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Climate of the Past Discussions

Interactive comment on "Reconstruction of the March–August PDSI since 1703 AD based on tree rings of Chinese pine (*Pinus tabulaeformis* Carr.) in the Lingkong Mountain, southeast Chinese loess Plateau" *by* Q. Cai et al.

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Anonymous Referee #1 Received and published: 11 December 2013

The Chinese Loess Plateau is an interesting area for climate change studies. In particular, the hydroclimatatic conditions in the Loess Plateau are very sensitive to climate change. Normally, it is very difficult to find trees more than 200 years due to

severe human disturbances. This manuscript made a 300-year PDSI reconstruction in the southeast Loess Plateau, showing up-to-date understanding of drought variations. This manuscript is based on standard dendrochronological methods. In general, it is well presented. I recommend its acceptance after a median revision.

Comments: 1. In the end of the Introduction, it is better to pose a hypothesis or question, proving a clue for presenting results and discussions. For example, the authors may have one question: whether did the drought severity or frequency increase in response to the warming? But, this is just one example. The authors may propose other questions.

Answer: we have posed two scientific questions at the end of the introduction and answered these questions in the revised manuscript as follows:

Questions: Results of this work would be conducive to answer the following two questions: Whether did the drought severity or frequency increase in response to the global warming? Whether the drought condition nowadays in Lingkong Mountain is unprecedented during the last three centuries?

Answers: It's visible that the severity and duration of dry or wet events seemingly strengthened after 1800 AD compared with the earlier stages, possibly due to the impact of global warming. Even so, the recent drought in 1993-2008 was still within the historical framework.

2. The authors should introduce some basic information about cambial activity of Chinese pine. Such information will be useful for explaining tree growth-climate relationships.

Answer: We added a new section in the fourth part of "Discussion" as 4.1 "Climate-growth relationship" (see following), answering both this question, the 7th question of Referee #2 and 6th question of Reviewer#3. The series numbers of the following parts in the original manuscript were according changed.

4.1 Climate-growth relationship

Lingkong Mountain belongs to the semi-arid area where annual evaporation is more than twice of annual precipitation. High precipitation during the growth season actually benefits the radial growth of tree by providing necessary water for the radial cell division and elongation, while low precipitation limited the radial growth. Inversely, increased temperature before and during the growth season inevitably strengthen the water stress by accelerating water consumption in the soil and trees through evaporation and transpiration, resulting in the formation of narrow rings, and vice versa. Reasonably, positive correlation of tree rings with monthly precipitation and negative correlations with monthly mean temperature in current growth year was identified in this study, and this climate-growth pattern was generally reported in the arid to semi-arid CLP (Gao et al., 2005; Liu et al., 2005; Cai and Liu, 2013) and other areas of northern China (Liang et al., 2007).

In the present work, monthly mean temperature from March to August exerts more important influences upon tree growth than monthly precipitation (Fig. 4), which is similar to studies in the Kongtong Mountain (Fang et al., 2012), Guiqing Mountian (Fang et al., 2010a) and the Ortindag Sand Land (Liang et al., 2007), showing the temperature-induced water stress was likely the key factor limiting tree growth. The correlation analysis between PDSI and tree-ring chronology further tested the above hypothesis. Significant correlation is identified from March to August, especially significant in May and June when the temperature is comparatively high and precipitation is very low (Fig. 2), indicating an intensified drought stress. PDSI is a measurement of dryness which was calculated based on a water balance equation, depending on not only temperature and precipitation, but also other parameters such as evapotranspiration and recharge rates. Thus, it's unsurprised that the monthly PDSI of previous year had significant influence on tree growth due to the well-known lag effect, though climatic factors in previous year (except the precipitation of September) showed weak correlation with tree growth.

Interestingly, the period of limiting months coincided with the results of cambial activity of trees in northern China. Tree-ring anatomical analysis disclosed that the radial wood formation of Chinese pine usually started at the end of April (Zhang et al., 1982), and fast growth usually happened from May to August (Zhang et al., 1982; Liang et al., 2009). Similar finding was reported from Larixprincipis-rupprechtii, a different coniferous species from Liupan Mountain, north-central China (Guan et al., 2007). Location of our studied sites is far south than the above reported sites, and it's warmer and wetter, therefore, it's possible that the radial growth of tree in Lingkong Mountain may start earlier.

3. The third site only includes eight cores from four trees. The author should explain why only four trees were selected. Normally, more trees are necessary for the analysis.

Answer: At the third site, trees older than 100 yr are very difficult to find, so only eight cores from four old healthy trees were collected. We explained it in the revised manuscript.

4. In this study of Lingkong Mountain, the year 1721 was identified as the third driest years, and 1719–1726 was identified as one of the dry periods during the past 306 yr. It is interesting to show this dry period. However, it is necessary for the authors to find historical documents to confirm this event and the story behind it.

Answer: We added historical documents to confirm the 1719-1726 dry event as follows:

1721 was documented as an extremely dry year in the whole region of Shaanxi province, a neighbor hood of Lingkong Mountain (Yuan, 1994). In this year, the farmers reaped nothing at harvest time due to low precipitation in spring and summer, and many people died of starvation due to this drought-induced famine. By analyzing historical documents of eastern China, Zhang (2004) identified 1721-1723 as one of the tenth typical dry period during the last 1000 yr. This drought event affected at least four provinces in eastern China, including our studied area.

5. “Possible linkage with ENSO and solar activity”. Apart from frequency analysis, more analysis is necessary to support the linkage between the drought variation and ENSO/solar activity. For example, the ENSO index can be used.

Answer: We deleted the discussion between PDSI and ENSO and changed the title of this part to “4.4 Possible linkage with summer Asian-Pacific oscillation and solar activity” for two reasons: 1) Though similar 2-7 yr cycles existed in the PDSI reconstruction and ENSO series, spatial correlations didn’t disclose significant correlations between the PDSI reconstruction and the SST of middle-east equator Pacific Ocean. So we should be cautious to explain the 2-7 yr cycles; 2) we found that the 2-7 year cycles also existed in the IAPO series (Chen et al., 2011b), and the PDSI reconstruction significantly correlated with IAPO series (an indicator of EASM strength), which suggested that our reconstructed PDSI variation was influenced by the large-scale land–ocean–atmospheric circulation systems. So we finally adjusted the interpretation of the 2-7 yr cycles, and moved the content related with IAPO to this part. Please see the revised manuscript.

Sunspots are temporary phenomena on the photosphere of the sun that appear visibly as dark spots compared to surrounding regions. It is one of the most basic and obvious phenomenon of solar activity. To further study the influence of solar activity on the drought conditions in Lingkong Mountain, the sunspot time series from 1700 to 2009 were derived from National Geophysical Data Center (http://www.ngdc.noaa.gov/) to compare with our PDSI reconstruction. The low-frequency variations of the two series, after 11 yr and 35 yr smoothing, significantly correlated with each other, r = 0.35 p<0.01) and 0.68 (p<0.01), respectively. As shown in Fig. 9b, dry conditions in the studied sites appeared when the sunspot numbers were low, and the contrary when the sunspot numbers were high. This convincingly supported that the dry/wet conditions in the Lingkong Mountain strongly response to the solar activity.

6. It is necessary to use RE and CE to show the quality of calibration/verification.

Answer: Ok, we used split calibration-verification method to test the regression model, instead of leave-one-out method. Statistics such as R2, RE and CE were given. Please see the following part and corresponding content in the new version:

The fidelity of the reconstruction was verified by comparison with the Dai-PDSI data and checked by the split calibration–verification method (Meko and Graybill, 1995). Result of the split period calibration-verification test showed that the regression model is stable over time. The explained variance (R2) for the verification period 1983-2005 was 52.1%, and reduction of error (RE) and coefficient of efficiency (CE) were 0.603 and 0.375, respectively, when the data during 1954-1982 was used to establish the regression model. R2, RE and CE were 32.3%, 0.411 and 0.113, respectively for the verification period 1954-1973, when data during 1974-2005 was chosen as calibration. RE and CE, the two rigorous verification statistics during verification periods showed positive values, indicating sufficient similarity exists between the reconstruction and Dai-PDSI data (Cook et al., 1999).

7. Table 1 can be deleted and add one sentence in the text.

Answer: Table 1 has been deleted, and the series numbers of following “Tables” were correspondingly changed. We used split calibration-verification method to test the regression model, instead of leave-one-out method, statistics such as R2, RE and CE were given in the text.

8. Table 3, all drought periods are indicated in a figure and it is not necessary to repeat them in a table.

Answer: Table 3 (Table 2 in the revised manuscript) showed the exact time of dry/wet periods in our reconstruction, we thought it’s very useful for researchers who want to make comparison with our PDSI reconstruction in the future. So we prefer to keep it in the text.

9. PDSI is not measured. Instead, the authors can use Dai-PDSI in Fig. 5 and the text.

Answer: We've made such adjustment.

10. It is interesting to show the linkage between the reconstructed PDSI and the summer IAPO. A deeper analysis about the mechanism between them is necessary.

Answer: We added such analysis in the revised manuscript. See the following part and corresponding content in the text:

Theoretically, on the decadal scale rather than the annual scale, when IAPO was in stronger stages, the thermal contrast between eastern Asia and the North Pacific was strengthened because the low-pressure system of lower-troposphere over eastern Asia strengthens, and the western Pacific subtropical high strengthens with its location shifting northwards (Zhao et al., 2007, 2008). Therefore, lower-troposphere of the East Asian region was dominated by stronger southwesterly winds, in other words, stronger EASM, resulting in more rainfall and wet condition in North China, and vice versa.

Please also note the supplement to this comment:
http://www.clim-past-discuss.net/9/C3237/2014/cpd-9-C3237-2014-supplement.pdf

Interactive comment on Clim. Past Discuss., 9, 6311, 2013.

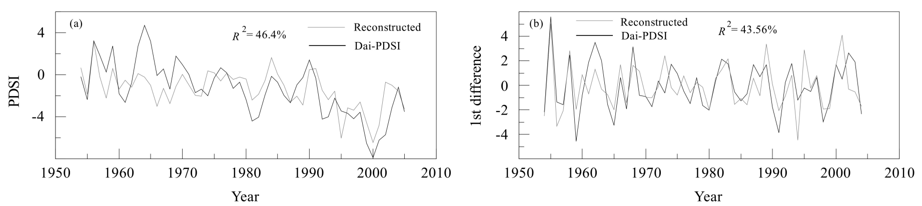

Fig. 5

Fig. 1. Figure 5

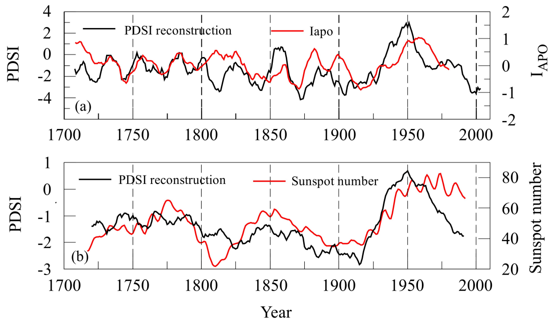

Fig. 9

Fig. 2. Figure 9