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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 1: We appreciate the valuable suggestions and constructive comments on the manuscript from the anonymous reviewer. These comments are very helpful for revising and improving our MS. Based on these comments, careful revisions have been made to the MS. The revisions made to the MS detailed below.

Comments: 1. Cambial cell division may end in end August in the study area. It has no meaning to make a correlation analysis between tree growth and climatic records until December of the current year. At most, the analysis can include until September.

The authors' response: Comment accepted. Months from the previous July to cur-

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rent August were selected for the analysis of the relationship between the climatic factors and the Korean pine growth (Fig. 1). Furthermore, the climate data included total monthly precipitation, mean maximum temperature, mean temperature, and mean minimum temperature. Months from the previous July to current August were selected for the analysis of the relationship between the climatic factors and the Korean pine growth.

2. Taking into possible inïňĆuence of climatic conditions in the last year, July-December of the previous year may be included for the analysis.

The authors' response: Comment accepted. In order to consider the last year of climate impact on tree growth, July-December of the previous year has been included for the analysis. (Fig. 1) Relationships between the STD and RES chronology of the Dunhua monthly climate data were shown in Fig. 1. Correlations between the tree-ring chronologies and monthly climate data showed temperatures was more crucial to Korean pine growth compared with precipitation. In contrast, correlations between Korean pine chronologies and mean minimum temperature were positive and higher than those for maximum and mean temperature. Fig. 1 showed that the significant correlation months between STD chronology and mean minimum temperature disappeared or poorly correlated for the RES chronology. This suggests that the STD chronology represents the minimum temperature signals in low frequency, but not at high frequency. 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 ($r=0.757$, $p<0.0001$) was found between STD chronology and April-July mean minimum temperature (MMT). Further, it is generally accepted that extreme temperature commonly, though not always, 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 (not shown here), 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. Northeastern China is warming in similar ways. 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). Early in the growing season, higher mean minimum temperatures can prevent frost damage, which 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 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. Therefore, we find that Korean pine tree-ring width is positively correlated with temperature. Second, we also find that 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).

3. The ïňĄrst paragraph in Introduction is too long. It is reasonable to start another paragraph line 8.

The authors' response: Comment accepted. The structure of the ïňĄrst paragraph is re-adjusted in Introduction. Global climate change presents major challenges for humans and the natural systems that provide ecosystem services. Consequently, it is urgent to better understand the climate change and its forcing mechanisms. Instrumental records are typically less than 100 years and often less than 50 years in most areas of the world. It is necessary to put the present climate regime in context with the long-term perspectives, which forces a reliance on natural proxy records to reconstruct the past climate. Tree rings have been widely applied in global climate change studies and paleoclimate reconstructions at both regional and global scales because they offer accurate and continuity temporal record as well as they are widespread and easily replicated (Corona et al., 2010; Bouriaud et al., 2014; Kress et al., 2014).

4. Line 25-26, page 2, "it is important to understand the longitudinal impacts of the climate change on forest ecosystems and human production activities in northeastern China." It is very confusing to read this sentence. This manuscript did not talk about "longitudinal impacts".

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 human production activities in northeastern China.

5. A scientiïňĄc question may be necessary to be presented in the end of Introduction.

The authors' response: Comment accepted. In the end of Introduction has been presented a scientiïňĄc question. Therefore, there is a demand for higher-quality climate reconstructions in a greater number of areas over longer periods and a larger group of climatic indicators for verification 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. Currently, a significant climate warming (mainly is the minimum temperatures) occurred in northeastern China since the 1980s. However, there still remains a lack of long-term climatic record (at least more than 300 years) in northeast China to explore what is the temperature regime in the past one or half thousand years. A new temperature reconstruction for the region can help answer the question, "is the current warming in northeast China unprecedented?"

6. Line 30: "our new temperature record not only furthers the tree-ring series in northeastern China". It has problem in grammar.

The authors' response: Comment accepted. The sentence was modified as follow: Our new minimum temperature record in northeastern China provides a new evidence of past climate variability, and can be used to predict the climate trend in the future in northeast China.

7. A map is necessary to show your study areas.

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

8. In order to show low-frequency signals, the author is better to test RCS detrending.

The authors' response: Thank you for this suggestion. In order to obtain low-frequency signals, we used the regional curve standardization (RCS) method to process the tree-ring series during the chronology development. The following figure showed that the RCS chronology and STD chronology display similar patterns of variation at low-frequency (Fig. 3). In addition, some cores did not pass the tree center, so it was not easy estimate the rings that was missed. Further, there are many issues with using RCS on living trees. For these reasons we used the STD chronology for analysis and we took care in dealing with the variation of the reconstructed series at low frequencies.

9. For "Climate-radial growth relationship" in page 4, it is necessary to re-organize the sentences. It will better to explain why the minimum temperature rather than the maximum temperature is crucial to determine the growth, why April-July is important?

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In your research site, how about the minimum temperature in April-July? It may be estimate by lapse rate along the elevation. It seems to be not very meaning to explain that high mean April-July minimum temperature reduce tree growth by inhibiting tree respiration.

The authors' response: Comment accepted. We have rephrased this section of climate-radial growth relationship (Please see lines 8-30, page 5 and lines 1-12, page 6 in the text). It was explained that the minimum temperature rather than the maximum temperature is crucial to determine the growth. In our study site, 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.

10. Tree may not start growth in April in your study areas.

The authors' response: Thank you for this suggestion. It is generally accepted that the growth of Korean pine starts from the mid- to late-April, when the activity of vascular cambium starts. April is the early stage of the growing season for Korean pine, and the main growing period is from May to August in our study area. As climate warms in northeastern China, trees seem to carry out photosynthesis at the early stage of growing season. Higher minimum temperature is conducive to produce more auxin, promote photosynthesis rate and increase the nutrient accumulation, thus, tree-ring width is positively correlated with temperature. In addition, when the mean minimum temperature in April is higher, the trees begin to grow ahead of time and come into the growing season in advance, which means that it is possible that an extended growing season is advantageous for the radial growth of trees (Wu, 1990; Akkemik, 2000; Makinen et al., 2003). Therefore, April is an important month of Korean pine growth in this area, and should be taken into account in this reconstruction.

11. Line 5-7, page 5, it is no meaning to explain a lag effect of climate conditions in

Autumn.

The authors' response: Comment accepted. The lag effect of climate conditions in Autumn was delete.

12. Fig 2, there is a low EPS period from 1660 to 1730. The sample depth is not enough before 1730.

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).

13. The cold period from 1914-1922 is different with other reconstructions.

The authors' response: We explored nearby regions and disagree with this statement. The cold period from 1914-1922 is consistent with the results of nearby tree-ring reconstruction in the Changbai Mountains and Xiaoxing'an Mountains (Wang et al., 2012; Zhu et al., 2015). In addition, this cold period is also consistent with the severe freezing period of 1909-1918 in Heilongjiang Province (Sun et al., 2007), and 1920 is an extremely cold damage event (Sun et al., 2007).

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-AC1-supplement.pdf

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

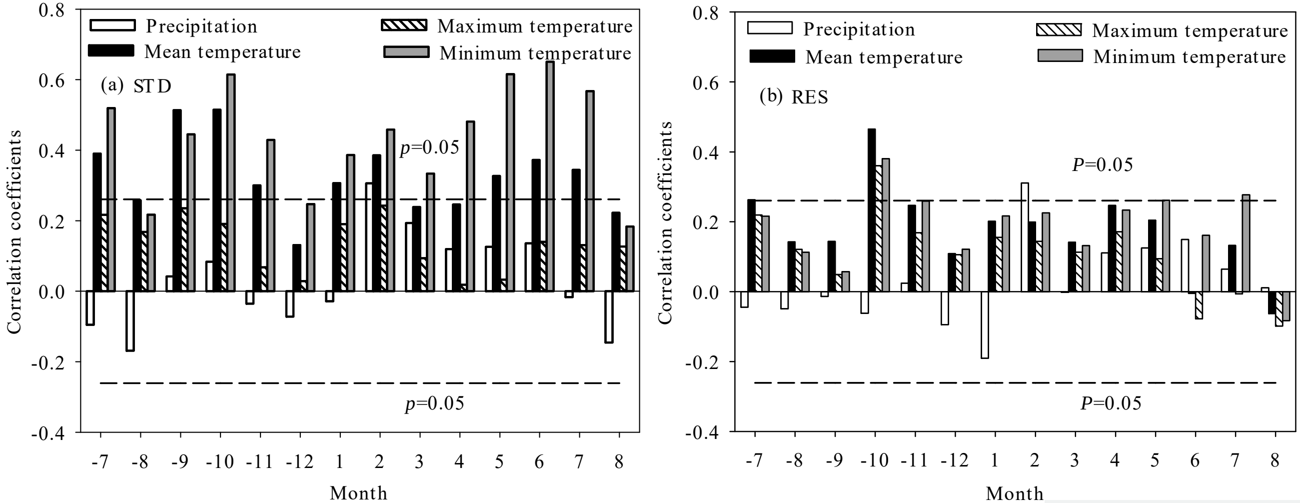

Fig. 1 Correlations between the monthly mean meteorological data (including mean temperature, mean maximum temperature, mean minimum temperature, and total precipitation) from Dunhua meteorological station (1956-2013) and (a) the STD chronology and (b) RES chronology, respectively. The dashed horizontal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

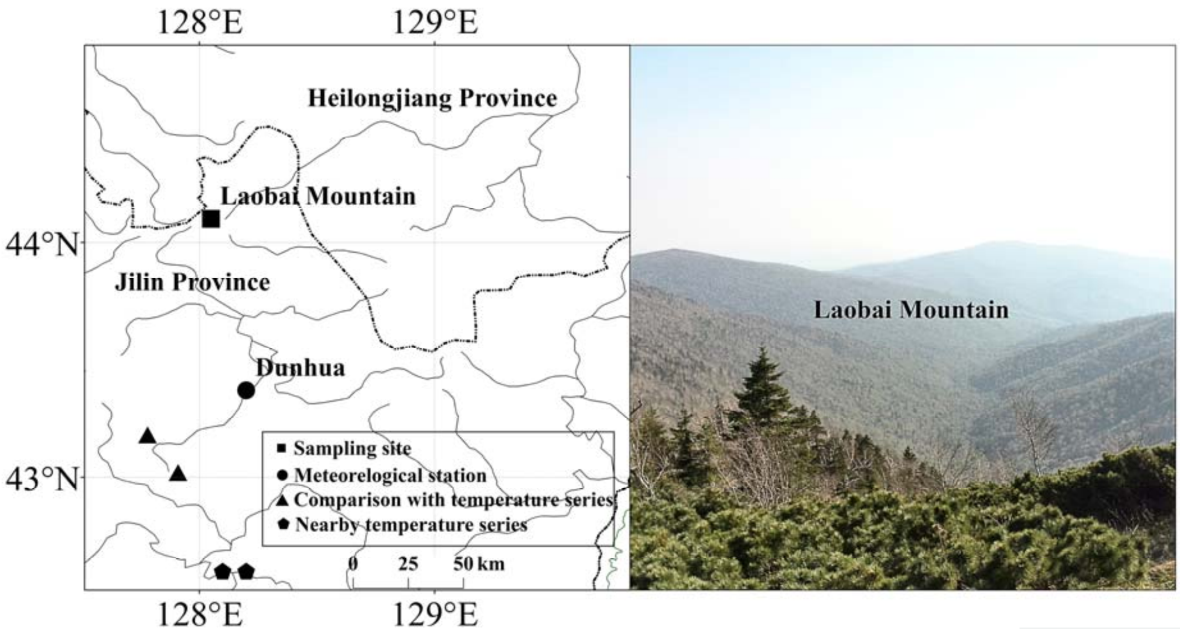

Fig. 2 Map of the sampling site, compared temperature series, nearly temperature series and meteorological station in northeastern China. The photo showed the sampled site in Laobai Mountain and the remarkable vertical vegetation distribution along altitude changes.

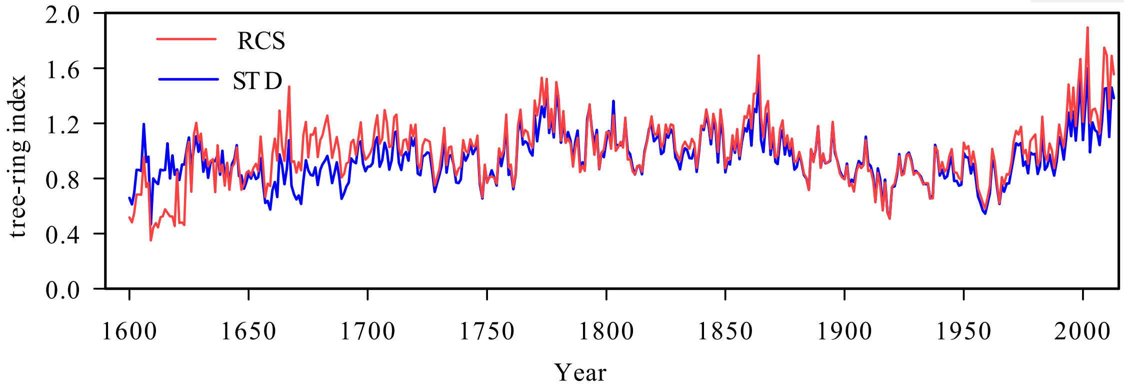

Fig. 3 Comparison of the STD and RCS chronologies in Laobai Mountains

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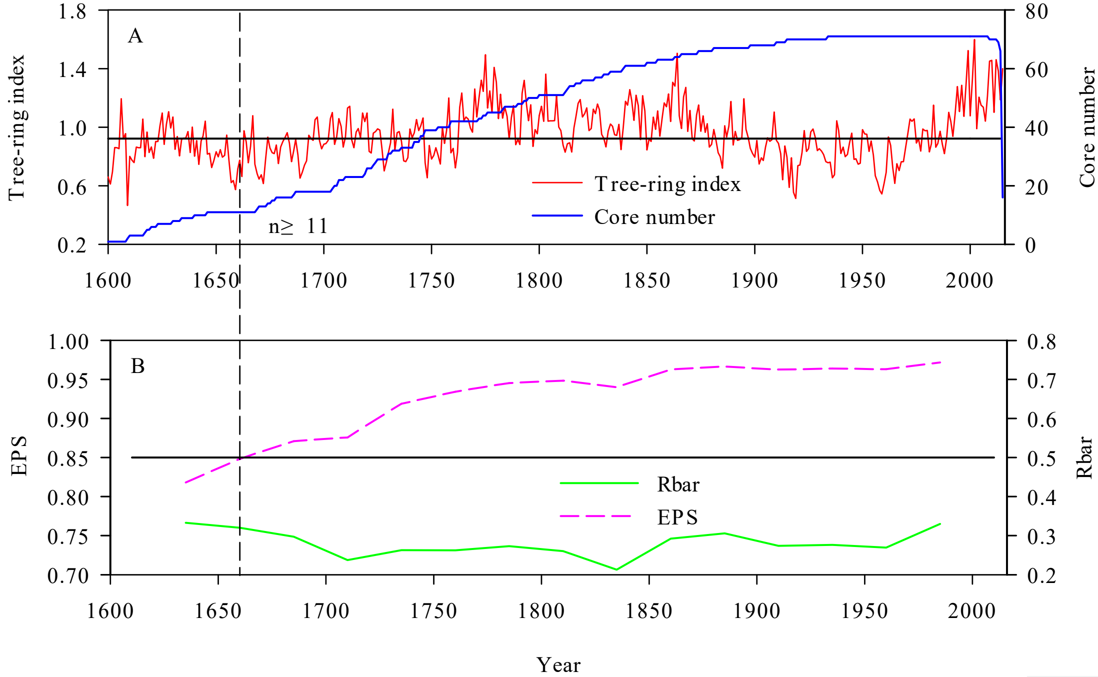

Fig. 4 Variations of (A) the STD chronology and sample depth, and (B) the expressed population signal (EPS) and average correlation between all series (Rbar) from 1600 to 2015.

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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).

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