Temporal and spatial variation of $\delta^{18}O$ in China since medieval warm period

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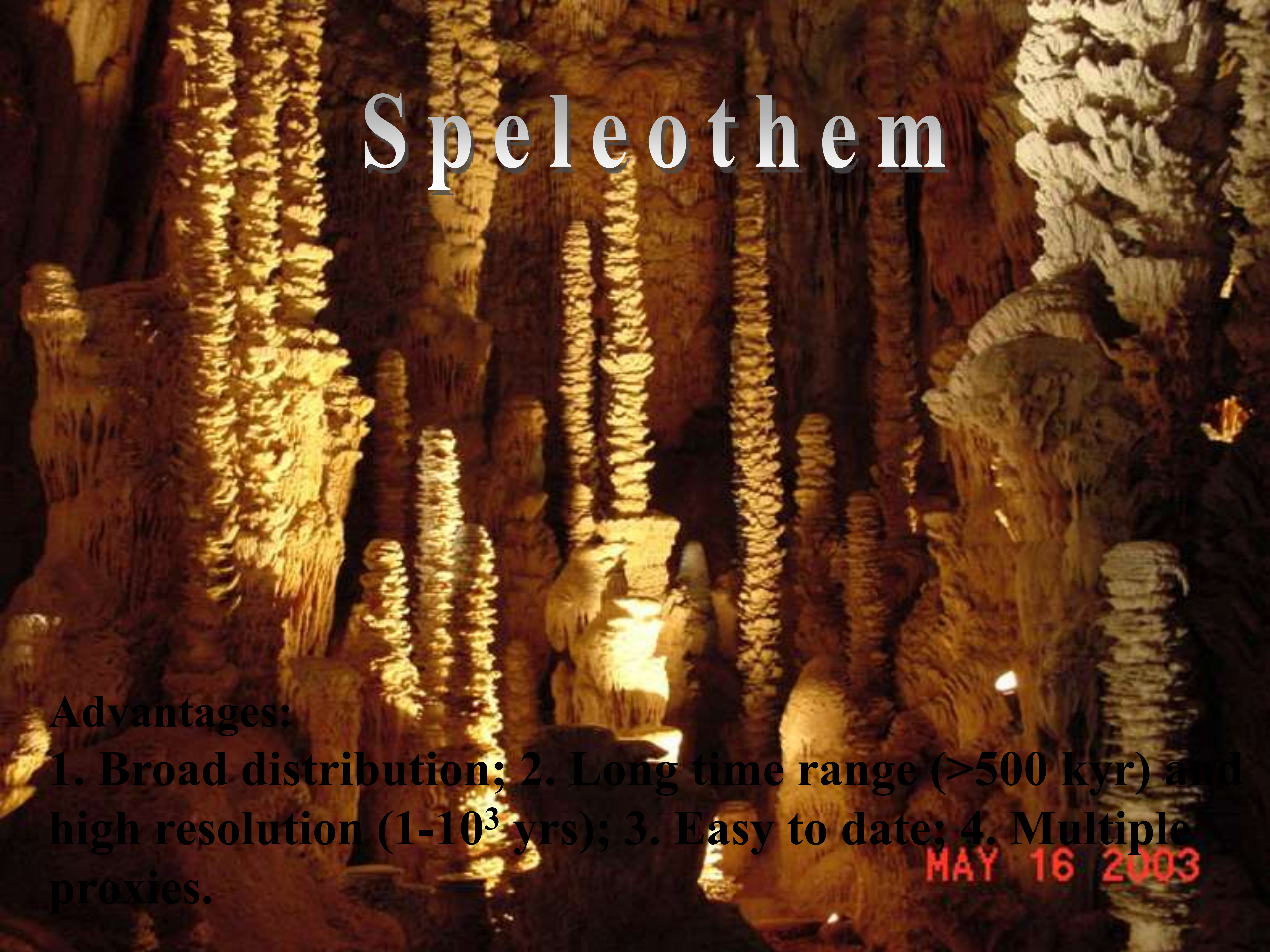
Outlines

- High-resolution (yearly) $\delta^{18}O$ Data since AD 900 from the Six Caves
- Trends Obtained form the Empirical Mode Decomposition
- Anomalies of $\delta^{18}O$ during Four Periods: MWP, LIA-1, LIA-2, MD
- Spatial Variability of East Asian Monsoon
- Conclusions

Speleothem



Advantages:

1. Broad distribution; 2. Long time range (>500 kyr) and high resolution (1-10^3 yrs); 3. Easy to date; 4. Multiple proxies.

$\delta^{18}O$ in speleothem…

$$\delta^{18}O_c(PDB) = 0.97\delta^{18}O_w\,(SMOW) - 0.2272T(^oC) + 4.2712$$

$\delta^{18}O$ of speleothem calcite

$\delta^{18}O$ of cavewater = annual mean $\delta^{18}O$ of surface water

Cave temperature = annual mean surface T

$\delta^{18}O_w = f\,(T, ppt, s, h, L)$

whereas T = air temperature, ppt = precipitation amount, s = moisture source h = altitude, L = latitude. However, For a given cave location, effects of s, h and L on $\delta^{18}O_w$ can be ignored.

$\delta^{18}O_w = a\,T + b$

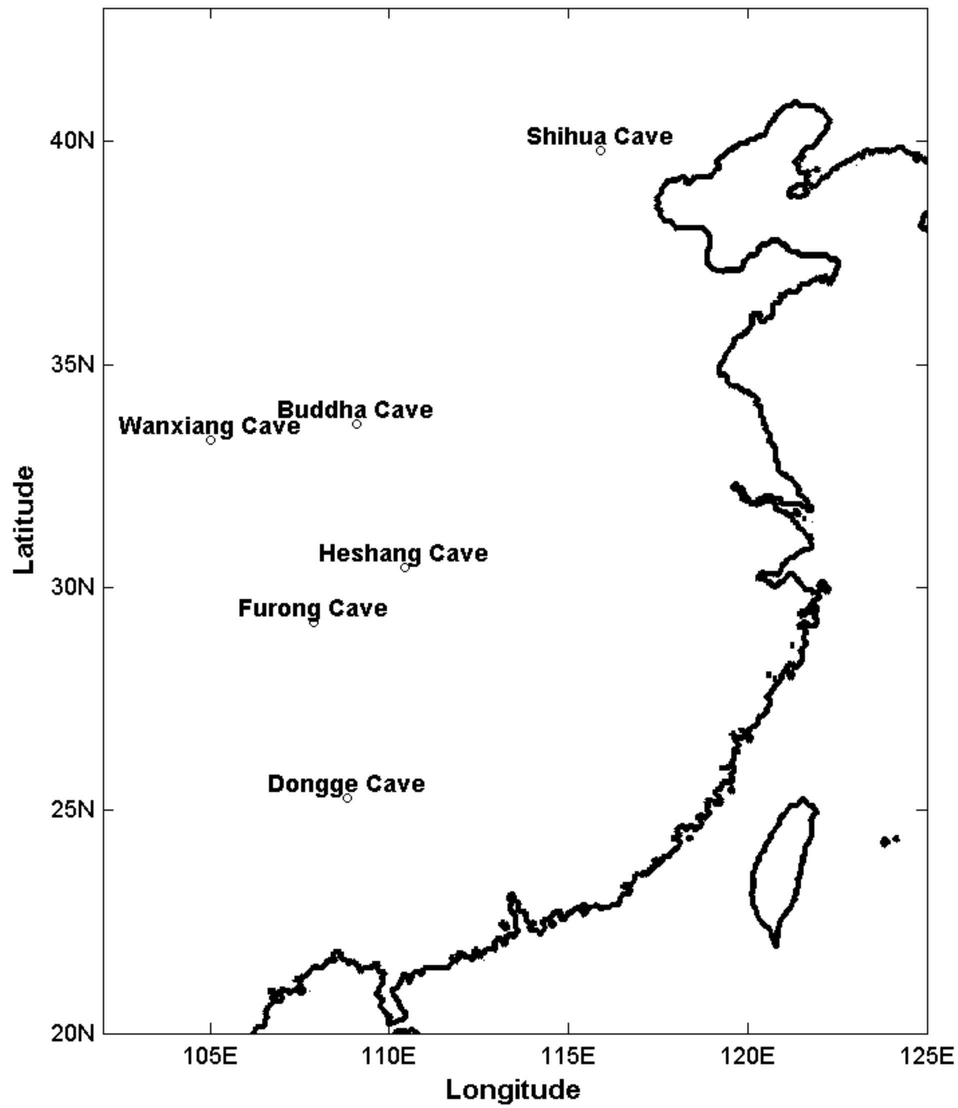
When a > 0.23, $\delta^{18}Oc$ and T have positive correlation.
When a < 0.23, $\delta^{18}Oc$ and T have negative correlation.

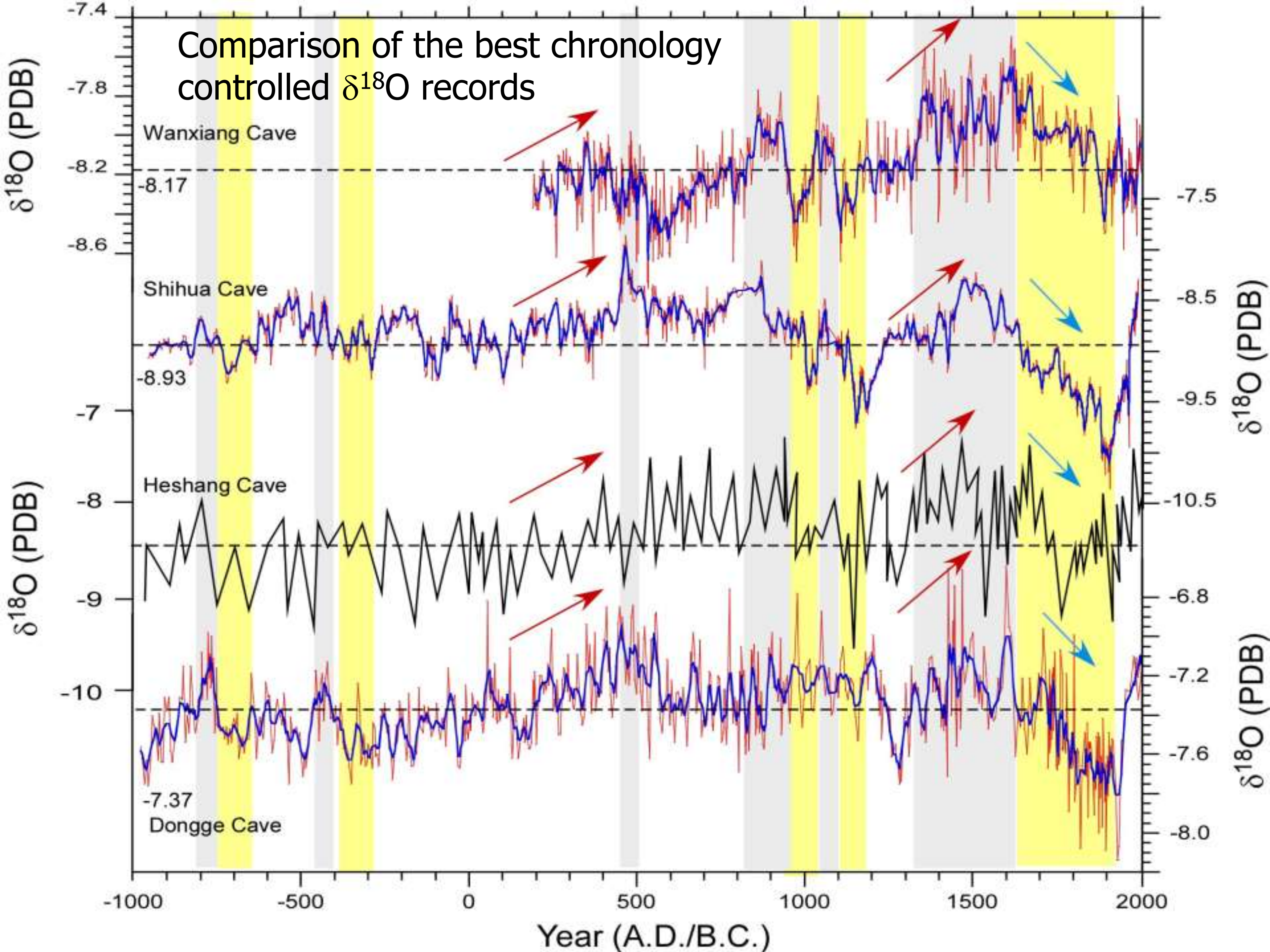
According to IAEA data base, a = 0.5 ~ 0.9 in N. America, Europe and mid-latitude where air mass is dominated by polar jet and westerly. On the other hand, a < 0.4 in monsoonal region.

Speleothem $\delta^{18}O$ in EAMS area

- Speleothem records in eastern China have been used for reconstruction of EASM strength, lighter d18O, stronger summer monsoon, with more rainfall (or wet and warm climates).

High-Resolution (Yearly) $\delta^{18}O$ Data from Six Caves





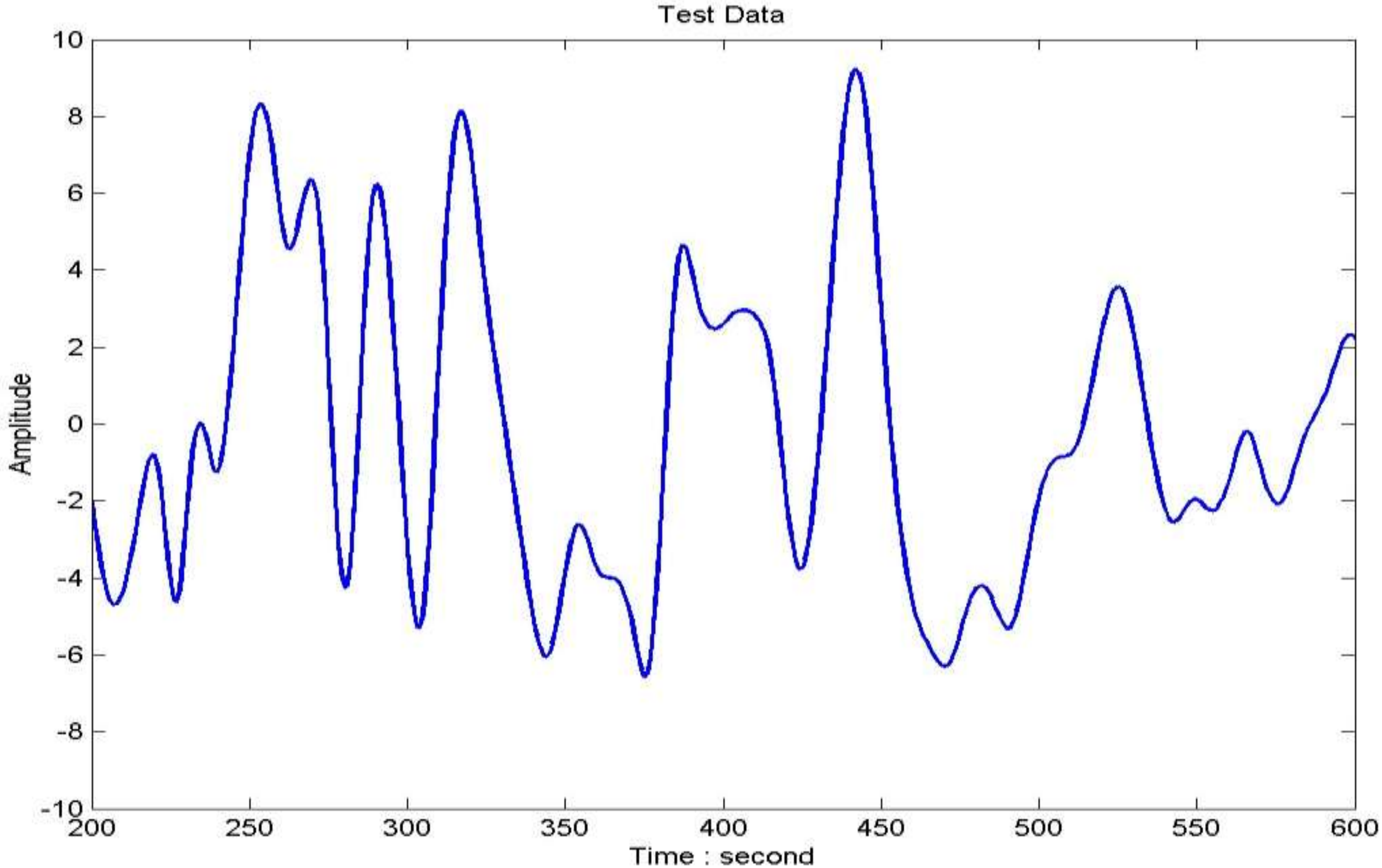
Comparison of the best chronology controlled δ18O records
Wanxiang Cave
-8.17
Shihua Cave
-8.93
Heshang Cave
-7.37
Dongge Cave
δ18O (PDB)
δ18O (PDB)
δ18O (PDB)
δ18O (PDB)
-7.4
-7.8
-8.2
-8.6
-7
-8
-9
-10
-7.5
-8.5
-9.5
-10.5
-6.8
-7.2
-7.6
-8.0
-1000
-500
0
500
1000
1500
2000
Year (A.D./B.C.)

What is the trend?

Empirical Mode Decomposition (Huang et al., 1998) → An Objective Method for Determining Trend

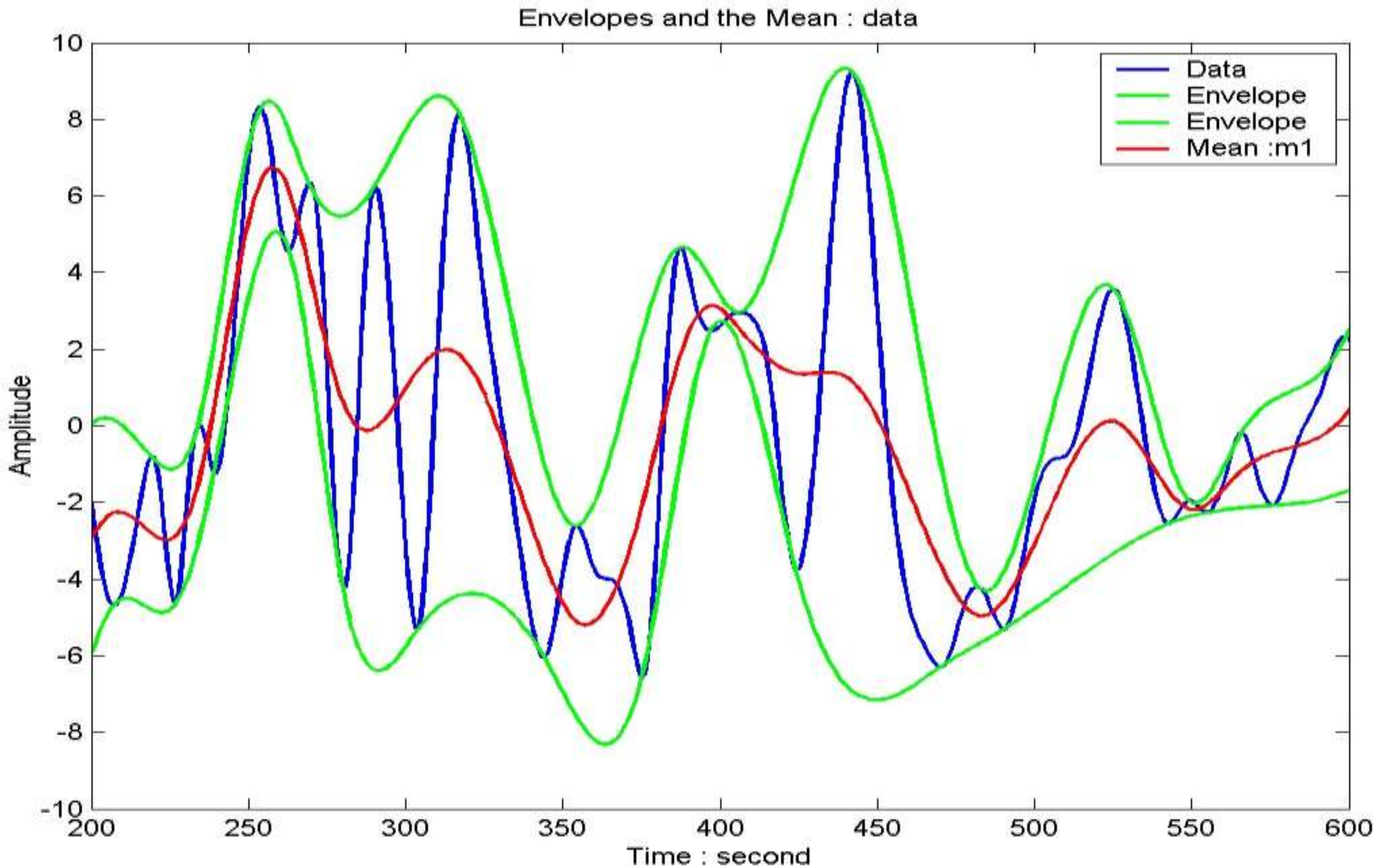
Empirical Mode Decomposition:

Methodology : Test Data



Empirical Mode Decomposition:

Methodology : data and m1



Empirical Mode Decomposition

Sifting : to get one IMF component

$$x(t) - m_1(t) = h_1(t),$$

$$m_1(t) - m_2(t) = h_2(t),$$

$$\cdots\cdots$$

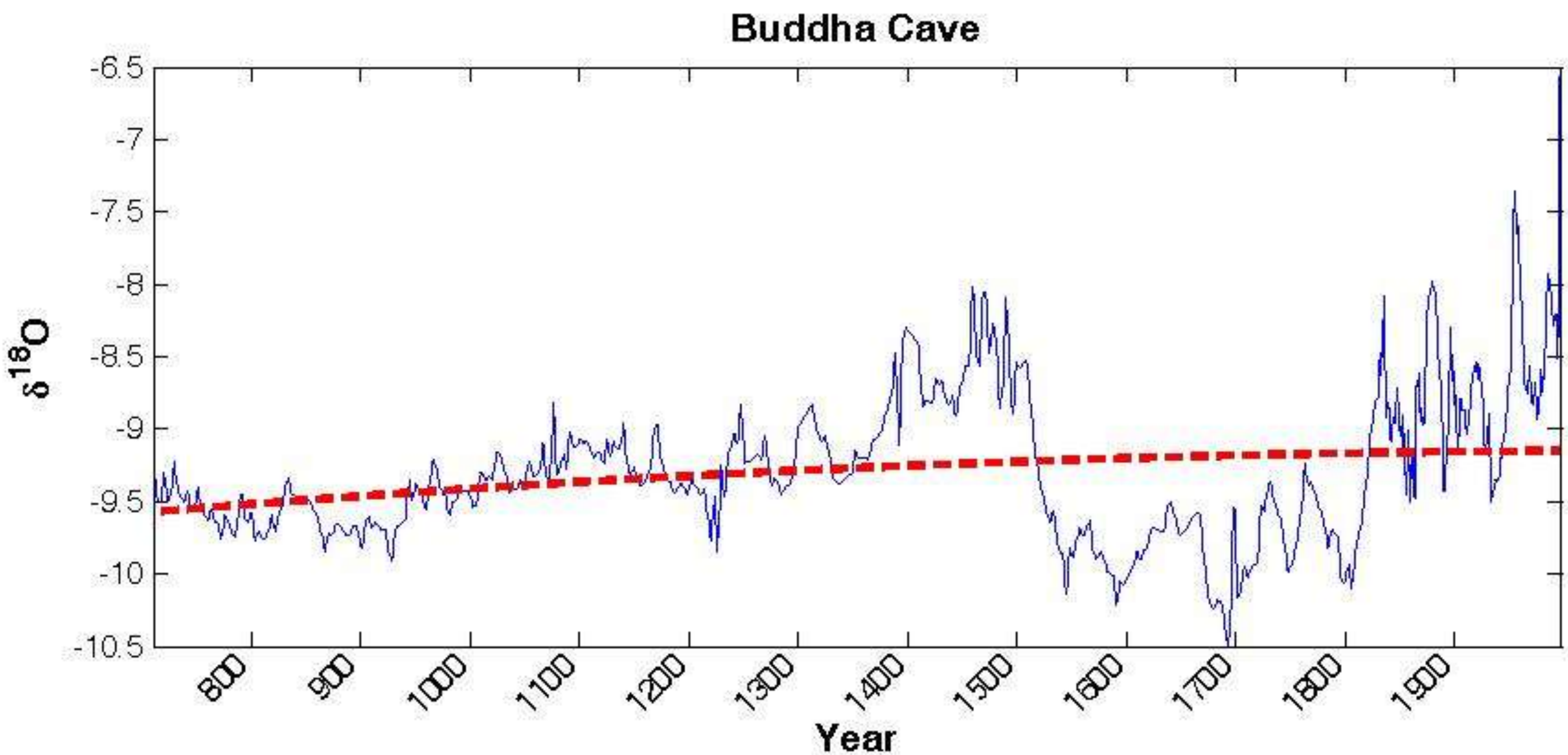
$$m_{k-1}(t) - m_k(t) = h_k(t).$$

$$\Rightarrow \quad x(t) = m_k(t) + \sum_{i=1}^{k} h_i(t).$$

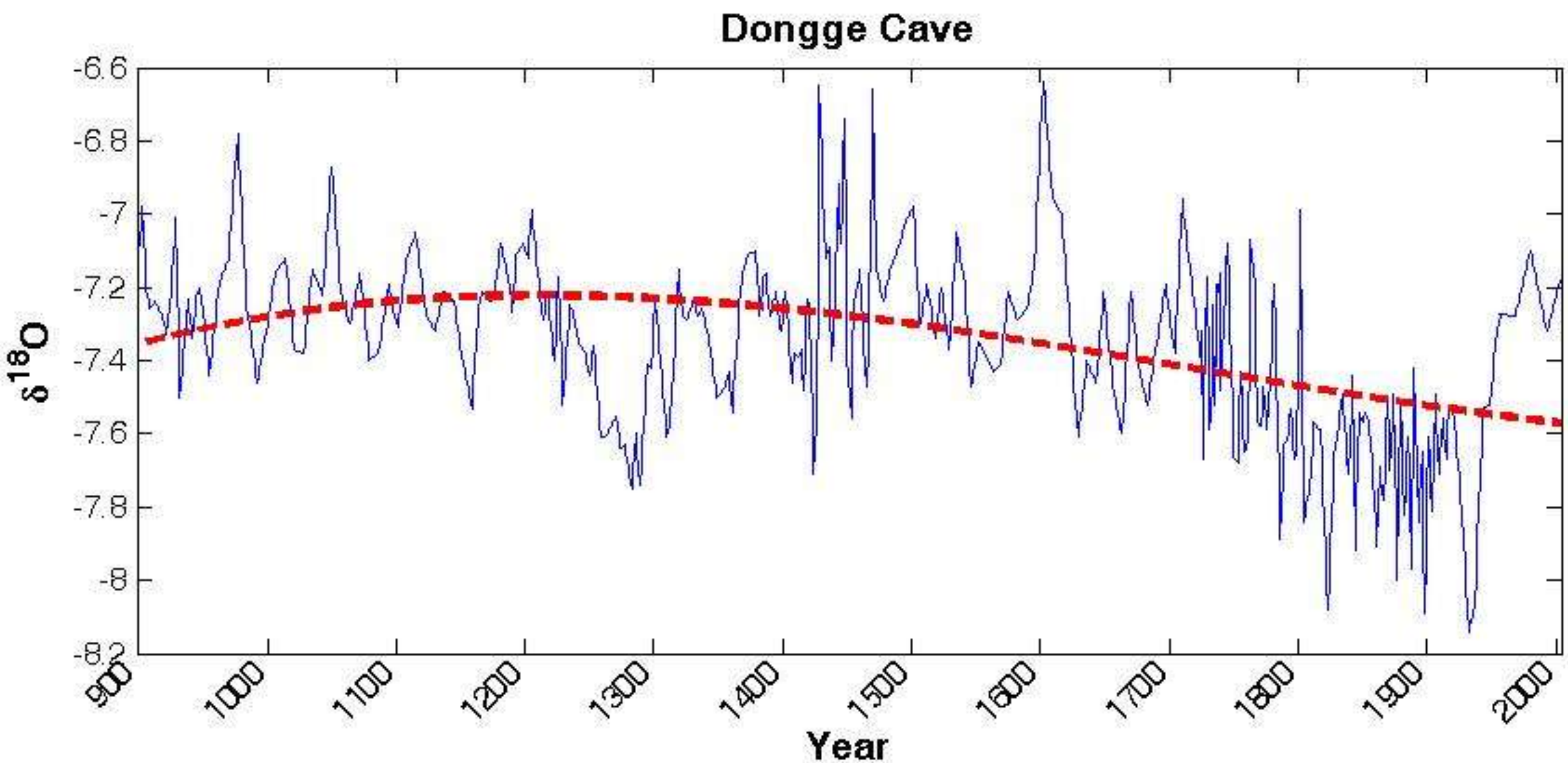
$h_i(t)$ → Intrinsic Mode Function (IMF)

$m_k(t)$ → Trend

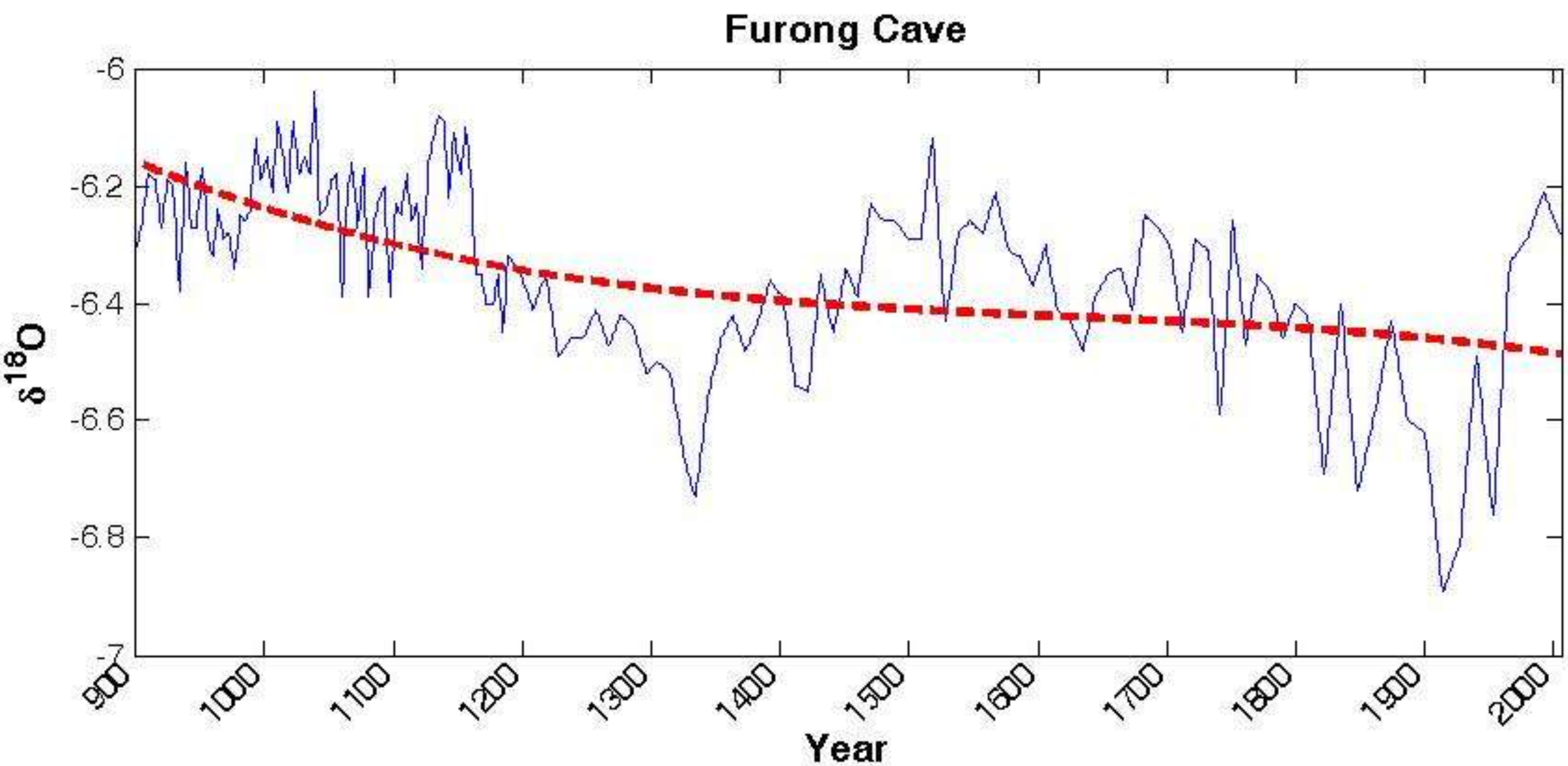
Trend – Buddha Cave



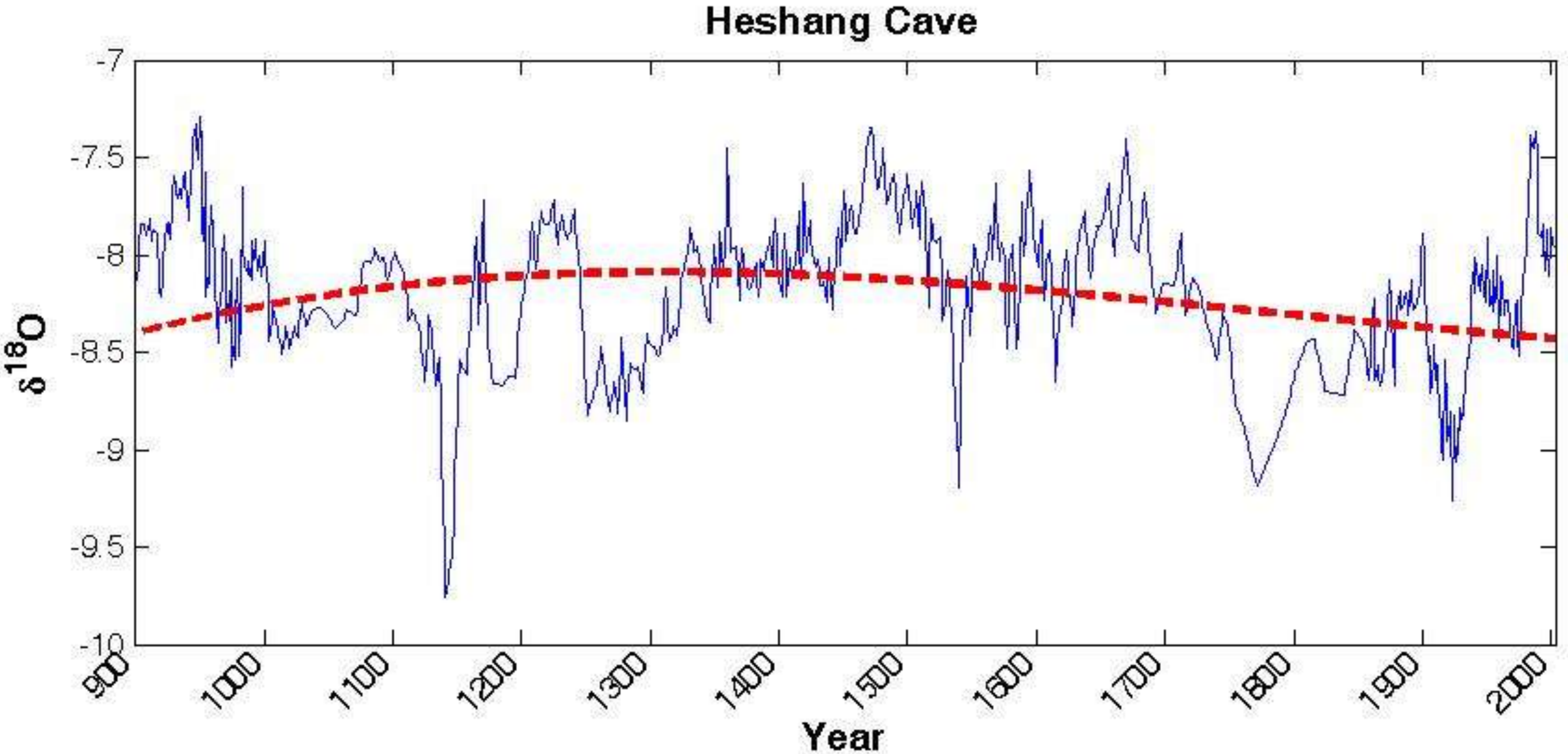
Trend – Dongge Cave



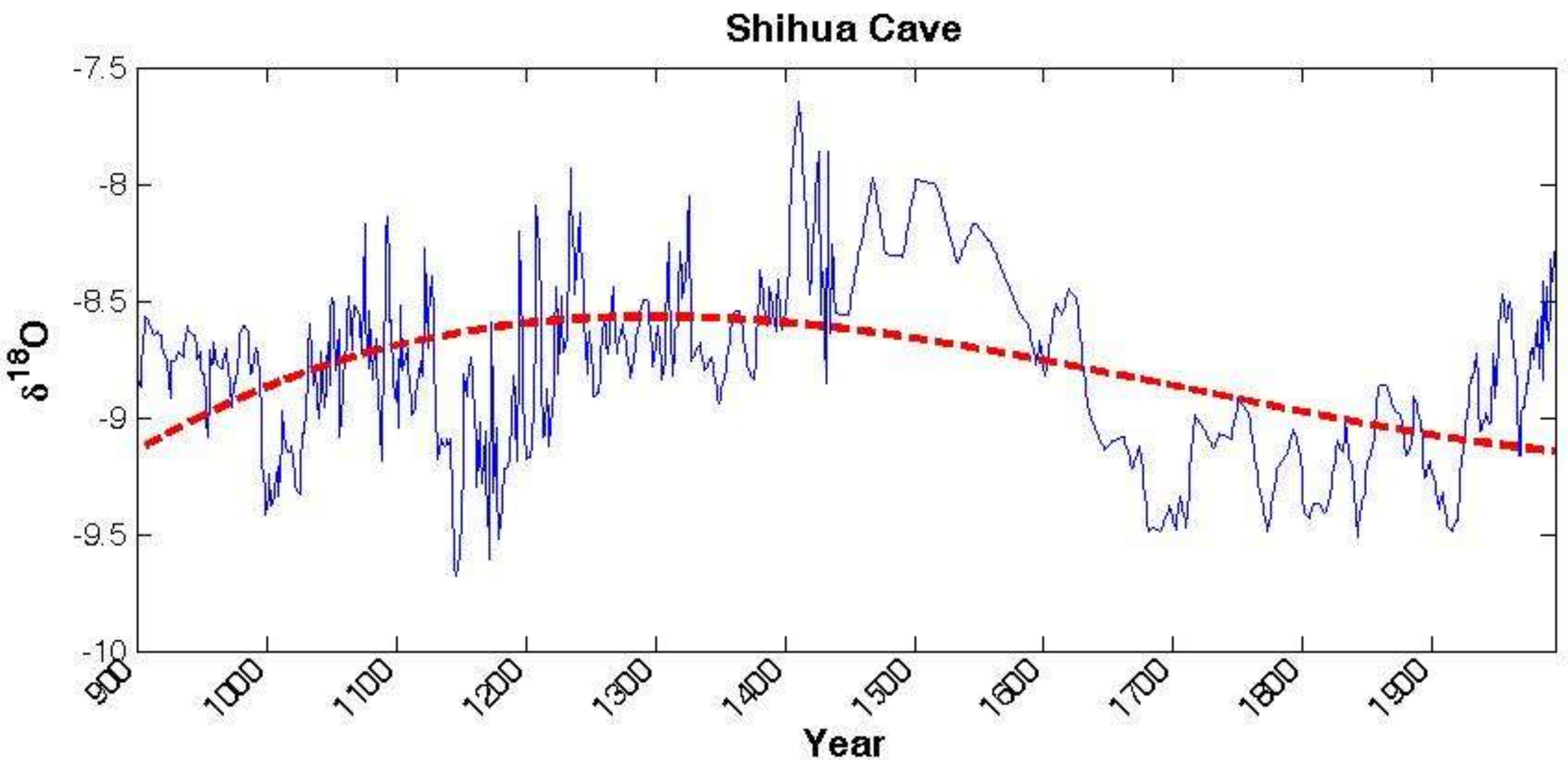
Trend – Furong Cave



Trend – Heshang Cave



Trend – Shihua Cave



De-trended Data (Anomaly)

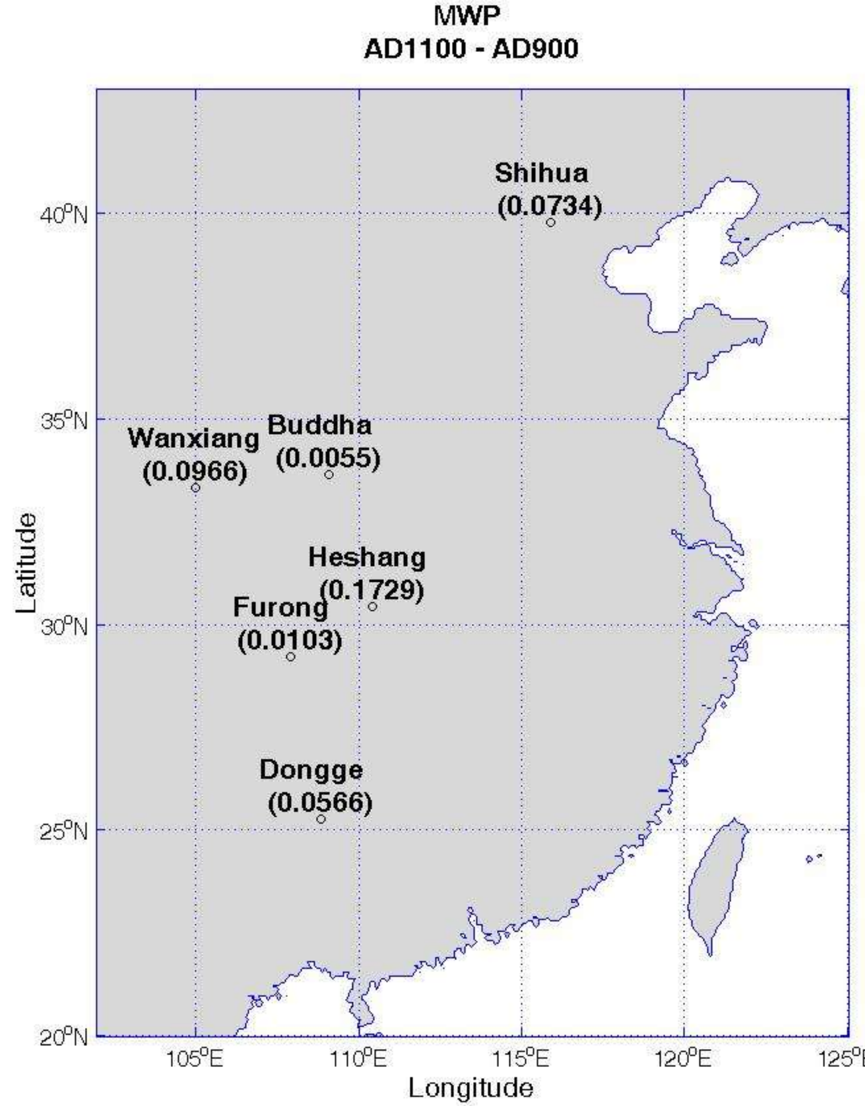
- Anomaly = Original - Trend

Four Periods

Medieval Warm Period **(MWP)**	AD 900 –AD 1100
Little Ice Age Phase-1 **(LIA-1)**	AD 1250 – AD 1550
Little Ice Age Phase-2 **(LIA-1)**	AD 1550 – AD 1850
Modern Period (MD)	AD 1850 – AD 2000

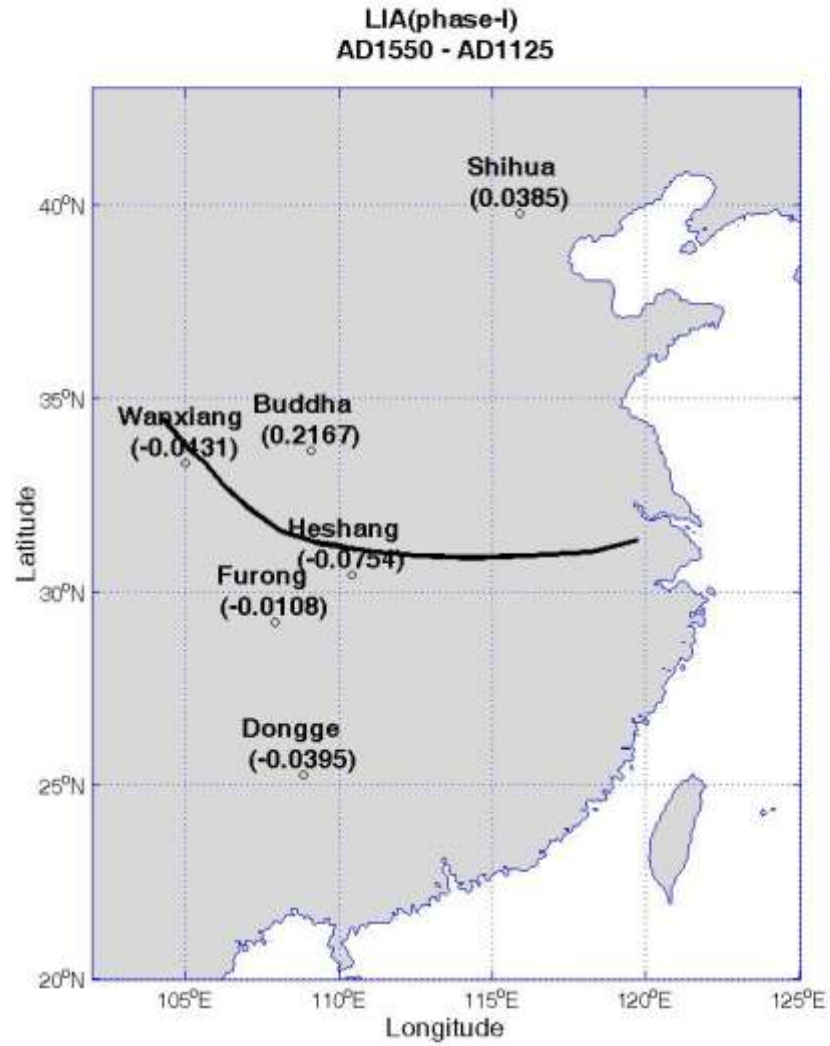
Averaged $\delta^{18}O$ Anomaly in MWP

- The $d^{18}O$ anomaly are all positive in six sites



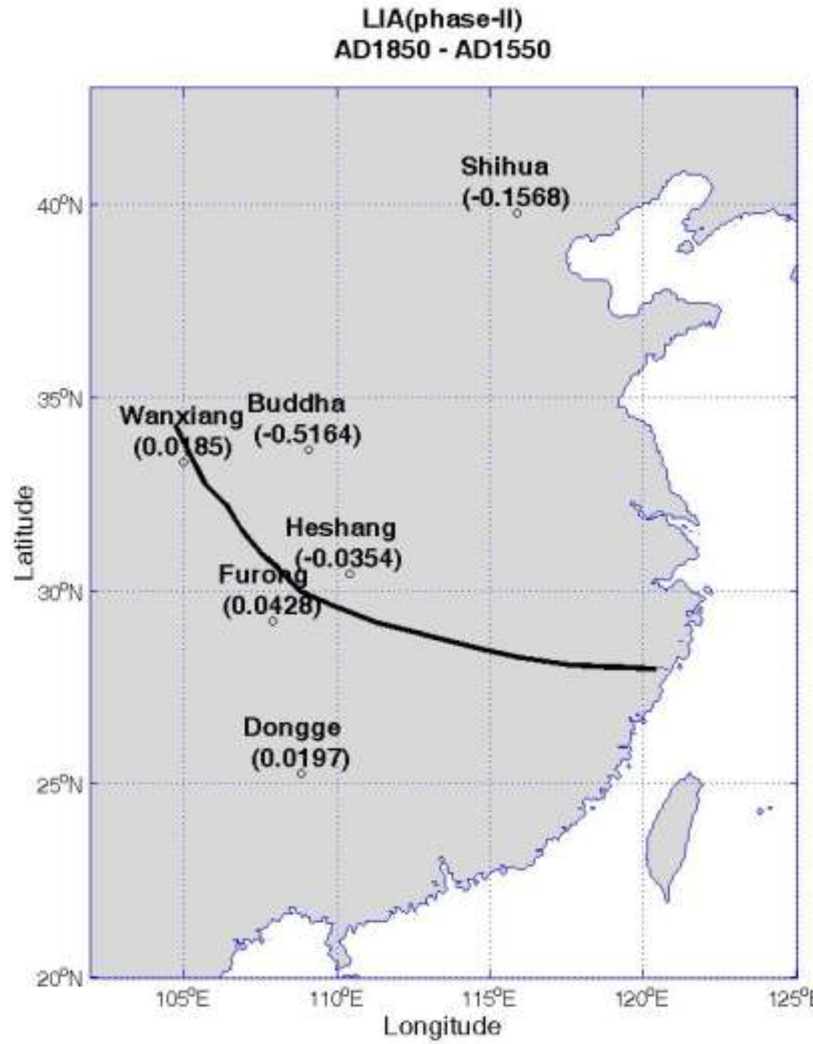
Averaged δ^{18}O Anomaly in LIA-1

- Northern China → Positive Anomaly
- Southern China → Negative Anomaly



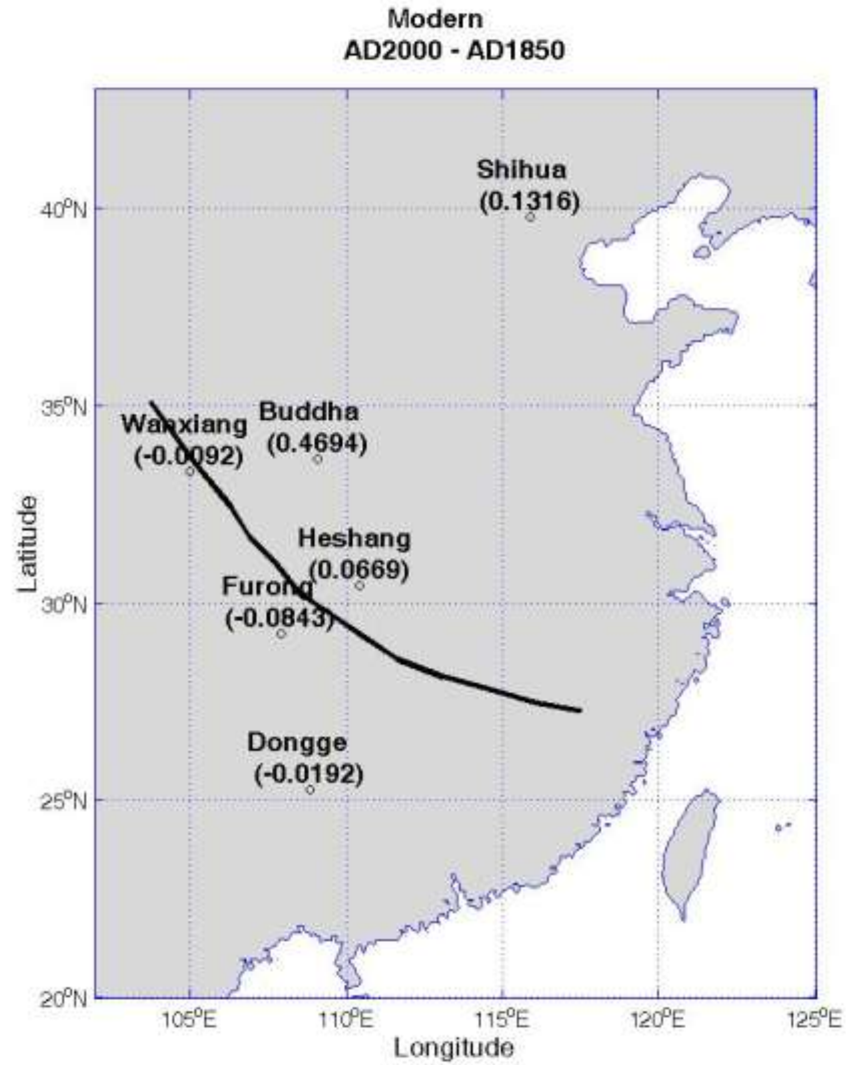
Averaged $\delta^{18}O$ Anomaly in LIA-2

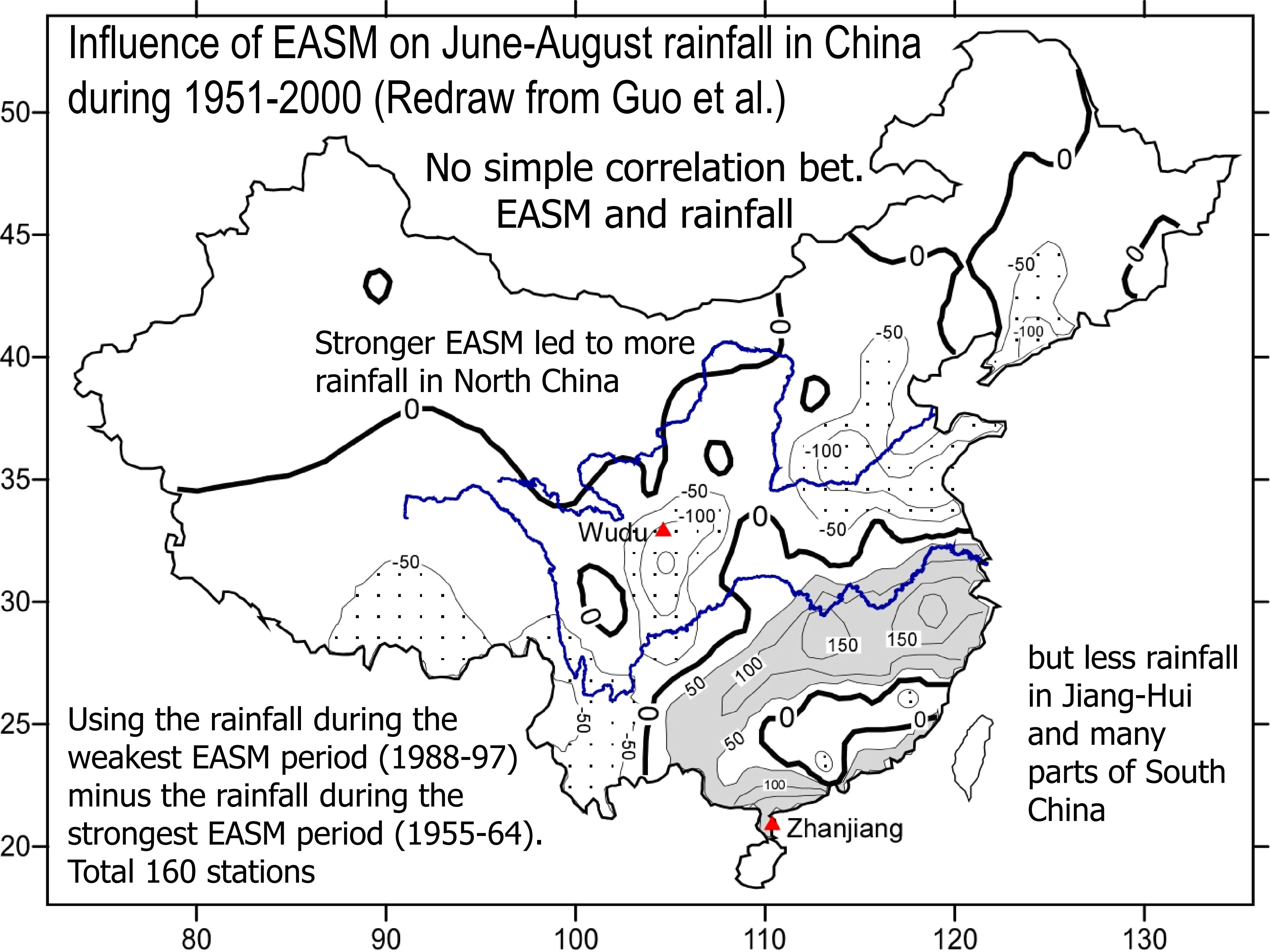
- Northern China → Negative Anomaly
- Southern China → Positive Anomaly



Averaged $\delta^{18}O$ Anomaly in MD

- Northern China → Positive Anomaly
- Southern China → Negative Anomaly




Influence of EASM on June-August rainfall in China
during 1951-2000 (Redraw from Guo et al.)
No simple correlation bet.
EASM and rainfall
Stronger EASM led to more
rainfall in North China
but less rainfall
in Jiang-Hui
and many
parts of South
China
Using the rainfall during the
weakest EASM period (1988-97)
minus the rainfall during the
strongest EASM period (1955-64).
Total 160 stations
Wudu
Zhanjiang
0
-50
-100
50
100
150
50
45
40
35
30
25
20
80
90
100
110
120
130

Conclusions

- **Both instrumental and historical climate records show strong spatial variations of rainfall and regional disparities of rainfall-EAM intensity relationship on 1-10 yrs scales over eastern China.**
- **Taking paleo-proxy records from a single locality in eastern China to imply changes in drought/wetness as to affect the cultural and political history of China is fraught with uncertainty.**
- **On 1-10 yrs scales, the thesis that $\delta^{18}O$ in speleothem can be used as a proxy for the EAM strength lacks empirical underpinnings.**

Thank you !