

前言

- 「由於近年考古學的飛越發展，中國上古史已經面目全非，遠遠超過傳統文獻歷史的範圍之外、、、今天的史學者不能不在寫史的時候並用兩種資料、、、要照顧到由考古學新產生的古文字史料及自然科學產生的歷史資料如地質、植物、海洋學、及同位素化學等學科所產生的對人類生活環境和採集食物、用物有關的數據和遺物。、、、建議將中國上古史用橫的眼光，以有關的論述和研究這些論題所用的史料為標準，做一個嶄新的重組。、、、研究這幾個題目需要的學科與資料是不同，這樣一來，過去中國上古史一個學科，現在要改成四個新的學科。各科專業者要接受不同的訓練。」

張光直（1997）對中國先秦史新結構的一個建議。《中國考古學與歷史學之整合研究》，中央研究院歷史語言研究所會議論文集之四，1 - 12頁。

中國夏商周文明發展的氣候背景： 古環境資料的整合與評析

2

台灣大學地質科學系

魏國彥

晚全新世中國南部石筍氧同位素值的時空變異

魏國彥, 莊智凱, 李紅春

地質科學系

國立臺灣大學

**SPATIOTEMPORAL PATTERNS
OF SUBORBITAL VARIATION IN
SPELEOTHEM OXYGEN
ISOTOPES IN SOUTH CHINA
DURING THE LATE HOLOCENE**

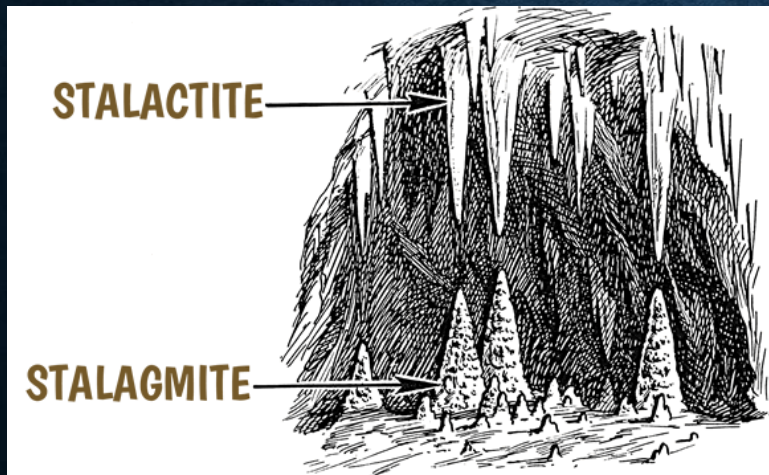
Kuo-Yen Wei, Zhi-Kai Chuang, Hong-Chun Li

Dept. of Geosciences

National Taiwan University

BACKGROUND

- **Speleothem $\delta^{18}\text{O}$ data of late Holocene** 晚全新世洞穴石灰岩氧同位素資料
- **Proxy for precipitation affected by atm. circulation and local conditions** 降水的代用指標，受到大氣環流與在地因素的調控
- **Modulated by solar insolation** 大趨勢受到太陽輻射的調控
- **Coherent with Greenland Ice Core $\delta^{18}\text{O}$** 趨勢與事件與格陵蘭冰芯氧同位素資料相呼應



<http://bilingualmonkeys.com/wp-content/uploads/2013/08/Stalactite-stalagmite.gif>

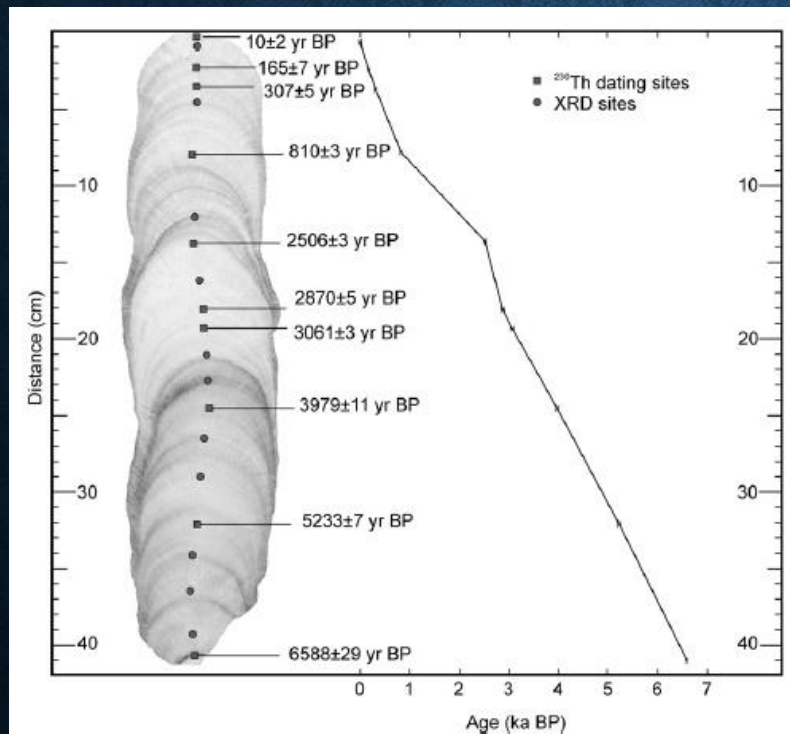
Contents lists available at [ScienceDirect](http://www.sciencedirect.com)

Earth and Planetary Science Letters

journal homepage: www.elsevier.com/locate/epsl

East Asian monsoon variability since the Mid-Holocene recorded in a high-resolution, absolute-dated aragonite speleothem from eastern China

Jason Cosford^{a,*}, Hairuo Qing^a, Bruce Eglinton^b, Dave Matthey^c,
Daoxiang Yuan^d, Meiliang Zhang^d, Hai Cheng^e

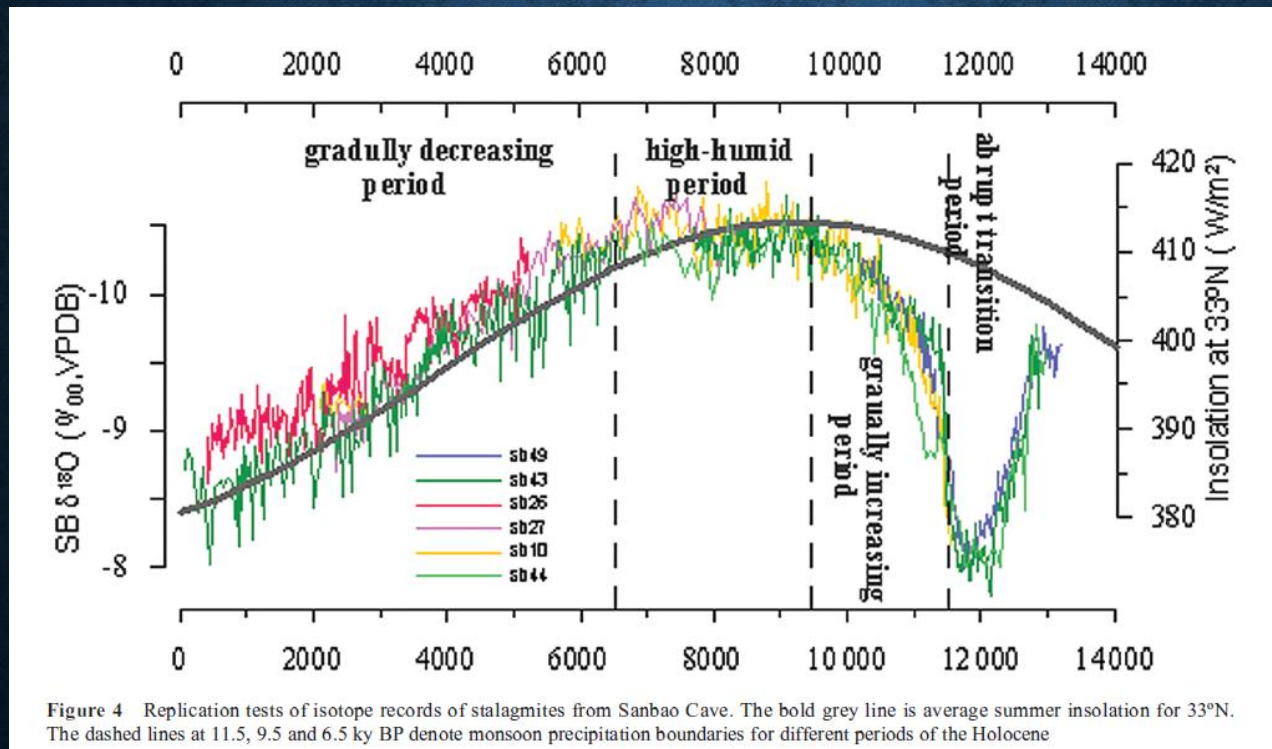


Absolute dates 絕對定年
High resolution 高解析度

Lianhua Cave, Hunan
湖南蓮花洞

湖北三寶洞石筍氧同位素紀錄，與北緯 33度夏季陽光照射量相符

The Holocene 20,2 (2010) pp. 257–264



A high-resolution stalagmite record of the Holocene East Asian monsoon from Mt Shennongjia, central China

Jinguo Dong,¹ Yongjin Wang,^{1,*} Hai Cheng,^{1,2} Ben Hardt,²
R. Lawrence Edwards,² Xingong Kong,¹ Jiangying Wu,¹
Shitao Chen,¹ Dianbing Liu,¹ Xiuyang Jiang,¹ and Kan Zhao¹

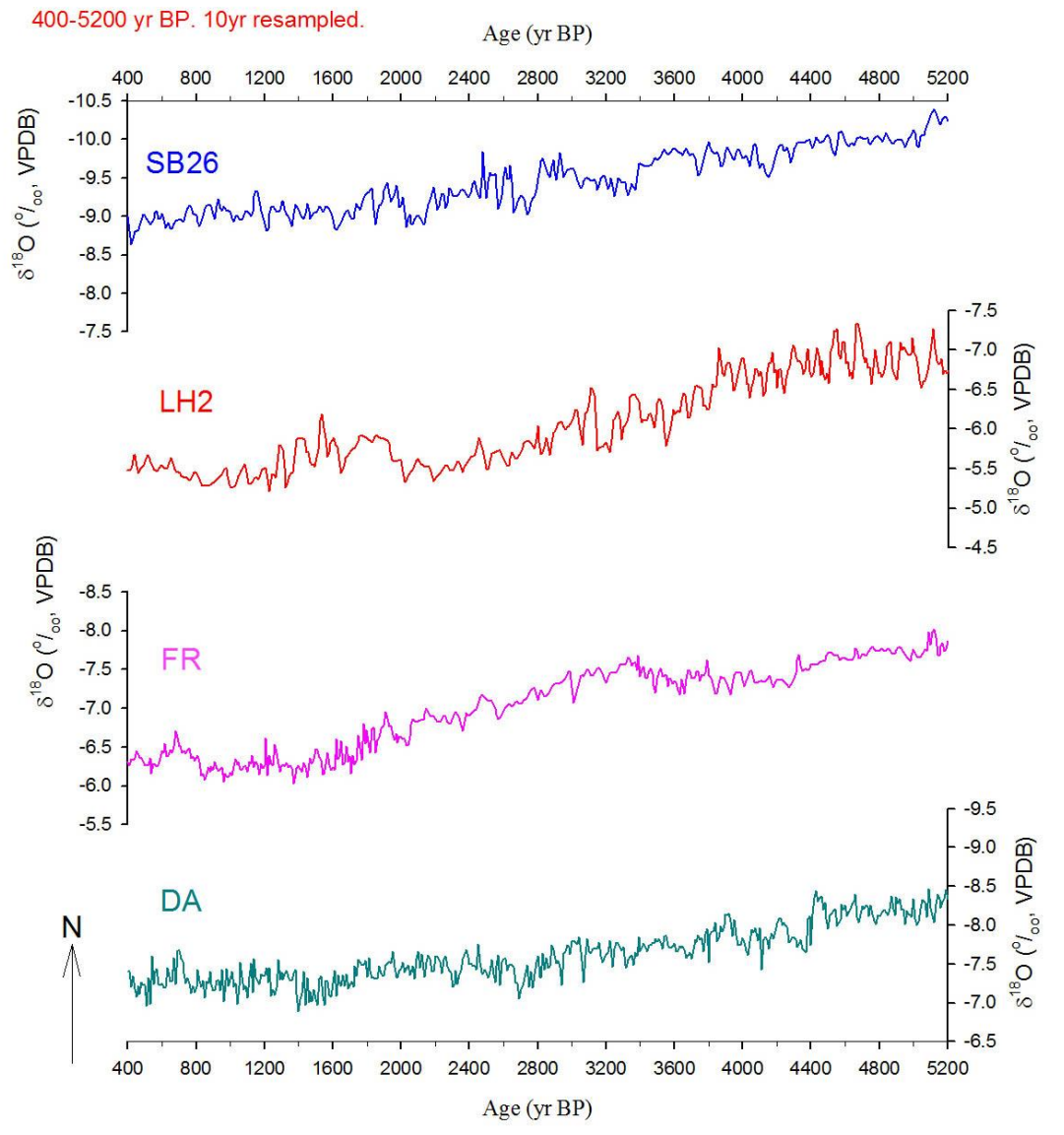
數據

三寶 31.7°N

蓮花 29.5°N

芙蓉 29.25°N

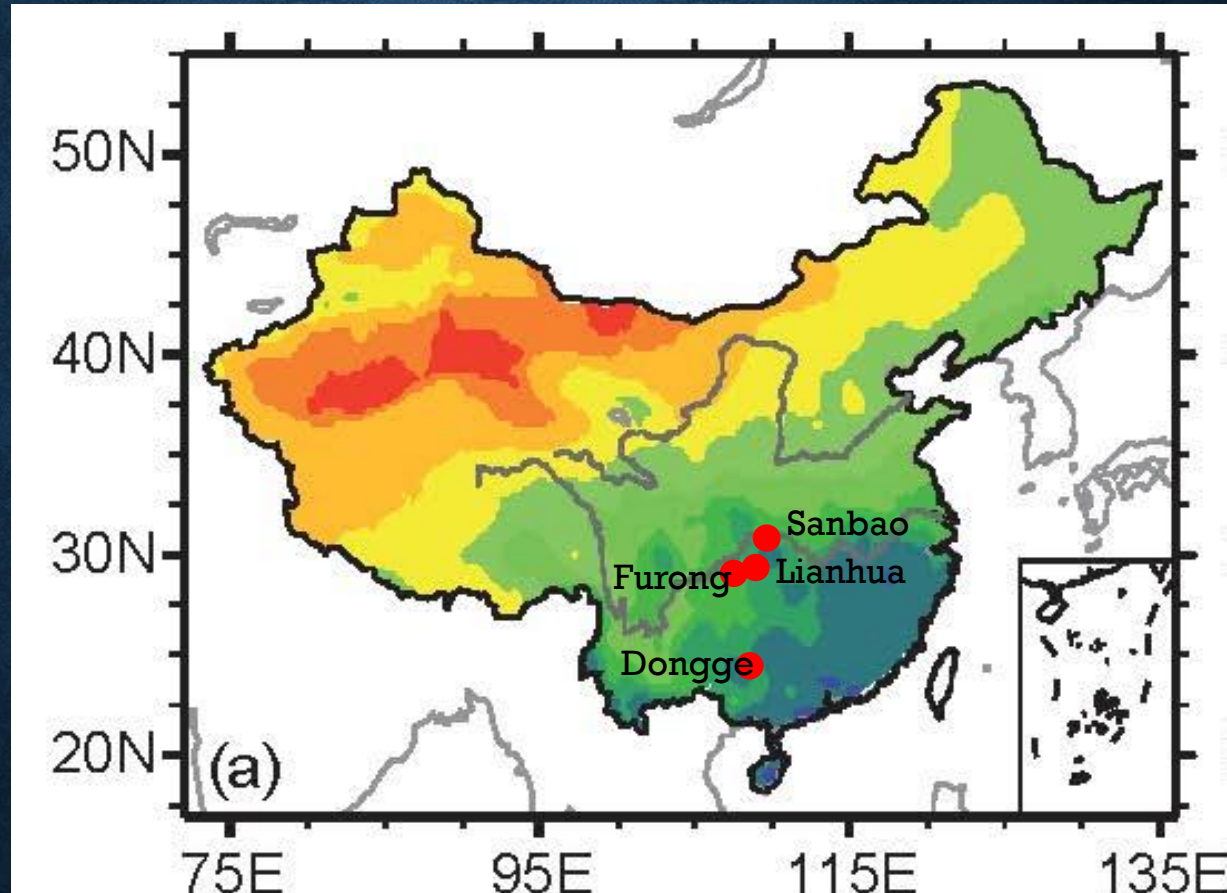
董哥 25.3°N



華南四石筍氧同位素時間序列、400-5200年前，每10年一數據點。

CAVE LOCATIONS & PRECIPITATION SETTING

三寶
31.7°N
蓮花
29.5°N
芙蓉
29.25°N
董哥
25.3°N



Precipitation mm/yr (1981 – 2000),
from CN05.1

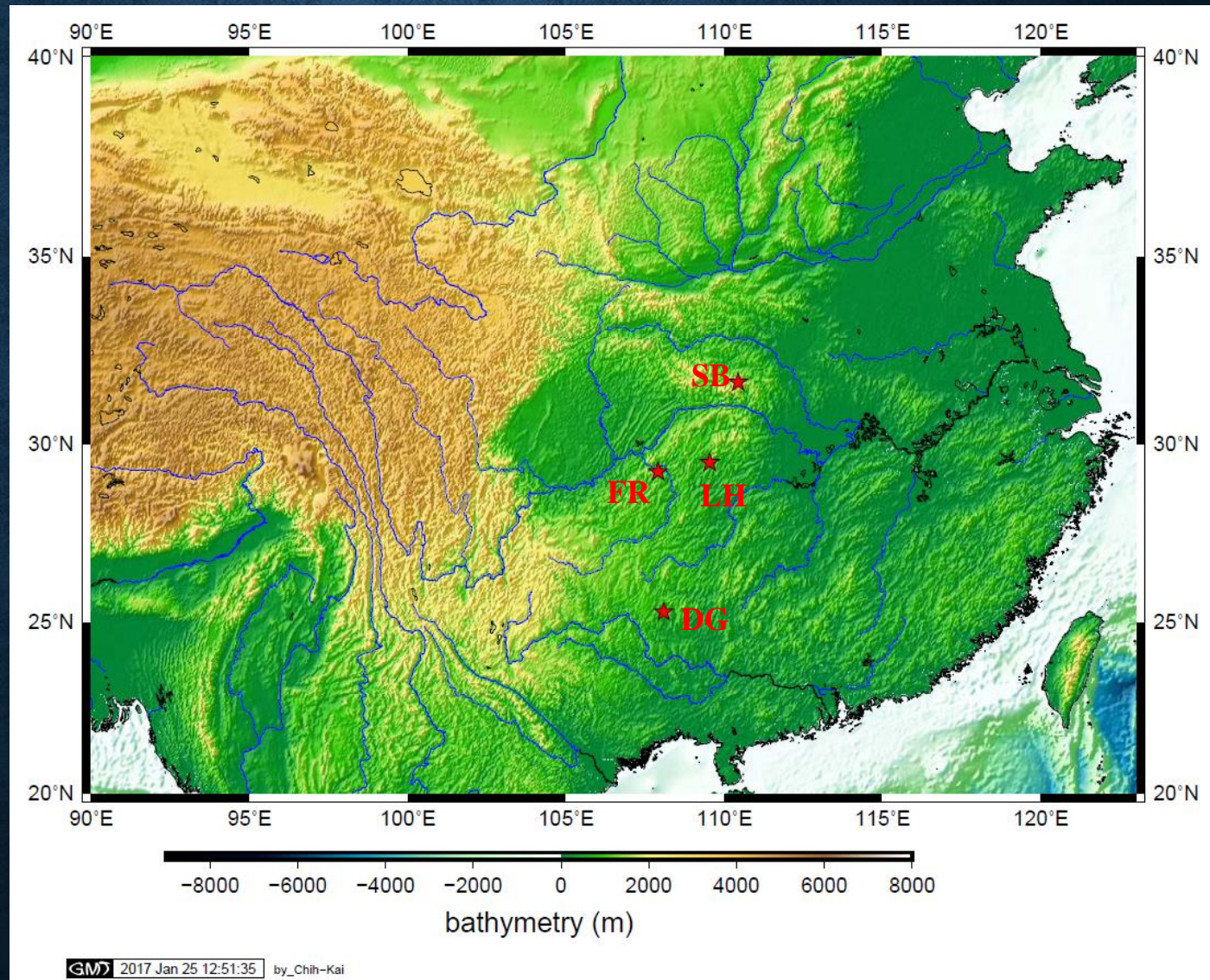
四個石灰岩洞位置

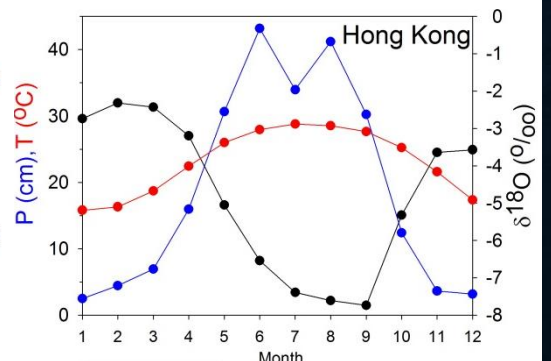
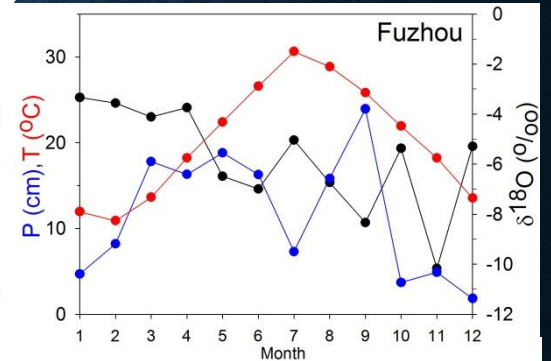
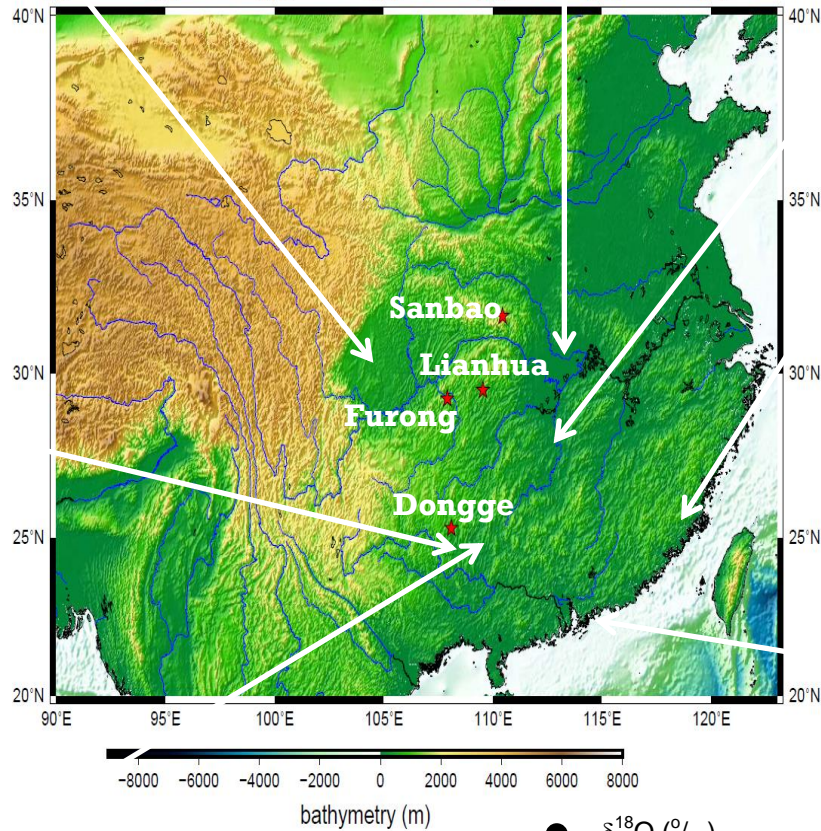
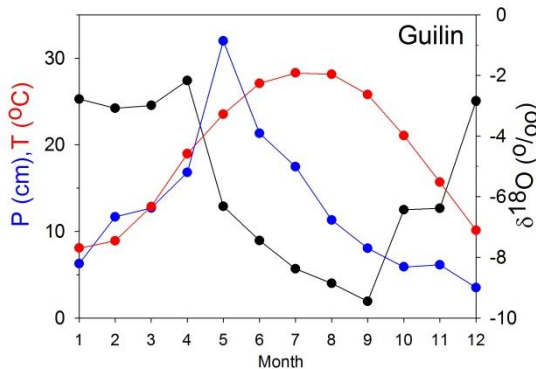
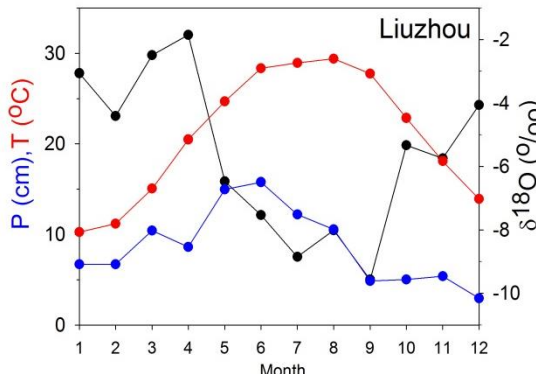
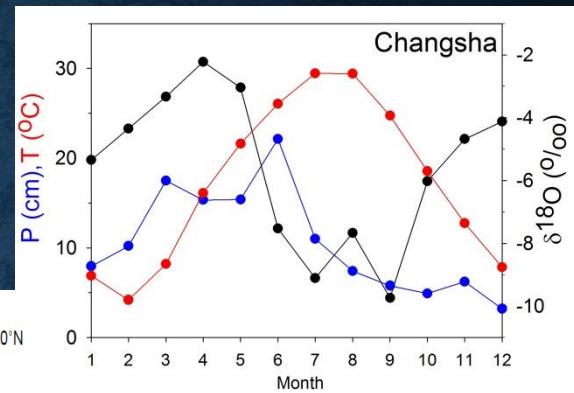
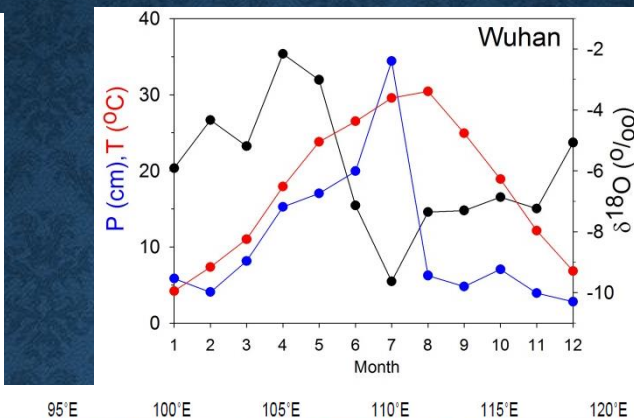
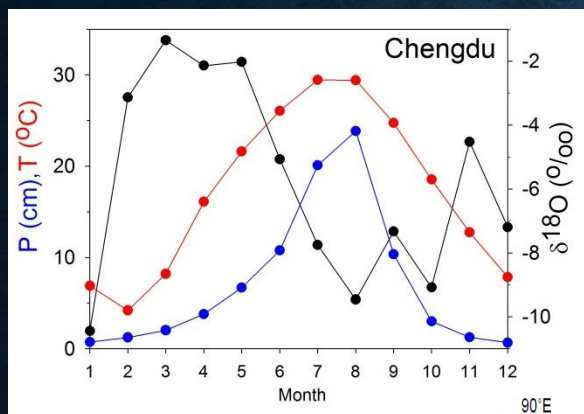
三寶 SB
31.7°N

蓮花 LH
29.5°N

芙蓉 FR
29.25°N

董哥 DG
25.3°N



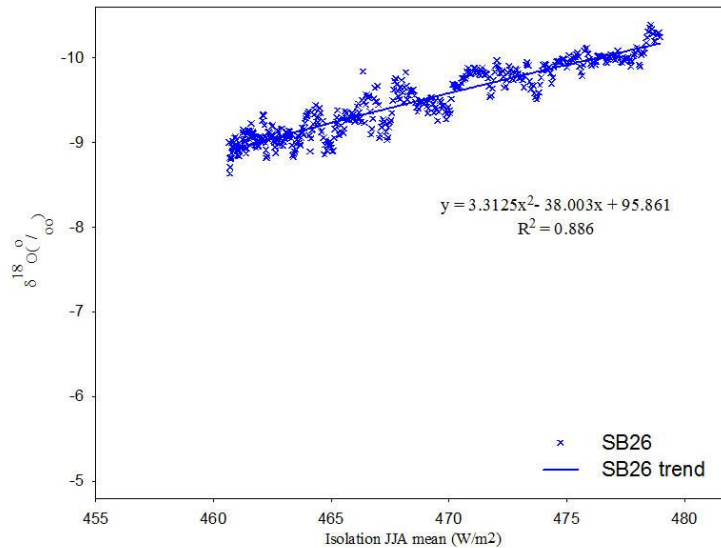


Data source: Global Network of Isotopes in Precipitation

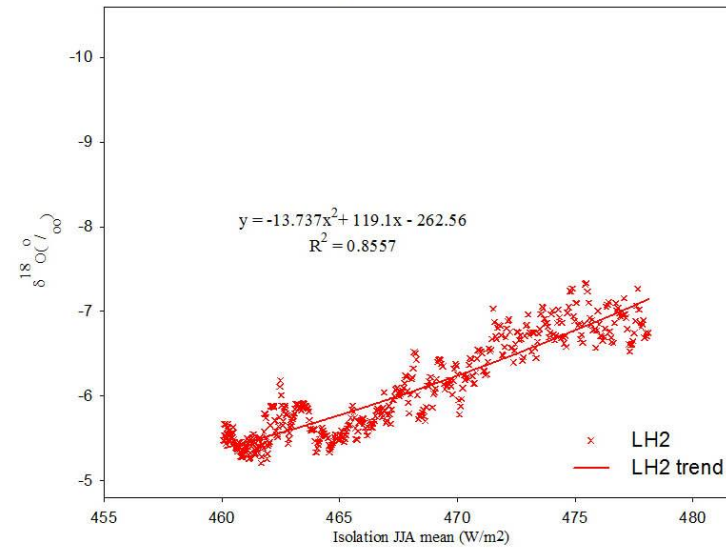
METHODS

- **De-trended** 去趨勢
- **Empirical orthogonal function (EOF)** 經驗正交函數
- **Spectral and wavelet analyses** 頻譜及小波分析
- **Cross spectral analyses** 交叉頻譜分析
- **Cross wavelet analysis** 交叉小波分析

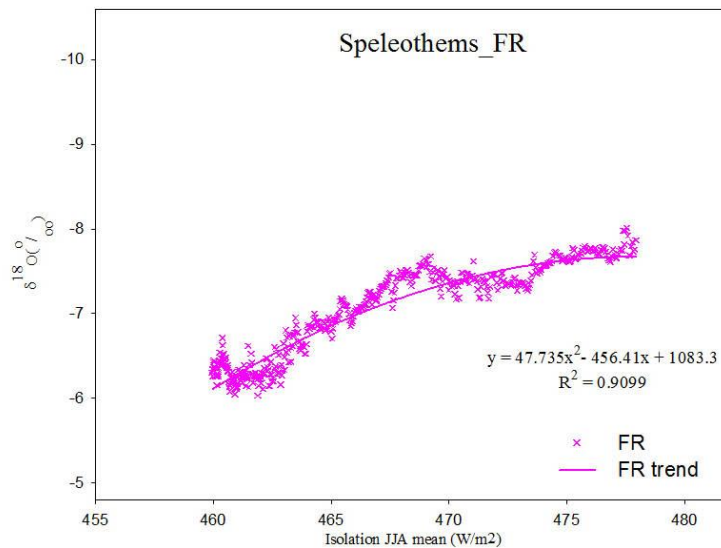
Speleothems_SB26



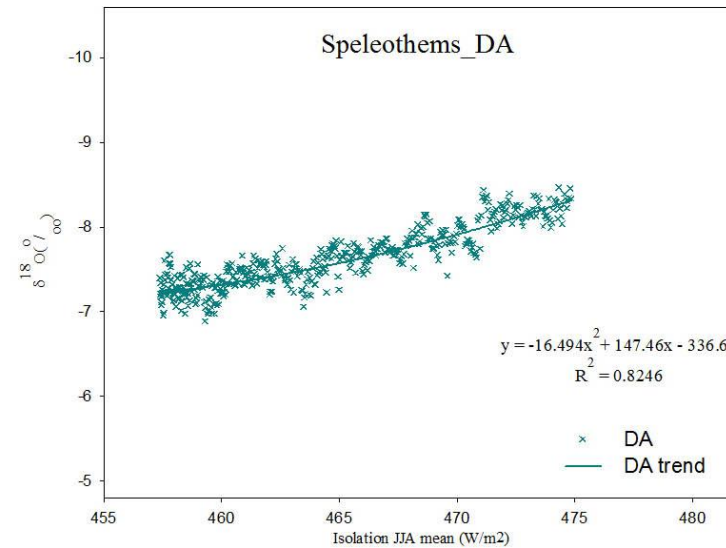
Speleothems_LH2



Speleothems_FR

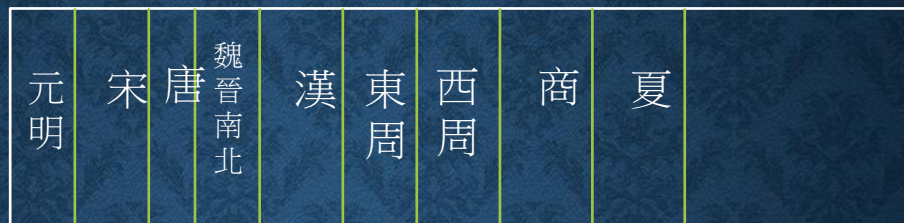


Speleothems_DA



Curve fitting with solar insolation (SI): $\delta^{18}\text{O} = a \text{SI}^2 + b \text{SI} + c$. $R^2 = 0.82\text{--}0.91$

TRENDS IN FOUR RECORDS

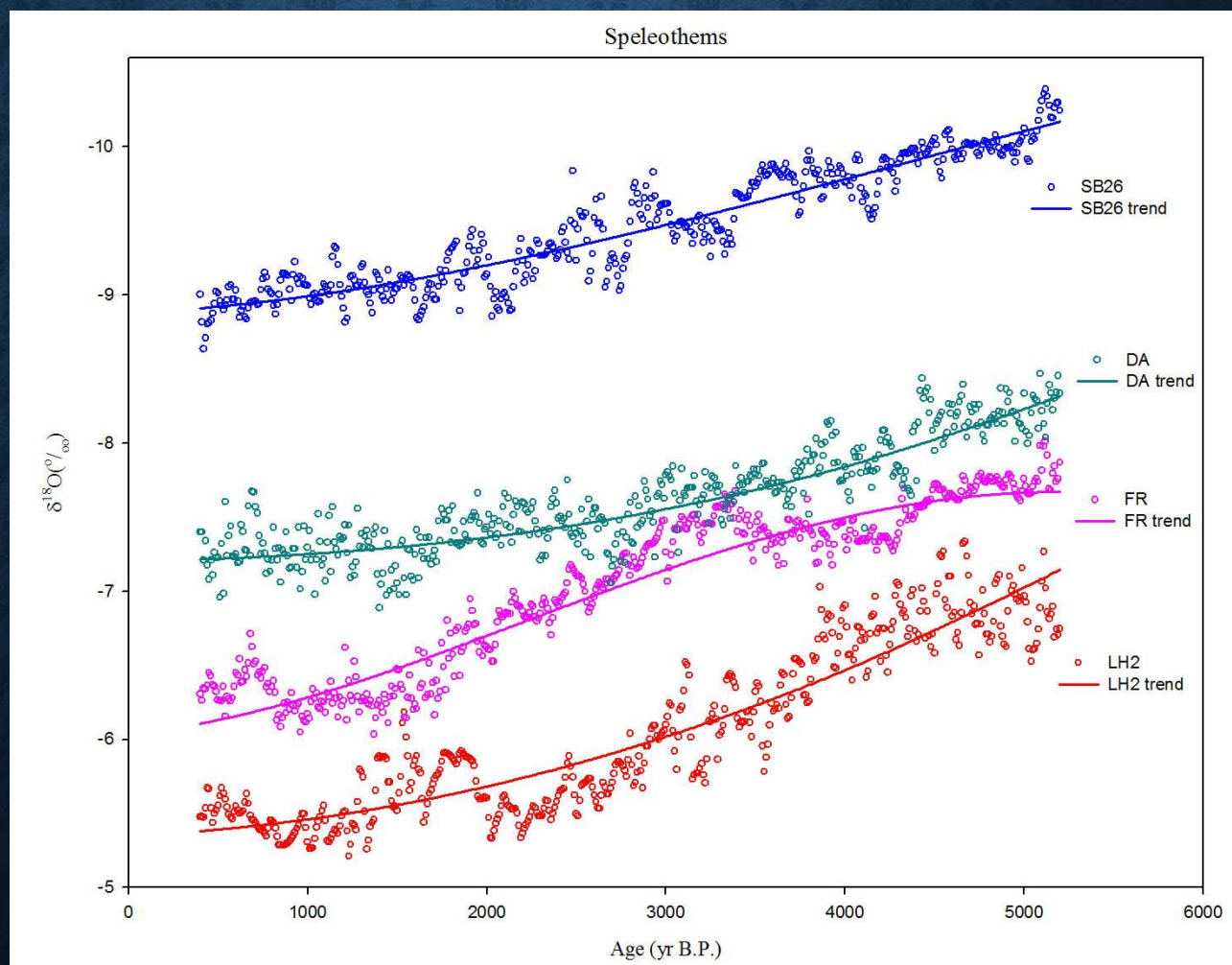


三寶 31.7°N

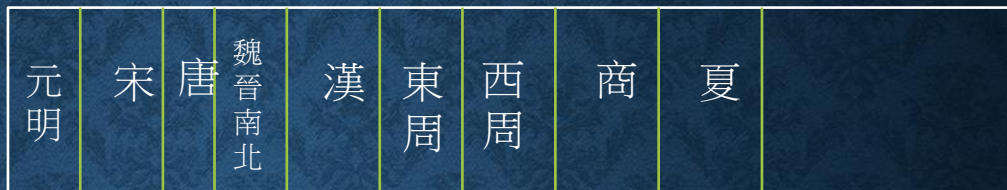
蓮花 29.5°N

芙蓉 29.25°N

董哥 25.3°N



DE-TRENDED ($\Delta^{18}\text{O}$) TIME SERIES

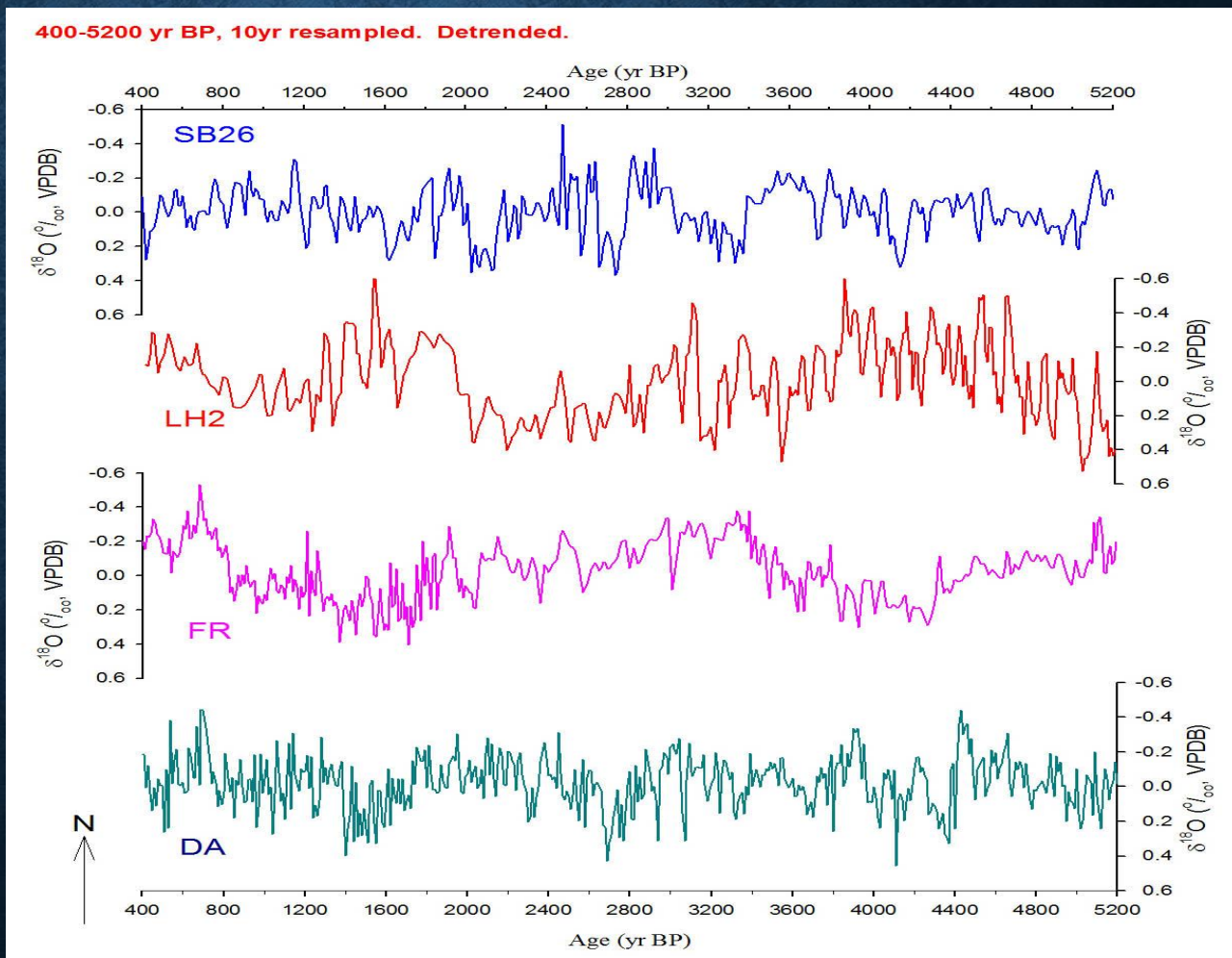


三寶 31.7°N

蓮花 29.5°N

芙蓉
29.25°N

董哥 25.3°N



SUMMER RAINFALL PATTERNS IN SOUTHERN CHINA 華南兩個夏季雨型 (1951-2014、66雨量站) — 趙俊虎等人 (2016) 大氣科學, 40卷, 6期

第40卷第6期
2016年11月

大气科学
Chinese Journal of Atmospheric Sciences

Vol. 40 No. 6
Nov. 2016

赵俊虎, 杨柳, 曾宇星, 等. 2016. 夏季长江中下游和华南两类雨型的环流特征及预测信号 [J]. 大气科学, 40 (6): 1182-1198. Zhao Junhu, Yang Liu, Zeng Xingyu, et al. 2016. Analysis of atmospheric circulation and prediction signals for summer rainfall patterns in southern China [J]. Chinese Journal of Atmospheric Sciences (in Chinese), 40 (6): 1182-1198. doi: 10.3878/j.issn.1006-9895.1601.15249.

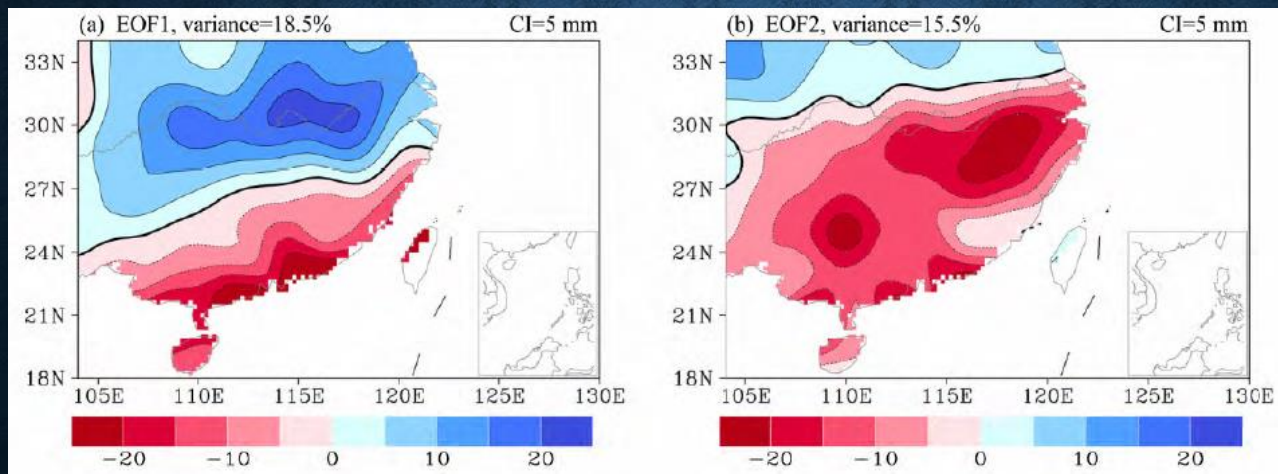
夏季长江中下游和华南两类雨型的环流特征及预测信号

赵俊虎¹ 杨柳² 曾宇星¹ 封国林^{1,2}

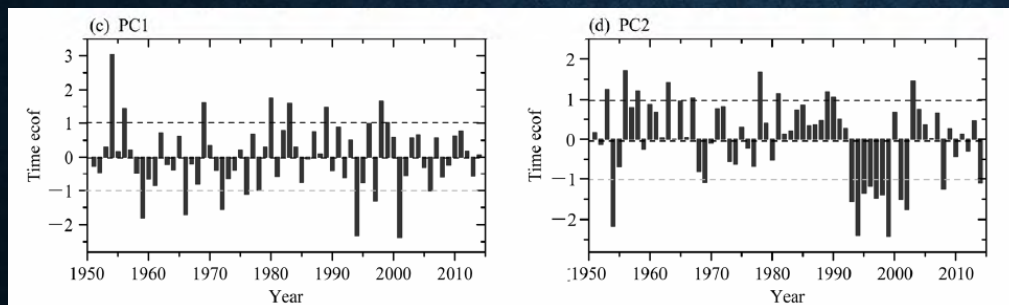
¹ 中国气象局国家气候中心中国气象局气候研究开放实验室, 北京 100081

² 扬州大学物理科学与技术学院, 扬州 225002

用EOF找出不相從屬的
空間模態, 及各模態時
間變化特徵



空間模態



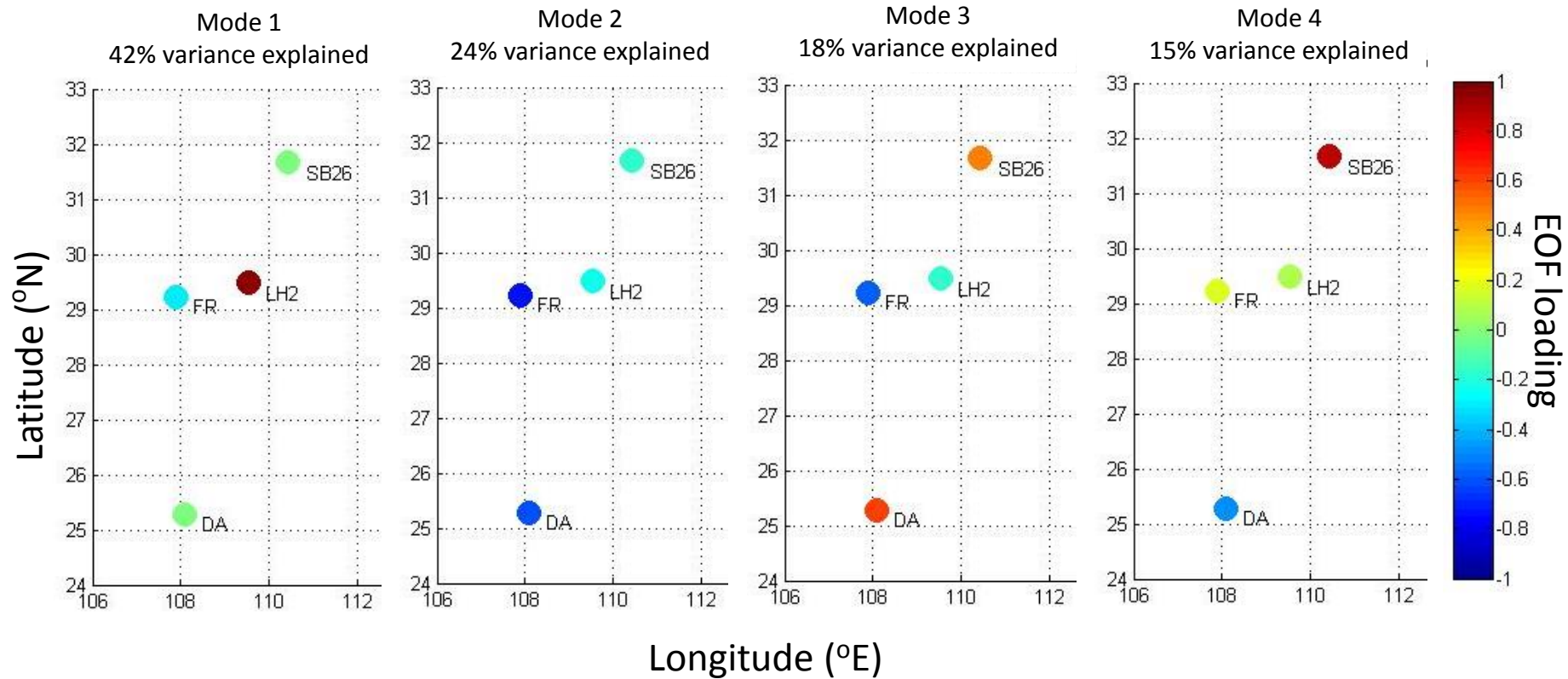
時間變化

Lianhua variability

SW dominance

Geographic heterogeneity

N-S gradient



TEMPORAL VARIATION AND SPECTRA OF 4 EOF MODES & CLIMATIC PARAMETERS

Spectral and Wavelet analyses of

- coefficient time series of EOFs 1 – 4
- Sun spot number
- $\delta^{18}\text{O}$ of GISP 2 Ice Core
- K^+ of GISP 2 Ice Core

Coefficient time series of EOF1

Coefficient time series of EOF2

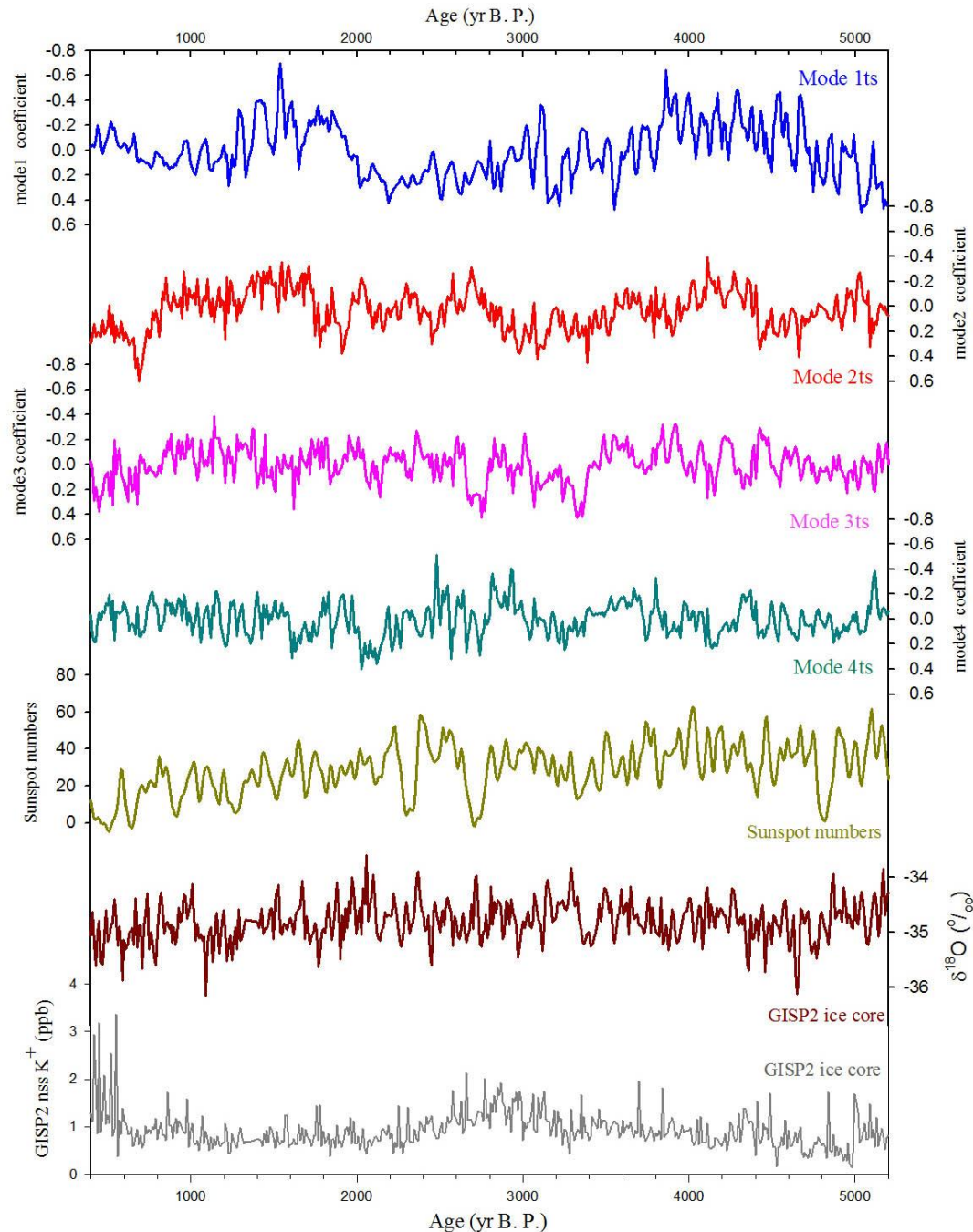
Coefficient time series of EOF3

Coefficient time series of EOF4

Sun spot number

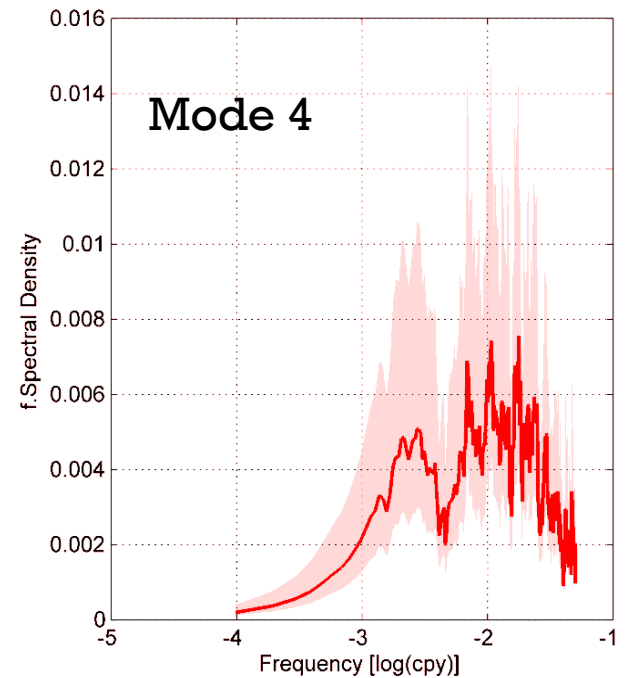
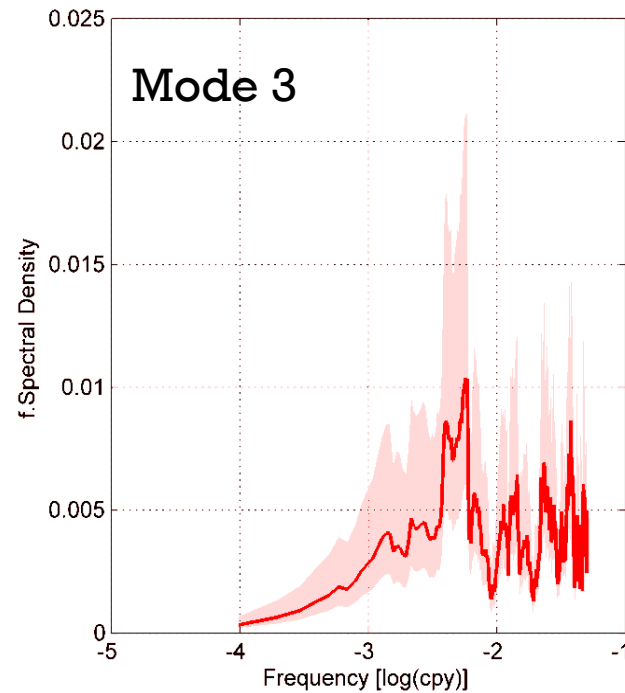
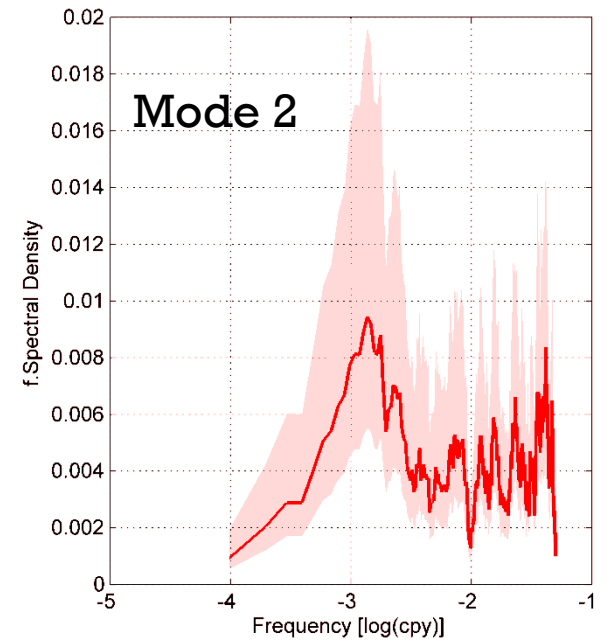
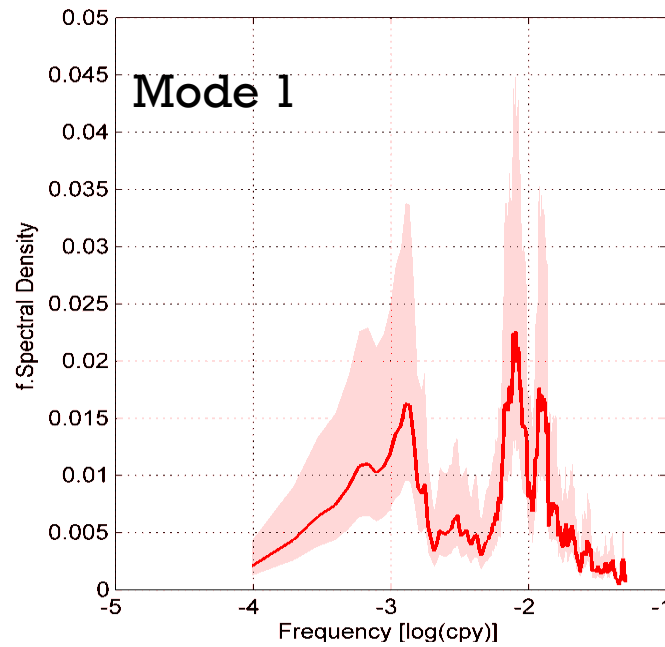
$\delta^{18}\text{O}$ of GISP2

K^+ of GISP2



Spectra of four EOF modes

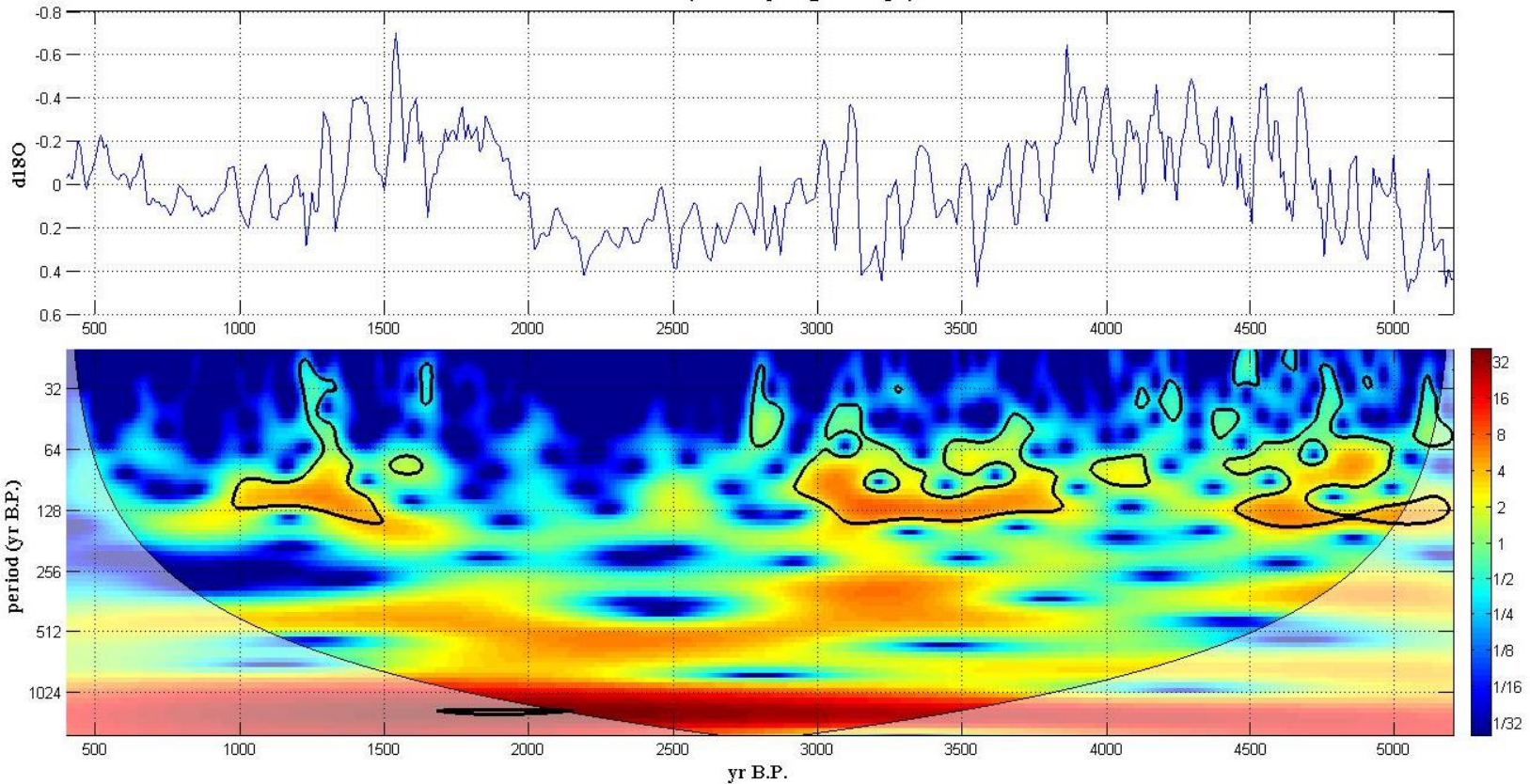
四種模態的頻譜



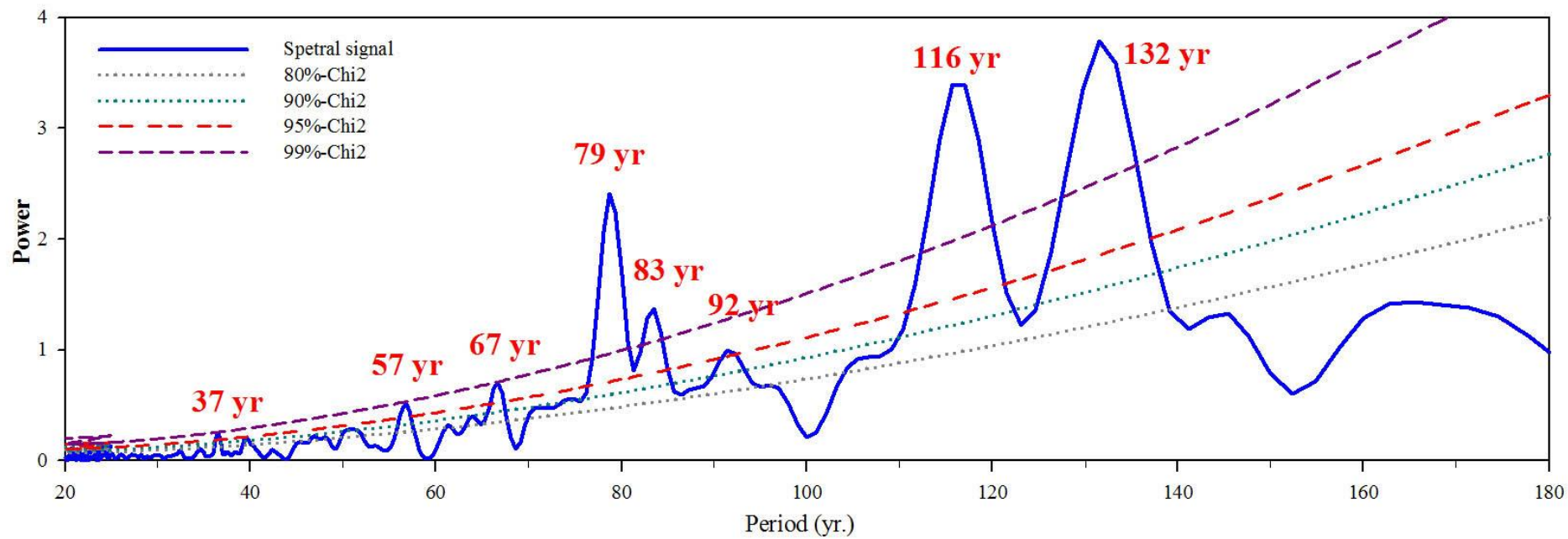
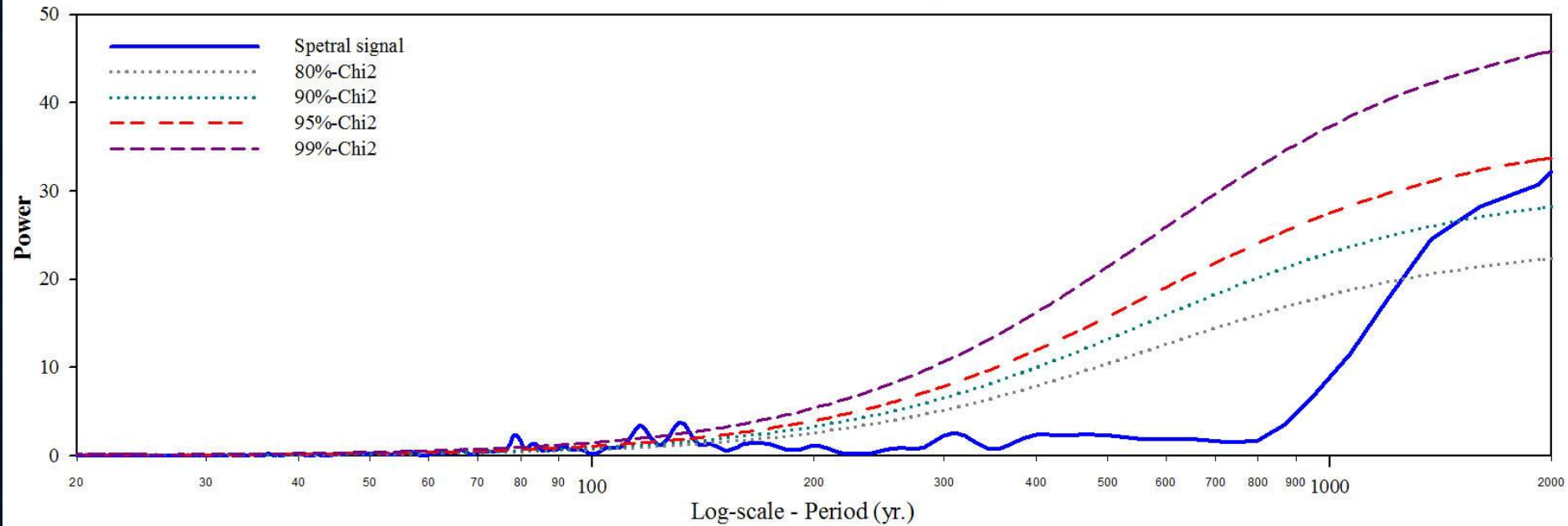
模態1：湖南蓮花洞主導，夏初、商末、魏晉南北朝、唐初較潮濕；周朝乾燥，有79、112、136年週期。



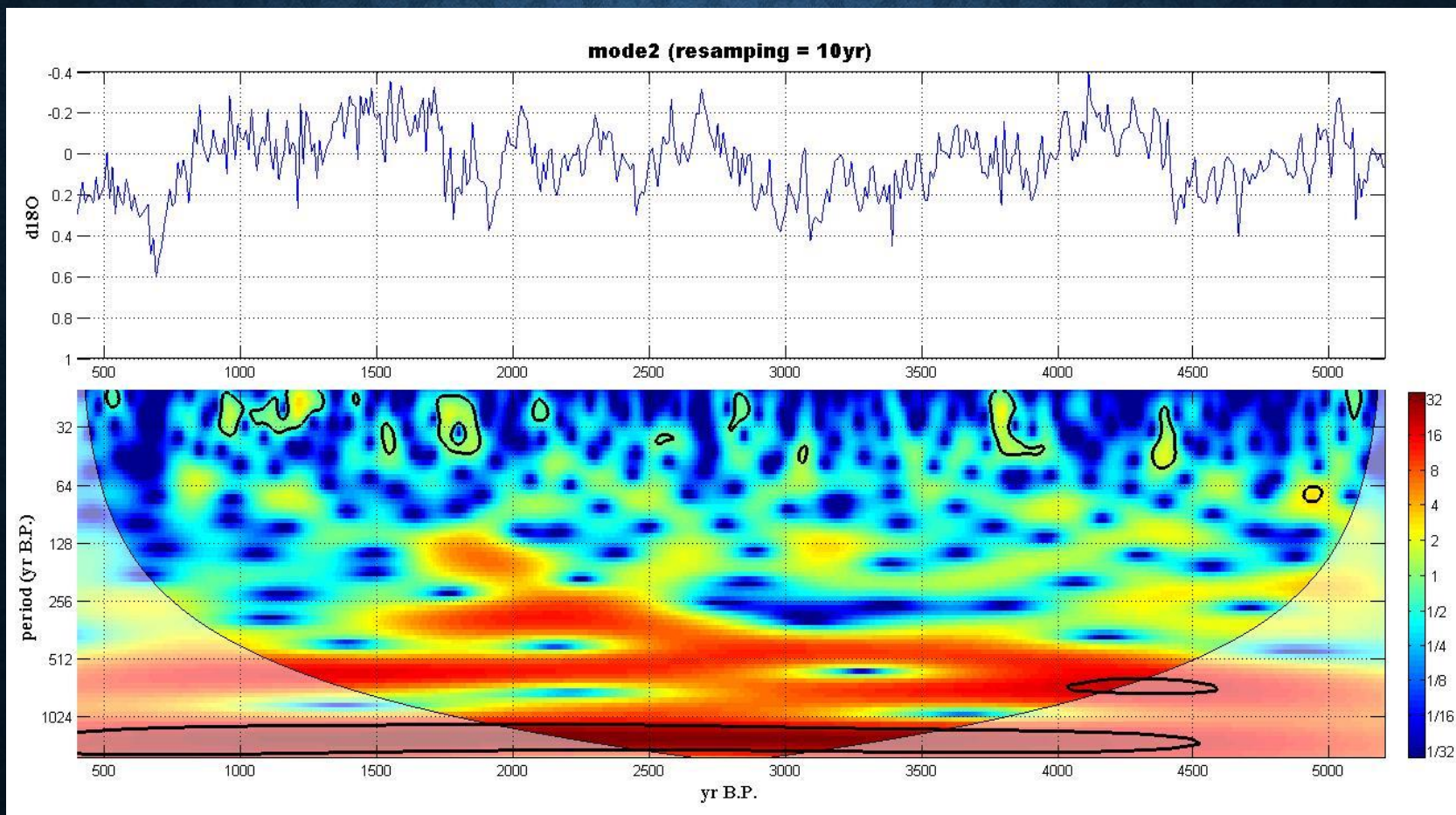
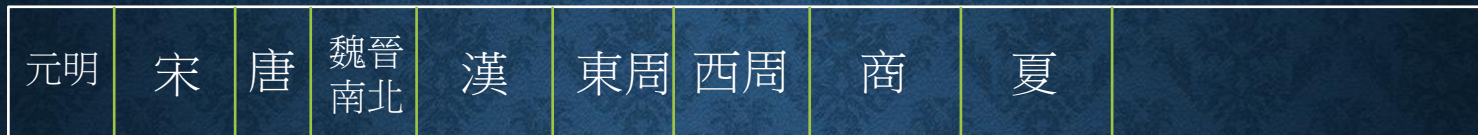
mode1 (resampling = 10 yr)



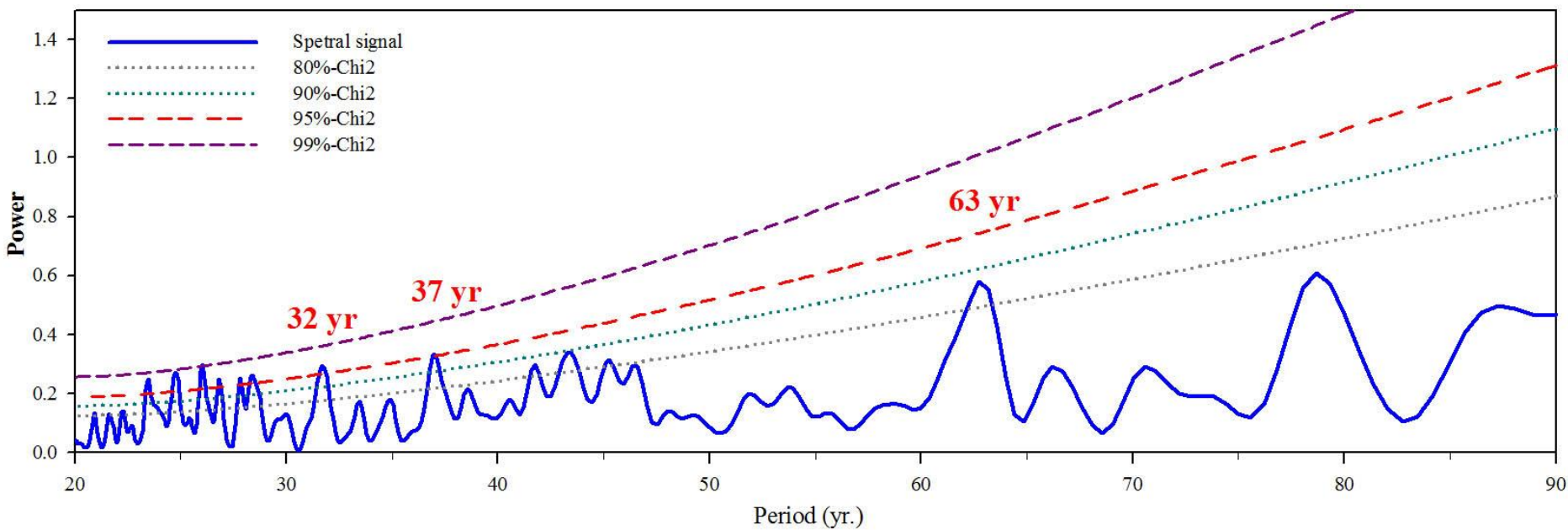
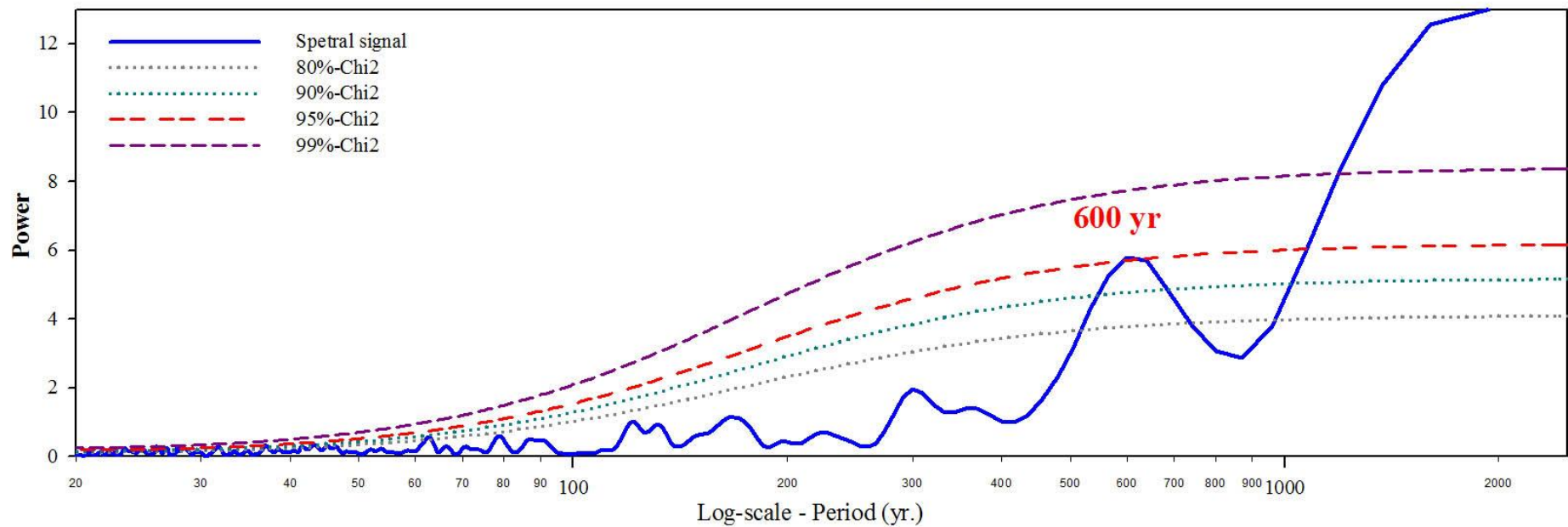
Mode 1ts 4cave_400 - 5200yr B.P.



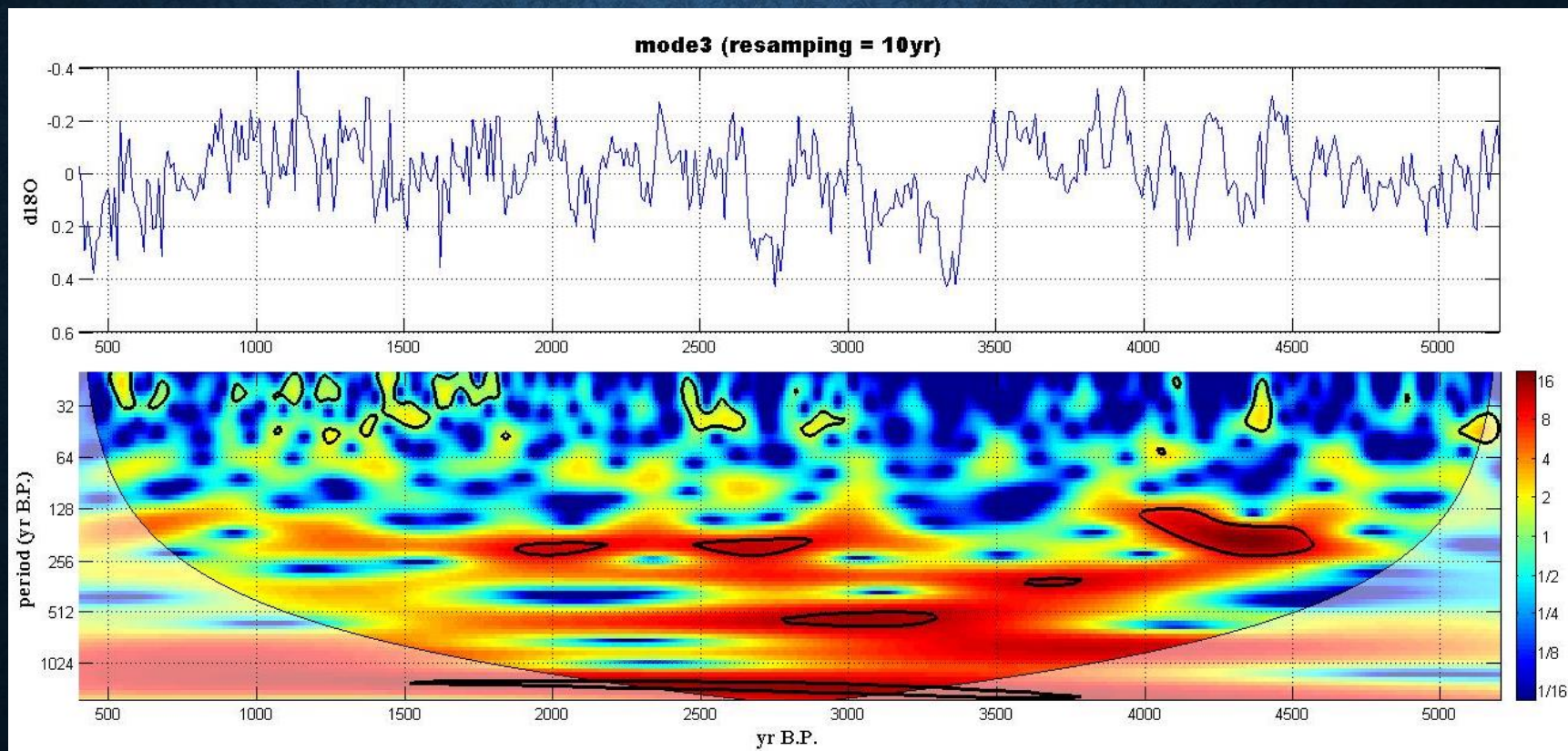
模態2：西南主導，四川貴州等地於西周晚期、魏晉南北、唐、宋朝較乾；商朝、東漢、元朝潮濕；缺乏明顯週期。



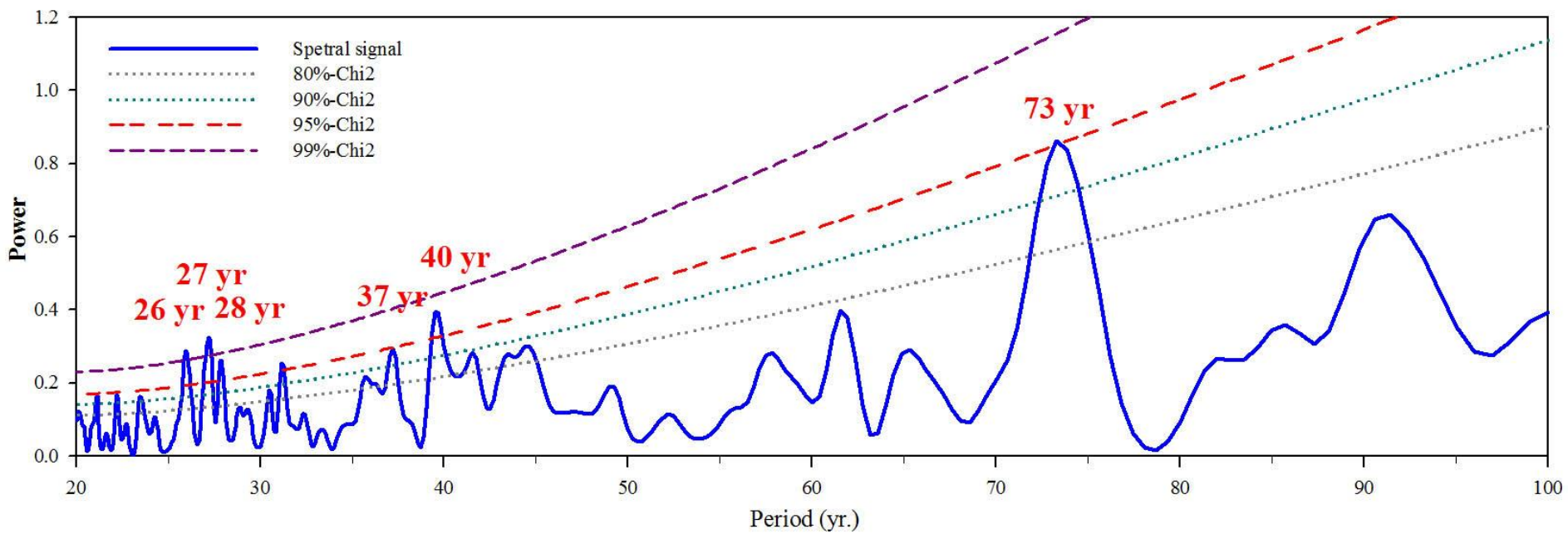
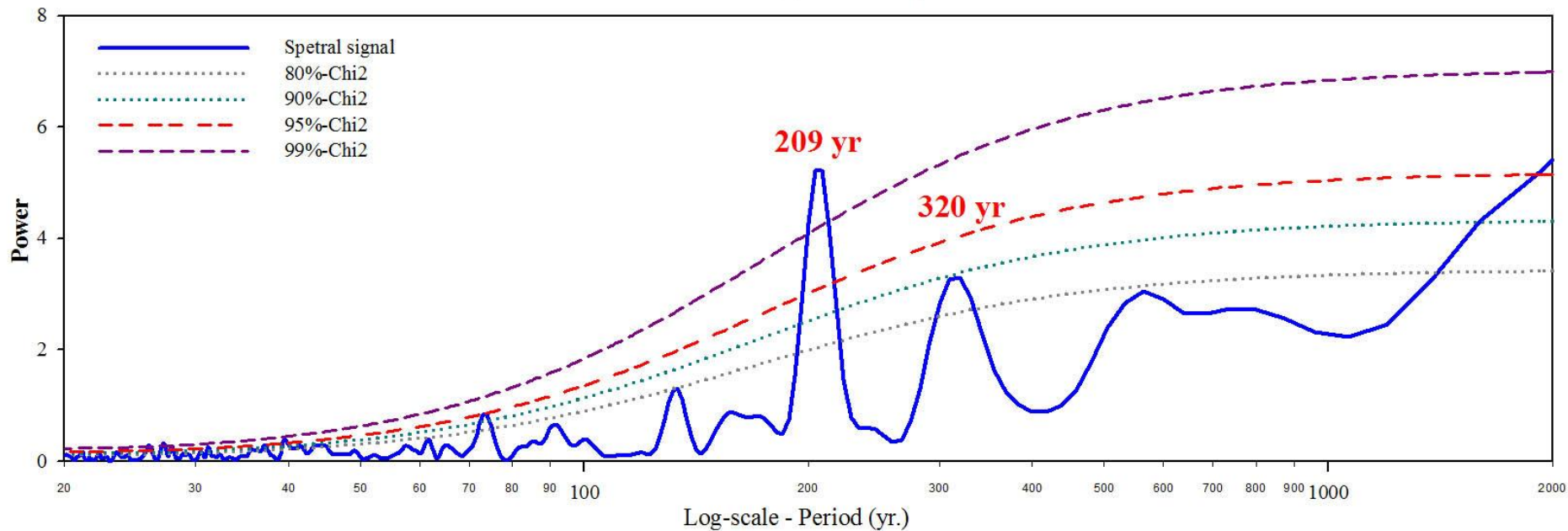
Mode 2ts 4cave_400 - 5200yr B.P.



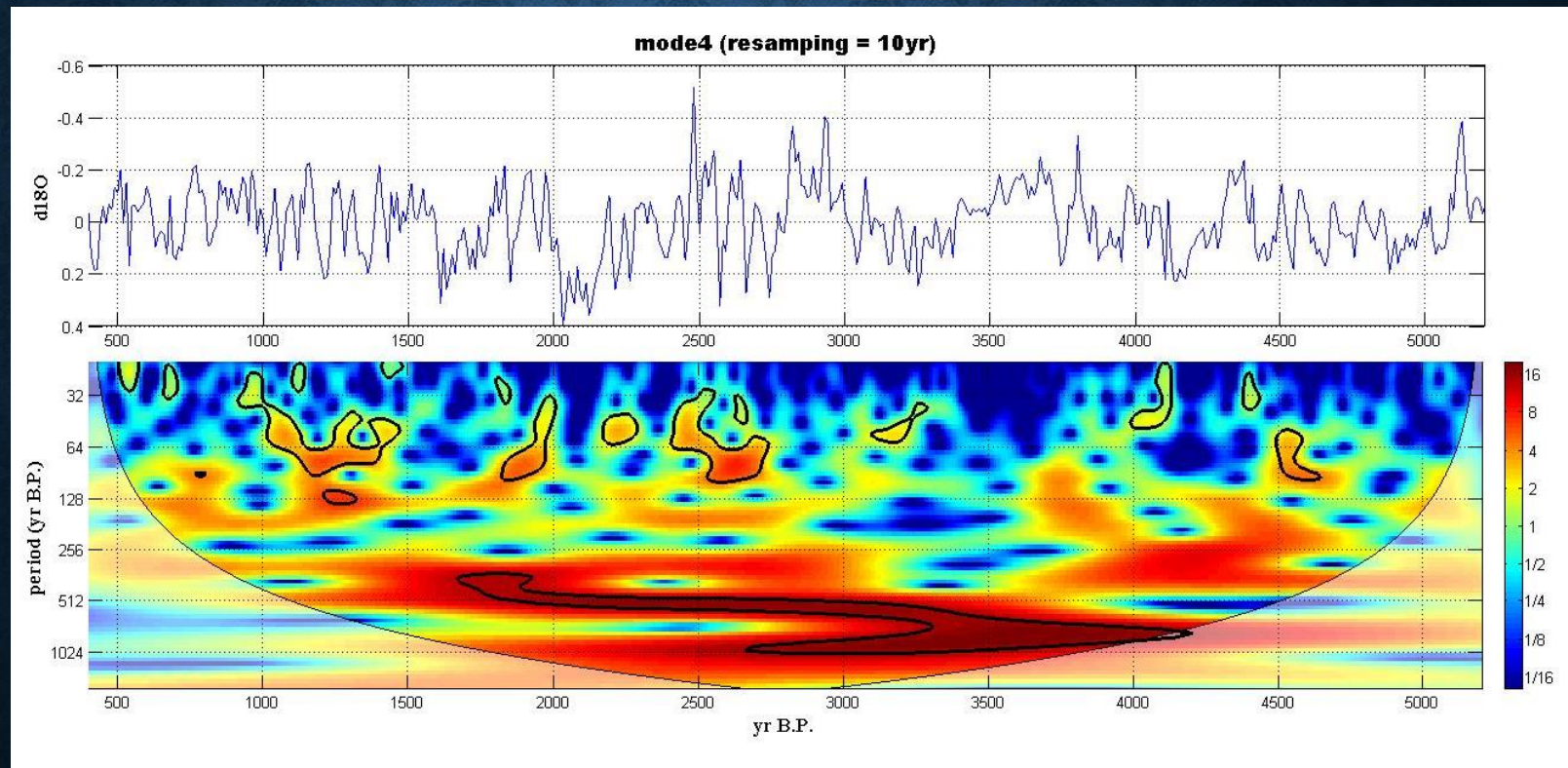
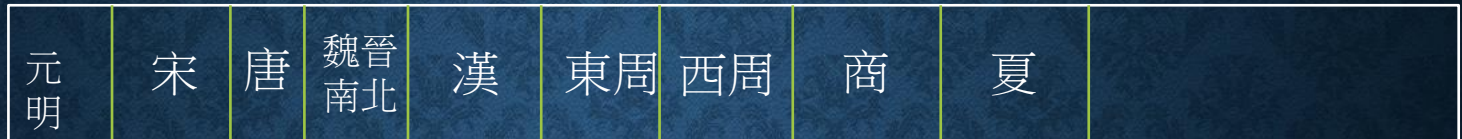
模態3：南北與中心的反差；商朝、西周中期，雨量集中於長江中游；夏朝、漢初、漢末、唐宋於湖北及貴州雨量較大；有520(?)、209、73、40、27年週期性。



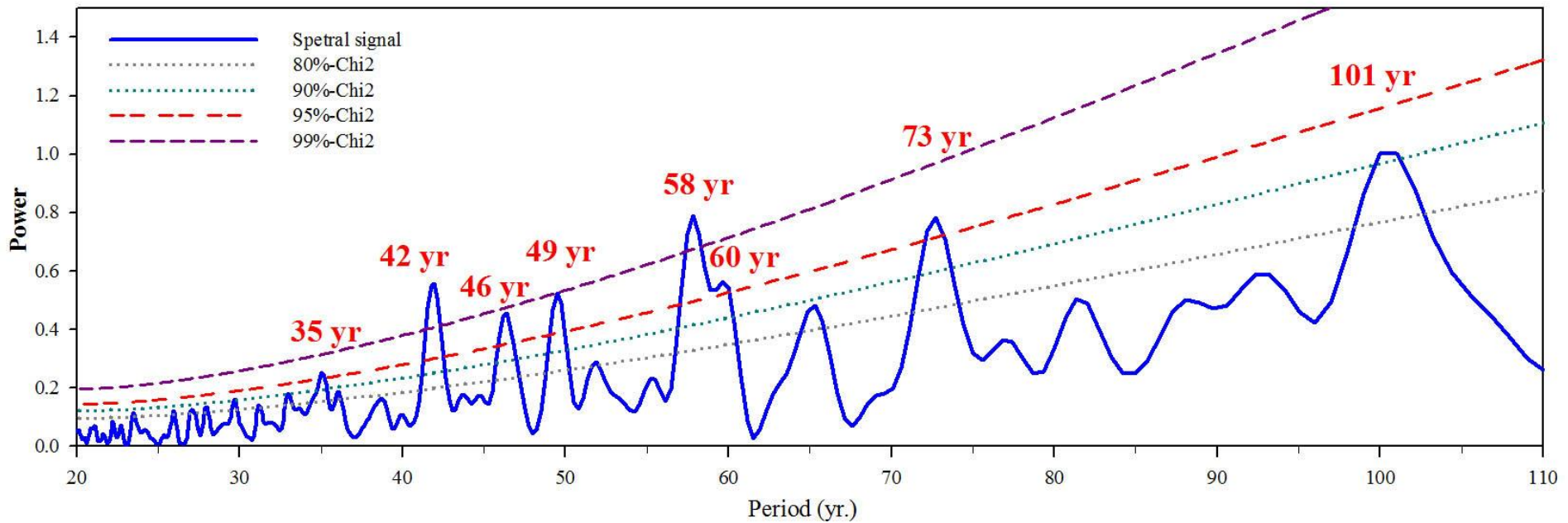
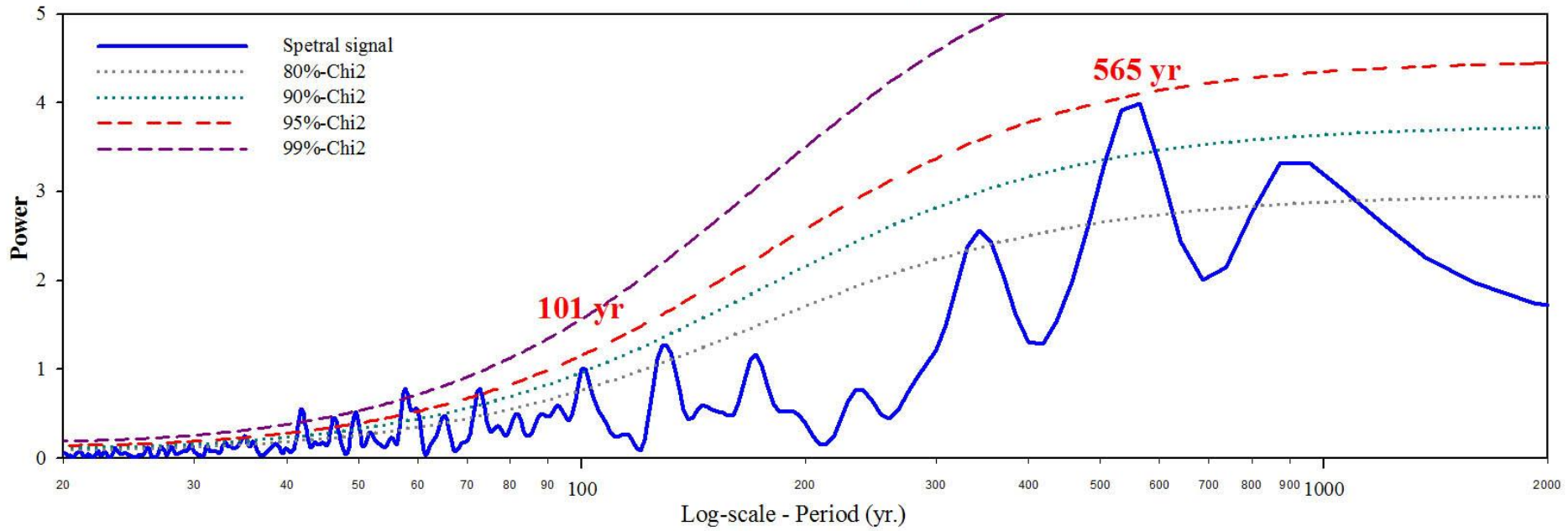
Mode 3ts 4cave_400 - 5200yr B.P.



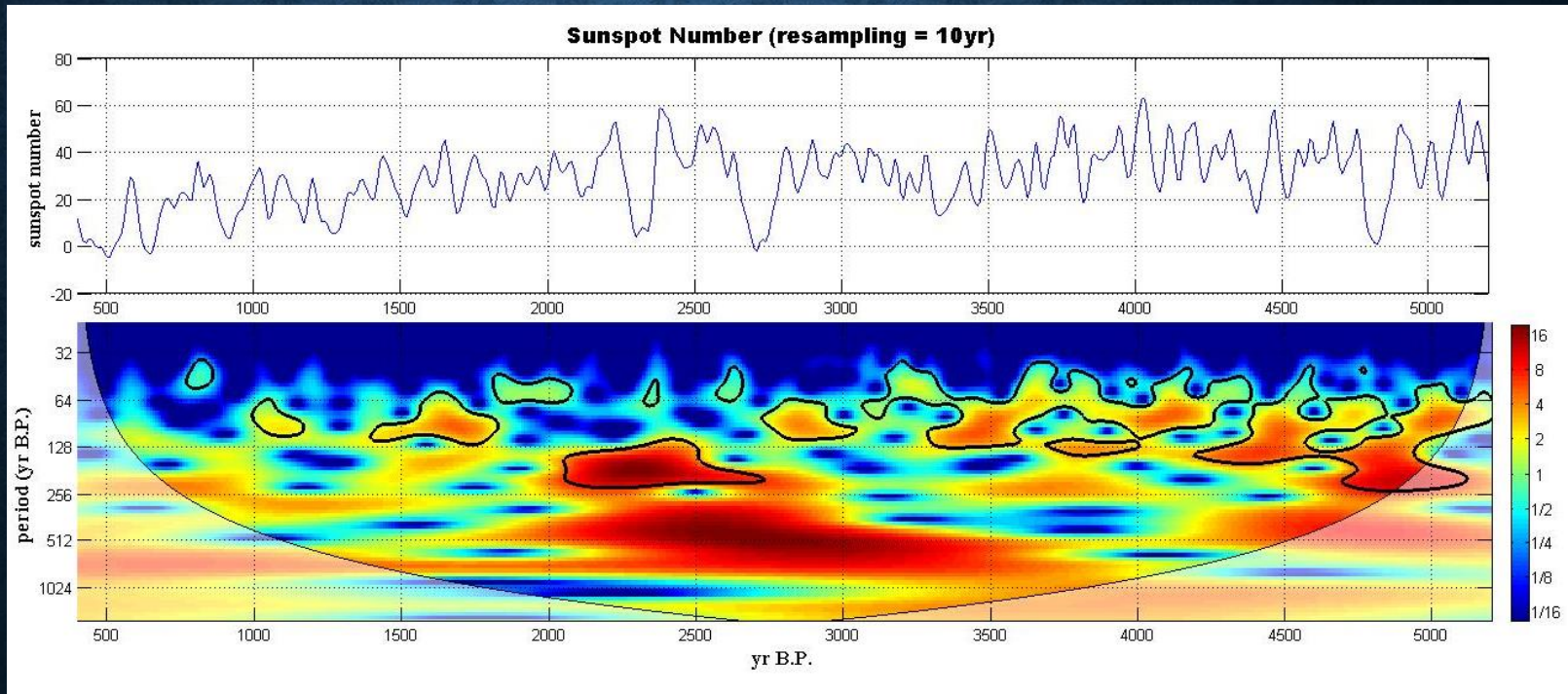
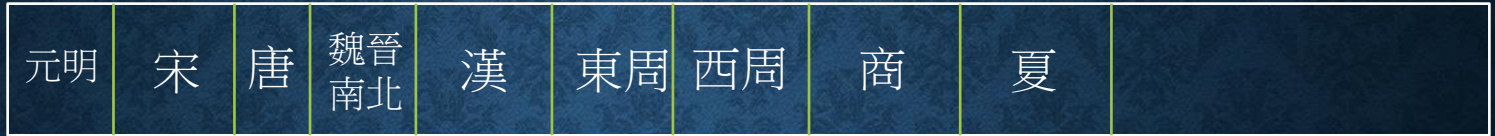
模態4：南北梯度（北方雨量較多），西周前期、東周初年北方（湖北）較濕；而西周晚期、漢初、三國時南方較濕、約有565、58、42年週期



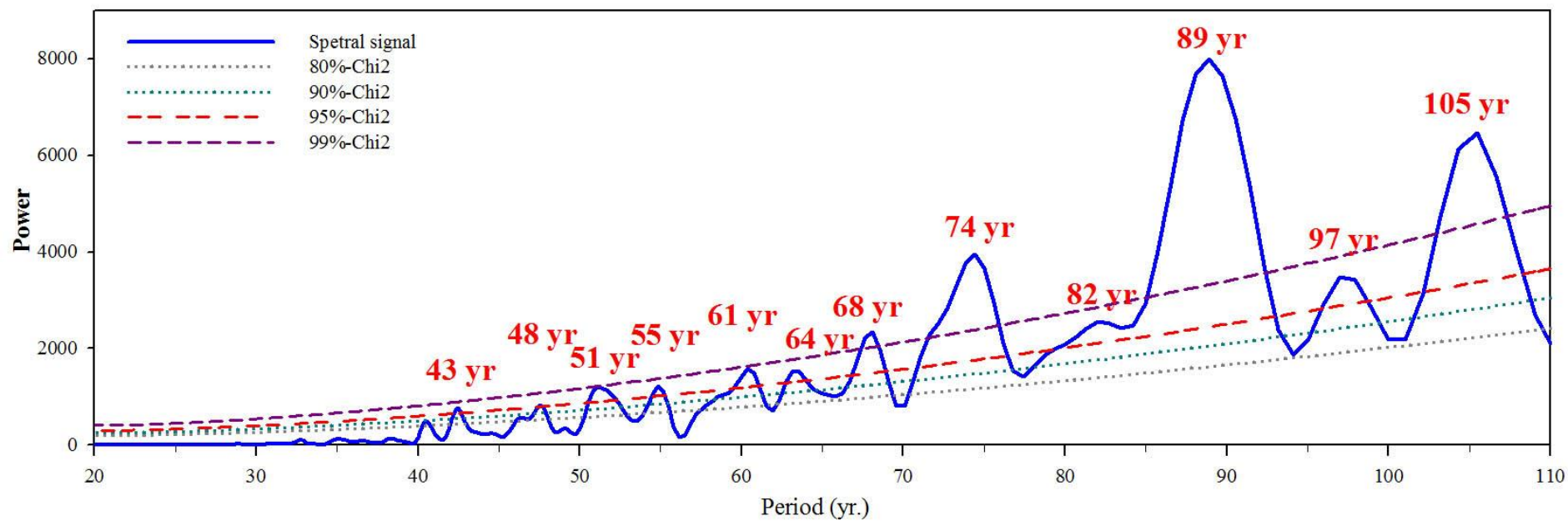
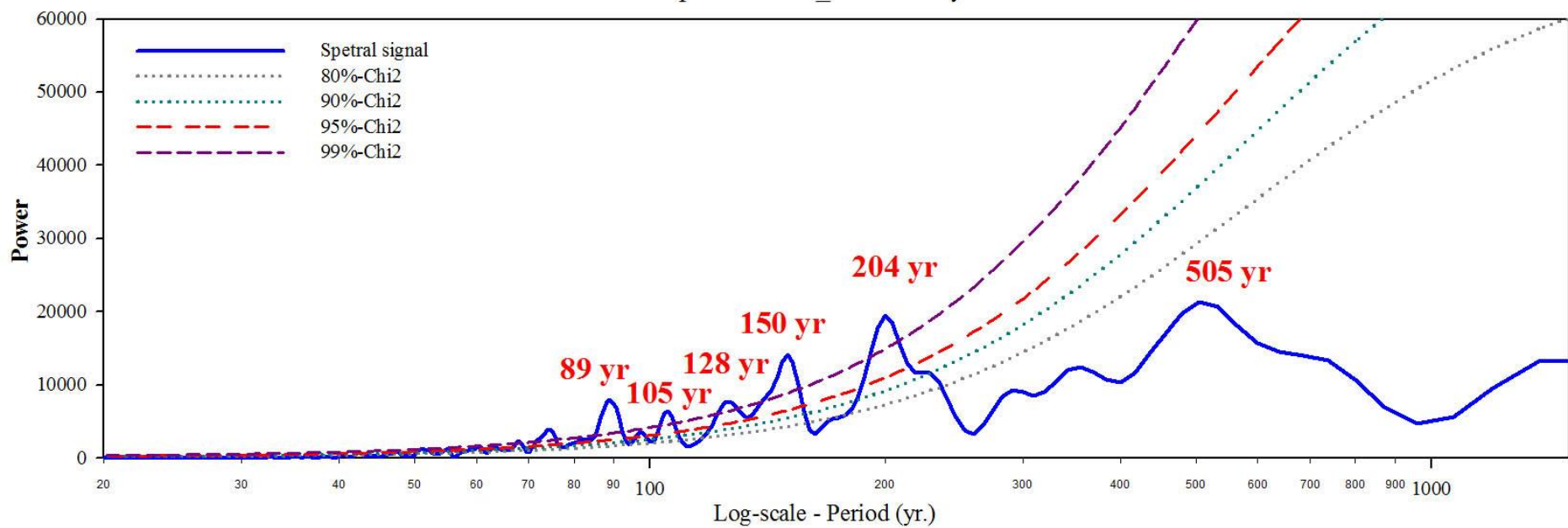
Mode 4ts 4cave_400 - 5200yr B.P.



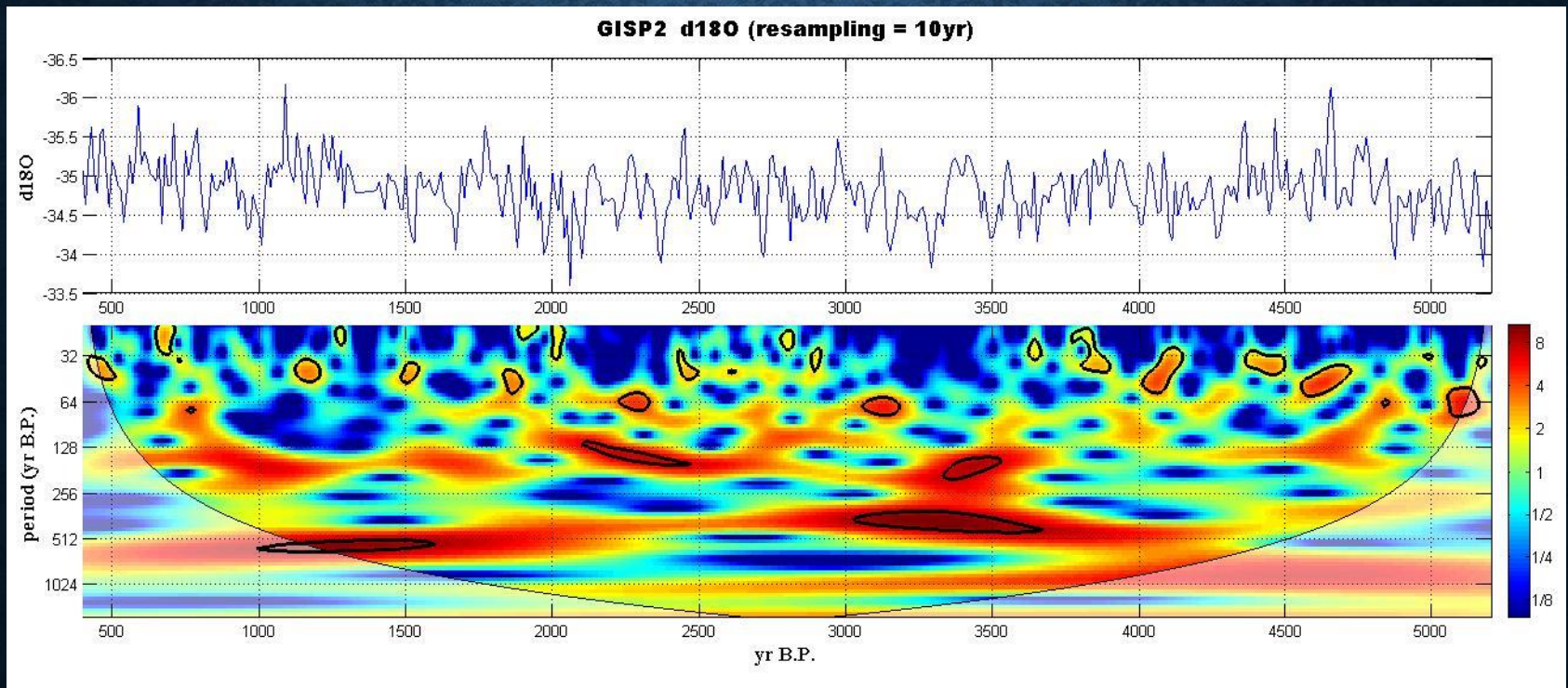
太陽黑子數目：具有565、417、204、150、105、89、74年週期，東周以後呈略微下降，西周、東周、元、明各有明顯低點



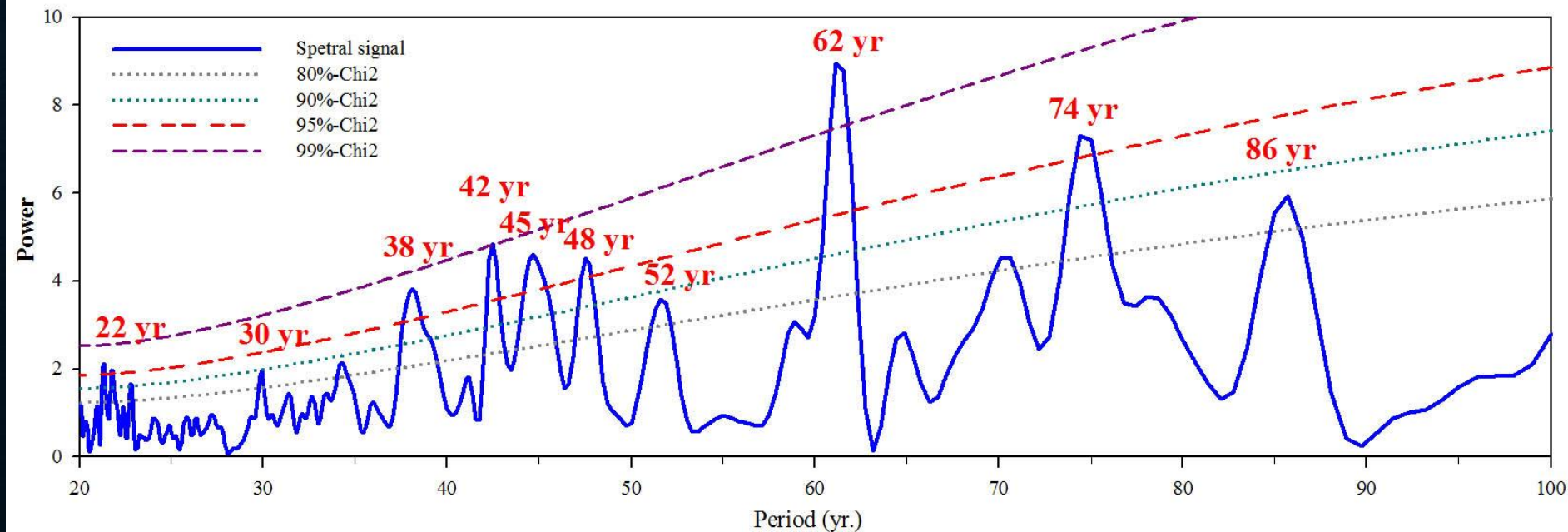
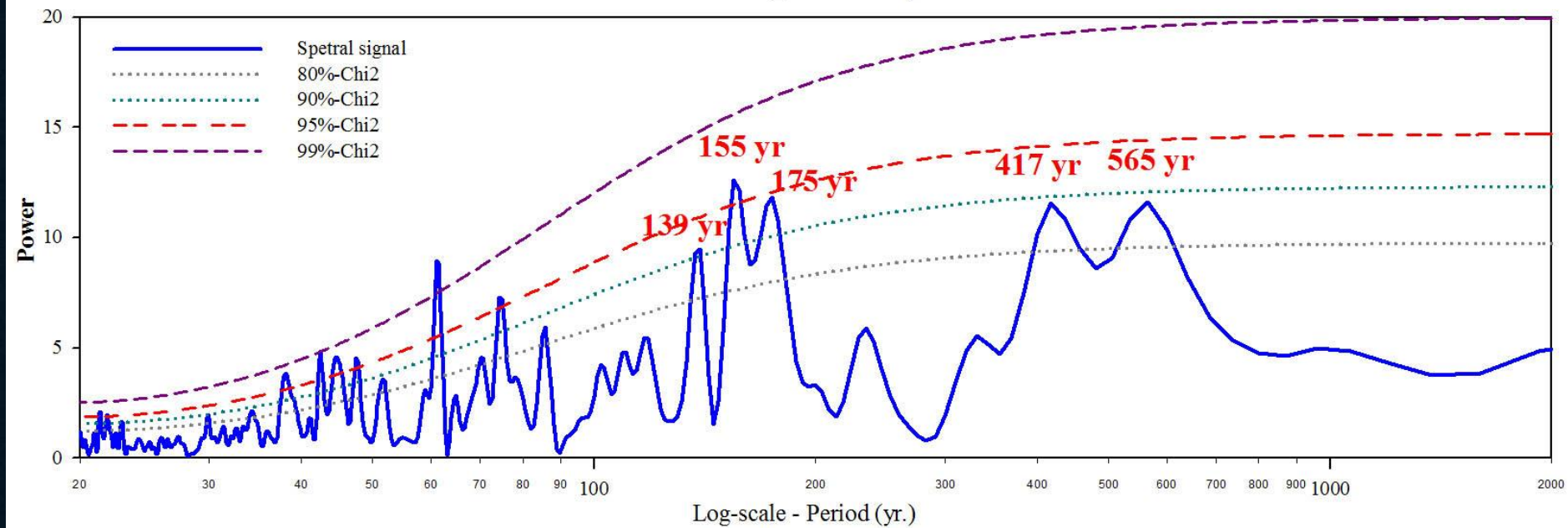
Sunspot numbers_400 - 5200yr B.P.



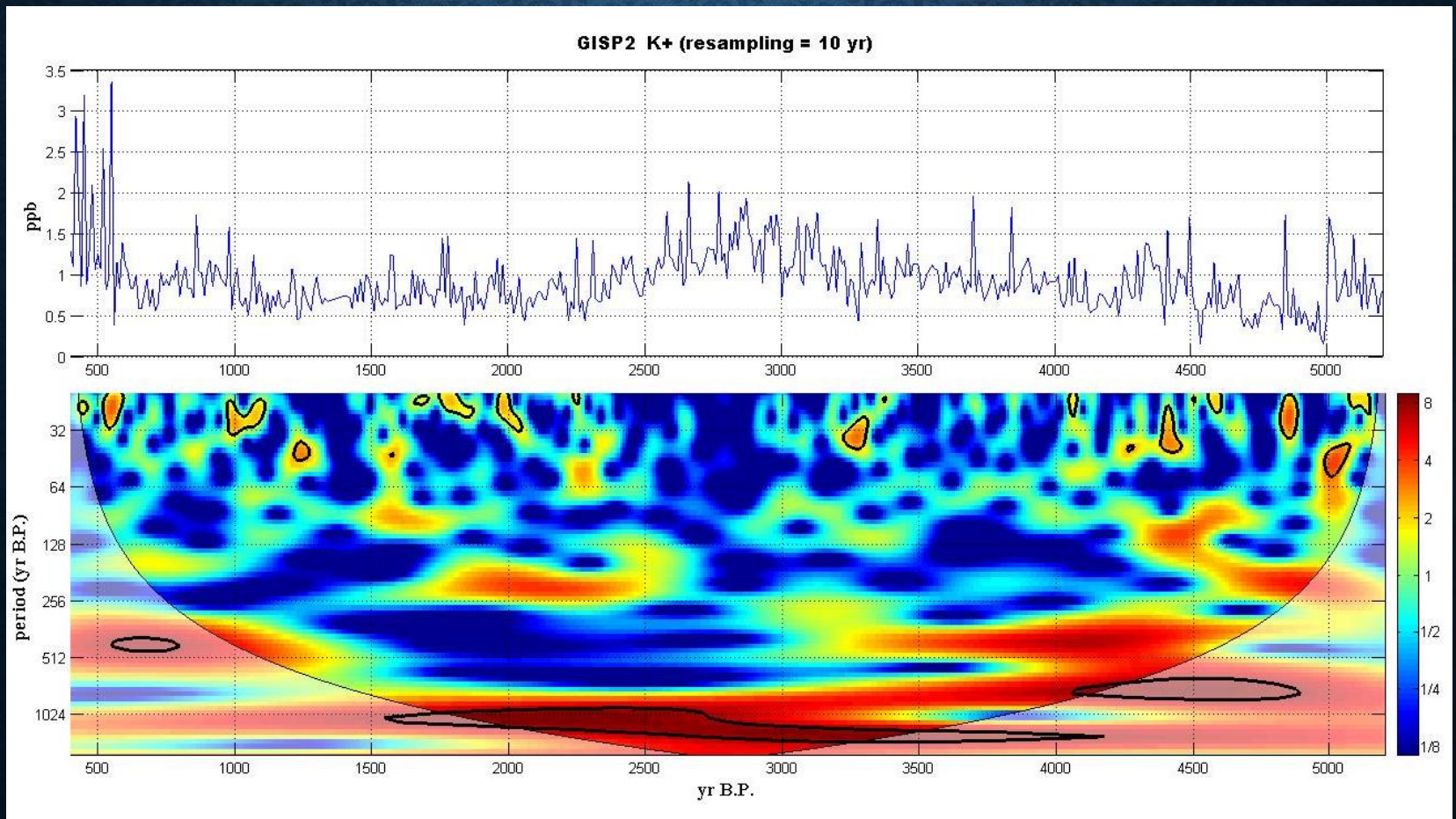
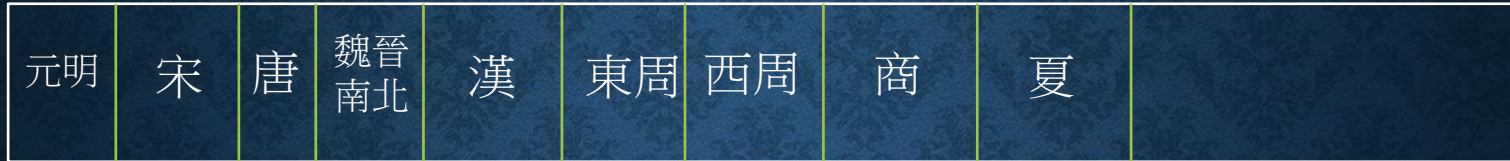
格陵蘭GISP2冰芯氧同位素 $\delta^{18}\text{O}$ ：62、42年週期



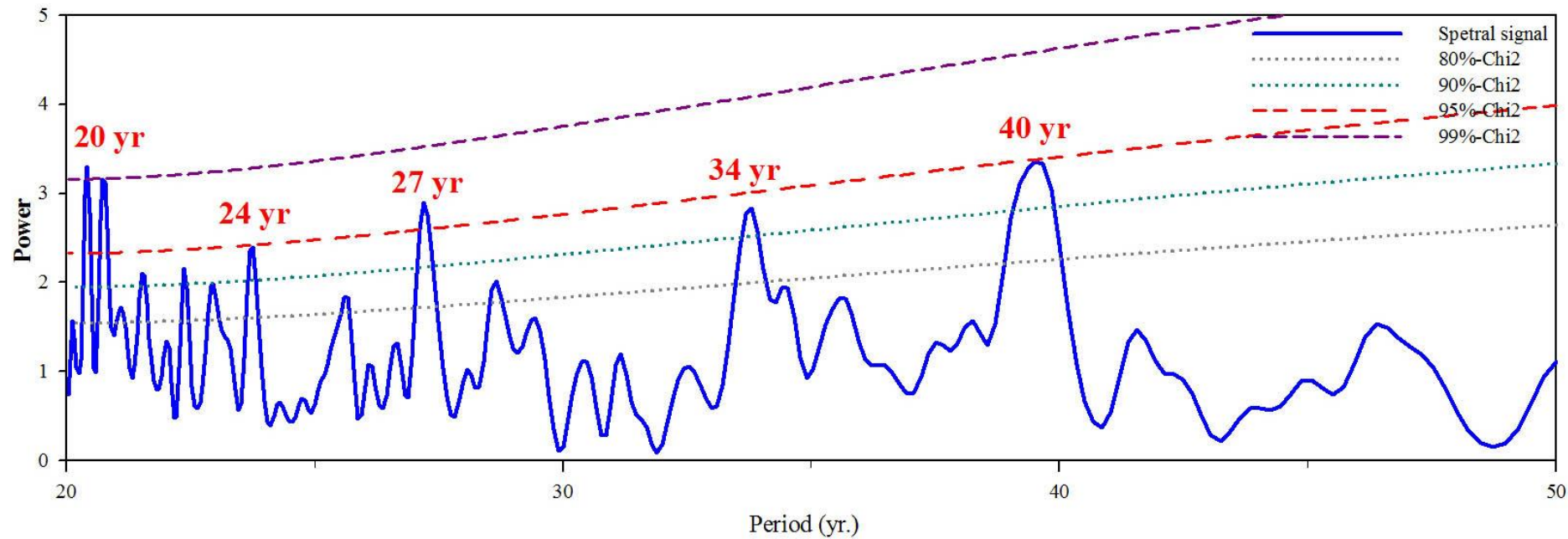
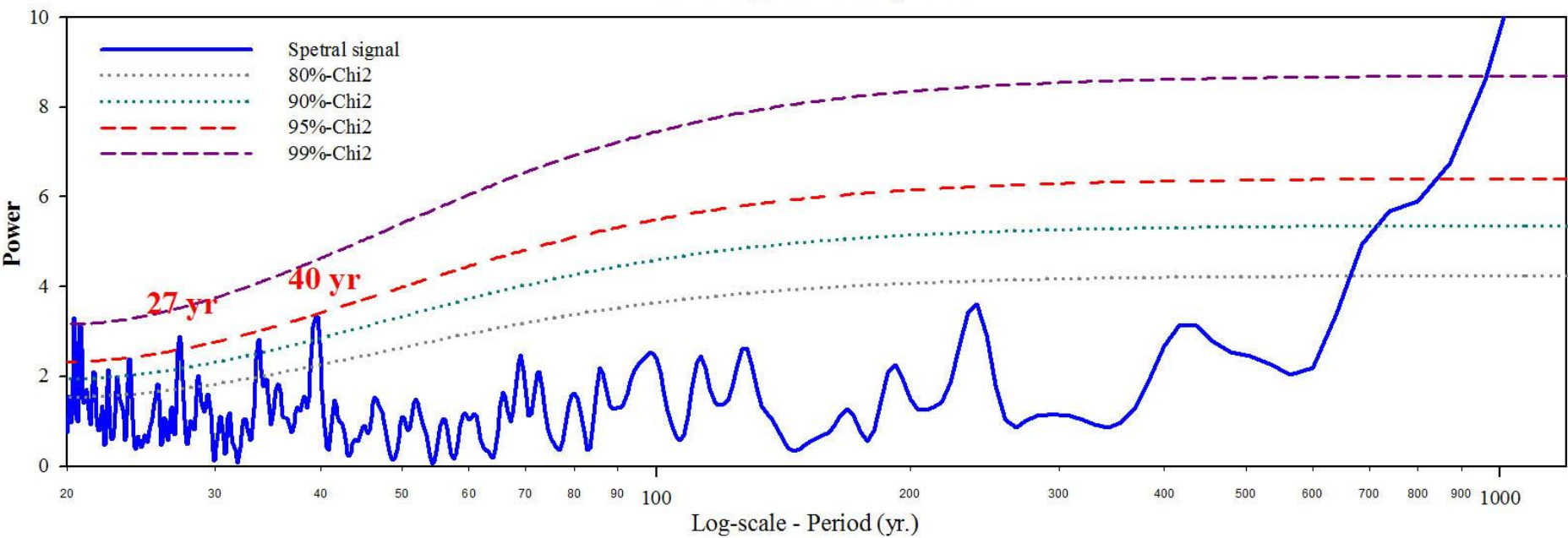
GISP2 d18O_400 - 5200yr B.P.



格陵蘭GISP2冰芯K離子濃度：有40、27、20年週期



GISP2 K⁺_400 - 5200yr B.P.



RECOGNIZED PERIODS OF VARIOUS EOF COEFFICIENT AND CLIMATE TIME-SERIES FROM SPECTRAL ANALYSIS AT THE 99% AND 95% SIGNIFICANCE LEVELS

	EOF 1	EOF 2	EOF 3	EOF 4	Sun spot number	d ¹⁸ O in GISP2	nnK ⁺ in GISP2
99 % significance level	132, 116, 83, 79, 67, 57, 37 years	---	209, 27, 26 years	58, 42 years	204, 150, 128, 105, 89, 74, 58 years	62, 42 years	---
95 % significance level	---	600, 37, 32 years	73, 40, 37, 28 years	73, 60, 49, 46, 35 years	97, 82, 64, 55, 51, 48, 43 years	155, 74 48, 45, 42, 38, 22 years	40, 27, 24, 20 years

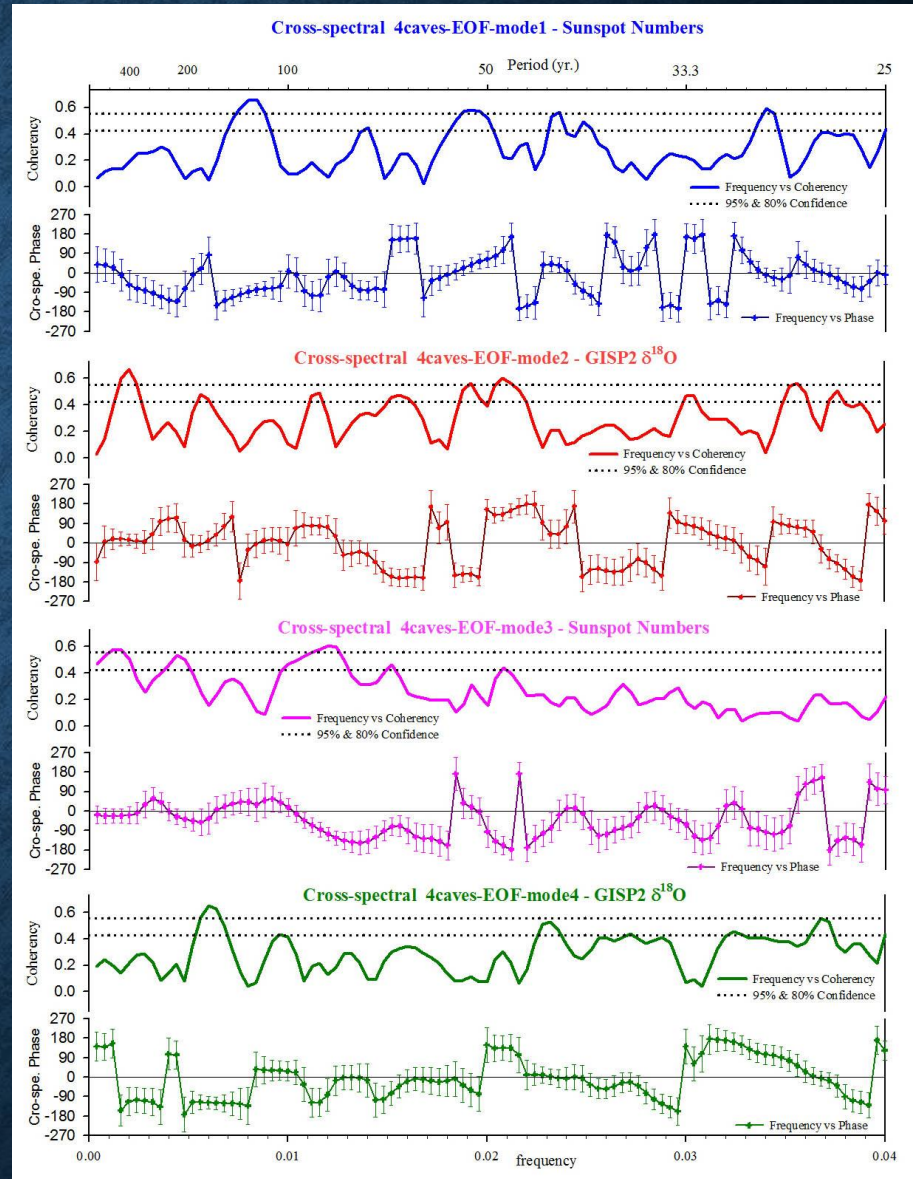
COHERENCE AND PHASE IN CROSS-SPECTRA BETWEEN EOF MODES AND CLIMATE PARAMETERS

EOF 1 with sun spot

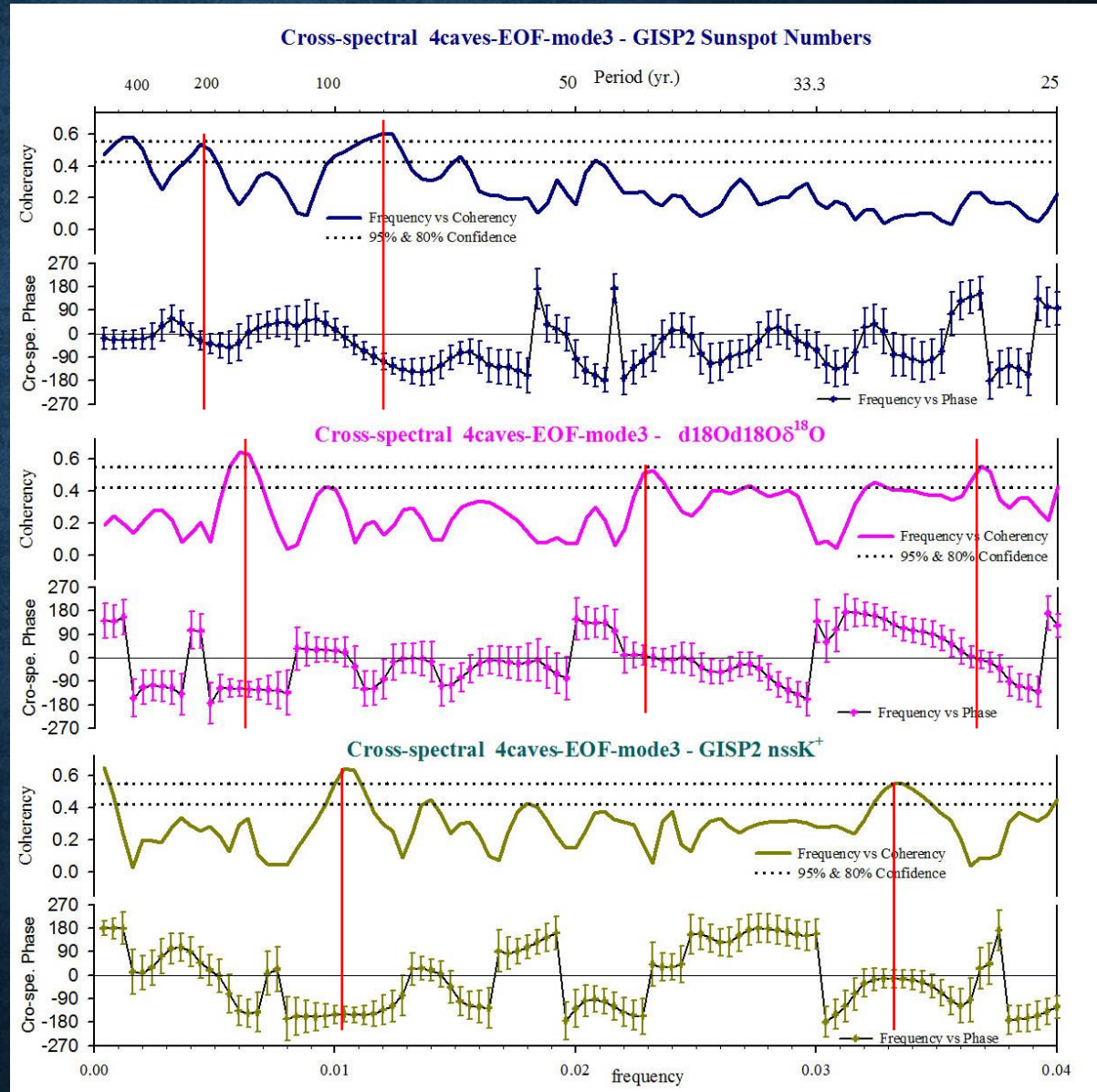
EOF 2 with ISP2 $\delta^{18}\text{O}$

EOF 3 with sun spot

EOF 4 with GISP2 $\delta^{18}\text{O}$



**CROSS
SPECTRAL
ANALYSES
OF EOF 3
WITH
SUN SPOT #
GISP2 $\Delta^{18}O$
GISP2
NSSK⁺**

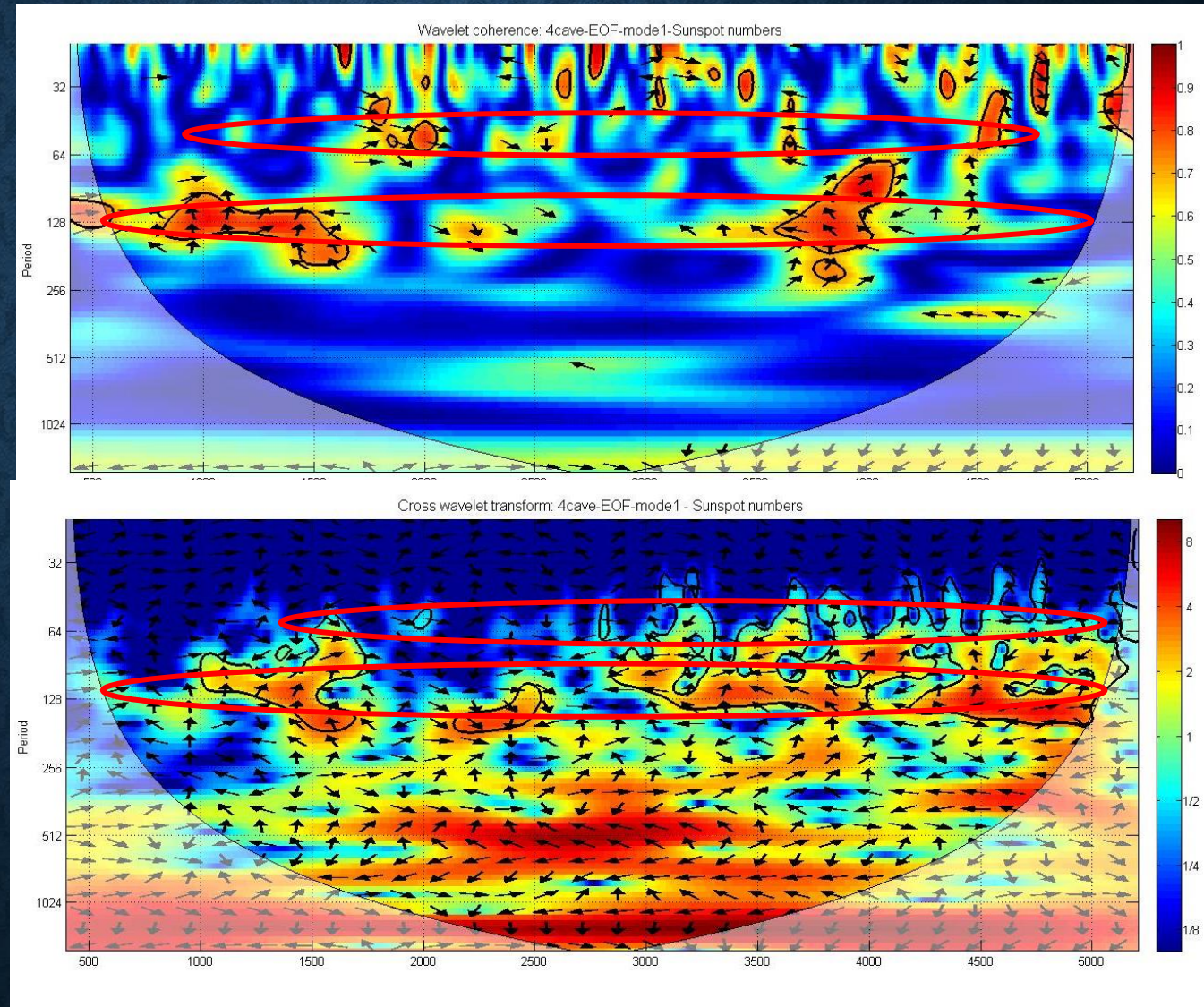


元明	宋	唐	魏晉南北	漢	東周	西周	商	夏
----	---	---	------	---	----	----	---	---

coherence

Mode1 vs. Sunspot:
125、55
year
periodicity

Spectral
power



元明

宋

唐

魏晉南北

漢

東周

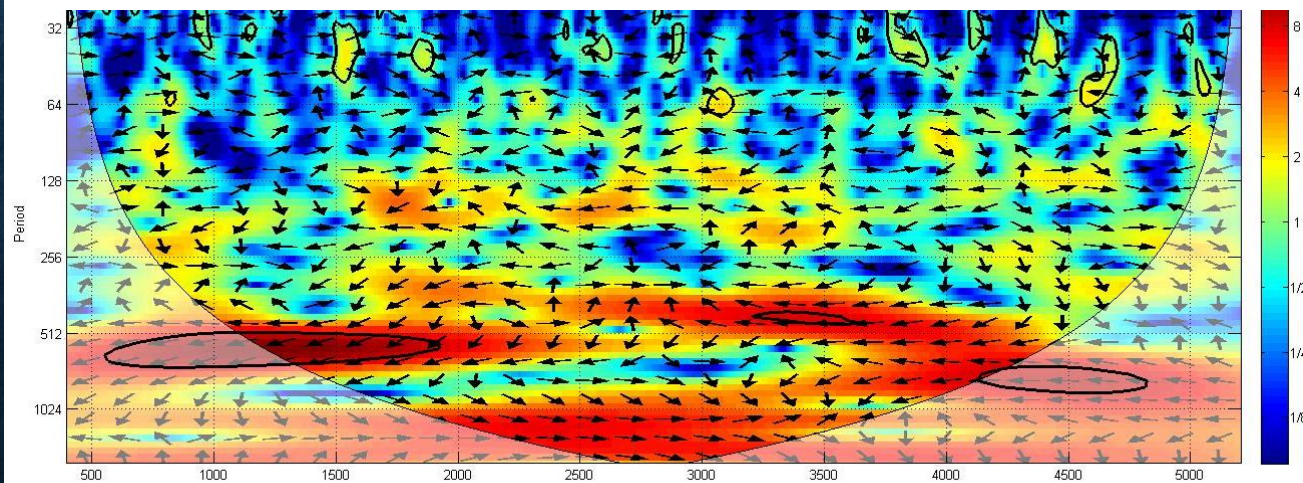
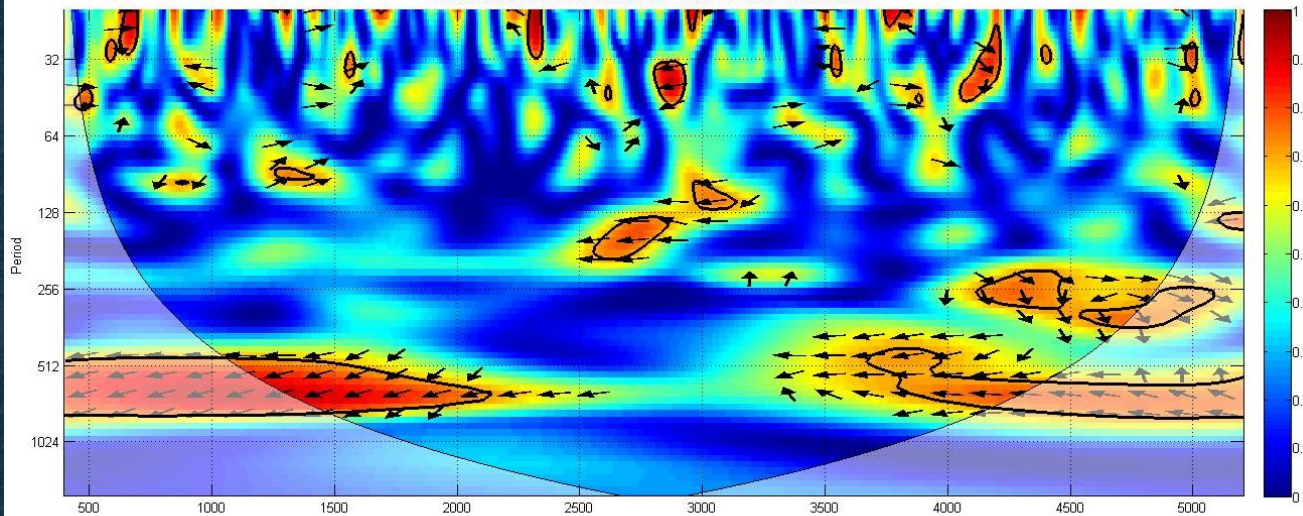
西周

商

夏

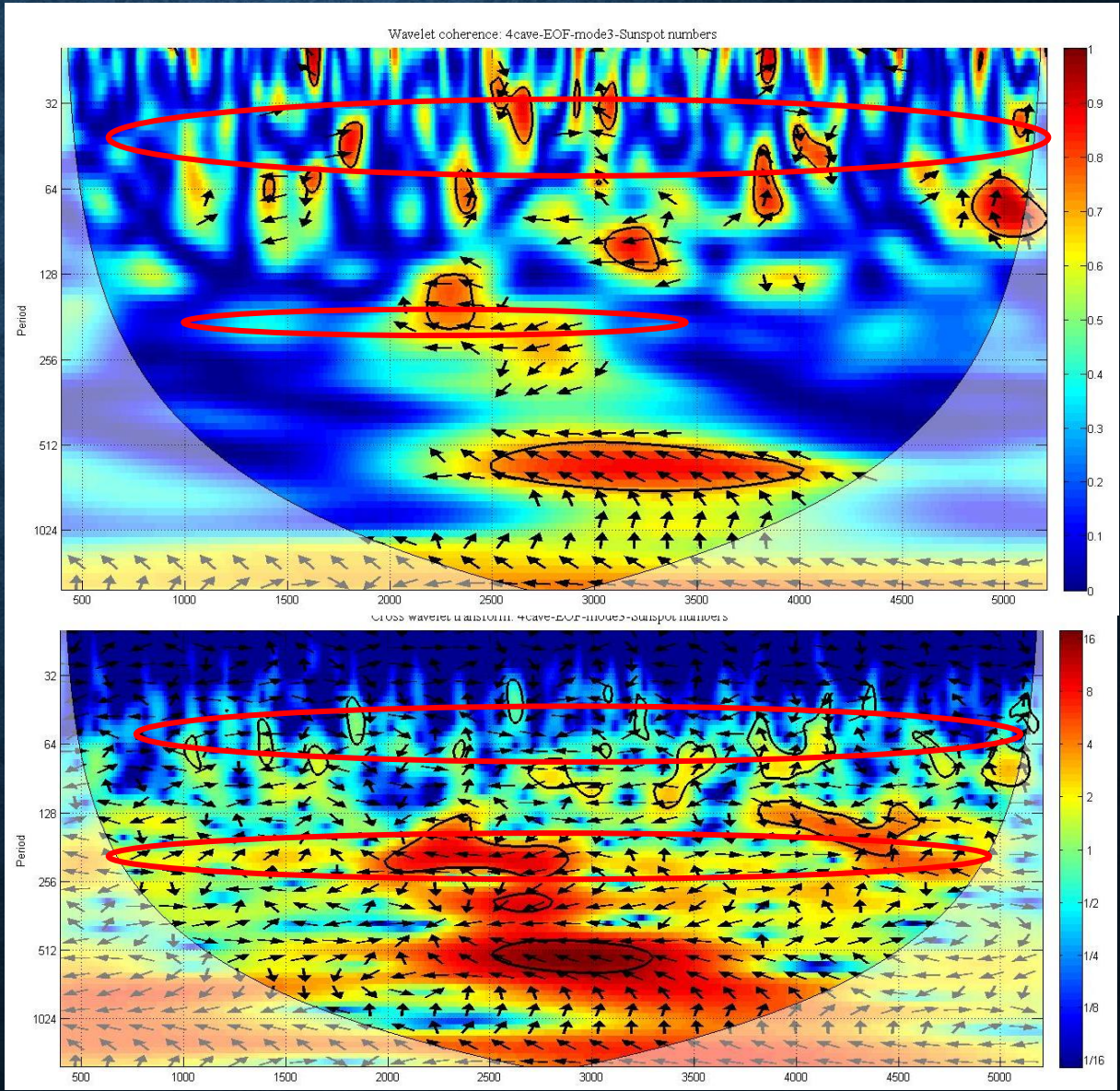
Mode2 vs. GISP2 $\delta^{18}O$

Wavelet coherence: 4cave-EOF-mode2 - GISP2 delta-O18



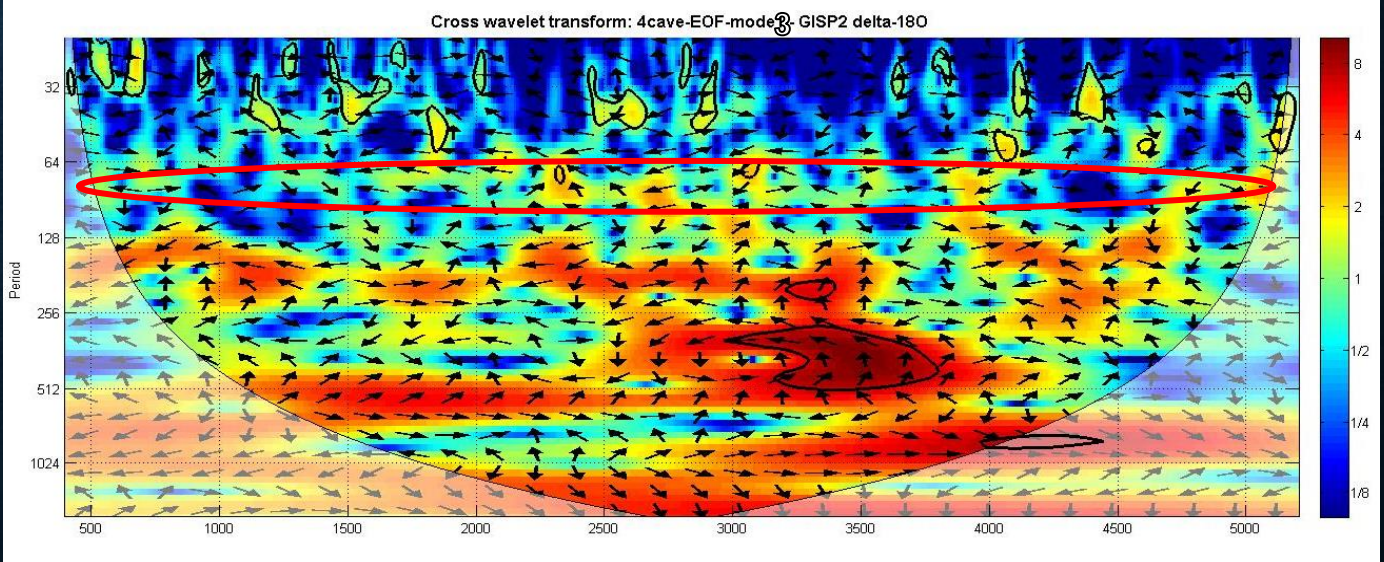
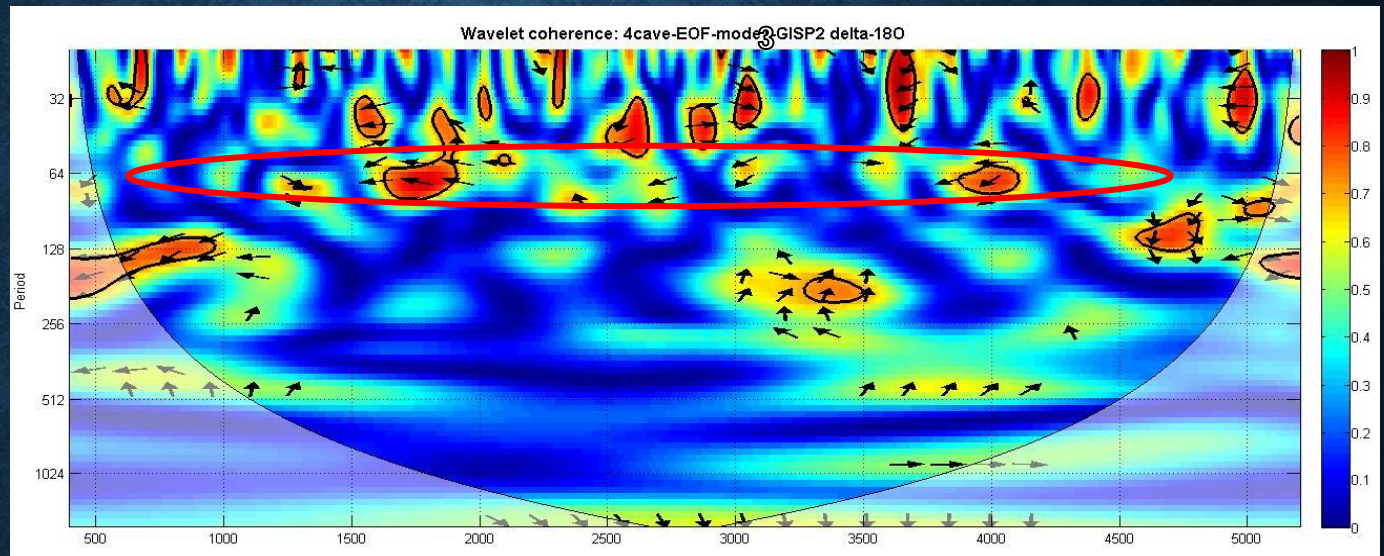
元明	宋	唐	魏晉南北	漢	東周	西周	商	夏	
----	---	---	------	---	----	----	---	---	--

**Mode3 vs.
Sunspot
numbers:
~220 (Suess
Cycle)
and ~80
(Gleissberg)
years' cycles**



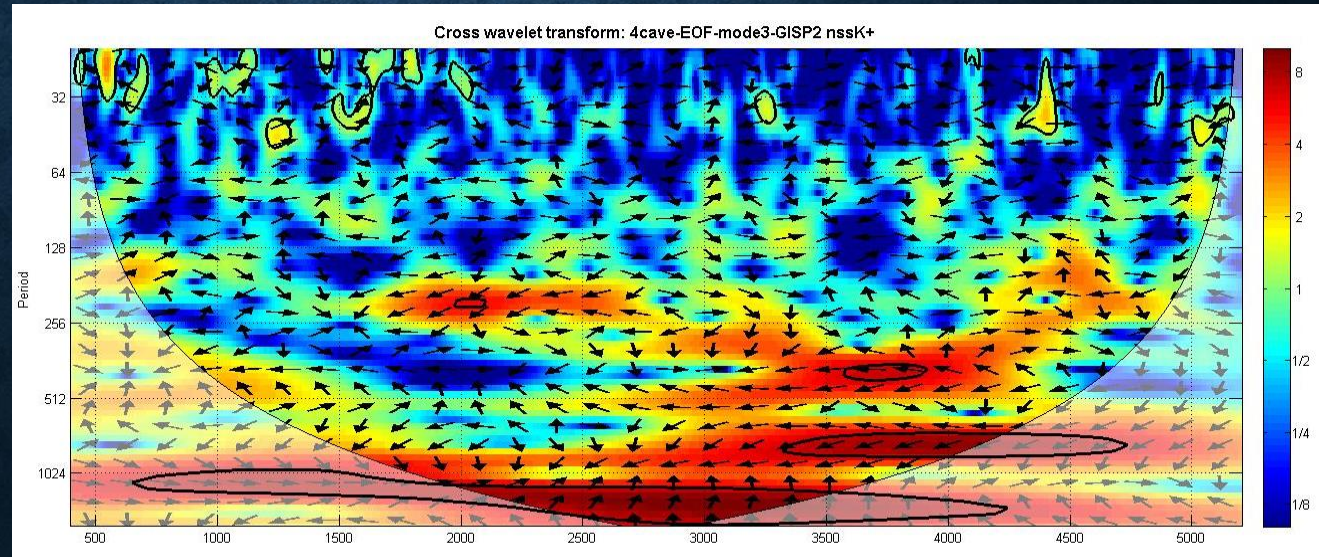
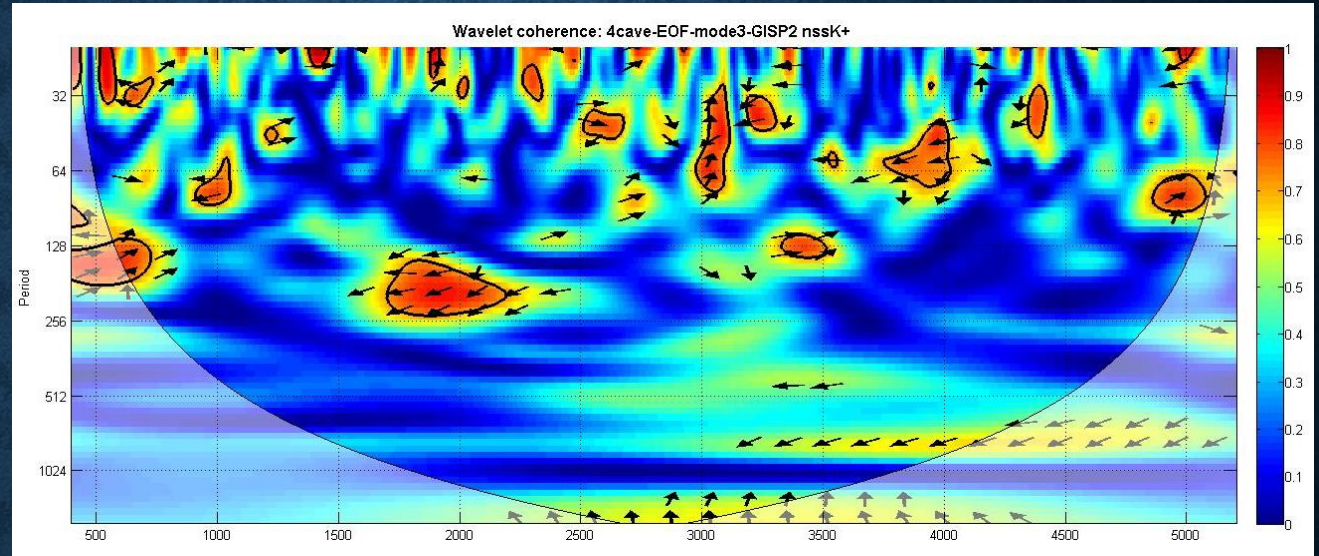
元明	宋	唐	魏晉 南北	漢	東周	西周	商	夏	
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Mode3 vs. GISP2 $\delta^{18}O$ 64 years



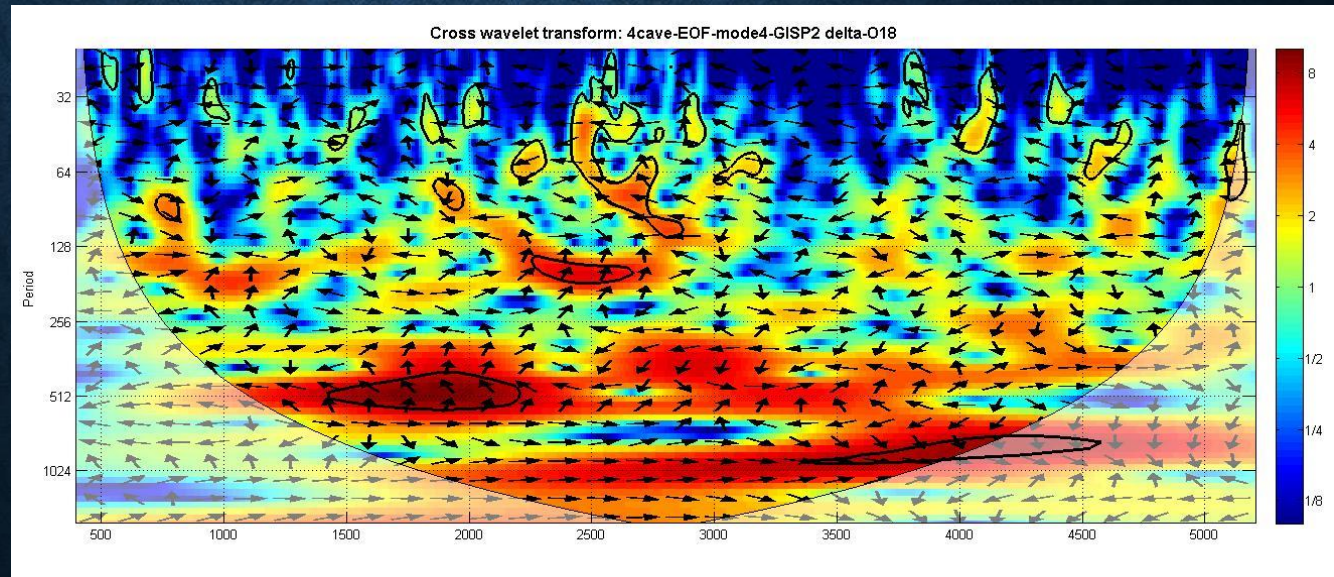
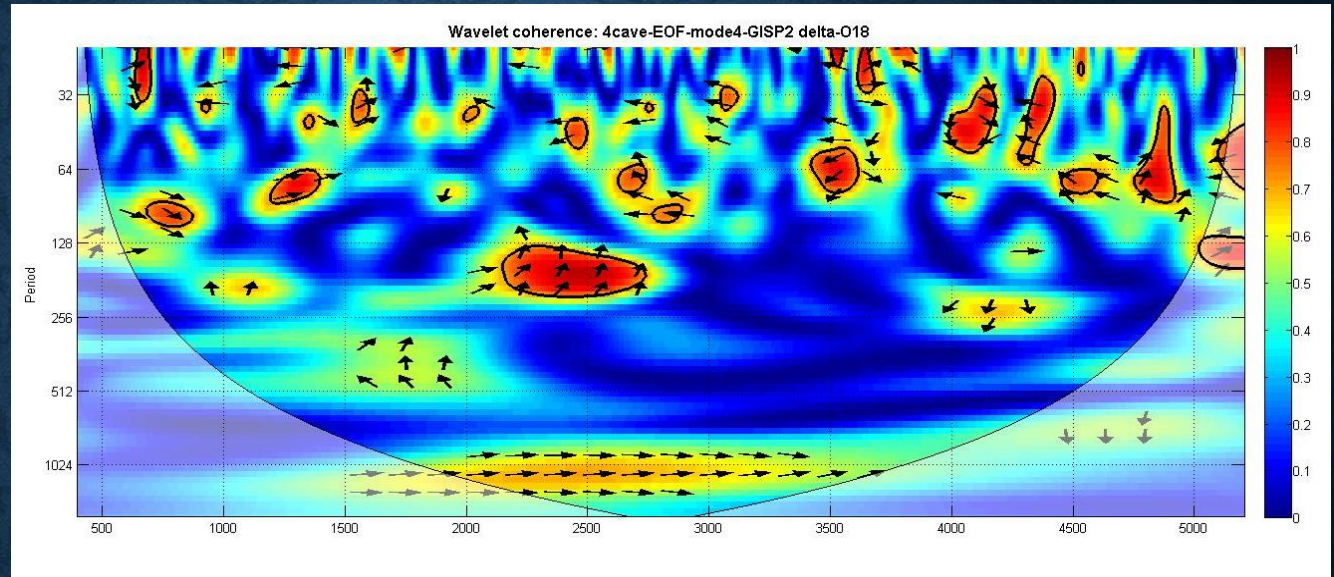
元明	宋	唐	魏晉南北	漢	東周	西周	商	夏	
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Mode3 vs.
GISP2
nssK⁺



元明	宋	唐	魏晉南北	漢	東周	西周	商	夏	
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Mode4 vs. GISP2 $\delta^{18}O$



PERIODS AND PHASE ANGLES BETWEEN EOF AND CLIMATE PARAMETERS OF HIGH COHERENCE WITH STRONG SPECTRAL POWER.

	Sunspot #	Sunspot #	GISP2 $\delta^{18}\text{O}$	Damon and Sonett (1989)
Mode 1	125 yrs. -84°	55 yrs. 0°	---	
Mode 3	220 yrs. -22°	80 yrs. 0°	64 yrs. 0°	208 yrs.: Suess cycle 88 yrs.: Gleissberg cycle

結論 (一)

- 使用「經驗正交函數」得到近五千年來華南石筍氧同素共四個地理模態的時空變異。
- 湖南蓮花洞表現最大變異，主導了第一模態（42%方差），夏初、魏晉南北朝、唐初雨量高，並與太陽黑子數在125年及55年週期有很好響應。
- 重慶芙蓉洞與貴州董哥洞主導了第二模態（24%方差），主要顯示西南—東北方向的變異，四川貴州等地魏晉南北、唐、宋較乾，商朝、漢朝、元朝潮濕。
- 第三模態（18%方差）代表中央站位與南北站位的反差性；商朝、西周中期，雨量集中於湖南、四川；而夏朝、漢初、漢末、唐宋則在湖北及貴州有較大雨量。與太陽黑子數目在~220年週期 (Suess cycle)、~80年 (Gleissberg cycle) 上有極佳之響應，並與北極上空溫度在~64年的週期上響應。

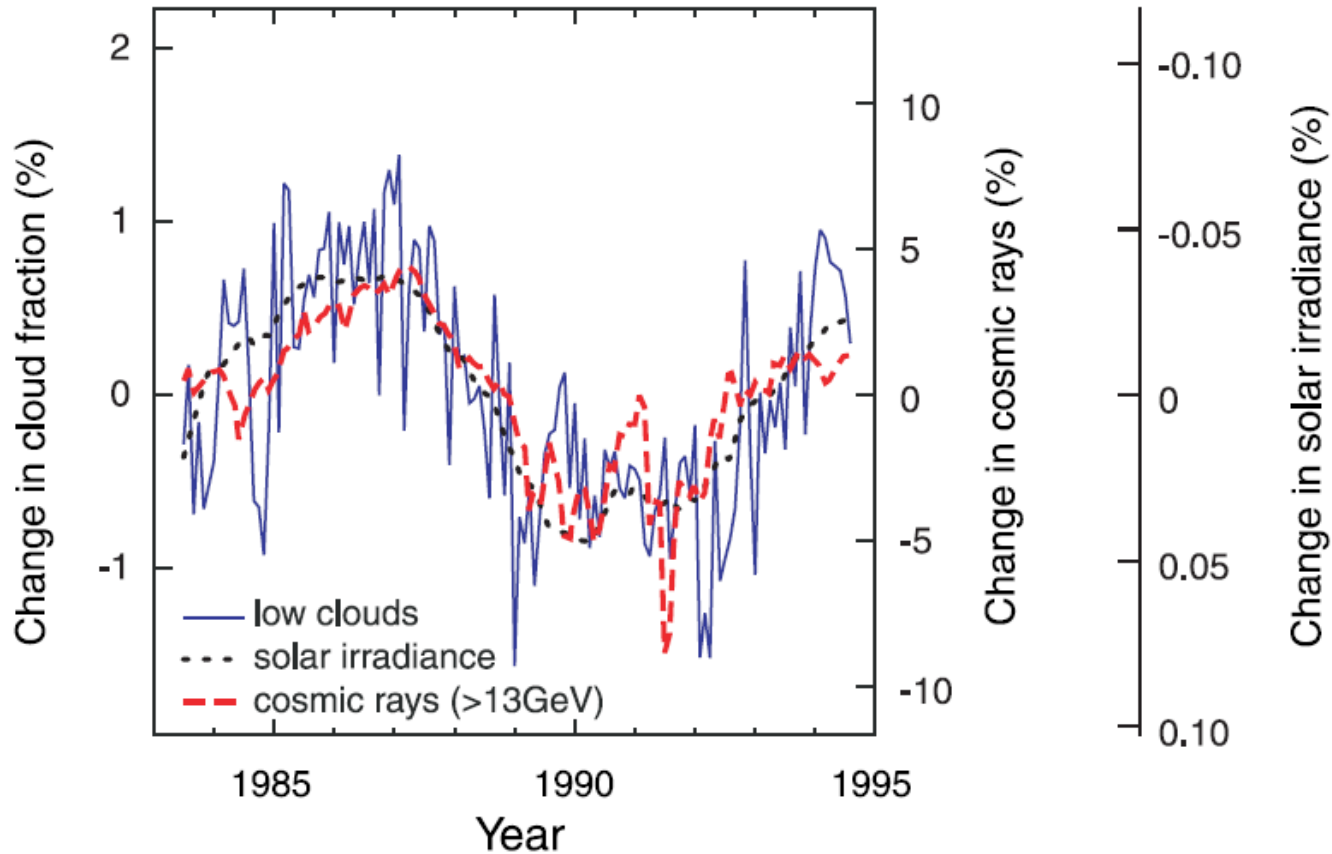
結論（二）

- 第四模態（15%方差）代表南北向雨量梯度；西周前期、東周初年北方（湖北）較濕；而西周晚期、漢初、三國時南方較濕、約有**565**、**58**、**42**年週期。
- 華南降雨的時空變異主要受控於**太陽黑子數目**、及北極上空溫度變化，分別在**220/125/80/55**年週期，及64年週期響應。
- 推測「太陽—東亞季風」的連結系透過銀河宇宙射線（GCR）影響雲形成所導致。

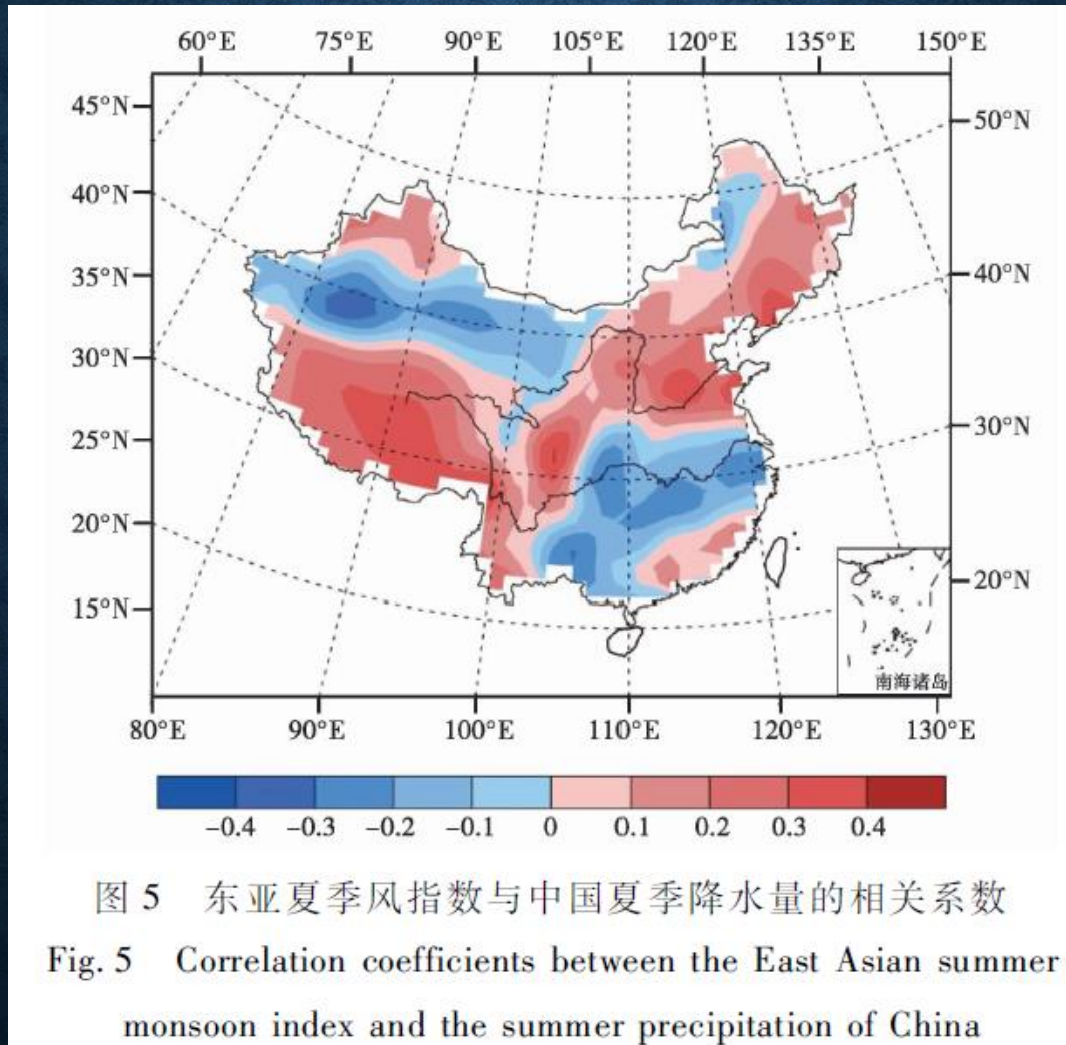


Cosmic Rays, Clouds, and Climate

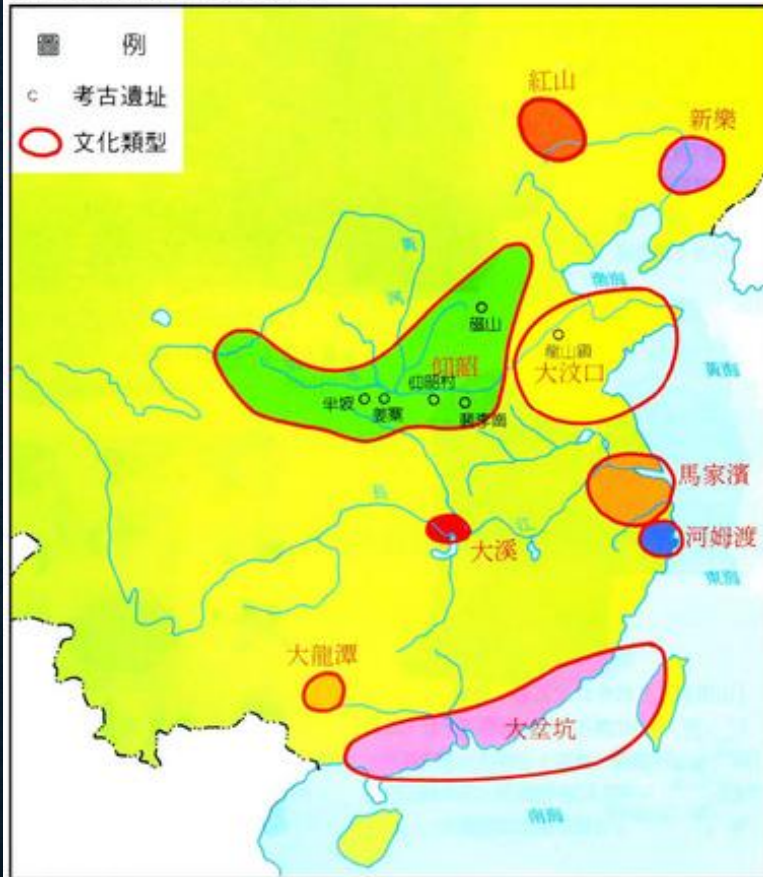
K. S. Carslaw,¹ R. G. Harrison,² J. Kirkby³



黃河與長江中下游降雨對於夏季季風指數有相反的反應 (王紹武等2009)



新石器時代重要文化遺址分佈圖



NEOLITHIC CULTURES IN CHINA

[http://masuda1108.pixnet.net/blog/post/50494295-%E9%AB%98%E4%B8%80%E4%B8%AD%E5%9C%8B%E5%8F%B2%3Ach1\(%E5%8F%B2%E5%89%8D~%E5%A4%8F\)%E8%A3%9C%E5%85%85](http://masuda1108.pixnet.net/blog/post/50494295-%E9%AB%98%E4%B8%80%E4%B8%AD%E5%9C%8B%E5%8F%B2%3Ach1(%E5%8F%B2%E5%89%8D~%E5%A4%8F)%E8%A3%9C%E5%85%85)

中國夏商周文明發展的氣候背景： 古環境資料的整合與評析

Climatic background of Xia-Shan-Zhou
civilization development: integration and
analyses of paleoclimate data

1

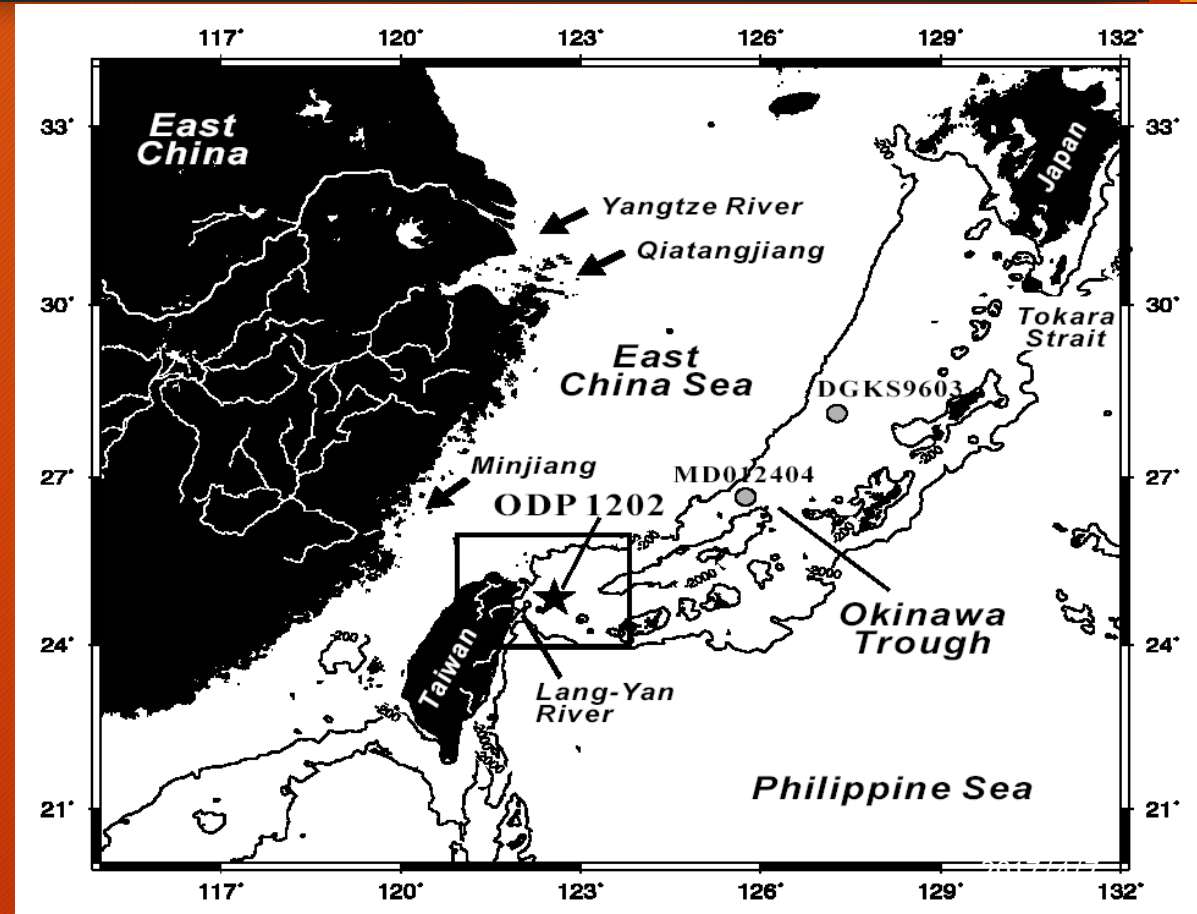
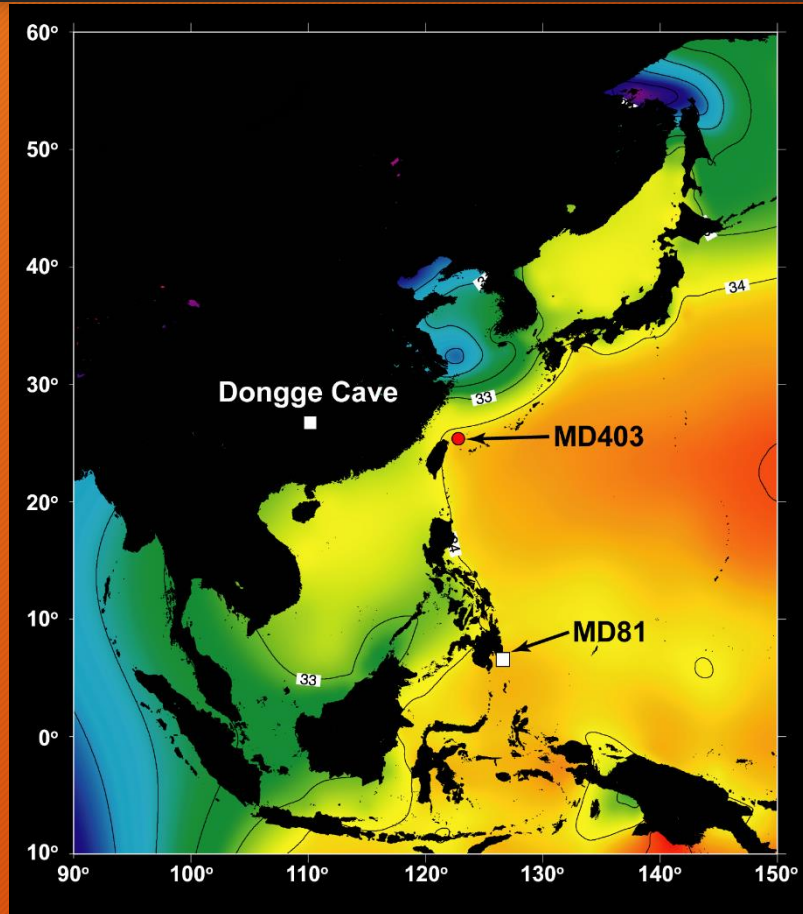
台灣大學地質科學系

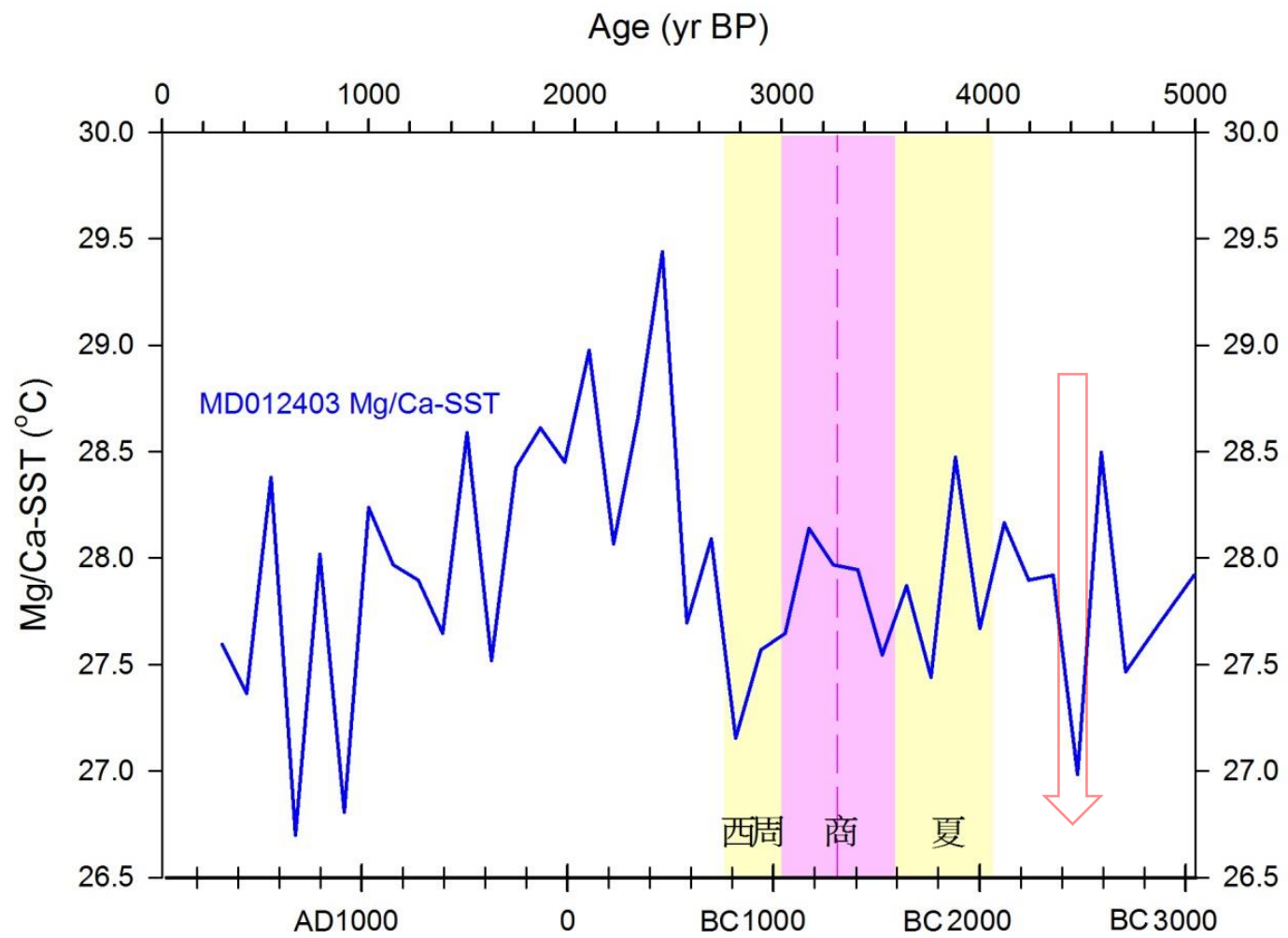
魏國彥

2017/4/7

ODP 1202, Southern Okinawa Trough

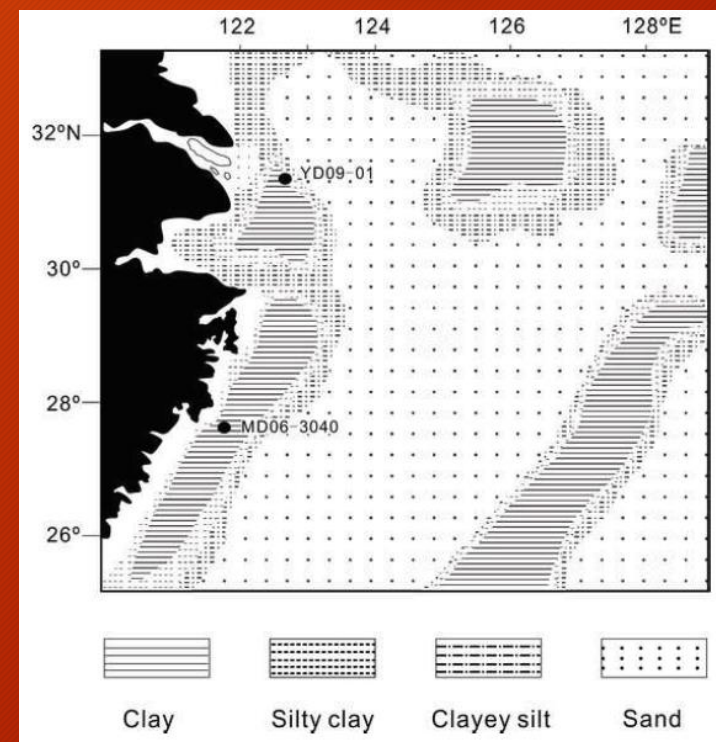
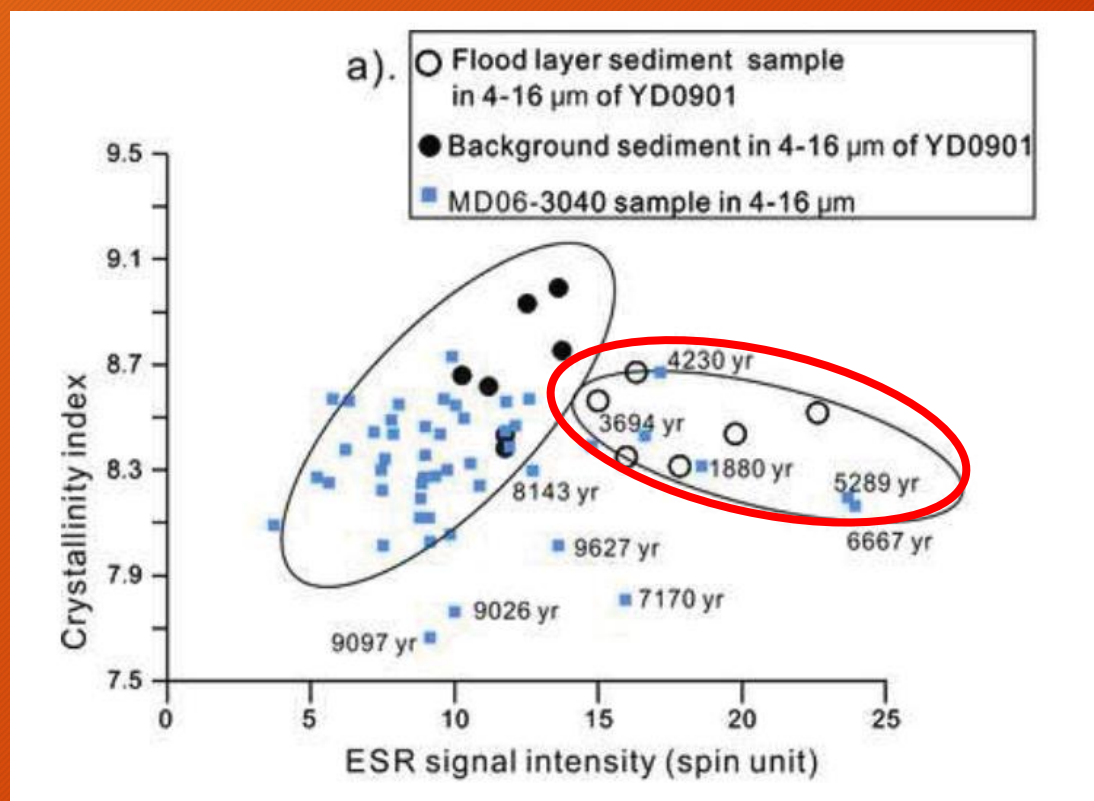
2





夏 : BC 2070 - BC 1600
商 : BC 1600 - BC 1300 (商前期)
BC 1300 - BC 1046 (商後期)
西周 : BC 1046 - BC 770

甌江口紀錄的長江下游大洪水事件 (1880, 3694, 4230, 5280, 6667年前)



2017/4/7

Circulation pattern during Asian summer monsoons 1971-2000

5

258 *The Holocene* 20,2 (2010)

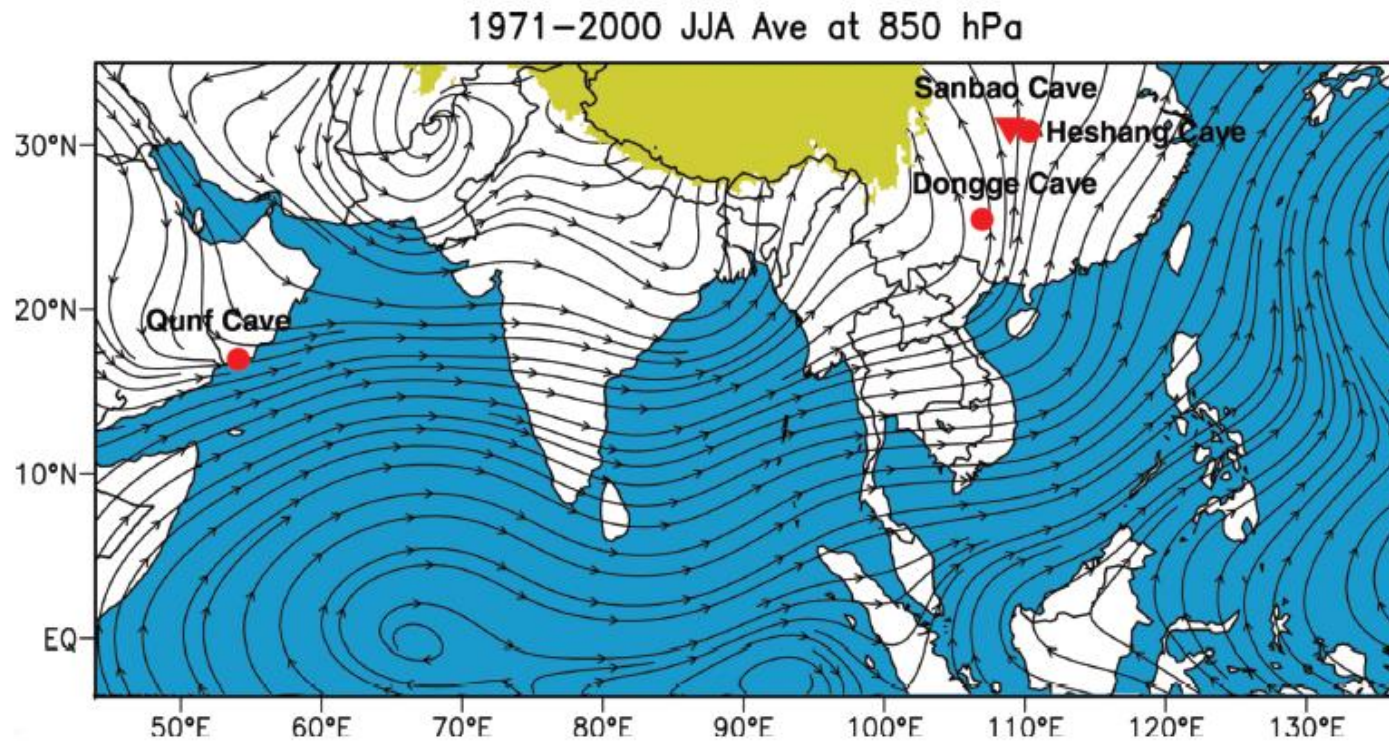
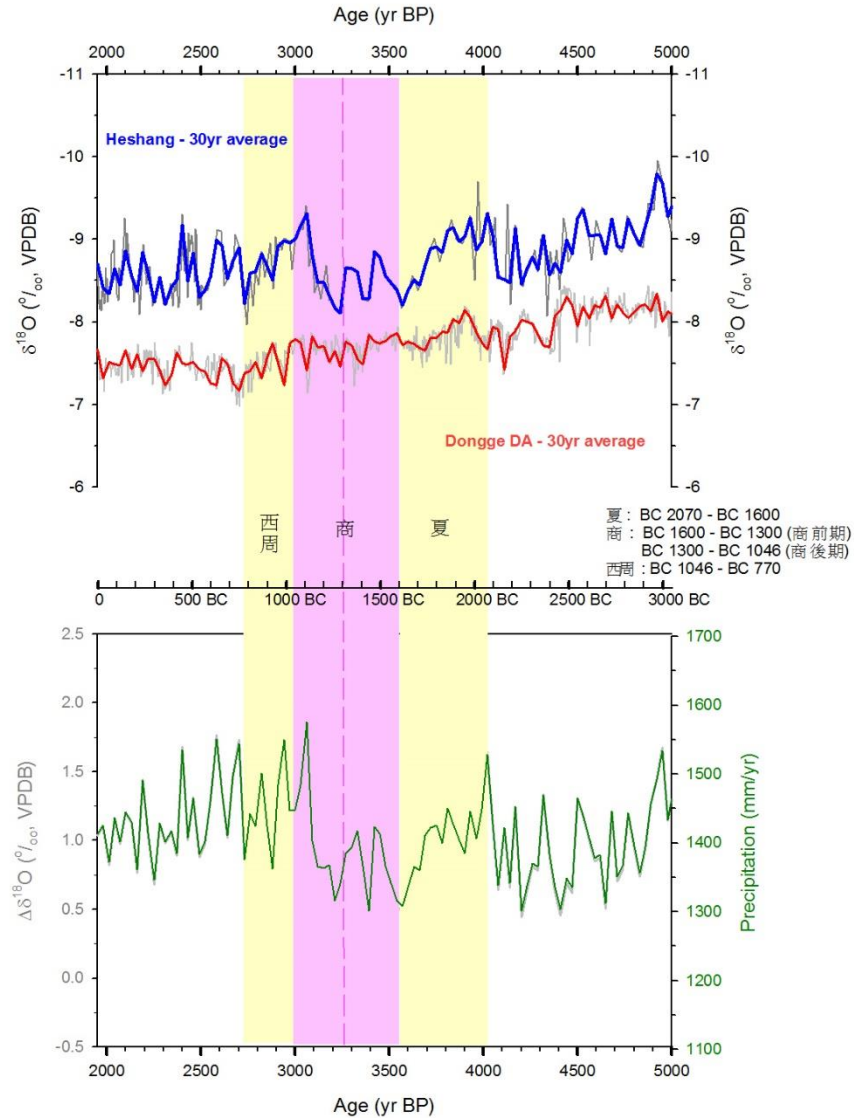


Figure 1 Study site location map and generalised circulation pattern of the Asian summer monsoon over the period from 1971–2000 (NCAR/NCFP, Kalnay *et al.*, 1996). The yellow shading represents the Qinghai-Tibetan Plateau. The red triangle indicates the location of Sanbao Cave (31°40'N, 110°26'E; this study). The locations of Heshang Cave (30°26'N, 110°25'E), Dongge Cave (25°17'N, 108°5'E) and Qunf Cave, Oman (17°10'N, 54°18'E) are depicted as red circles

A high-resolution stalagmite record of the Holocene East Asian monsoon from Mt Shennongjia, central China

Jinguo Dong,¹ Yongjin Wang,^{1,*} Hai Cheng,^{1,2} Ben Hardt,² R. Lawrence Edwards,² Xinggong Kong,¹ Jiangying Wu,¹ Shitao Chen,¹ Dianbing Liu,¹ Xiuyang Jiang,¹ and Kan Zhao¹

2011-11



After Hu et al., 2008.
 Precipitation = $189.08(\Delta\delta^{18}\text{O}) + 1217.4$

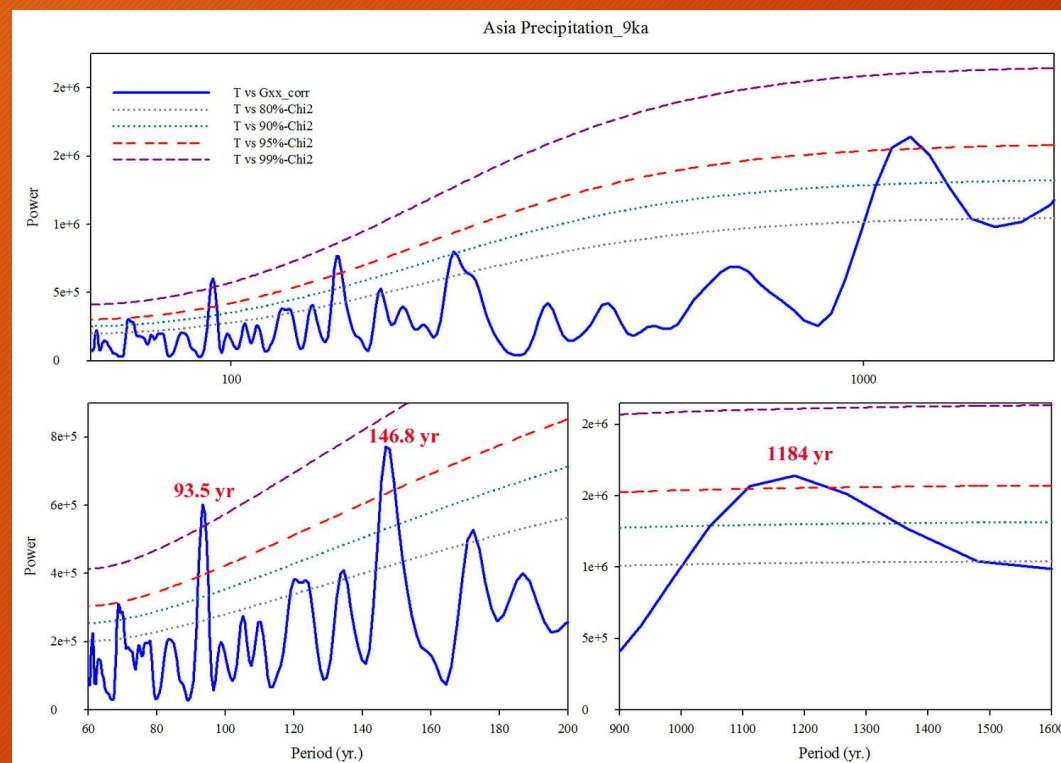
上圖：和尚洞、董哥洞石筍氧同位素變化紀錄。

下圖：過去五千年長江中游雨量變化（和尚洞—董哥洞差值～雨量效應）。

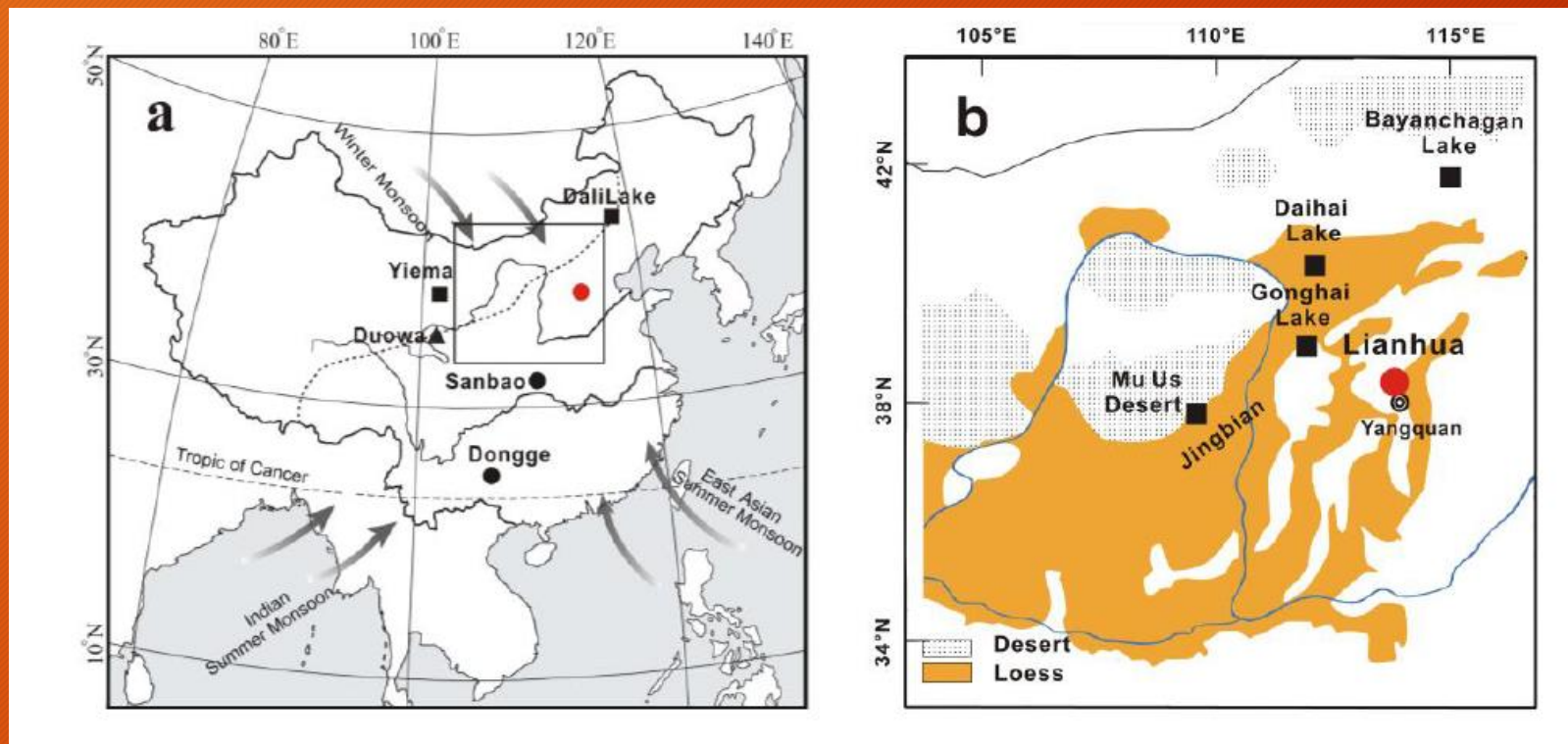
2017/4/7

長江中游9000年來雨量頻譜分析顯示有三個週期：1184年、147年、94年。

7

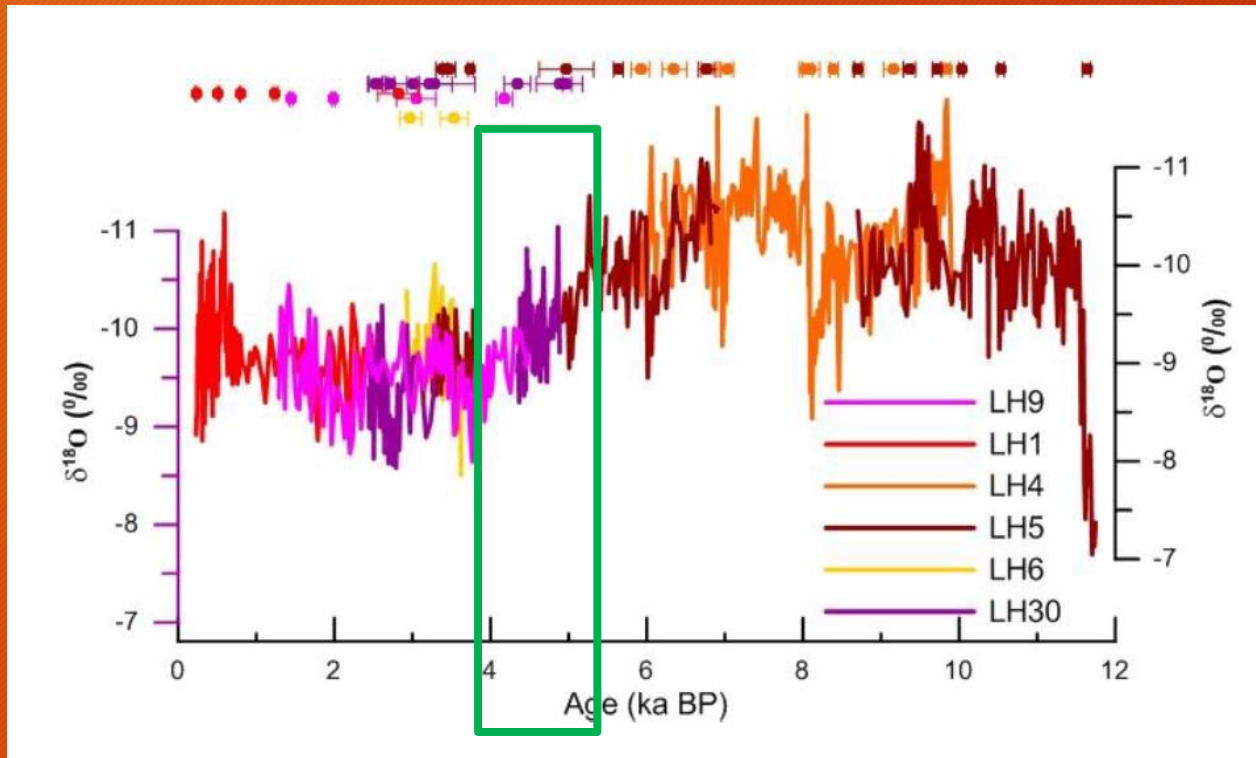


黃河北方的石筍紀錄： 蓮花洞（山西省陽泉市， $38^{\circ}10'N$ 、 $113^{\circ}43'E$ ）



山西蓮花洞石筍氧同位素紀錄 (Dong et al., unpublished)

9



- 做為中國大陸東緣的海域氣候背景，東海海表溫在夏商周時期並未比現今溫暖，並未能支持竺可楨（1972）的結論。
- 4200年前左右有一次明顯顯的降溫事件，海表溫從28.5°C降到27.0°C。
- 夏朝末年到商王盤庚遷殷之前長江徑流流量係處於相對較低的狀態，換言之，長江流域較為乾旱。但是，在公元前2280年、1744年前後有兩次大規模的洪氾事件 (Wang et al., 2014)。
- 從夏朝初年（公元前2000年）到商朝後期（公元前1150年）長江中游處於一個東亞夏季季風減弱，較低雨量的時期，氣候少波動，相對穩定。
- 山西蓮花洞石筍氧同位素紀錄 指示夏商周處於相對乾旱的情況（董，未發標）。