Dear Prof. Hans Linderholm,

We really appreciate your comments and suggestion on our paper "**A 424-year tree-ring based PDSI reconstruction of *Cedrus deodara* D. Don from Chitral HinduKush Range of Pakistan: linkages to the ocean oscillations**" (cp-2019). We have revised our manuscript according to your comments. In following page, you can find the response to your questions. Your comments are listed in black, and our response are in blue. Thank you for all your help in processing our manuscript. We are looking forward to hearing from you soon.

Best wishes,

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On behalf of all co-authors
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Recommendations:

The language needs to be thoroughly revised. I have started making some changes in the attached pdf, but I don't have the time to check the entire manuscript, and this must be done throughout. Maybe you should contact a language editing service with scientific competence?

Response: Fully accepted. The language has been edited by the Elsevier Language Editing Services. The editing certificate was attached.

Line 53 ff.: You should briefly describe the association between precipitation and large-scale atmospheric (ocean) circulation patterns in northern Pakistan and you need references using observations or climate models rather than proxy data to substantiate the claim.

Response: Fully accepted. The South Asian summer monsoon (SASM) is an integral component of the global climate system (Cook et al., 2010). Owing to the annually recurring nature of the SASM, it is a significant source of moisture to the subcontinent and to surrounding areas such as northern Pakistan (Betzler et al., 2016). The active phase of the monsoon includes extreme precipitation in the form of floods and heavy snowfall, while the break phase mostly appears in the form of drought, thereby creating water scarcity. The active/break phases of the monsoon are also concurrent with El Niño-Southern Oscillation (ENSO) and land-sea thermal contrast (Xu et al., 2018; Sinha et al., 2007, 2011). The large-scale variability in sea surface temperature (SST) is induced in the form of Atlantic Multidecadal Oscillation (AMO), Pacific Decadal Oscillation (PDO), and some external forcing, i.e., volcanic eruption and greenhouse gases (Malik et al., 2017; Wei and Lohmann, 2012; Goodman et al., 2005).

Line 78 ff.: You need to provide some more information on dendroclimatological research in Pakistan as I'm sure that more has been done than Treydte et al. 2006 and Khan et al. 2019 (which is not in the reference list).

Response: **Fully accepted.** Before 2010, there are few tree-ring studies in Pakistan. Bilham et al. (1983) found that tree rings of *Juniper* trees from the Sir Sar Range in the Karakoram have the potential to reconstruct past climate. Esper et al. (1995) developed a 1000-year tree-ring chronology at the timberline of Karakorum and found that temperature and rainfall are both controlling factors of *Juniper* growth. More Juniper tree-ring chronologies were developed at the upper timberline in the Karakorum (Esper, 2000; Esper et al., 2001; Esper et al., 2002). *Abies pindrow* and *Picea smithiana* were also used for dendroclimatic investigation in Pakistan (Ahmed et al., 2009; Ahmed et al, 2010). Recently, more studies on tree-rings research have been carried out in Pakistan (Ahmed et al., 2010; Ahmed et al., 2011; Khan et al., 2013; Akbar et al., 2014; Asad et al., 2017a; 2014; Asad et al., 2017b; Asad et al., 2018; Shad et al., 2019), but few have used tree rings to reconstruct the past climate, especially the drought index.

Line 87: How can tree-rings be used to forecasting future climate?

Response: It is very few, but do have. Modeling the relationship between tree rings and climate to predict future climate change. A reference (Liu et al., 2004) was added.

Liu, Y., Shishov, V., Shi, J., Vaganov, E., Sun, J., Cai, Q., Djanseitov, I., and An, Z.: The forecast of seasonal precipitation trend at the north Helan Mountain and Baiyinaobao regions, Inner Mongolia for the next 20 years, Chinese Science Bulletin, 49, 410-415, 2004.

Line 108: The sampling site needs to be better described: elevation, aspect, stand density, ground vegetation etc.

Response: **Fully accepted.** The elevation of the study area ranges from 1070 to 7708 m, with an average elevation of 3500 m. The sampled Jigja site is located in the east slope of the mountain.

The stand density is relatively uniform with the dominant species. Among the tree species, *Cedrus deodara* is the most abundant, with 156 individuals' hm^{-2} and basal area of 27 m^2 hm^{-2}. The Chitral forest is mainly composed of *C. deodara*, *Juglans regia*, *Juniperus excelsa*, *Quercus incana*, *Quercus dilatata*, *Quercus baloot*, and *Pinus wallichiana*. *C. deodara* was selected for sampling because of its high dendroclimatic value (Khan et al., 2013). The soil at our sampling sites was acidic, with little variation within a stand of forest. Similarly, the soil water holding capacity ranged from 47%±2.4% to 62%±4.6% while the soil moisture ranged from 28%±0.57% to 57%±0.49% (Khan et al., 2010).

Line 140: What do you mean by "All false one has been modified…"? Modified in what way? How many false rings were encountered (i.e. were they usual?)?

Response: The false one means the tree-ring series with error prompt in the test of COFECHA program. We checked them and revised the errors. So, the false one was not the actual false ring. There are do some false rings, but they are normal, mostly in the latewood.

Line 187: Can you confirm that the EPS is calculated on trees rather than cores? Looking at the tree-ring width chronology, the variance changes considerably back in time. How can this be explained?

Response: Yes, we confirm that the EPS is calculated on tree. However, the number of trees is the same as that of the cores because we took one core per tree. Yes, if directly seen from the figure, it seems that the variance decreases back in time. This may be due to the increase of abnormal dry and wet years after 1900 (Duan et al., 2020), similar phenomena also appeared in the series of Treydte et al. (2006).

Duan, J., Wu, P., Ma, Z., and Duan, Y.: Unprecedented recent late-summer warm extremes recorded in tree-ring density on Tibetan Plateau, Environmental Research Letters, 15, 024006.

Line 213-216: Move to method part, not a result.

Response: Fully accepted. It has been moved to method part.

Line 263: I assume that you mean pointer years, and these actually include both the most narrow and wide rings. Thus, it would be good to show and discuss also very wet years.

Response: Fully accepted. Similarly, the seventeen wettest years found that has been observed from wide rings in the year of 2010, 2009, 2007, 1998, 1997, 1996, 1993, 1931, 1924, 1923, 1908, 1696, 1693, 1691, 1690, 1689, and 1688.

The wet years of 1997, 1996, 1993, 1696, 1693, 1691, 1690, 1689 and 1688 are in agreements with the results of Khan et al., (2019). Similarly the wet years of 1923, 1924, 1988, 2007, 2009 and 2010 coincide with results of Chen et al., (2019) reconstruction.

Line 276: Good discussion, but It almost seems like there are two different chronologies that are combined, with large variance from 1900 until now, and much less before that. I think you need to consider this, and provide as much information on the tree-ring data as possible (see above), including if the trees were all living, if they were sampled at different elevations/environments etc. Does this agree with other drought reconstructions from central Eurasia?

Response: We compared this reconstruction with tree-ring-based reconstructions of drought and precipitation from central Eurasia and China, which were adjacent to the northern areas, to test coherency for drought periods, but none of them matched perfectly. The dry periods of our reconstruction showed resemblance with certain periods of 1629–1645 and 1919–1933 of Sun and Liu (2019) reconstruction, while we found more consistent drought periods with He et al.'s (2018) May–June reconstruction from the south-central Tibetan Plateau for 1593–1598 (1580–1598), 1647–1660 (1650–1691), 1785–1800 (1782–1807), and 1870–1878 (1867–1982). The discrepancy might have been caused by the differences in precipitation, geography, species, and reconstruction indexes, among other reasons (Gaire et al., 2019).

It would be informative to compare the reconstructions mentioned in line 286 ff. to yours, as well as indicating the historical droughts mentioned in the text in a figure. I'm pretty sure that you would be able to get hold of those reconstructions.

Response: **Fully accepted.** Our reconstruction featured nine dry and eight wet periods of 1593–1598, 1602–1608, 1631–1645, 1647–1660, 1756–1765, 1785–1800, 1870–1878, 1917–1923, and 1981–1995 and 1663–1675, 1687–1708, 1771–1773, 1806–1814, 1844–1852, 1932–1935, 1965–1969, and 1990–1999, respectively. The dry periods of 1598–1612, 1638–1654, 1753–1761, 1777–1793, and 1960–1985 and the wet periods of 1655–1672, 1681–1696, 1933–1959, and 1762–1776 coincided with that reconstructed by Chen et al. (2019) in northern Tajikistan. The most serious drought in 1871, 1881, and 1931, and the short-term drought from 2000 to 2002 mentioned by Ahmed et al. (2004) were also found to be very dry in our reconstruction.

It would make sense to have all discussion related to the drivers of droughts separated from the comparison between reconstructions. Thus, I suggest moving the sentence in line 293 as well as the short mention of volcanic influences (which could be expanded)

Response: **Fully accepted.** The sentence in line 293 and the short mention of volcanic influences were removed.

The paragraph regarding the comparison with the Treydte data is a bit confusing, both stating that there is a "strong consistency" and then providing several reasons for why the two records disagree. Maybe it will become a bit clearer if you turn either of the records as suggested above.

Response: **Fully accepted.** Here, the lack of discrepancies means that discrepancies exist with some periods, while in this sentence "In addition, the lack of consistency between different data sets or regions may be due to the dominance of internal climate variability over the impact of natural exogenous forcing conditions on multi-decadal timescales (Bothe et al., 2019)", describing the lack of consistency with the overall differences with other reconstructions. This sentence has been moved to the end of paragraph now.

The discussion regarding the influence of ENSO is very confusing. What do you mean by "The spatial correlation exhibited the significant similarity of El Niño-Southern Oscillation (ENSO) in the region"? The whole section is very speculative, and why not compare the reconstruction with an ENSO record (or at least look into the possible association between droughts/pluvials and El Niño/La Niña years etc.?). Also, while utilising climate explorer, you could see if there are any correlations between drought in N Pakistan and SST in the e.g. Niño 4 region (removing the trends first).There indeed seems to be some connection with AMO, but it would be interesting to see if there are any connections to more close oceans, like the Indian Ocean or the Pacific (which you already hit on regarding ENSO).

Response: **Fully accepted.** The sentence "The spatial correlation exhibited the significant similarity of El Niño-Southern Oscillation (ENSO) in the region" was removed. The correlations between the reconstruction and the ENSO index series (Table 2) and SST field (Fig. 10) were added, and this discussion was revised.

The high frequency of the drought cycle (2.1–3.3 y) may be related to ENSO (van Oldenborgh and Burgers, 2005). The ENSO index in different equator Pacific regions has a significant positive correlation with our reconstructed drought index with a lag of 8 months (Table 2 and Fig. 10), so it further indicated that the water availability in this area may be related to large-scale climate oscillations. There is a lag effect of ENSO on drought in the study area, the lag time is about 4-11 months. The lags in the ENSO impact are very complex and different in different regions (Vicente-Serrano et al., 2011). Therefore, the decrease of drought in our study area may be linked to the enhancement of ENSO activity. However, Khan et al. (2014) showed that most of northern Pakistan is in the monsoon shadow zone, and the Asian monsoon showed an overall weak trend in recent decades (Wang and Ding, 2006; Ding et al., 2008). Previous studies (Wang et al., 2006; Palmer et al., 2015; Shi et al., 2018; Chen et al., 2019) have confirmed that ENSO is an important factor regulating the hydrological conditions related to the AMO. In the past, severe famine and drought occurred simultaneously with the warm phase of ENSO, and these events were related to the failure of the Indian summer monsoon (Shi et al., 2014).

Table 2. Correlation coefficients (*r*) and *p* value between monthly ENSO index and reconstructed PDSI with a lag of 8 months calculated by the KNMI Climate Explorer.

PDSI Month	ENSO Month	NINO3		NINO3.4		NINO4	
		r	*p*	*r*	*p*	*r*	*p*
Jan	May	0.19	0.0445	0.21	0.0270	0.26	0.0063
Feb	Jun	0.23	0.0156	0.26	0.0053	0.28	0.0028
Mar	**Jul**	**0.25**	**0.0094**	**0.28**	**0.0030**	**0.27**	**0.0043**
Apr	**Aug**	**0.22**	**0.0226**	**0.25**	**0.0083**	**0.26**	**0.0087**
May	**Sep**	**0.22**	**0.0202**	**0.26**	**0.0074**	**0.28**	**0.0045**
Jun	**Oct**	**0.18**	**0.0599**	**0.24**	**0.0117**	**0.29**	**0.0033**
Jul	**Nov**	**0.19**	**0.0488**	**0.25**	**0.0078**	**0.28**	**0.0033**
Aug	**Dec**	**0.16**	**0.0773**	**0.22**	**0.0157**	**0.26**	**0.0049**
Sep	Jan	0.20	0.0432	0.24	0.0103	0.26	0.0057
Oct	Feb	0.26	0.0061	0.30	0.0010	0.28	0.0031
Nov	Mar	0.27	0.0038	0.28	0.0020	0.27	0.0040
Dec	Apr	0.25	0.0090	0.27	0.0030	0.31	0.0009

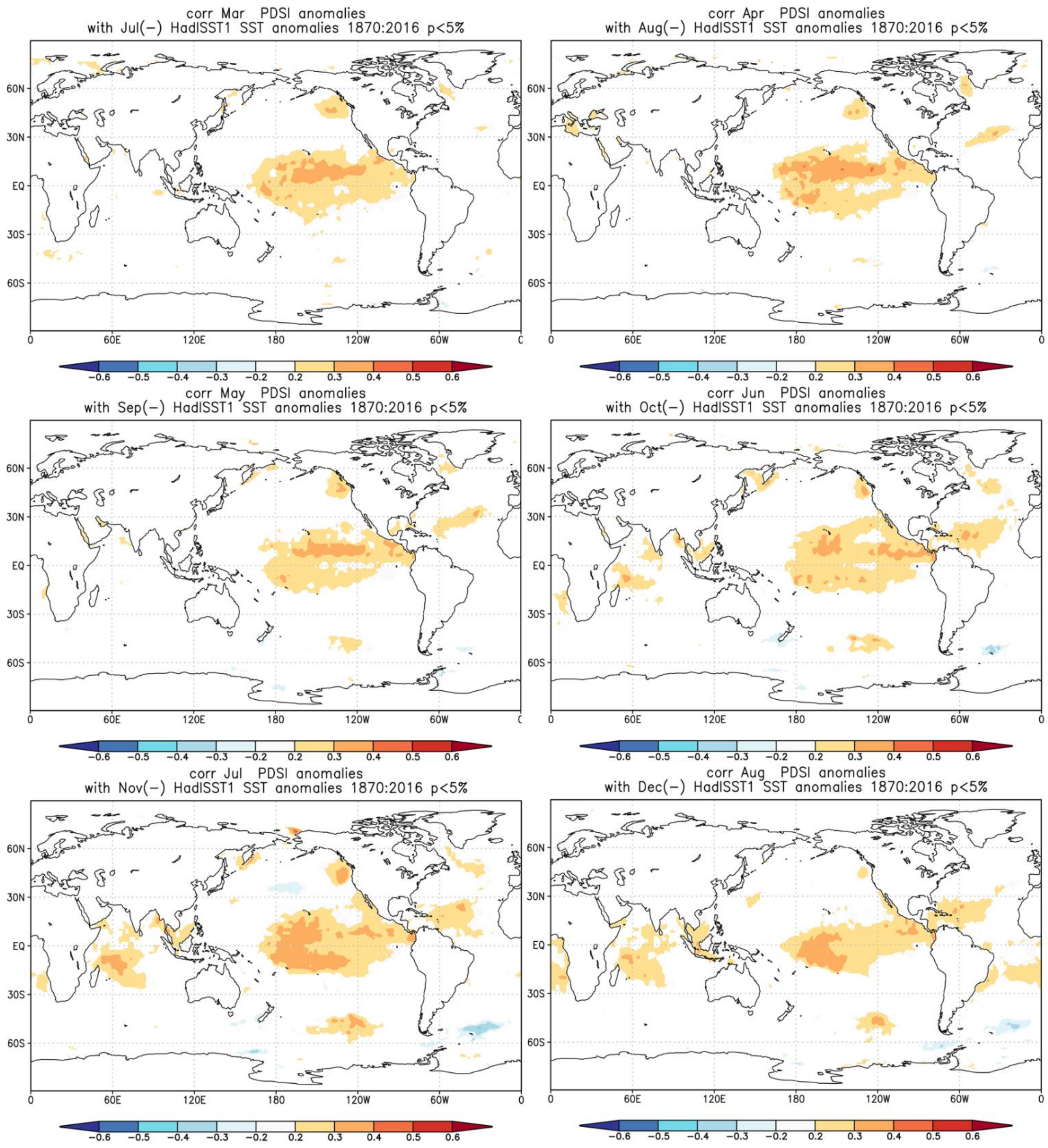

Fig. 10 The field correlation between the monthly HadISST1 sea surface temperature and reconstructed PDSI with a lag of 8 months calculated by the KNMI Climate Explorer (1870-2016). The contours with $p > 0.05$ were masked out.

I don't understand the statement on Line 366: "Due to reconstruction indices, species, geographical differences and other reasons, it does not remain the same with the whole period."?

Response: This sentence has changed and made it understandable. To test the consistency of the drought period, we compared this reconstruction with other drought and precipitation based on tree-ring- reconstructions in central Eurasia and China, which were adjacent to our study area, but none of them are completely matched. The dry periods of our reconstruction are similar to some periods of the reconstruction by Sun and Liu (2019) in 1629–1645 and 1919–1933. However, we found that our drought periods are more consistent with the drought periods of May–June reconstruction in the south-central Tibetan Plateau (He et al., 2018), such as 1593–1598 (1580–1598), 1647–1660 (1650–1691), 1785–1800 (1782–1807), and 1870–1878 (1867–1982). This difference may be due to differences in geographical location, species, and reconstruction indices, among others (Gaire et al., 2019).

Line 375: I would be very surprised if there is a consistent EPS>0.85 for only 5 trees throughout the chronology. This is not even achieved using MXD from extremely temperature sensitive trees from high latitudes.

Response: **Full accepted.** The value fore EPS >0.85 start in 1693 (13 trees).

Figure 3. It would be beneficial to include the EPS values in the figure

Response: **Fully accepted.** The EPS value has been added.

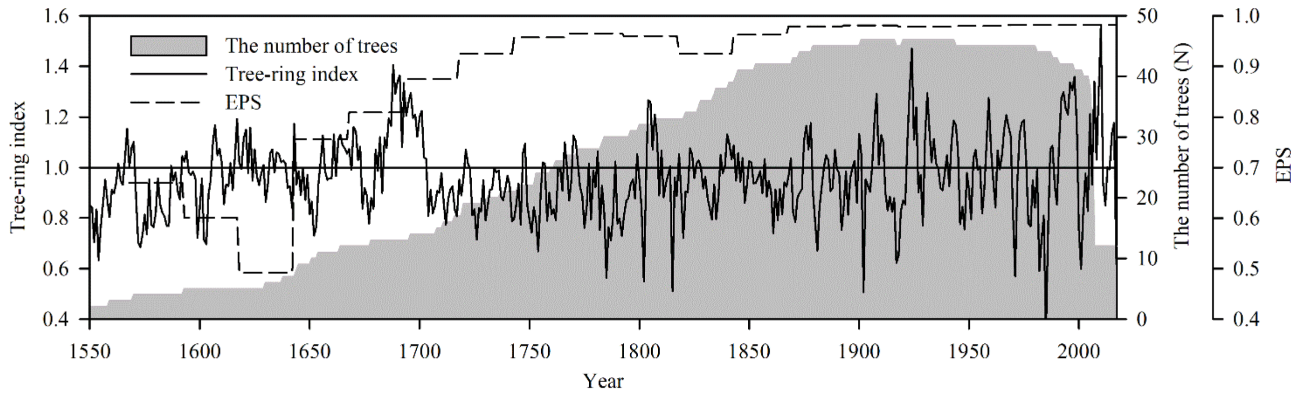

Figure 4. This figure is not very nice. Please increase the scale on the left figure (the * are outside the box) and refrain from using red/green colours in the right hand figure (difficult to read for colour blind persons). You also need to include information on which data you used and sources.

Response: **Fully accepted.** Done.

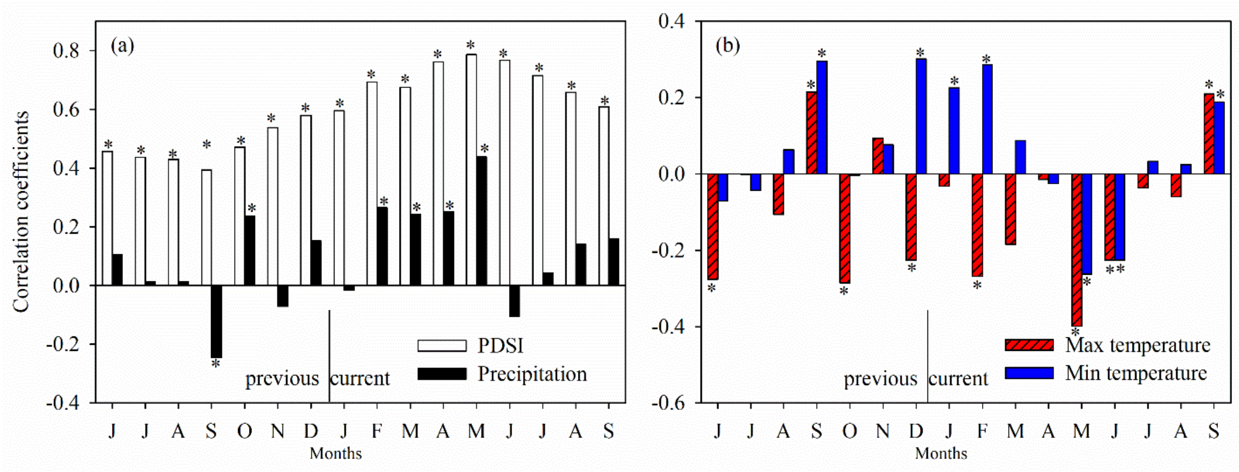

Fig. 4 Pearson correlation coefficients between the tree-ring index of *C. deodara* and monthly total precipitation (1965-2013) and scPDSI (1960-2013) (a) and monthly maximum and minimum temperature (1965-2013) (b) from June of the previous year to September of the current year. Significant correlations (p<0.05) are denoted by asterisks. The "previous" and "current" represents the previous and current year, respectively. The data of monthly precipitation, maximum temperature and minimum temperature were obtained from the meteorological station of Chitral in northern Pakistan. The PDSI data was download from data sets of the grid point (35.36 °N, 71.48 °E) through the Climatic Research Unit (CRU TS.3.22; 0.5° latitude × 0.5° longitude)

Figure 6. Why not reverse the Treydte data to make the two records more comparable?

Response: **Fully accepted.** Done.

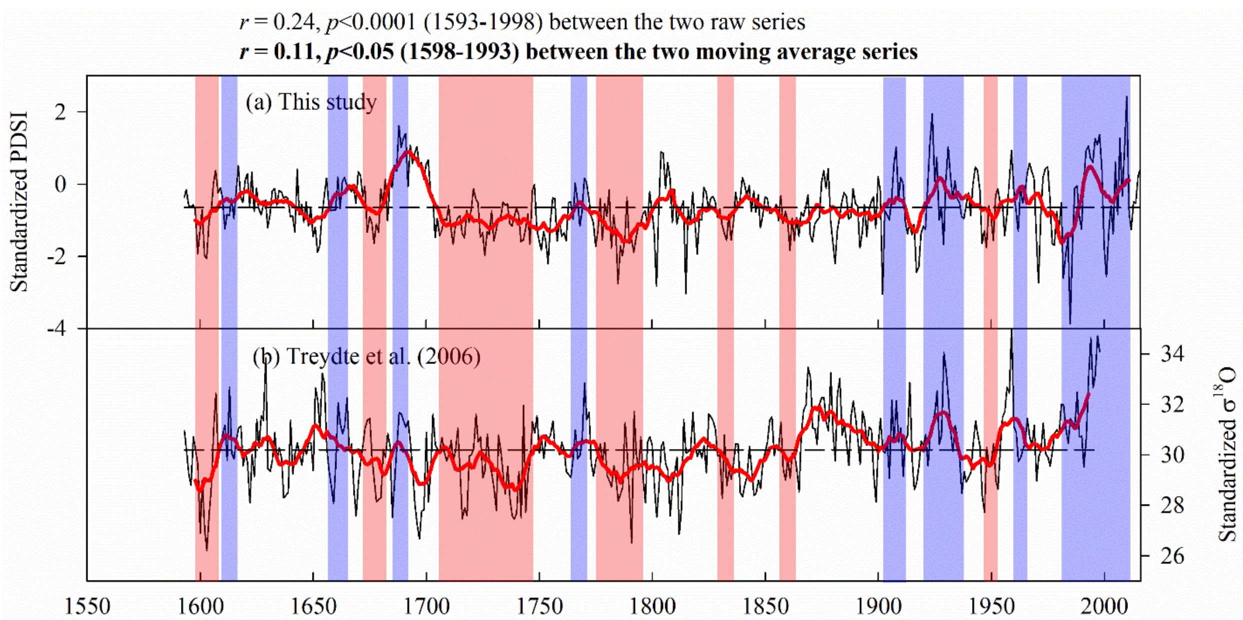

Fig. 6 Comparison of our PDSI reconstruction (a) with the reversed precipitation reconstruction

(tree-ring $\delta^{18}O$) of Treydte et al. (2006) (b) in northern Pakistan. Purple and brown shaded areas represent the consistent wet and dry periods in the two reconstructions, respectively. Two correlation coefficients (r = 0.24 and r = 0.11) are the correlation of two original annual resolution reconstruction series and two 11-year moving average series, respectively.

Figure 9. Again, you need to cite the data you are using. In the AMO comparison, I suggest removing the trend in your reconstruction (this is done for the AMO). What is SAMS? Why compare with JJA-SAMS?

Response: **Fully accepted.** The data used for AMO reconstruction has been cited "Mann et al., 2009".

The SAMS is the South Asian Summer Monsson. The SASM is one of the important sources of moisture in northern Pakistan (Betzler et al., 2016). June to August is the driest season in northern Pakistan. Therefore, we compared the reconstructed PDSI with the SASM from June to August (JJA-SASM). The JJA-SASM is the available reconstruction for monsoon region downloaded from MADA (Cook et al., 2010).

There is no reference to figure 9 in the text.

Response: **Done. Thanks.**

This showed that our reconstruction was reliable and could reflect the drought situation in the region. In addition, the PDSI of low-frequency (the 31-year moving average) reconstruction had good consistency with the AMO (r = 0.53; $p < 0.001$; 1890–2001) and SASM (r = 0.35; $p < 0.001$; 1608–1990), which indicated that these are the potential factors affecting the drought patterns in the region (Fig. 9).