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Tree-ring based evidence of the multi-decadal climatic oscillation during the past 200 years in north-central China

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ABSTRACT

As the northern fringe of the Asian summer monsoon region, north-central China (hereafter NCC) is highly sensitive to climate change. It is important to understand drought variability and the associated mechanisms in this region since precipitation changes have direct impacts on human society in this semiarid-arid area. In this study, a new tree ring-width based drought reconstruction (AD 1804–2010) was established in the Songmingyan Nature Reserve, which lies in NCC. This reconstruction illustrates the severe drought periods occurring in the 1860s, 1928–1932 and 1991–2000, with recurring drought intervals being about 60 years. The first principal component of the five chronologies from NCC shows strongly coherent drought variability with the other single-site records and can thus be used as an indicator of regional moisture variations. Combining the Monsoon Asia Drought Atlas (hereafter MADA) dataset and the dry-wet index (hereafter DWI) dataset from eastern China, the spatial distribution of moisture variability for three selected drought events is mapped. It is found that northern China and Mongolia experienced dry conditions during the three severe drought periods, whereas wet conditions prevailed in the middle and lower reaches of the Yangtze River. The Pacific Decadal Oscillation (hereafter PDO) might have been one of the possible causes responsible for multi-decadal drought variability over NCC, with the PDO warm phases being associated with drought conditions and the cold phases corresponding to wet conditions over NCC.

1. Introduction

Moisture variations in north-central China (hereafter NCC) are predominantly influenced by the Asian summer monsoon (hereafter ASM; Chen et al., 2008). The varying intensity of the ASM activity results in the occurrence of severe drought and floods, which impact on agricultural harvest yields in NCC and the economic wellbeing of many people. Therefore, detailed understanding of the intensity of climate change and its possible physical mechanisms over the NCC region is necessary. Based on meteorological records, previous studies have demonstrated the interconnections between precipitation variability in North China and the atmospheric circulation over the Pacific Ocean (Ma, 2007). Observational composite analysis reveal that the warm Atlantic Multi-decadal Oscillation (hereafter AMO) is linked to enhanced precipitation in the north of East China and reduced precipitation in the south (Li and Gary, 2007). However, the shortness of regional instrumental records limits the understanding of long-term drought variability and its forcing mechanisms in this area. Tree-rings are one of the most important proxy indicators for studying past climatic changes (Shao et al., 2007). A number of tree-ring studies have focused on the arid western regions of China (He et al., 2013; Yang et al., 2012a, 2013a; Qin et al., 2010, 2013). Tree-ring studies conducted in NCC have revealed climate changes during recent centuries (Fang et al., 2010; Li et al., 2007; Song and Liu, 2011). However, most of these dendroclimatological studies were conducted using single-site reconstruction. Meanwhile, new techniques of tree-ring record standardization have been developed and improved the strength of the paleoclimatic information stored in tree-ring variations (Yang et al., 2012b,c).

We have investigated regional moisture variations and their possible association with the air-sea coupling system in NCC. In this

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