East Asian monsoon variability since early-Holocene recorded in high-resolution, absolute-dated stalagmites from Northeast China

Jinguo Dong [a], Yongjin Wang [a], Hai Cheng [b]

a College of Geography Science, Nanjing Normal University, Nanjing 210097, China

b Department of Geology and Geophysics, University of Minnesota, Minneapolis, MN 55455, USA E-mail: jgdong@yahoo.cn

Abstract: The Asian monsoon is a primary component of the global climate system. It has been uncertain, however, whether current interglacial climate changes between the East Asian and Indian monsoon systems were in- or anti-phase related on orbital and millennial time scales, leading to various hypothesis for monsoon dynamics and its global linkage. Here, we present a high-resolution composite record of millennial-scale monsoon changes through the Holocene, using $\delta^{18}O$ values (500 measurements) from five precisely dated (21 ^{230}Th dates) stalagmites from Nuanhe Cave, Liaoning Province, China. The $\delta^{18}O$ values are interpreted to reflect precipitation amount effect related to the strength of summer monsoon circulation. Comparisons between Nuanhe with previous published data from stalagmite HS-4 from Heshang Cave, stalagmites SB43 and SB10 from Sanbao Cave and stalagmites DA and D4 from Dongge Cave, demonstrate the timing of Holocene Thermal Maximum (HTM) fell approximately between 9500 and 6000 ka BP in Southern-and Northern China. This observation supports the idea that the shifts of the calcite $\delta^{18}O$ recorded across China reflect a large-scale regional coherence in the summer monsoonal circulation. Further Comparing our record with a U/Th dated Holocene Indian monsoon record from Oman supports an idea of insolation-induced ITCZ shift as a major control for the Holocene monsoon evolution at low-latitudes, leading to synchronous changes of Indian and East Asian monsoons on orbital and millennial scales.

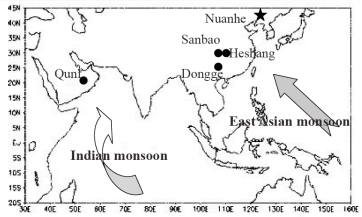

Fig.1. Cave locations in the Asian monsoon region. Four black dots indicate locations of the Sanbao Cave (110°26´E, 31°40´,Dong et al., submitted) and Heshang Cave (110°25´E, 30°26´, Hu et al., 2008),where have been possibly affected by East Asian monsoon(Zhang et al., 2007); Dongge Cave (108°5´E, 25°17´, Wang et al., 2005) and Qunf Cave (54°18´E, 17°10´, Fleitmann et al., 2003), where have been mainly affected by Indian monsoon. Black star show this studying location of the Nuanhe Cave, where have been mainly affected the East Asian monsoon. Arrow show dominant summer wind directions.

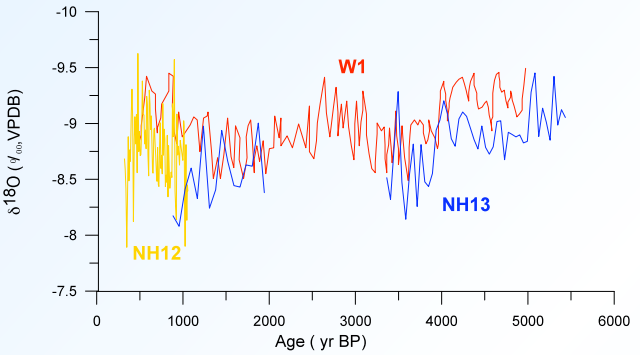

Fig.2 A replication test of stable isotope records from different caves in the northeast China. Stalagmites NH is located more than 100 km west of Water cave, Benxi (Tan et al., 2006). Both NH (NH13,blue; NH12, yellow) and W1(red line) show a remarkably similar $\delta^{18}O$ pattern suggesting regional climatic changes are detectable in cave stalagmites.

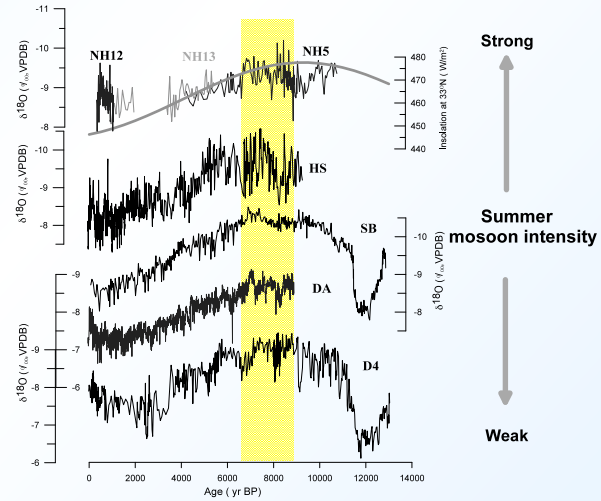

Fig.3 Comparison of absolute-dated stalagmite $\delta^{18}O$ records in East Asian monsoon region from 17ºN to 42ºN. (a) $\delta^{18}O$ record of stalagmites from Nuanhe Cave in the northeast China. (b) and (c) $\delta^{18}O$ records from Heshang Cave and Sanbao Cave in the middle China, respectively (Hu et al., 2008; Dong et al., submitted). (d) and (e) $\delta^{18}O$ profiles of stalagmites DA and D4 from Dongge Cave in southwest China region (Wang et al., 2005; Dykoski et al., 2005). Yellow band indicates the timing of lead or lag of Holocene thermal maximum is very small in the region covered by cave stalagmites.

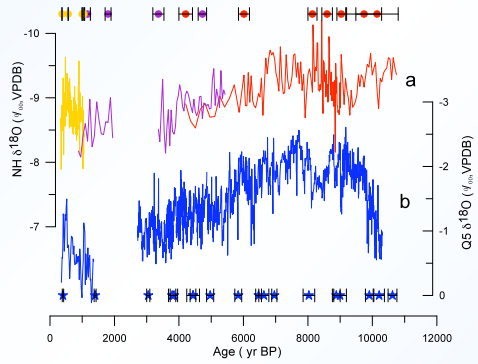

Fig.4 Comparison of between the Asian two monsoons. (a) proxy record for East Asian monsoon from $\delta^{18}O$ time series (NH5, red; NH13, purple; NH12, yellow) from stalagmites from Nuanhe Cave, Northeast China. (b) proxy record for Indian summer monsoon from $\delta^{18}O$ time series (Q5, blue) from stalagmites from Qunf Cave, South Oman (Fleitmann et al., 2003), color dots and stars show ^{230}Th ages with 2 error bars for Nuanhe cave and Qunf cave stalagmites, respectively.

Conclusions:

1. Three high-resolution and well-dated stalagites from Nuanhe Cave in northeast China, provide a composite record of East Asian monsoon during the Holocene. Comparisons of these independently-dated stalagmites δ18O records regions by the Asian monsoon along a latitude transect from 17ºN to 42 ºN, indicate the Holocene thermal maximum occurred between 9500 and 6500 yr BP, with a few centuries errors.
2. Composite of Nuanhe with Q5 δ18O records from Oman shows the Indian and the East monsoon systems are in-phase relative to one another in millennial-centennial scales. the results is consistent with the idea that the shifts in mean position of ITCZ induced by orbital changes of summer insolation may control temporal variability of precipitation throughout the entire low-latitude region.