## Supplementary Materials

**Records used.** Six of the records we used were from the same sites strategically selected by Zhou et al. (2016) from hundreds of records (e.g., An et al., 2000; Zhao et al., 2009; Ran & Feng, 2013; Jiang et al., 2019; Zhang et al., 2020). Additionally, the recently published record from the Xinjie Site in the Lower Yangtze River Valley (Lu et al., 2019) was selected. As pointed out by Zhou et al. (2016), records were selected based on the six following criteria: 1) the study sites are located in the EAM domain; 2) the elevations of the sites are lower than 2,000 m asl in order to avoid the impact of high elevation on vegetation and pollen-based precipitation changes; 3) high-resolution and precise dating were available, which means that there are enough $^{14}C$ dates on terrestrial plant residues or the chronology was based on more reliable methods, such as varve counting; 4) the chronology at each site covers the entire Holocene; 5) profiles of pollen or pollen-based precipitation are available. This is because pollen records are spatially widely distributed, and precipitation changes can be quantitatively reconstructed by pollen records; and 6) the average temporal resolution of the proxies are higher than ~200 yr. In this study, the records from Lake Bayanchagan and Daihai Lake, which were previously used in Zhou et al. (2016), were removed because they are near the monsoon margin, where pollen records might be influenced by other factors. Lastly, seven reconstructed precipitation records were selected in this study.

**The chronological framework of different sites.** Age uncertainty is one of the important factors influencing interpretations concerning the onset time of the Holocene monsoon precipitation maximum. Here we discuss the potential inaccuracy of the ages from each record. First, the chronology of the sediments of Sihailongwan Maar Lake was based on both the $^{14}C$ dating and the varve counting, and the age uncertainty is less than 370 yr during the whole Holocene. The chronologies for Dahu Peat, Gonghai Lake, Moon Lake and Tianchi Lake are mainly based on $^{14}C$ dates of terrestrial plant residues, and there are at least 15 $^{14}C$ dates in these sediments. Dating materials in sediments from Dajiuhu Peat are peat cellulose, which might be less accurate than using terrestrial plant residue such as leaves and wood. However, the comparison between $^{14}C$ dating on pollen residues and bulk sediment organic carbon only shows ~300 yr differences (Zhang et al., 2018), indicating that the chronology is adequate for studying precipitation trends during the Holocene. Although the chronology of Xinjie Site might be less relabile than those of other sites, the record of Xinjie site was still used because $^{14}C$ dating materials in the sediment contain charcoal samples. Therefore, we concluded that the chronologies of the seven records are precise enough to study the Holocene monsoon precipitation trends.

**Reconstruction of precipitation changes.** Five of the precipitation records reconstructed from pollen percentages were directly collected from previously published studies, including those from Tianchi Lake, Lake Sihailongwan, Gonghai Lake, Dajiuhu Peat, and Xinjie Site. No precipitation records were reconstructed from Moon Lake and the Dahu Peat. Therefore, in these two sites, the quantitative reconstructions of the annual precipitation were obtained by applying the plant functional type-modern analogue technique (PFT-MAT) (Peyron et al., 1998) on the fossil pollen data. The quantitative reconstruction was accomplished based on a modern pollen dataset from China (Members of China Quaternary Pollen Data Base, 2000, 2001). The pollen record from Huguangyan Maar Lake was also used in Zhou et al. (2016). Although that record had a precise chronology, it was not used in our study because there were insufficient pollen data from the surface samples and so quantitative precipitation reconstructions using the PFT-MAT method would be unreliable.

**Defining the time of the HMPM.** To define the time of the HMPM, the trend of each precipitation record was extracted using the method of Singular Spectrum Analysis (Ghil et al., 2002). This method can separate time series data into the trend components, oscillatory components, and noises. Then, the profiles were normalized by the equation: $V = (V_i - V_{min})/(V_{max} - V_{min})$, where $V_{min}$ is the lowest value and $V_{max}$ the highest value from 11,700 to 2,000 Cal a BP, the time with no large human impacts on the vegetation covers around most of the study sites. The identified time of the HMPM for each site, using 0.6–0.7 as a range of thresholds, is similar to that defined in the published studies; thus, it allows us to identify a range of depths over which the onset of HMPM occurs. A depth was then randomly selected from the depth range, and its corresponding age and age uncertainty were calculated using the Bayesian BACON modelling approach with the R package "rbacon" (v.2.3; Blaauw and Christen, 2011). The same procedure (i.e., randomly selecting a depth and calculating its corresponding age and age uncertainty) was repeated 1000 times. Lastly, the mean value and standard deviation of the output were calculated.

**Table S1 Records used.**

| Site Name | Latitude | Longitude | Dating Method | Dating Material | Number of Dates | Age range (a BP) | References |
|---|---|---|---|---|---|---|---|
| Dahu Peat | 24º15'N | 115º02'E | AMS $^{14}$C | plant fragments | 17 | 16,500-0 | Xiao et al. (2007) |
| Xinjie | 119°42′E | 31°22′N | AMS $^{14}$C | charcoal, peat, TOC | 10 | 13,100-0 | Lu et al. (2019) |
| Dajiuhu Peat | 31º29'27"N | 109º59'45"E | AMS $^{14}$C | peat cellulose | 10 | 15,760-0 | Sun et al. (2019) |
| Gonghai Lake | 38º54'N | 112º14'E | AMS $^{14}$C | stem, leaf | 25 | 14,700-0 | Chen et al. (2015) |
| Sihailongwan Maar Lake | 42º17'N | 126º36'E | AMS $^{14}$C, varve count | leaves, wood, seeds & moss | 36 | 15,287-0 | Stebich et al. (2015) |
| Moon Lake | 47º30'25"N | 120º52'05"E | AMS $^{14}$C | plant fragments, TOC | 17 | 14,000-0 | Wu & Liu (2012) |
| Tianchi Lake | 48º44'24"N | 126º00"E | AMS $^{14}$C | leaves, seeds, TOC | 15 | 13,120-0 | Liu et al. (2019) |

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