Moisture Variability Derived from Historical Documents and Stalagmite Records in Eastern China over the Last 2000 years

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1. INTRDUCTION

Researches on regional climatic and environmental changes over the last two millennia play an important role on the CLIVER in WCRP and PAGES. Both the natural archives (ice cores, pollen and spores, tree-rings, stalagmites, valves, etc.) and literacy archives (historical documents) provide veracious records and reliant information for climatic change study. As an large area deeply influenced by the Asian Monsoon System (AMS), eastern China (25~40° N, east of 105° E) has a characteristically great precipitation variability, which varies distinctly in the impress modes, ranges, periods in different scopes. As a result, the whole area is divided into the northern and the southern region by the border of 33° N line roughly. We present proxy series of moisture variability derived from Chinese historical documents and stalagmites records over eastern China for the past 2000 years to analyze the moisture variability, which will lead to a better understanding on the relationship between moisture variability and Asian Monsoon circulation.

2. DATA AND SEARIES

Eastern China is one of the most developed and civilized regions in ancient periods with large quantities of detailed historical documents and phonological records, which are the main resources for climatic change study. Moreover, the southern region of eastern China under the control of AMS provides deep background for speleothem to grow up well, in which the $\delta^{18}O$ is regarded as signals for AMS, and numbers of previous research work laid foundations for further discussions on climatic change study within this area. Consequently, three stalagmites on the basis of much recent work are represented here as the speleothem proxy. In the northern region of eastern China, we choose drought/ flood grading series in Haihe River Basin for its long time span of last 2000 years and the similar variation types as DWI series for the 21 stations in North China Plain. Besides of stalagmite records, in the southern region of eastern China, we choose drought/wet index (DWI) datasets from 10 stations in Jiang-Huai and 17 stations in Jiang-Nan areas. In the whole area, we choose DWI datasets from 48 stations in eastern China.

area	position	proxy	resolution	time/A.D.	Length (approximately)	resources
northern region	Haihe River Basin(25-44° N)	drought/flood grading	10a	0-2000	2000	*Yan* et al, 2000
	North China Plain (34-40° N approximately)	DWI	annual	505-1995	1500	*Zheng* et al, 2006
southern region	DA4 from Dongge Cave, Guizhou(25° 17'N,108° 5E, 680m)	$\delta^{18}O$	annual	498-2000	1500	Wang et al, 2005
	HS4 from Heshang Cave, Hubei(30° 27'N, 110° 25'E, 294 m)	$\delta^{18}O$	annual	993-2001	1000	*Hu* et al, 2008
	WX42B from Wangxiang Cave, Gansu (33° 19'N, 105° 00'E, 1200 m)	$\delta^{18}O$	annual	192-2003	1800	*Zhang* et al, 2008
	Jiang-Nan area (25 - 31° N approximately)	DWI	annual	505-1995	1500	*Zheng* et al, 2006
	Jiang-Huai area (31 - 34 N approximately	DWI				*Zheng* et al, 2006
eastern China	east of 105° E; 25 - 40° N approximately)	DWI	annual	505-1995	1500	*Zheng* et al, 2006

Table: Showing detailed information of data and series, including proxy types, locations, resolution, time scales, and originations.

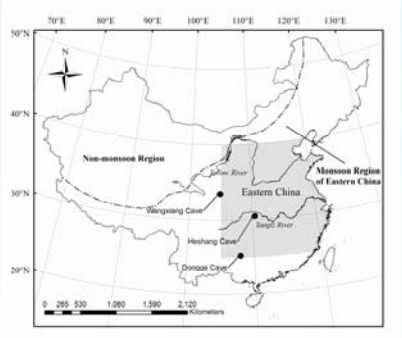

Fig1. Showing the proxy locations of historical documents and stalagmites: Haihe River Basin, North China Plain, Jiang-Nan area, Jiang-Huai area; black dots represent WX42B from Wangxiang Cave, HS4 from Heshang Cave and DA4 from Dongge Cave; the light grey shadow represent eastern China, and the dash dot line is the border of monsoon and non-monsoon region in China.

3. MOISTURE VARIABILITY

Northern Region

In the northern region of eastern China, Yan reconstructed decadal average drought/ flood grading series from 50B. C. to 1979 A. D. by historical documents in North China Plain, Haihe River Basin and Xi'an region, the decade- and century- scale climatic jumps were recognized by symbol detection and moving T-test methods; comparing with the 21-station DWI series in North China Plain from Zhen et al, Yan's series possess the similar variation type with longer time scale and it represents the moisture variability in northern region of eastern China.

It was a dry period until the Little Ice Age (LIA) came, then diverted into humid again after 1900's with a dry jump in 1913 A.D.. During 1470's~1620's, the northern region was a considerable wet period but dry in LIA with a humid jump in 1640A.D.. Comparing with Zhen's series, a three-point FFT smoothing after 10-year averaging calibration, it was humid before 900's and combination of dry and wet in the Medieval Warm Period (MWP). A common humid period 840's~1040's and a similar variation type 1120's~1970's are recognized in both series, experienced two humid and dry process along with a driest period in 1210 A.D..

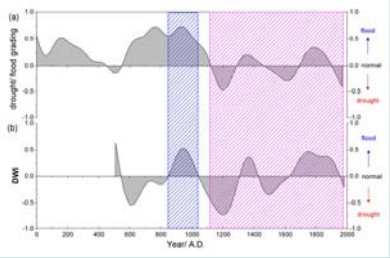

Fig2. Showing moisture variability of last 2000 years in northern region derived from historical documents : (a) three-point FFT smoothing after decadal averaging drought/ flood grading series of 2000 years in Haihe River Basin and (b) three-point FFT smoothing after decadal averaging DWI series of 1500 years in Northern China Plain; magenta bias represents dry periods and blue bias represents wet periods.

Southern Region

In the southern region of eastern China, numbers of stalagmite records with high resolution, long time scale and fine continuity reflect the strength and weakness, advance and retreat of the monsoon. The $\delta^{18}O$ in stalagmites is a signal of the monsoon, and the precipitation variability is controlled by strength variability of monsoon, so the $\delta^{18}O$ in stalagmites ought to be regard as the precipitation proxy in the southern region. In order to compare with historical documents result, unified data processing method is adopted by five-point FFT smoothing after decadal interpolation averaging for DA4, HS4 series and eleven-point FFT smoothing after standardization for WX42B series of stalagmites in southern region.

In the centennial scale, WX42B, DA4 and HS4 all present the similar variation type of wetter periods 1320's~1630's and drier period in 1870's~1920's; a main humid period of three or so centuries between LIA and MWP, then it convert to a much wetter period after LIA, and it goes drier at the end of the 1900's; however, the LIA is not so typical in WX42B for possibly its location on the monsoon margin. HS4 displays a small wet/ dry fluctuation under the main variability background as the DA4, being wet during 1900's~1950's and dry after 1950's. Comparing with the stalagmite records, a similar variability type is exhibited in the historical document records, which holds a dry period before 750's then a humid period lasting to 1250's, the MWP is dry and LIA is wet. Finally, the southern region experienced two dry and three wet periods.

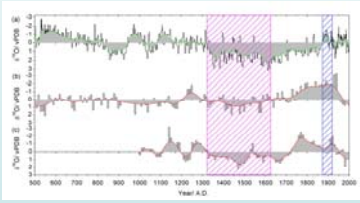

Fig3. Showing moisture variability on centennial scale of last 2000 years in southern region derived from

δ 18O records in stalagmites: (a) WX42B from Wangxiang Cave, (b) DA4 from Dongge Cave and (c) HS6 from Heshang Cave; red line represents five-point FFT smoothing; green line represents eleven-point FFT smoothing; magenta bias represents dry periods and blue bias represents wet periods.

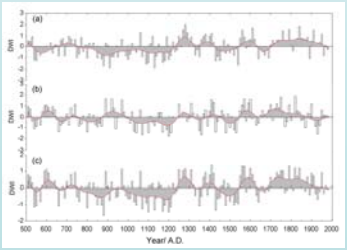

Fig4. Showing moisture variability of last 1500 years in southern region derived from historical documents: (a) DWI series from 17 stations in Jiang-Nan area, (b) DWI series from 10 stations in Jiang-Huai area and (c) standard averaging series of Jiang-Nan and Jiang-Huai areas; red line presents five-point FFT smoothing.

Eastern China

In eastern China, a newly recalibrated DWI series of in eastern China from 48 stations, through five-point FFT smoothing after decadal averaging standardization from historical documents. As it shows in the figure, the whole eastern area experienced three wet and two dry periods in the last 1500 years, 500's~900's and 1000's~1250's dry, 900's~1000's, 1250's~1450's and 1650's~1950's wet, separately. The humid variability characteristics of Zhen's DWI series are also reflected in a humidity evolution coefficient series derived from 45 stations historical documents in eastern China by Zhang(1995).

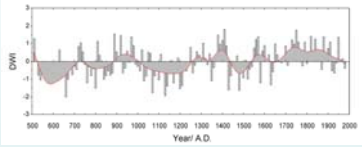

Fig5. Showing moisture variability of last 1500 years in eastern China reconstructed from DWI derived from historical documents: red line represents five-point FFT smoothing.

4. PRELIMINARY CONCLUSIONS

In the northern region of eastern China, it was a humid period before LIA but dry when LIA came; a combination of dry and wet fluctuation in MWP followed with another humid period during 1470's~1620's. A common humid period from 840's to 1040's and a similar variation type from 1120's to 1970's are recognized in both series, with two humid and arid converting process and a driest period in 1210 A.D..

In the southern region of eastern China, $\delta^{18}O$ in stalagmites records from both western and eastern part of the region reflect similar moisture variability type, which are wetter periods from 500's to 1200's, drier in MWP and a main humid period of two centuries between LIA and MWP, then converting to a more wetter period after LIA and drier at the end of 1900's; the historical document records exhibited the similar characteristics with two dry and three humid periods.

In the whole eastern area, it experienced three humid and two dry periods in the last 1500 years, dry in 500's~900's and 1000's~1250's, wet in 900's~1000's, 1250's~1450's and 1650's~1950's, separately, which are also exhibited in a humidity evolution coefficient series.

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