 1684-1690 is a cold period and 1787-1793, 1795-1801 and 1803-1808 are warm periods (Table 3, Fig. 4b).

The authors' response: Thank you for this suggestion. We checked it again. The cold period of 1684-1690 was consistent with cold period of 1689-1690 in Heilongjiang Province (Gong et al., 1979). The warm periods of 1787-1793, 1795-1801 and 1803-1808 were found in nearby tree-ring reconstruction series in Changbai Mountains (Wang et al., 2012; Shao et al., 1997).

5. The time span in Table 1 is 1600-2014. Should it be 1600-2013?

The authors' response: Thank you for this suggestion. The time span of STD chronology in Laobai Mountain is 1600-2015 in Table 1, but the time span of the reconstructed minimum temperature series is 1600-2013.

6. 1600-2013 is 414 year, not 413 year

The authors' response: Comment accepted. All such errors in the MS were corrected.

7. The percentage of references during recent 5 years, especially during recent 3 years is too low.

The authors' response: Comment accepted. New reference during recent 5 years (such as Zhu et al., 2015; Wu et al., 2013; Yin et al., 2015; Porevor et al., 2013, etc.) were added into the appropriate locations of the main text.

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-AC2-supplement.pdf

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

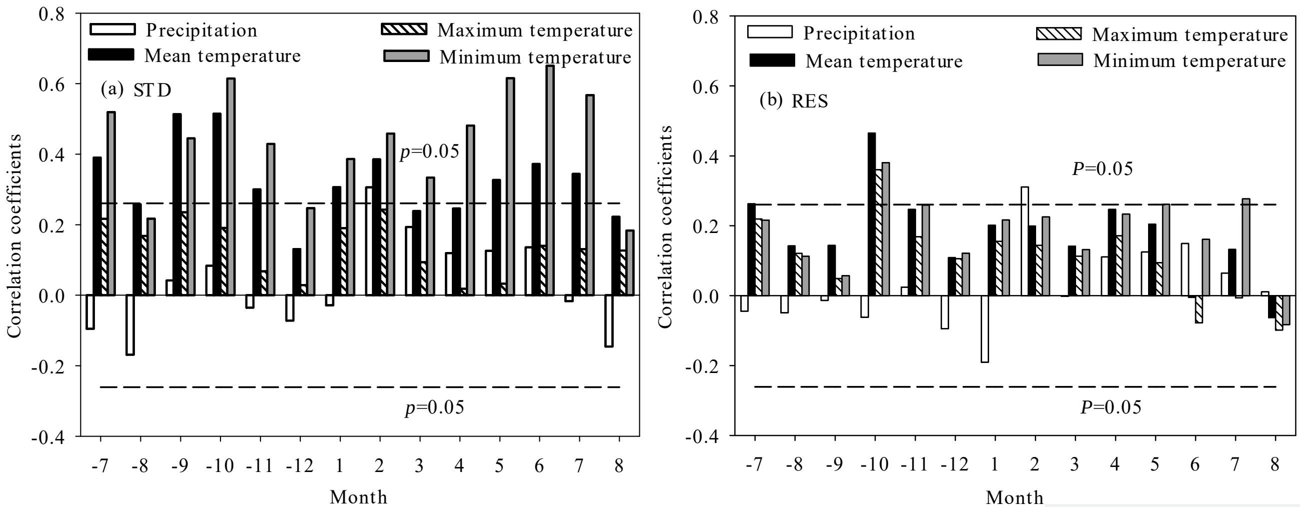

Fig. 1 Correlations between the monthly mean meteorological data (including mean temperature, mean maximum temperature, mean minimum temperature, and total precipitation) from Dunhua meteorological station (1956-2013) and (a) the STD chronology and (b) RES chronology, respectively. The dashed horizontal line represents the 95 % confidence limit.

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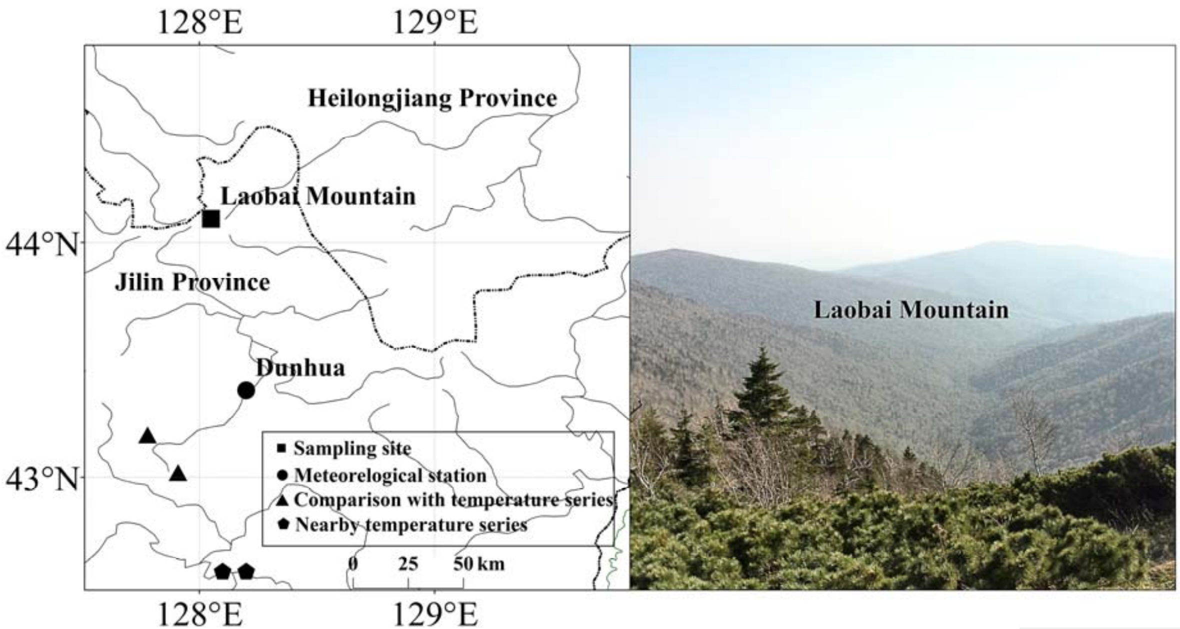

Fig. 2 Map of the sampling site, compared temperature series, nearly temperature series and meteorological station in northeastern China. The photo showed the sampled site in Laobai Mountain and the remarkable vertical vegetation distribution along altitude changes.

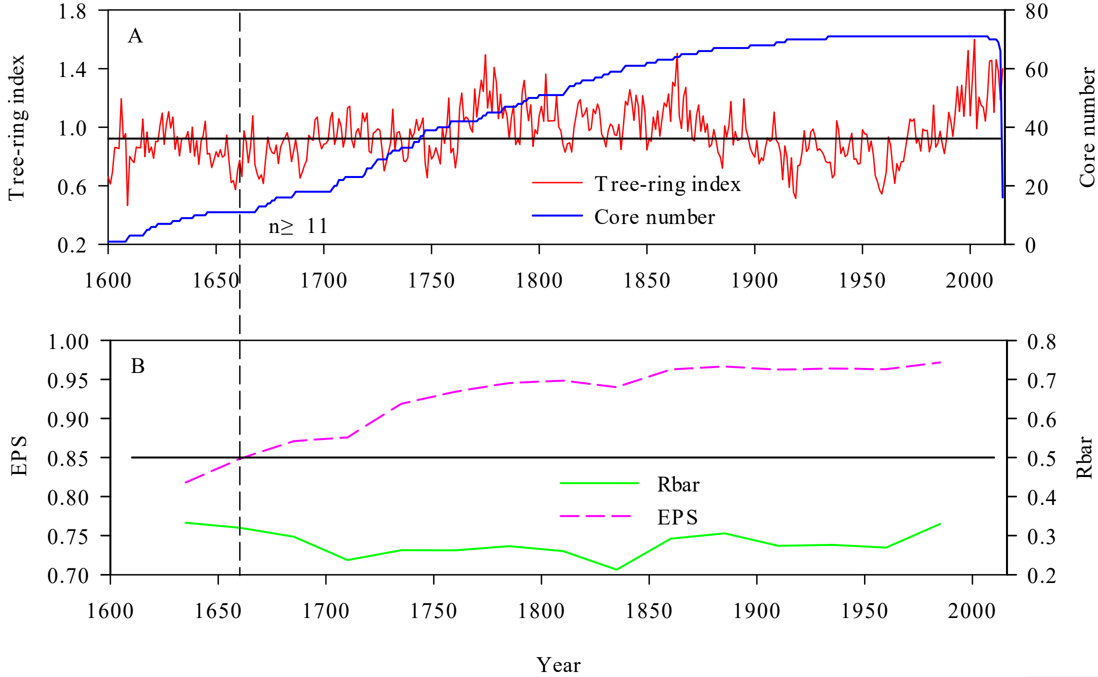

Fig. 4 Variations of (A) the STD chronology and sample depth, and (B) the expressed population signal (EPS) and average correlation between all series (Rbar) from 1600 to 2015.

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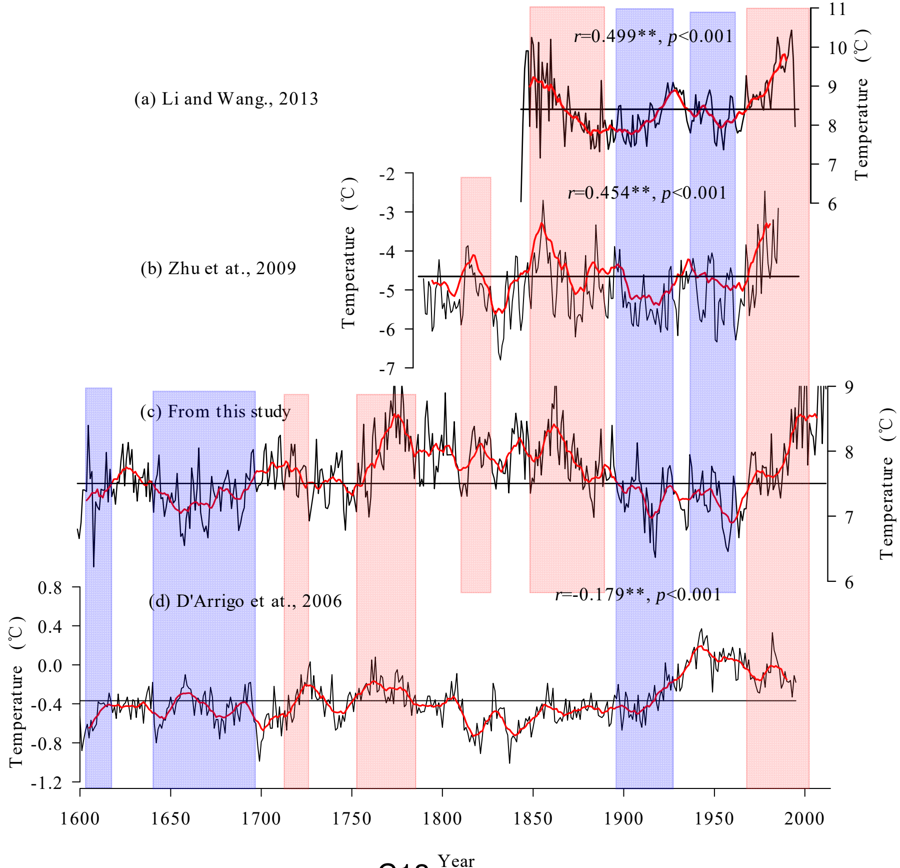

Fig. 5 (a) April-September mean minimum temperature in Dunhu reconstructed by Li and Wang

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Table 1. Correlation coefficients between the STD chronology and the climate data of different 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 the common period of 1956-2013

Calibration	R	R^2	Verification	R	Reduction of Error	Coefficient of efficiency	Sign Test	Product Mean Test
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^{**}	$(20, 9)^{*}$	4.586^{**}
Back Section (1985-2013)	0.632^{**}	0.400^{**}	Front Section (1956-1984)	0.414^{*}	0.738^{**}	0.634^{**}	$(22, 7)^{**}$	6.099^{**}

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