

**Dear Dr. Nathalie and reviewers,**

Thank you for giving us a chance to revise our manuscript (cp-2018-31). We greatly appreciate the two anonymous reviewers and you for your valuable and helpful comments, which greatly improved the quality of our manuscript. All comments were fully accepted, and we have revised our manuscript according them. The point by point response to the reviewers' comments are in the following sections. The reviewers' comments are listed in blue, and our responses are in black. Thanks again for all your help in processing our manuscript.

Best wishes,

Xiaochun Wang

On behalf of the authors.

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## **Response to anonymous Referees**

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### **Anonymous Referee #1**

This manuscript presented 260-year PDSI reconstruction based on tree-ring record in the central Daxing'an Mountains, NE China. It is a necessary supplement of past climate proxy records in this area, especially for the annual drought reconstruction and its implication for different drought patterns in recent at the Daxing'an Mountains and Mongolian Plateaus (mild drier), NE Asia. Overall this manuscript is well-written, the work seems to be of high quality and is appropriate for Climate of the Past. Therefore, I would recommend this manuscript for publication in this Journal after the following issues are addressed.

C1. The manuscript will benefit from a last check by a native speaker. However, readability will improve quite a lot following the careful language check done by reviewer 2.

**Response: Fully accepted.** The MS will be revised by the native English speaker. We will go through the MS and make sure the language suitable for publish.

C2. The study shows the drought history of Daxing'an Mountains associated with the Pacific and Atlantic Ocean oscillations, while in the discussion section you linked both PDO and AMO to the Asia Monsoon. Is the PDO or AMO modifying the Asia Monsoon or the Asia Monsoon modifying the PDO? Please check it.

**Response: Fully accepted.** We have double check the describe. We make sure the PDO or AMO could modify the Asia Monsoon (Ma et al., 2007; Cook et al., 2010; Li et al., 2015; Linderholm et al., 2011; Sun et al., 2008; Chen et al., 2015; Bao et al., 2015).

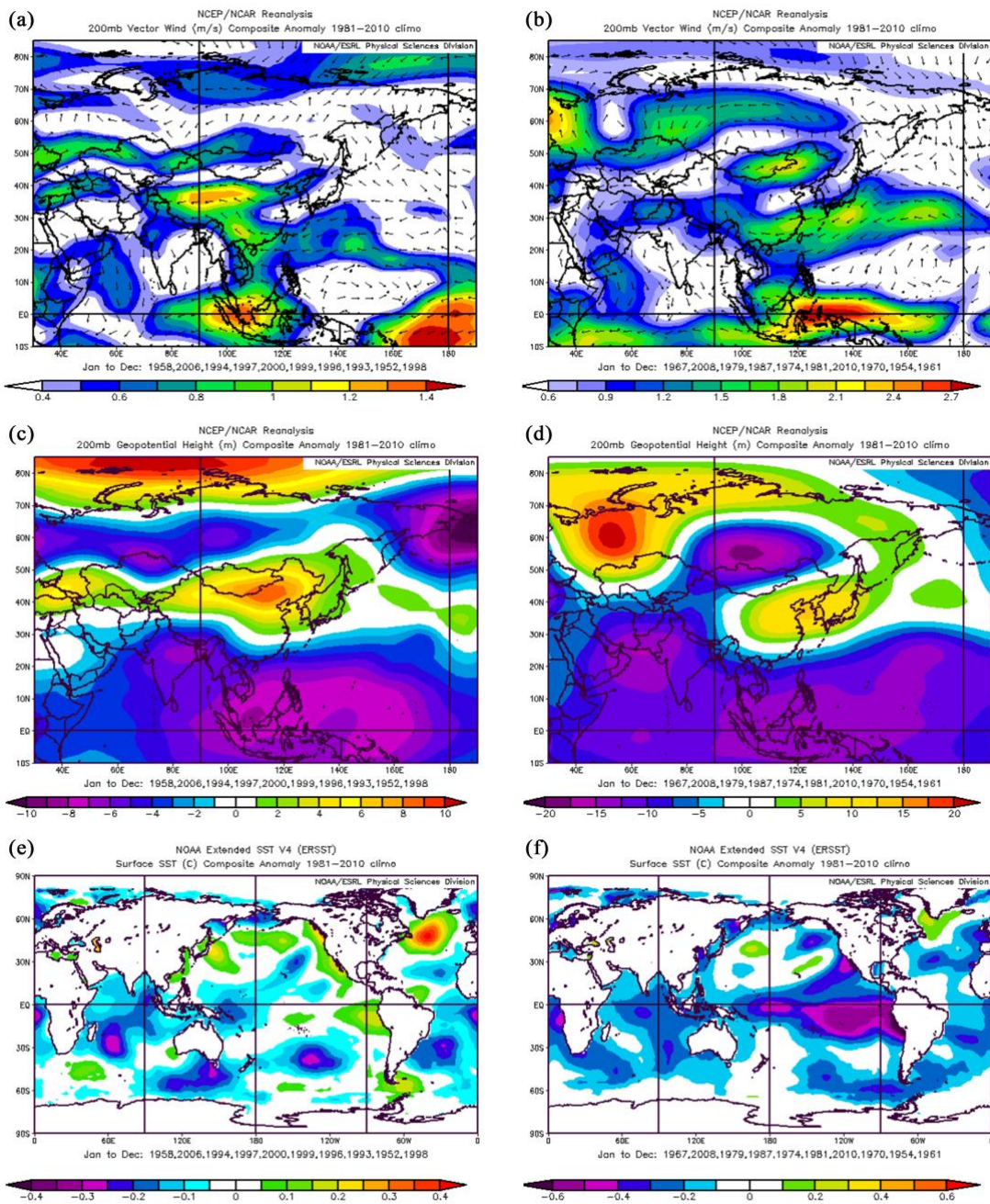
C3. In discussion section, the author thinks both the PDO and AMO have potential to drive or affect the Asian monsoon, which could affect the drought of NE China. Could you give some evidence to prove the Asia Monsoon influence the drought. It's better for you to give some evidence of climate dynamics to prove the mechanism.

**Response: Fully accepted.** We have added the composite anomaly maps of the 200-hPa vector wind and geopotential height, and the SSTs (from January to December) for the 10 wettest and 10 driest years for the Dai-PDSI reconstruction during the period 1948–2010. Some new explanations (following) of climate dynamics were added in discussion section.

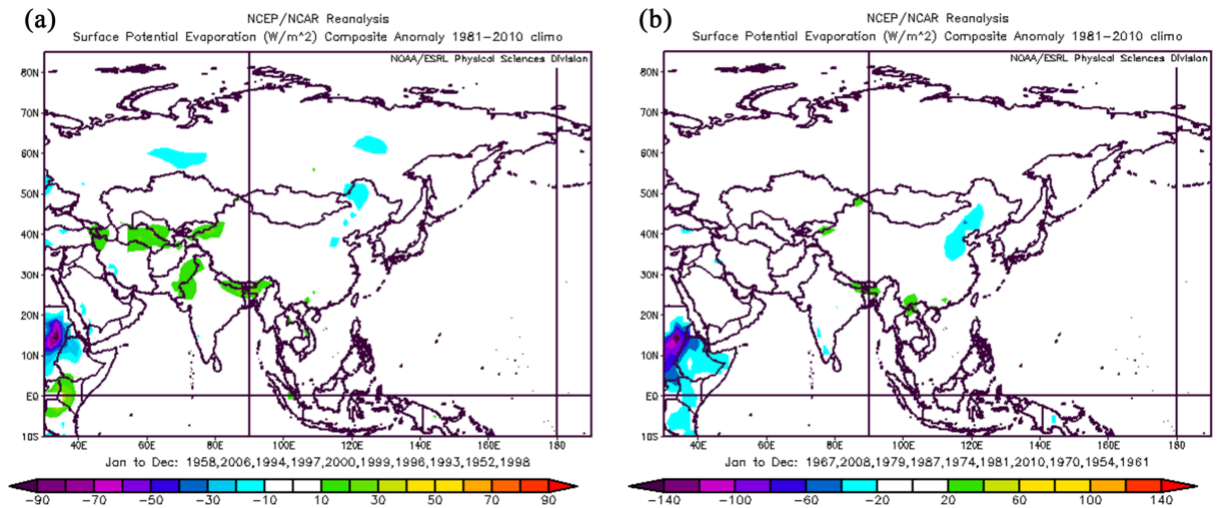
Previous studies have found that drought variation in northeast Asia may be associated with Asian monsoon activity (Bao et al., 2015; Chen et al., 2015; Cook et al., 2010; Li et al., 2015; Linderholm et al., 2011; Sun et al., 2008). In wet years, the strengthened southerlies and easterlies entered inland China associated with a positive pattern over northeast Asia and some negative height-anomaly centers in west Russia and south Asia as well as the Indian and north Pacific oceans, which strengthened the westerly circulation (Fig. 10a, c). In dry years, however, strengthened southerlies and south-westerlies entered northeast China associated with a positive pattern over east

Asia and western Russia, and some negative height-anomaly centers in southern Russia and south Asia as well as the Indian and south Pacific oceans (Fig. 10a, c).

The composite of 200-hPa geopotential height of the most humid 10 years (positive anomaly) in the central-north Daxing'an Mountains is opposite to that of the most arid 10 years (negative anomaly) (Fig. 10c, d). Positive and negative SST anomalies were also found in the western and northern Pacific Ocean during the wettest and driest years (Fig. 10e, f). In the wet years, abundant moisture is transported from the Pacific Ocean through Mongolian Plateau to the Daxing'an Mountains *via* the strong east Asian monsoon's southeasterly moisture flux joined with a strong Westerly circulation (Fig. 10a). This negative anomaly combined with positive SST in the western and northern Pacific Ocean lead to an enhanced dry jet (south-westerlies) across/toward the Daxing'an Mountains (Fig. 10b, c, e). Several studies have reported that the dry and wet variations in northeast Asia are strongly linked with the Asian monsoon and SSTs in the Pacific and Atlantic oceans (Bao et al., 2015; Chen et al., 2015; Cook et al., 2010; Li et al., 2015; Linderholm et al., 2011). In addition, the potential evaporation pattern in the Daxing'an Mountains is extremely low in the wettest years, and it also supports the above remote-connection assumptions (Fig. S4).



**Fig. 10** Composite anomaly maps of the 200-hPa vector wind and geopotential height, and the SSTs (from January to December) for the 10 wettest (a, b and e) and 10 driest (c, d and f) years of the Dai-PDSI reconstruction during the period 1948-2010.



**Fig. S4** Composite anomaly maps of the surface potential evaporation ( $W/m^2$ ) (from January to December) for the 10 wettest (a) and 10 driest (b) years for the Dai-PDSI reconstruction during the period 1948–2010.

C4. From the abstract and conclusion, the readers may feel this tree-ring-based PDSI reconstruction is about the whole region of Daxing'an Mountains, NE China. In fact, it's just a single site PDSI reconstruction. I suggest authors revise it, and specific the study area. For example, just use the central Daxing'an Mountains.

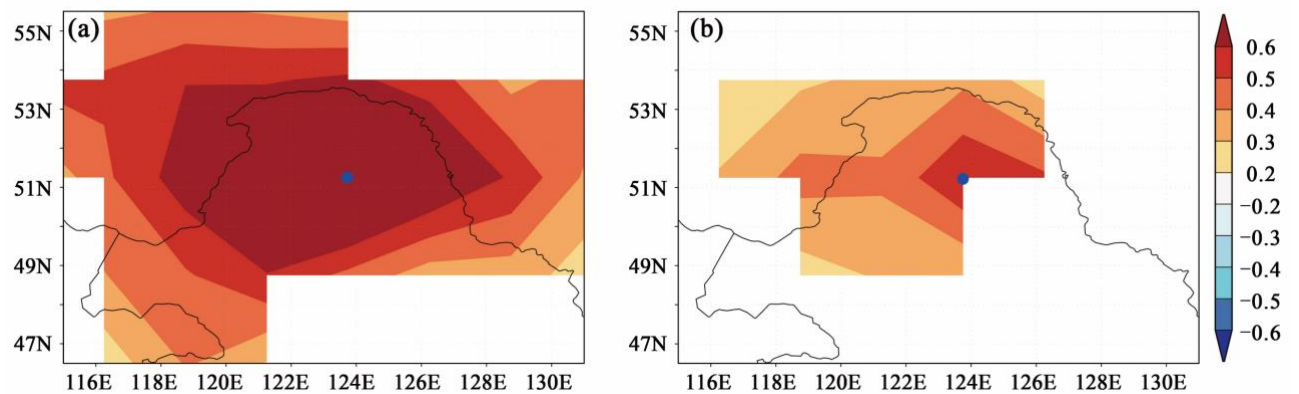
**Response: Fully accepted.** We have revised it.

C5. In figure 9a, the low frequency MADA series looks not match with its high frequency series. Please check it.

**Response:** we have double check the data. We make sure that it's right.

C6. It's hard to see the reconstruction point (red) in figure 6, please use different color.

**Response: Fully accepted.** We have changed the figure. The new figure is following:



**Fig. 5** Spatial correlation fields between (a) the instrumental and (b) reconstructed annual Dai-PDSI for the Daxing'an Mountains and the regional Dai-PDSI during the period 1911-2010 (<http://climexp.knmi.nl/>). The blue circle is the reconstructed PDSI grid.

C7. Seven tables and twelve figures in your MS, it's too many, some of them could be put in the supplementary materials but in the text.

**Response: Fully accepted.** We have moved some figures (figure 3, 8 and 11) and tables (Table 2) to the supplementary materials. Now only six tables and ten figures is left.

C8. For the mean correlation coefficient between all tree-ring series, use RBAR (in figure 3 and the text) or Rbar (in table 2), please keep it consistent.

**Response: Fully accepted.** Done.

C9. For the statistic coefficient of correlation, use “*R*” or “*r*”, please keep it consistent.

**Response: Fully accepted.** Done.

C10. References in text of the manuscript should be listed in chronological order.

**Response: Fully accepted.** Done.

C11. Line 48: delete “Therefore”.

**Response: Fully accepted.** Done.

C12. Line 214: replace “A” with “The”.

**Response: Fully accepted. Done.**

C13. Line 261: replace “: The” with “: the”.

**Response: Fully accepted. Done.**

C14. Line 273: delete “transitional”.

**Response: Fully accepted. Done.**

C15. Line 282: replace “by large-scale climate oscillation of the ENSO” with “by ENSO”.

**Response: Fully accepted. Done.**

## **Anonymous Referee #2**

General comments:

By compositing tree-ring width records from four sites in NE China, the authors have reconstructed a regional PDSI history of past 260 years, and find an increasing PDSI (decreasing drought stress) trend with a warming climate. The historical extreme dry/wet years were identified and discussed. This reconstruction was validated by other drought related reconstructions. The potential impacts of large-scale climate variability, such as AMO, PDO, ENSO etc. were tested by correlation analysis.

The long-term regional moisture history is valuable for understanding the response of moisture variability to a warming climate. However, high quality PDSI reconstruction is still lacking in NE China. The PDSI reconstruction present in this study is based on sufficient tree-ring with data which are produced by standard dendrochronology procedure. The reconstruction results could provide an important insight into the driving mechanisms of PDSI variability of past centuries.

The language of this manuscript needs to be largely improved by native speakers or by professional editing service. I suggest this MS being accepted by CP if the coauthors can address all reviews' concerns and taking into account of comments in CPD (if they are reasonable)

**Response: Fully accepted.** The third coauthor (David Cooper) of this MS is a native English speaker. He has gone through the MS and improved the language.

Specific comments:

Lines 9-10: “our reconstruction is accurate and representative, and recorded the same dry years/periods” Does it mean your reconstruction is more accurate and representative than previous ones? If yes, this statement is supported by a more coherence of your reconstruction (than previous ones) with historical documents and fire history?

**Response: Fully accepted.** We have revised it as: Our reconstruction is coherence with local historical documents and other nearby hydroclimate reconstructions.

Line 27 preserved should be replaced by recorded?

**Response: Fully accepted.** Done.

Line 33 producing should be leading to?

**Response: Fully accepted.** Done.

Line 40-41 should be improved as: 81 million people and more than 720,000 farmland hectares were suffered from water shortage

**Response: Fully accepted.** Done.

Line 42-45 River cannot on fire, I think you are referring to the Daxing'anling forest fire in May 1987 of Heilongjiang Province, please improve this part correspondingly.

**Response:** we accepted. We have revised it as: In addition, drought is in favor the occurrence of large wildfires, and the drought of Daxing'an Mountains especially in spring and summer is often accompanied by high risk of forest wildfire disasters and (Sun 2007). For example, the forest fire in May 1987 killed over 200 people and burned ~73,000 km<sup>2</sup> (Sun 2007; Yao et al. 2017).

Line 46-48 This part could be improved as: In order to better character current and project future drought conditions, an improved understanding of past drought variabilities and potential forcing mechanisms is required. However, the short



meteorological records of Daxing'an Mountains since the 1950s has limited the understanding of drought history at long- time spectrum.

**Response: Fully accepted.** Done.

Line 48 remove Therefore

**Response: Fully accepted.** Done.

Line 48 provide should be serve as

**Response: Fully accepted.** Done.

Line 52 could improve as: monsoon Asia using 327 tree-ring width chronologies

**Response: Fully accepted.** Done.

Line 53 could improve as: some disagreements between the MADA results and tree-ring-based local drought reconstructions or instrumental drought data, especially in eastern Asia, which might due to an insufficient tree-ring network used by MADA (Li et al. 2015; Liu et al. 2016).

**Response: Fully accepted.** Done.

Line 66 farther should be further?

**Response: Fully accepted.** Done.

Line 67 should be clarified

**Response: Fully accepted.** Done.

Line 70 high-latitude forested portion should be high-latitude forests

**Response: Fully accepted.** Done.

Line 73 remove extreme

**Response: Fully accepted.** Done.

Line 111 should be improved as: Pearson correlation analysis was conducted to estimate climate–tree growth relationships

**Response: Fully accepted.** Done.

Line 112 should be improved as: The gridded climate dataset is much longer and has higher homogeneity and coherency than station data.

**Response: Fully accepted.** Done.

Line 115-116 remove “, a most commonly used drought index,”

**Response: Fully accepted.** Done.

Line 146 you should specify here which “large-scale climate” indexes are tested

**Response: Fully accepted.** Done.

Line 162 is it ok to substitute “PDSI data among the annual, seasonal or individual month scales” with all seasonal PDSI compositions?

**Response: Fully accepted.** Done.

Line 166-167 is it ok to replace “The regression model between the tree-ring indices (predictors) and annual PDSI (predicted) for the calibration period was as follows” with the linear model for PDSI reconstruction is?

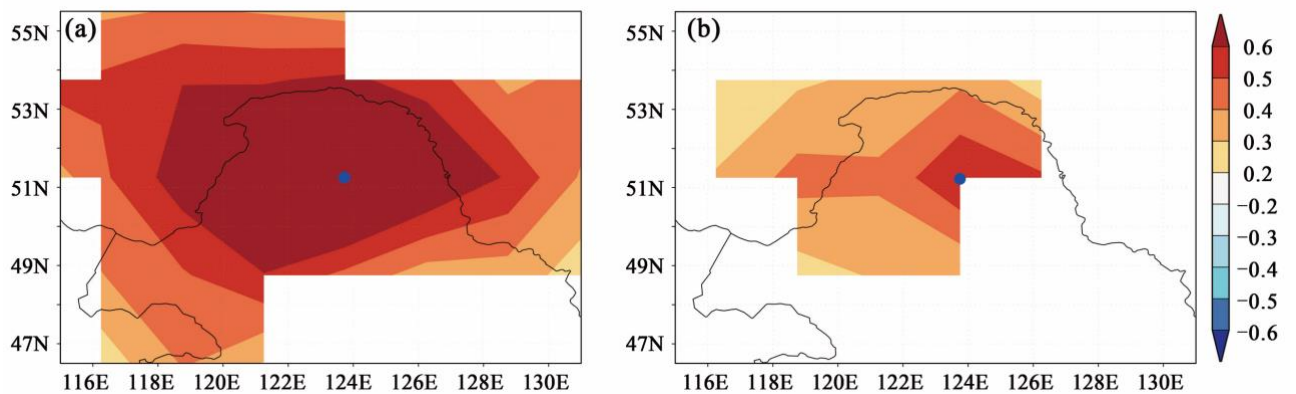
**Response: Fully accepted.** Done.

Line 171 please replace “actual” and “estimated” with instrumental and reconstructed throughout this manuscript

**Response: Fully accepted.** Done.

Line 173-174 is figure 6a a correlation between one PDSI index with another PDSI index? I think figure 6a and 6b could be replace a spatial correlation map between PDSI reconstruction and dai-PDSI.

**Response: Fully accepted.** We have changed figure 6.



**Fig. 5** Spatial correlation fields between (a) the instrumental and (b) reconstructed annual Dai-PDSI for the Daxing'an Mountains and the regional Dai-PDSI during the period 1911-2010 (<http://climexp.knmi.nl/>). The blue circle is the reconstructed PDSI grid.

Line175 please specify which two calibration periods.

**Response: Fully accepted.** Done.

Line175-178 please move this section after “is the tree- ring index at year t.” of line 169, and add a sentence at the end of this paragraph, such as: suggesting this linear model is robust for PDSI reconstruction.

**Response: Fully accepted.** Done.

Line 170-174 should be another paragraph after “suggesting this linear model is robust for PDSI reconstruction”

**Response: Fully accepted.** Done.

Line 179 please replace “Drought-wet variations” with historical PDSI variability

**Response: Fully accepted.** Done.

Line 188 replace greatest with greater

**Response: Fully accepted.** Done.

Line 191 and 193 Table 5 only show the individual dry/wet years, consecutive dry/wet periods were absented in Table 5, is that right?

**Response: Fully accepted.** In fact, the consecutive dry/wet periods were shown in Table 6. We have revised it in the text.

Line 196 replace “the dry and wet variations” with “historical PDSI variability”.

**Response: Fully accepted.** Done.

Line 202-203 replace “main climate limitation for its radial growth” with “main climate factor limiting its radial growth”.

**Response: Fully accepted.** Done.

Line 218-219 this section is not clear so far. Is it possible that the positive correlation of tree growth and winter temperature could arise from less frost damage if the winter temperature is higher? Is Scots pine in your study an evergreen tree species? If yes, the positive correlation of tree growth and winter temperature could also because higher winter photosynthetic rates and more photosynthetic products stored if temperature is high in winter, these photosynthetic products will be used for tree growth in summer of next year (storage effect). The positive correlation with spring temperature could due to earlier and larger snow melting which supplies the spring soil water, and eventually stimulated tree growth? Anyway, this section should be improved accordingly.

**Response: Fully accepted.** we have revised this section according you comment: On the contrary, a significant positive response of radial growth to non-growing season temperature was found. It is possible that higher winter photosynthetic rates and more photosynthetic products stored in warm winter could be used for tree growth in summer of next year (storage effect), and higher winter temperature could also arise from less frost damage; the positive correlation with spring temperature could due to earlier and larger snow melting which supplies the spring soil water, and eventually stimulated tree growth (Holleisen et al. 2015; Zhu et al. 2017).

Line 225-226 is the “local historical record” and “historical documents” have been specified in the Data and Methods part? Since I can’t find them before section 4.2.

**Response: Fully accepted.** We added the description of those data in the Methods section: Local historical drought data recorded in book “Meteorological disasters

dictionary of China” (Shen 2008; Sun 2007) were used to verify our PDSI reconstruction.

Line 234 Are PDSI reconstructions in Mengkeshan and Pangu from your data, or previous studies of other people? If they are from previous studies outside your sampling region, is it possible to do the same SEA analysis with your own data of this study?

**Response:** In fact, the data in Mengkeshan and Pangu which were used for SEA analysis are the forest fire event data. The fire event data were reconstructed by fire scars (Yao *et al.*, 2017). Forest fires usually occur in dry years, so the occurrence of forest fires can reflect drought events from the side. The SEA analysis between forest fire history and reconstructed drought variables could further validate the accuracy of our reconstruction.

Line 243-253 I agree with you that Cook’s MADA reconstruction is inaccurate and sometime useless in regions with no or a few tree-ring data, such as your study region.

**Response:** Although, the divergence of between the MADA and individual tree-ring-based drought reconstruction has been found in some studies (Li *et al.*, 2015; Liu *et al.*, 2016; and this study), more evidence still need to be found.