Referee #2

In their work, combining a new tree-ring isotope record with the existing records, Chenxi et al have constructed a regional tree ring cellulose oxygen isotope record for the northern Indian Subcontinent. The authors further show correlation between the tree-ring isotopic record and various indices of the monsoonal strength. After establishing this coherence, the authors further use the tree-ring isotope record for understanding long term variation in monsoonal precipitation. Overall the manuscript is written well and arguments are coherently presented. I recommend publishing the manuscript with minor revision.

Following points should be considered while revising the manuscript.

(1) Section 3.3 is too long to read. Consider subdividing into smaller sections.

Answer: Thanks for your helpful suggestions. The previous Section 3.3 was divided into three parts. New Section 3.3 (Interannual variability of the ISM inferred from the regional tree ring $\delta^{18}O$ record), Section 3.4 (Centennial variability of the ISM inferred from the regional tree ring $\delta^{18}O$ record) and Section 3.5 (Comparison of regional tree ring $\delta^{18}O$ record with speleothem $\delta^{18}O$ record in northern India).

(2) Page 9 first paragraph: epikarst dynamics could be more responsible for the incoherence of the two records. Some discussion is required.

Answer: Thanks for your helpful suggestions. We added the related discussion on epikarst dynamics. Please see the following paragraph.

3.5 Comparison of regional tree ring $\delta^{18}O$ record with speleothem $\delta^{18}O$ record in northern India

The H5 regional tree ring $\delta^{18}O$ record does not exhibit significant decadal to multi-decadal periodicities (Figure 7), while the main spectral component of high-resolution speleothem $\delta^{18}O$ records (a proxy of ISM rainfall in northern and central India) consists of multi-decadal periodicities (~15, 20, 30, 60 and 70 years) (Sinha et al., 2011; Sinha et al., 2015). This inconsistency may be the result of the different types of proxy record used together with micro-environmental differences between the sampling sites. Although decadal to multi-decadal variability of the H5 tree ring $\delta^{18}O$ record is not strongly developed, the record does contain decadal to multi-decadal changes. Decadal to multi-decadal variability was extracted using bandpass filters (15-80 years) (Figure 11, red line). From the perspective of decadal to multi-decadal changes, the H5 record shares similarities with the speleothem record, while the H5 record are out-of-phase with speleothem $\delta^{18}O$ records during several intervals (Figure 11).

Based on the oxygen isotope fractionation theory, tree ring $\delta^{18}O$ and speleothem $\delta^{18}O$ should share similar changes (Managave, 2014) if both of them inherit a common source water $\delta^{18}O$ signal, as shown by Ramesh, et al (2013). The following reasons may cause incoherence between regional tree ring $\delta^{18}O$ and speleothem $\delta^{18}O$. Other controlling factors differentially affect tree ring $\delta^{18}O$ and speleothem $\delta^{18}O$ values. Relative humidity has an important impact on tree ring $\delta^{18}O$ in regions where the variation of relative humidity during the growing season exceeds 1% (Managave, 2014), while the cave epikarst dynamics affect speleothems $\delta^{18}O$ significantly (Lachniet, 2009). The infiltrating water from different rainfall events may be stored and mixed in the epikarst. Lag times of $\delta^{18}O$ values in drip waters relative to rainfall are several years or decades in some locations (Lachniet, 2009), and a slow transit time smoothed climate signal. In addition, limited three ^{230}Th dates points (3 control points) and relative large age uncertainty (9-31 years) of speleothems $\delta^{18}O$ time series during the common period of 1743-2000 may result in the incoherence between tree ring and speleothems $\delta^{18}O$. Long-term process-based study on tree ring $\delta^{18}O$ and speleothem $\delta^{18}O$ variations in future study are needed for a better understanding for climatic implication of two proxies.

(3) It would be helpful for the reader if authors describe the nature of long-term variations in modern instrumental rainfall data. Analysis by Sontakke et al Holocene 2008 and Bhutiyani et al IJC 2010 could be helpful. In fact, the latter article also points out to a significant decreasing trend since 1866 in the monsoonal rainfall.

Answer: Thanks for your helpful suggestions. We have added the description of nature of long-term variations in modern instrumental rainfall data based on the Sontakke et al., (2008) and Bhutiyani et al., (2010) in the Introduction and Section 3.4 (*Centennial* *variability of the ISM inferred from the regional tree ring $\delta^{18}O$ record*). Please see the Section 3.4.

3.4 Centennial variability of the ISM inferred from the regional tree ring $\delta^{18}O$ record

There are also significant centennial-scale variations in the H5 record (Figure 7), which were extracted using a 100-year low-pass filter (Figure 10c, red line). The record exhibits a decreasing trend from 1743 to 1820 CE and an increasing trend since 1820 CE, which indicates a weakening trend of the ISM during the interval from 1820-2000 CE. A reduction in the monsoon precipitation/relative humidity of the ISM in the last 200 years is also evident in other areas influenced by the ISM. Maar lake sediments in Myanmar exhibit a decreasing trend of monsoonal rainfall since 1840 CE (Sun et al., 2016); a tree ring $\delta^{18}O$ record from southeast Asia exhibits a drying trend since 1800 CE (Xu et al., 2013a); a stalagmite $\delta^{18}O$ record from southwest China reveals an overall decreasing trend in monsoon precipitation since 1760 CE (Tan et al., 2016); and in southwest China, tree ring $\delta^{18}O$ and maar lake records indicate reduced monsoon precipitation/relative humidity/cloud cover since 1840 or 1860 CE (Chu et al., 2011; Grießinger et al., 2016; Liu et al., 2014; Wernicke et al., 2015; Xu et al., 2012). Monsoon precipitation in northwestern India shows a significant decreasing trend during the period of 1866-2006 (Bhutiyani et al., 2010).

However, in contrast, marine sediment records from the Western and Southeastern Arabian Sea exhibit an increasing trend of ISM strength over the last four centuries (Anderson et al., 2002; Chauhan et al., 2010). In addition, a recent study indicated that the contrasting trends in the ISM during the last several hundred years observed in geological records resulted from the different behavior of the Bay of Bengal branch and Arabian Sea branch of the ISM (Tan et al., 2016). However, the tree ring $\delta^{18}O$ record in northwest India, influenced by the Arabian Sea branch of the ISM, exhibits a drying trend since 1950 CE (Sano et al., submitted), which does not support the idea of a strengthening ISM (Anderson et al., 2002). Moreover, there are no calibrated radiocarbon dates for the last 300 years for the two records from the Arabian Sea (Anderson et al., 2002a; Chauhan et al., 2010). We suggest that further high-resolution and well-dated ISM records from western India are needed to improve our understanding of the behavior of the ISM.

Although reconstructed All India monsoon rainfall does not show a significant decreasing trend during the period of 1813-2005 (Sontakke et al., 2008), the data from only four stations extend back to 1826 CE and four longest stations locate in central or southern India. Monsoon season drying trend in northern India revealed by H5 regional tree ring $\delta^{18}O$ record may indicate that inland areas appear to be particularly sensitive to the weakening of monsoon circulation.

The H5 record suggests a decreasing trend of ISM strength, which is supported by most of the other well-dated and high-resolution ISM records in ISM margin areas. A previous study has indicated that solar irradiance has a significant influence on the ISM on multi-decadal to centennial timescales, and that reduced solar output is correlated with weaker ISM winds (Gupta et al., 2005). However, solar irradiance has increased since 1810-1820 CE (Bard et al., 2000; Lean et al., 1995) and therefore it cannot be the main reason for the weaker ISM since 1820 CE. Atmospheric CO_2 content is another forcing factor for the ISM, with higher atmospheric CO_2 content resulting in a stronger ISM (Kripalani et al., 2007; Meehl and Washington, 1993). Thus, the increased atmospheric CO_2 content during the last 200 years is unlikely to be the reason for the weakened ISM.

Several studies show that increased Indian Ocean SSTs caused a reduction in ISM rainfall (Fan et al., 2009; Naidu et al., 2009; Sun et al., 2016). The Indian Ocean SST has increased since 1840-1860 CE (Tierney et al., 2015; Wilson et al., 2006), which supports this explanation. Although the SST of the Indian Ocean significantly affects the ISM, the land-sea thermal contrast is also an important influencing factor (Roxy et al., 2015). In particular, heating anomalies over the Tibetan Plateau have a significant influence on the ISM via their effect on the atmospheric temperature gradient between the Tibetan Plateau and the tropical Indian Ocean (Fu and Fletcher, 1985; Sun et al., 2010). The history of land-sea thermal contrasts is reconstructed based on temperature differences between the Tibetan Plateau and the Indian Ocean (Figure 10a), and centennial variations in this record are shown in Figure 10b. Three reconstructed land-sea thermal contrasts showed a decreasing trend since 1800 CE and 1820 CE (Figure 10b), and the H5 record exhibits a similar pattern of changes on a centennial scale (Figure 10c). The decreasing land-sea thermal contrast since 1800 and 1820 CE has resulted in a weaker ISM, and the increasing trend of the H5 record since 1820 CE also indicates a reduced ISM intensity. In addition, aerosol emissions may be another reason to cause weakened ISM. Because, aerosol emissions could result in a slowdown of the tropical meridional overturning circulation, cooler temperatures over Europe and Asia relative to the ambient oceans, and a corresponding weakening of the ISM circulation (Bollasina et al., 2011; Cowan and Cai, 2011).

(4) The way regional isotope record is constructed (average of averages of d18O records of different sites) underestimates the uncorrelated variability. Quantification regarding this should be added to Table 2.

Answer: Thanks for your helpful suggestions. We have added the uncertainty in regional tree ring oxygen isotope chronology in Figure 4f to evaluate the inter-site variability. In addition, we checked the uncorrelated variability by comparison between regional tree ring oxygen isotope chronology and PC1 of five tree ring oxygen isotope chronologies in northern Indian sub-continent. The regional tree ring oxygen isotope chronology is highly correlated with PC1 of five tree ring oxygen chronologies ($r=0.998$, $n=200$, $p<0.001$), which indicates that regional tree ring oxygen isotope chronology reflect the main common signal of five tree ring oxygen isotope chronologies.