歷史、社會與氣候變遷

王寶貫
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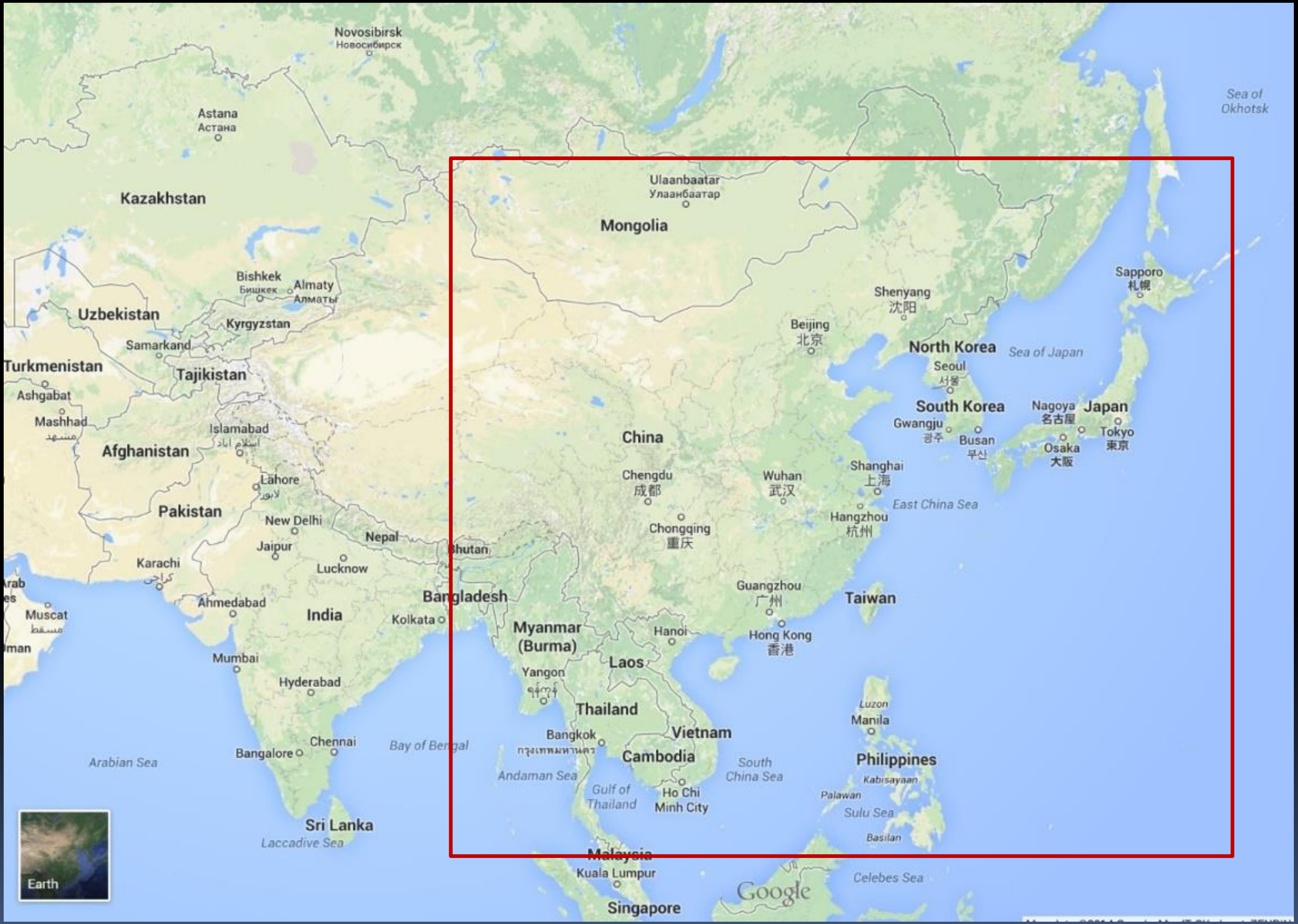
Center for Climate Research, University of Wisconsin-Madison, Dec. 1990

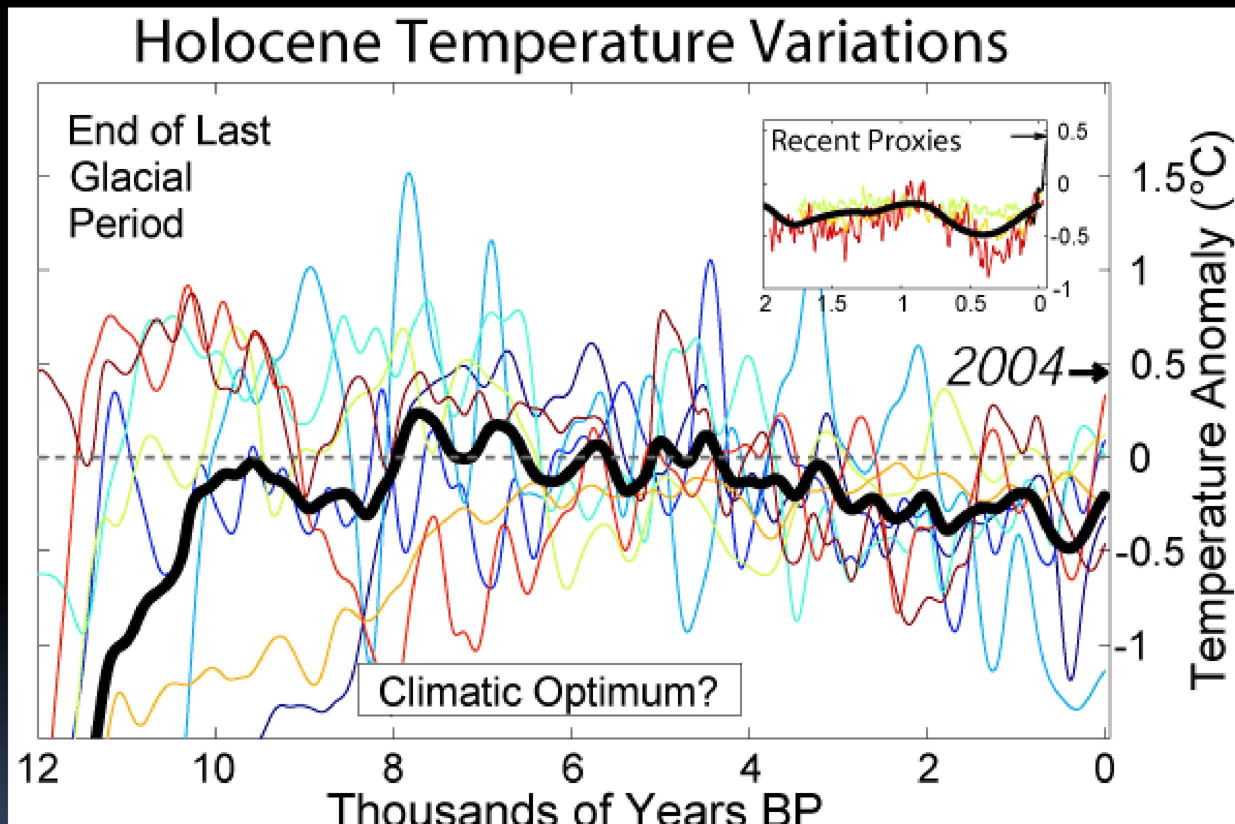
Area of Concern



東亞地區歷史時期氣候的長期背景

Holocene Climatic Optimum

全新世氣候最適宜期

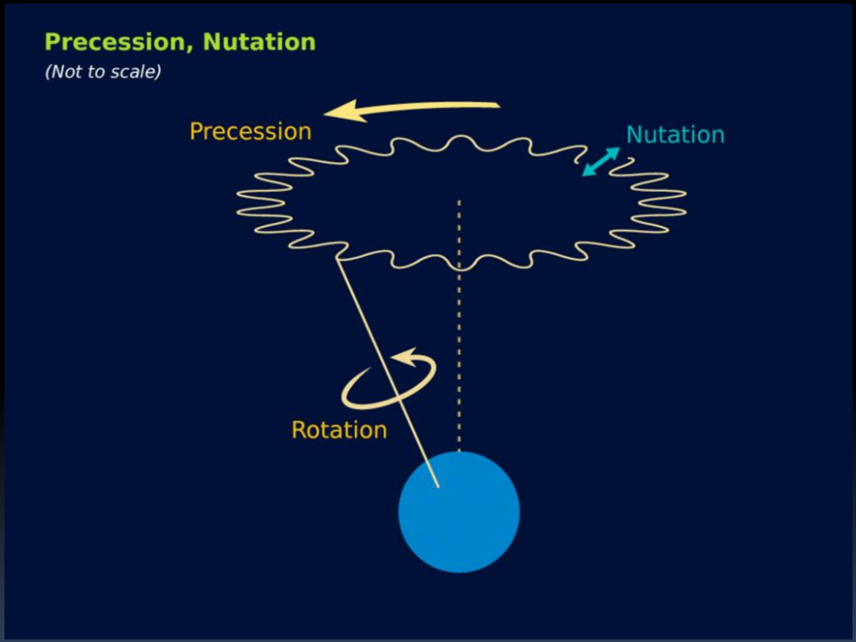


Robert A. Rohde

Milankovitch Forcing
米蘭科維奇驅動力

- This climatic event was probably a result of predictable changes in the Earth's orbit (Milankovitch cycles) and a continuation of changes that caused the end of the last glacial period
- The effect would have had maximum Northern Hemisphere heating 9,000 years ago when axial tilt was 24° and nearest approach to the Sun (perihelion) was during boreal summer.
- The calculated Milankovitch Forcing would have provided 8% more solar radiation (+40 W/m^2) to the Northern Hemisphere in summer, tending to cause greater heating at that time. There does seem to have been the predicted southward shift in ITCZ.
- However, orbital forcing would predict maximum climate response several thousand years earlier than those observed in the Northern Hemisphere. This delay may be a result of the continuing changes in climate as the Earth emerged from the last glacial period and related to ice-albedo feedback.

Precession = 歳差
Nutation = 章動



Is this reflected in E. Asia?

- Winkler, M., and P. K. Wang, 1994: The late Pleistocene and Holocene climate of China. in *Global Climates Since Last Glacial Maximum*, Wright et al., eds, Univ. of Minnesota Press, 221-264.
- It is a review of biogeologic evidence in China and a comparison with GCM climate simulations.
- Pollen, stratigraphy, microfossil, tree ring , paleosol, etc.

reprinted from
Global Climates since the Last Glacial Maximum
H. E. Wright et al., ed.
University of Minnesota Press, Minneapolis, 1993

CHAPTER 10

The Late-Quaternary Vegetation and Climate of China

Marjorie G. Winkler and Pao K. Wang

Recent geologic, palynologic, and archaeologic studies in China provide much evidence for the paleoenvironmental changes that have taken place during the late Pleistocene and the Holocene. Many studies have been translated into English and published in synthesis volumes (Whyte, 1984a,b; Liu, 1985a,b; Walker, 1985a,b; Liu *et al.*, 1985), the glacial (Liu, 1985b) and paleolimnological (Li *et al.*, 1985; Wang and Fan, 1987; Fang, 1991) history of the Qinghai-Xizang Plateau and the Tian Shan and other regions of China, and vegetation and climate changes in Yunnan Province in southwestern China (Xu *et al.*, 1984; Walker, 1986)

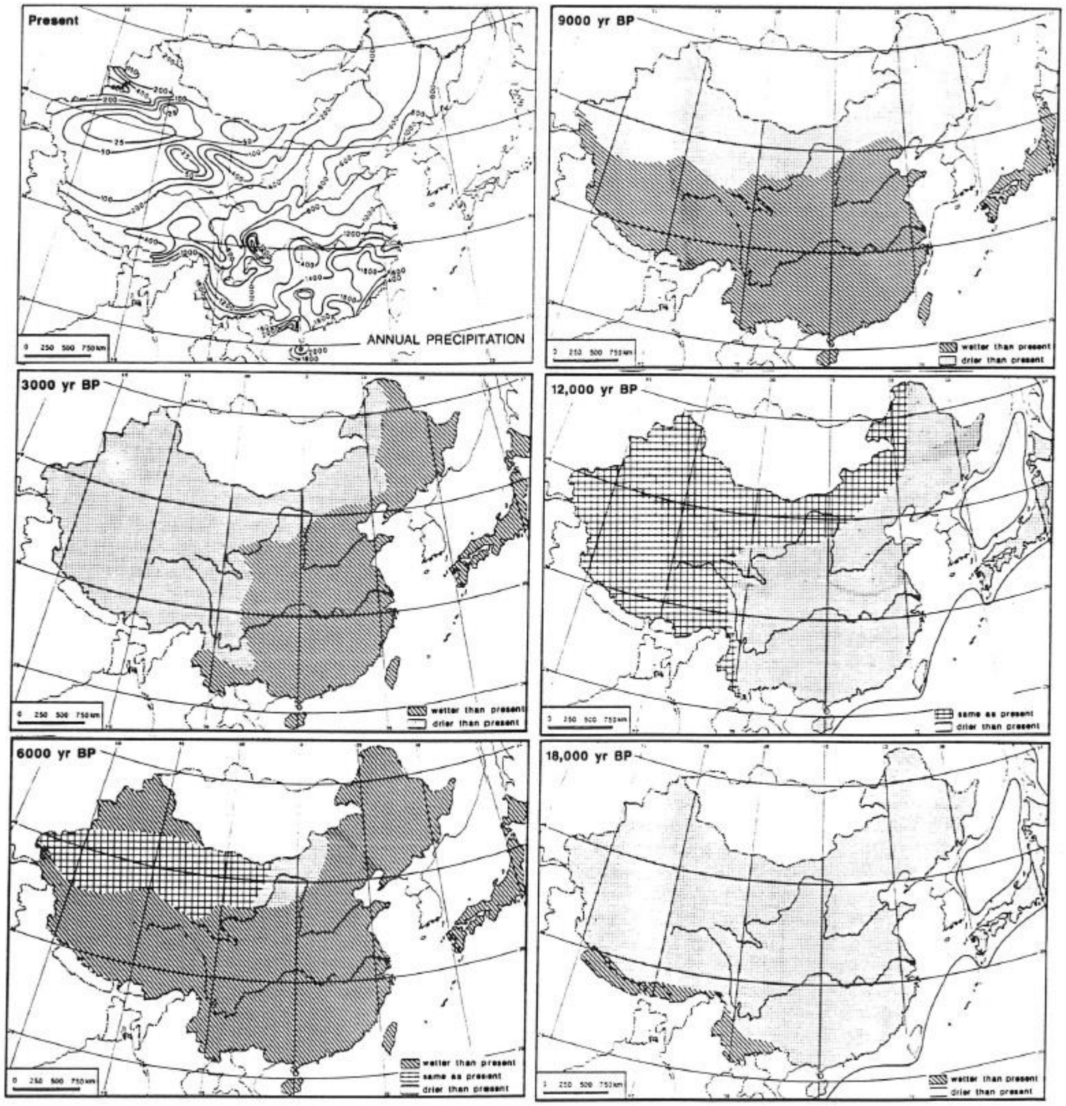
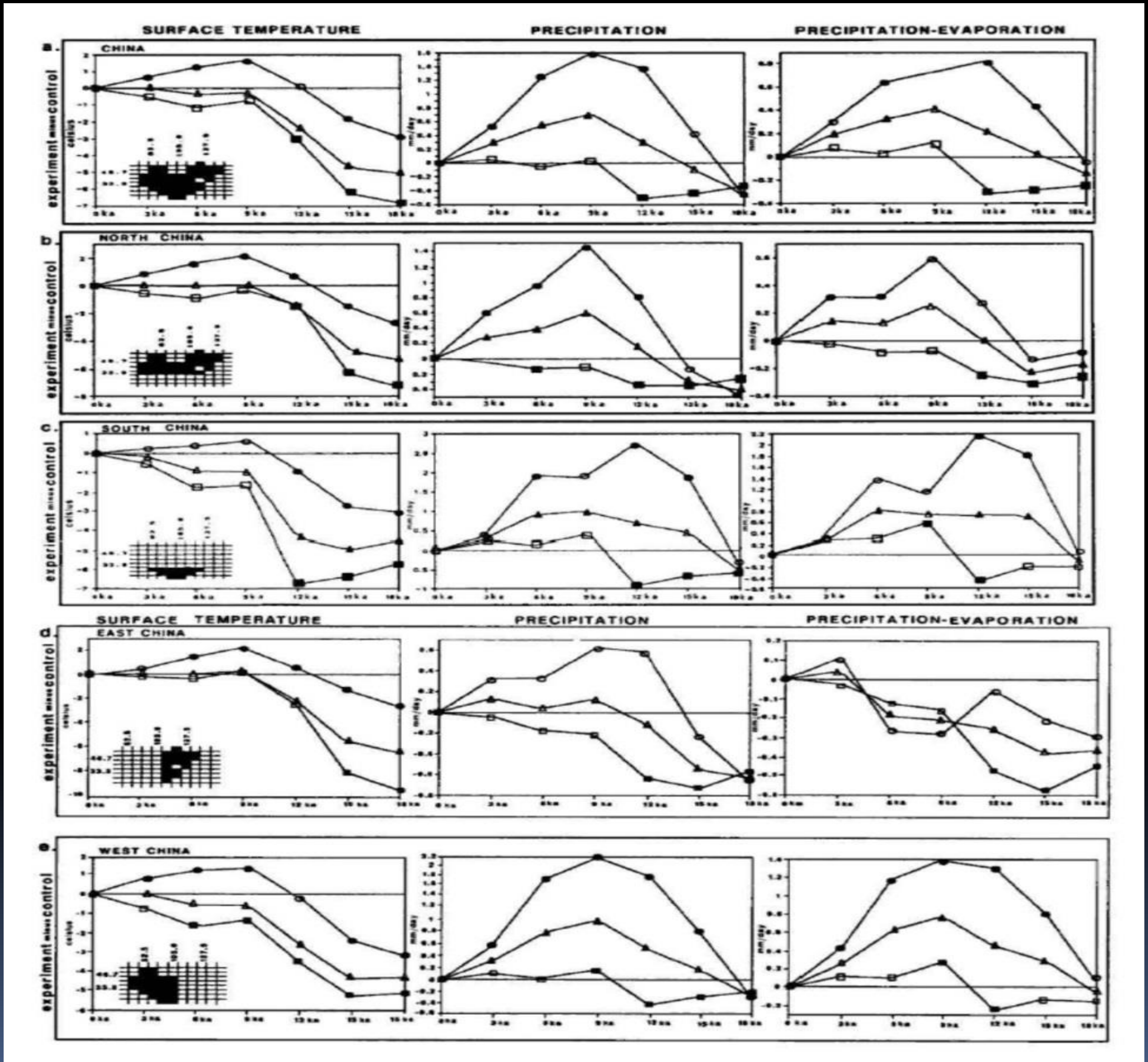


Fig. 10.10. Paleoprecipitation maps (showing areas wetter than, drier than, or the same as at present) constructed from biogeologic evidence for 18,000, 12,000, 9000, 6000, and 3000 yr B.P., and present mean annual precipitation (mm) (modified from Ren *et al.* 1985).

CCM中國地區的模擬結果-1



time

Winkler and Wang, 1994

CCM中國地區的模擬結果-2

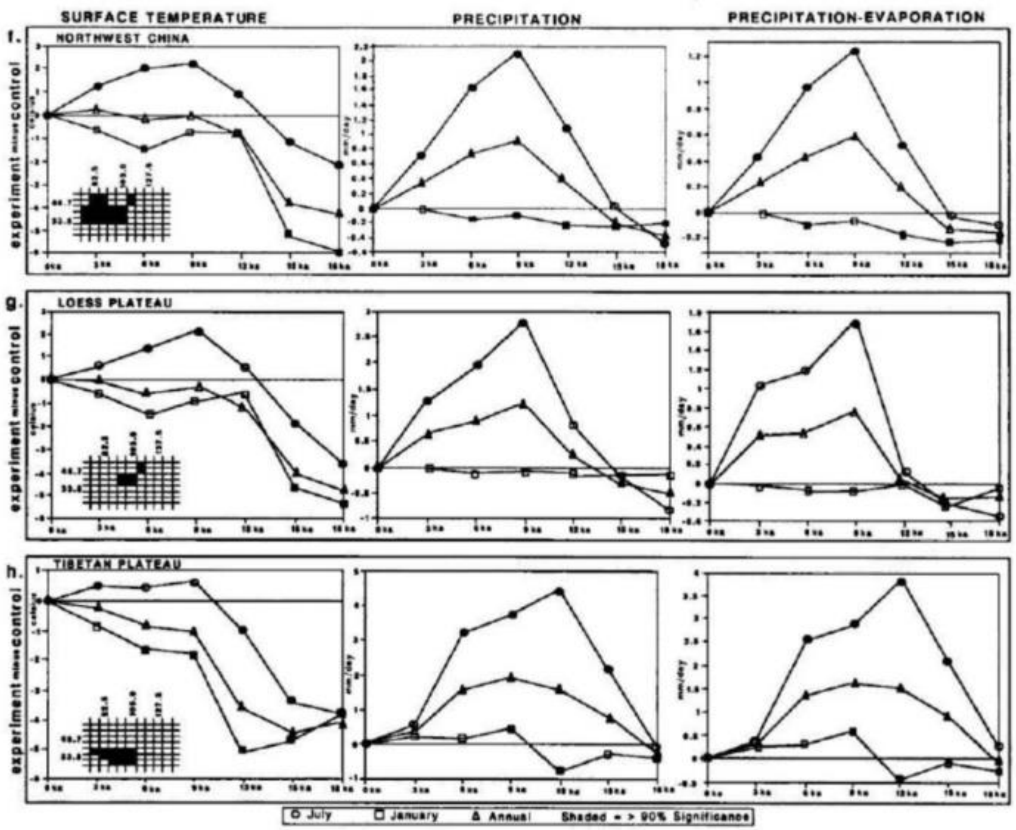


Fig. 10.12 Paleoclimatic variables simulated by the Community Climate Model (CCM): surface temperature (°C), precipitation (mm/day), and precipitation-minus-evaporation (P-E) (mm/day) for (a) all of China, (b) north China, (c) south China, (d) east China, (e) west China, (f) northwest China, (g) Loess Plateau, and (h) Tibetan Plateau. Mean July (○), January (□), and annual (△) values are plotted for each variable. Shaded symbols indicate values with statistical significance greater than 90%. Inset maps of the CCM map grid with each region show latitude and longitude and number of grid squares averaged to obtain the data for each entry.

time

Winkler and Wang, 1994

理論 vs 資料

No solar activity in ancient historical period (Eddy, 1976)

乙卯允明，霧，三焰食日，大星。

18 June 1976, Volume 192, Number 4245 SCIENCE

The Maunder Minimum

The reign of Louis XIV appears to have been a time of real anomaly in the behavior of the sun.

John A. Eddy

It has long been thought that the sun is a constant star of regular and repeatable behavior. Measurements of the radiative output, or solar constant, seem to justify the first assumption, and the record of periodicity in sunspot numbers is taken as evidence for the second. Both records, however, sample only the most recent history of the sun.

When we look at the longer record—of the last 1000 years or so—we find indications that the sun may have undergone significant changes in behavior, with possible terrestrial effects. Evidence for past solar change is largely of an indirect nature and should be subject to the most critical scrutiny. Most accessible, and crucial to the basic issue of past constancy or inconstancy, is a long period in the late 17th and early 18th centuries when, some have claimed, almost no sunspots were seen. The period, from about 1645 until 1715, was pointed out in the 1890's by G. Spörer and E. W. Maunder. I have reexamined the contemporary reports and new evidence which has come to light since Maunder's time and conclude that this 70-year period was indeed a time when solar activity all but stopped. This behavior is wholly unlike the modern behavior of the sun which we have come to accept as normal, and the consequences for solar and

The Sunspot Cycle

Surely the best-known features of the sun are sunspots and the regular cycle of solar activity, which waxes and wanes with a period of about 11 years. This cycle is most often shown as a plot of sunspot number (Fig. 1)—a measure of the number of spots seen at one time on the visible half of the sun (*1*). Sunspot numbers are recorded daily, but to illustrate long-term effects astronomers more often use the annual means, which smooth out the short-term variations and average out the marked imprint of solar rotation.

There is as yet no complete physical explanation for the observed solar cycle. Modern theory attributes the periodic features of sunspots to the action of a solar dynamo in which convection and surface rotation interact to amplify and maintain an assumed initial magnetic field (*2*). Dynamo models are successful in reproducing certain features of the 11-year cycle, but with these models it is not as yet possible to explain the varying amplitudes of maxima and other long-term changes.

The annual mean sunspot number at a typical minimum in the 11-year cycle is about six. During these minimum years there are stretches of days and weeks

zero. In contrast, in the years around a sunspot maximum there is seldom a day when a number of spots cannot be seen, and often hundreds are present.

Past counts of sunspot number are readily available from the year 1700 (*3*), and workers in solar and terrestrial studies often use the record as though it were of uniform quality. In fact, it is not. Thus it is advisable, from time to time, to review the origin and pedigree of past sunspot numbers, and to recognize the uncertainty in much of the early record.

A Brief History

Dark spots were seen on the face of the sun at least as early as the 4th century B.C. (*4*), but it was not until after the invention of the telescope, about 1610, that they were seen well enough to be associated with the sun itself. It would seem no credit to early astronomers that over 230 years elapsed between the telescopic "discovery" of sunspots and the revelation of their now obvious cyclic behavior. In 1843, Heinrich Schwabe, an amateur, published a brief paper reporting his own observations of spots on the sun for the period 1826 to 1843 and pointing out an apparent period of about 10 years between maxima in their number (*5*).

Rudolf Wolf, director of the Observatory at Bern and later at Zurich, noticed Schwabe's paper and shortly after set out to test the result by extending the limited observations on which the 10-year cycle was based. In 1848 he organized a number of European observatories to record spots on a regular basis and by a standard scheme, thus inaugurating an international effort which continues today. Wolf also undertook a historical search and reanalysis of old data on the sun in the literature and in observatory archives. More than half of the record of sunspot numbers in Fig. 1, and all of it before 1848 is the result of

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ANCIENT CHINESE OBSERVATIONS OF PHYSICAL PHENOMENA ATTENDING SOLAR ECLIPSES

P. K. WANG and G. L. SISCOE

Department of Atmospheric Sciences, University of California, Los Angeles, CA 90024, U.S.A.

Abstract. The realization that solar activity probably undergoes changes in qualitative character on time scales greater than the 11 or 22 year cycle but short compared to the duration of recorded history gives renewed importance to historical documents describing the state of solar activity. Modern eclipse observation reveal the presence of solar activity through the appearance of coronal structures and prominences. It has been widely remarked that eclipse records prior to the 18th century are uniformly silent on these conspicuous solar eclipse features, raising the possibility, however unlikely, that a change in solar activity has occurred which rendered them only recently noticeable. We present here material from ancient Chinese sources, primarily astrological, that describe phenomena attending solar eclipses that are almost certainly coronal structures and prominences. Thus, these aspects of the present character of solar activity have apparently occurred at other times in history, if not continuously.

1. Introduction

The ancient Chinese observations on solar eclipse can be traced back to more than 4000 years ago. The earliest record was that written in Shu-Chin (literally, The Book) (see Appendix). A royal astronomer who failed to predict the solar eclipse at that time was killed. According to Chen (1955) this event occurred at October 22, 2137 B.C. which was the time of Hsia dynasty (2183–1751 B.C.) in China (another Calenderist, Liu (1945), dated it on October 23, 2110 B.C.). Since then there were continuous record on solar eclipses in Chinese official histories of all dynasties. Chu (1933, 1934) compiled 916 occurrences of solar eclipses from ancient Chinese literature from 2137 B.C.–1785 A.D.

The most important reason for ancient astronomers in China to record solar eclipses was to check the accuracy of calendar systems. There were a number of official astronomers who were discharged when their calendar systems failed to predict either a solar or a lunar eclipse. Since a solar eclipse is such a spectacular, heavenly phenomenon, people tended to link it to the fate of political systems, especially to the stability of the throne of emperors. On the occasion of an eclipse, an emperor was supposed to think what wrong or evil he had done to the people and then to correct it in an appropriate way. Of course this was no more than a gesture. As Shun Chin (313–238 B.C.) pointed out, all rites about rescuing the eclipsed Sun, praying for rain, or devining to make important decisions, were not really in the sense that these would work, but were no more than formality.

The way in which solar eclipses were noted in the official records was very simple. For example, the above mentioned 2137 B.C. eclipse was recorded as "At the 1st day (the new moon day) in late fall (i.e. the 8th month), the Sun and Moon could not live peacefully together in the sky", which was followed by a description of what people did during the eclipse. A more typical way of recording a solar eclipse is

Solar Physics **66** (1980) 187–193. 0038–0938/80/0661–0187$01.05.
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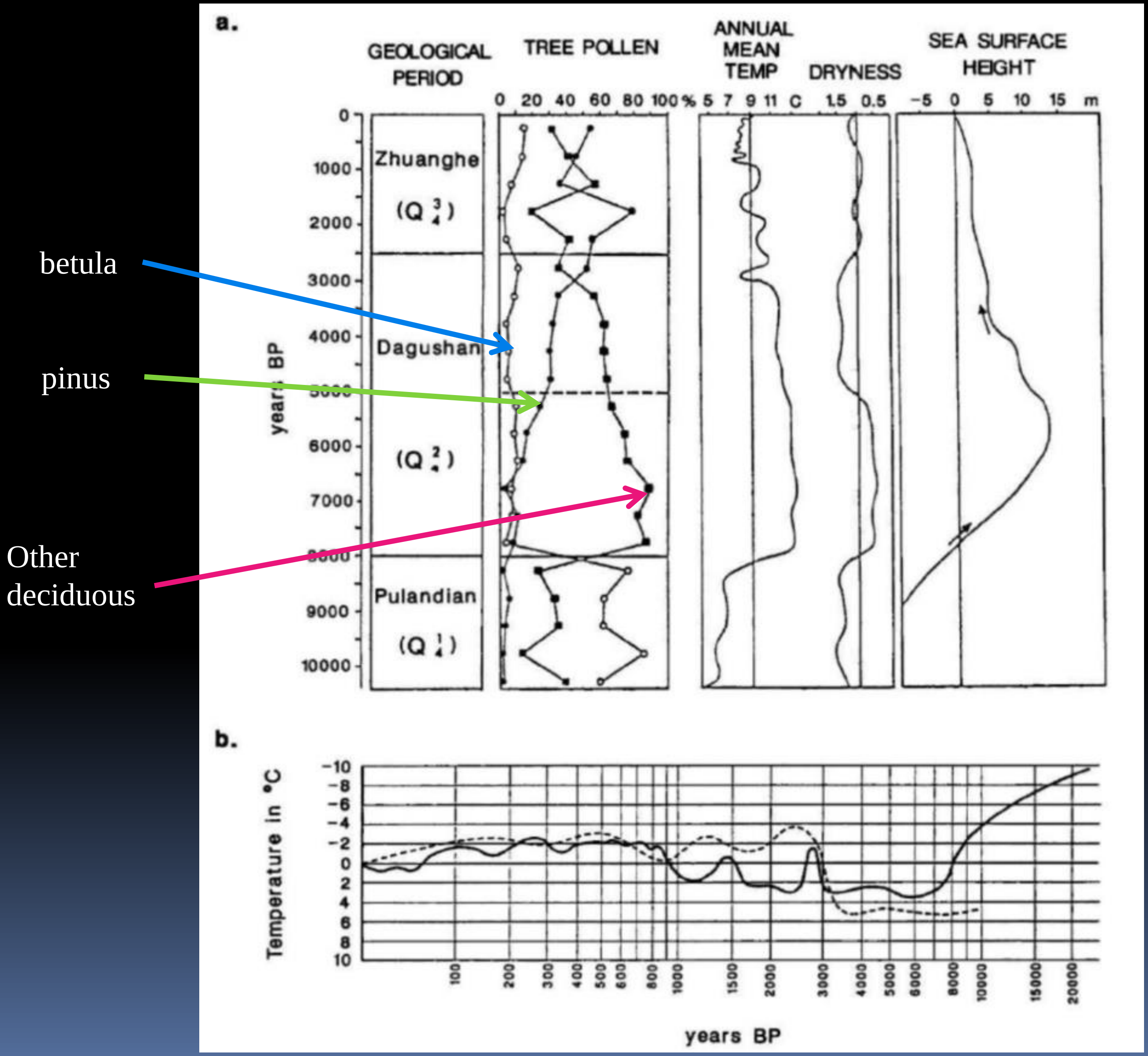
乙卯允明，霧，三焰食日，大星。

採用驗證資料舉例：遼寧 普蘭店孢粉序列



Winkler and Wang, 1994

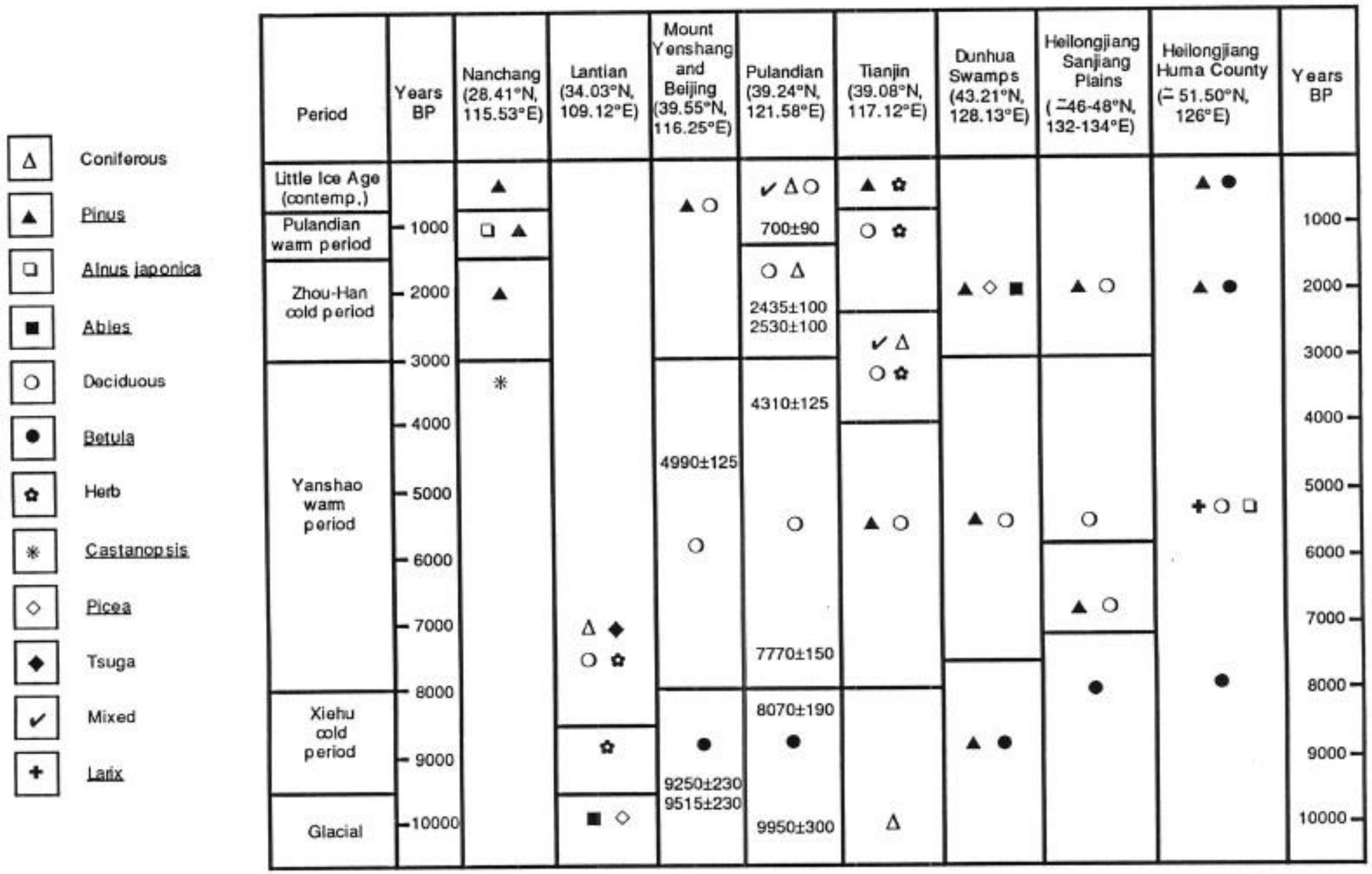
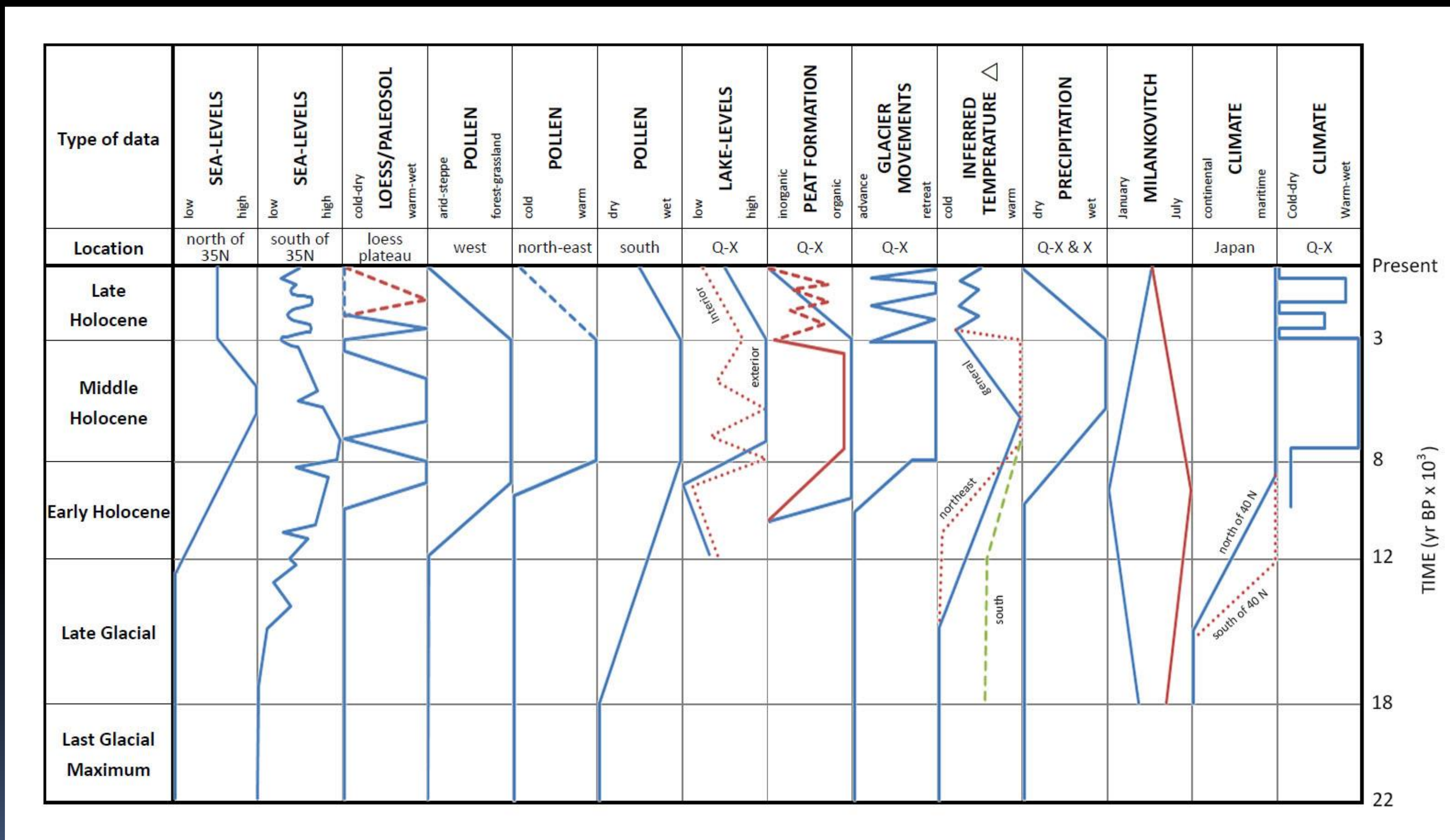


Fig. 10.7 Summary of pollen data from sites in eastern China. Translated and modified from Duan *et al.* (1981); stratigraphic data (columns from left to right) from Wang (1972); Institute of Botany (1966) and Lee and Huang (1966); Zhou (1965) and Liu *et al.* (1965); Chen *et al.* (1965); Hebei 7th Team (unpublished [1978]); Zhou *et al.* (1984); Changcun Institute of Geography (unpublished); and (Huabei) North China Institute of Geography (unpublished).

中國地區綜合資料分析結果



Winkler and Wang, 1994

東亞地區歷史時期氣候的重建

歷史時期的氣候狀況

- 早期限於電腦資源及技術，CCM的解析度及參數化都嫌太粗糙
- 要了解氣候過程，我們需要更精確，時空解析度更高的氣候資料
- 東亞地區，特別是中國，有豐富的歷史文獻可作為重建高解析度氣候序列的原始資料
- 中短期氣候預報需要高時空解析度的氣候模式來進行計算，同時也需要高時空解析度的歷史氣候資料作為驗證

- 除了重建氣候序列之外，由於氣候變遷對人類社會有重大影響：
  - 氣候變遷可能導致災變（水、旱、蝗、饑饉、等等）
  - 嚴重的災變造成社會極大動蕩，甚至政治系統之覆亡。（例：明朝之覆亡與明末大旱之關係）
  - 試圖從歷史記錄中找出氣候變遷與社會動盪之關連

商代 －甲骨文中的氣候訊息

- Shang dynasty (商代，殷代，殷商）
- Circa 1600 BC – c. 1046 BC, so ~ 3700-3100 BP
- Used to be thought as just legend, but the findings of oracle bones in Henan (河南）proved that it is real

Think ECMWF is advanced? Think again！

- 癸巳這一天占卜，「一月」這個月會不會下雨，商王根據占卜的結果判斷說：「丙」日（丙申，第四日）會下雨。一旬以後的壬寅（第10天）、甲辰（第12天）、己酉（第17天）、辛亥（第19天）都會下雨，這是對一個月內的「氣象預報」。

Karl A. Wittfogel(魏復古)

- Wittfogel, K. A.（1940）： Meteorological records from the divination inscriptions of Shang, *Geographical Review*, **30**, 110-133.
- 從超過14,500片的甲骨中找出317片有時間記載（至少有月份）的甲骨來，只有總數的2~3%，
- 317片按內容再分類，其中有108片有關天氣，有42片是有關收成的，其餘167片是有關軍事、旅行、狩獵及其他的卜辭。

Oracle bone findings

- Many contain questions about whether it's going to rain or not in winter months
  - Must indicate that rain is not uncommon in winter
- Rain is highly unlikely to occur in today's N. China (mostly snow if anything).
  - This indicates that the climate must have been warmer and more humid than today during Shang period
- Other archaeological findings seem to confirm this conclusion.

殷商：暖濕氣候？

- 殷商時期，華北氣候可能比現代暖而溼。水災似乎也不少。從《尚書．盤庚》中：「茲由不常寧，不常厥邑，于今五邦」以及《國語．魯語》中的：「冥勤其官而水死」（冥是商的一位「先王」，因太努力治水，結果淹死），許多人認為是指由於水災頻仍，結果弄到遷都遷了五次之多。如此事屬實，也是潮溼氣候的一個旁證。
- 近代的考古發掘，在殷墟挖出大量水獐、竹鼠、水牛、象等遺骨，這些都是當今出現在較暖溼氣候的動物群落，尤其是象。當然，「象」也有可能是南方進貢之物，不見得殷墟原產。不過，卜辭中曾有打獵時獲得一頭象的記載，而河南古稱「豫」，有人認為是一人牽一象的象形文字。似乎在在顯示，象是當地野生，而非外地引進。

Non-weather oracle bones: seasons

- 有關軍事、旅行、狩獵的卜辭，雖然並非直接的天氣資料，然而這些行動無疑和天氣的關係極大。你若挑個大雨滂沱的時節去打仗，除非你是在「出奇兵」，要不然把大隊人馬陷在爛泥淖裡進退不得，恐怕只有等著被敵人修理了。
- 同理，在如此季節去狩獵只怕被野獸捕獲的機會更大。打獵最好是秋高氣爽，「草枯鷹眼疾，雪盡馬蹄輕」的時節。因此，從這幾樣行動的卜辭所代表的月份頻率分布，也可以看出乾季、雨季的情況。
- 六月戰事卜辭最少，代表這一段時間一定是不適合打仗的雨季
- 在四月至七月，占卜雨水的頻率驟降，而占卜軍事順否的頻率也驟降，代表這一季節一定是多雨，不適合打仗。
- 而從八月到十一月（尤其是十月和十一月）卻是卜收成的好壞頻率多，卜雨頻率降低，代表這一段期間一定比較乾燥。
- 商人打仗何時多？似乎是在春季以及秋季，而以二月及十月為高峰點

冬雷事件頻率

UNUSUAL LIGHTNING EVENTS IN ANCIENT CHINESE LITERATURE

By PAO-KUAN WANG and JAN-HWA CHU

OF ALL WEATHER DISPLAYS IN THE SKY, lightning and thunder are among the most awe-inspiring. They are the most visible, the most audible and, not infrequently, the most deadly. No wonder they have long been regarded as the weapon of the gods. The Bible relates that thunder and lightning occurred on Mount Sinai before Moses climbed it to receive the Ten Commandments. The ancient Greeks believed that lightning was the weapon of Zeus. When Salomoneus, the King of Elis, was attempting to mimic Zeus by throwing flaming brands from his chariot as he clamored over a bronze bridge, legend has it that he was struck by a real thunderbolt from Zeus, teaching him the difference between Divine and Mortal weapons (Viemeister, 1961).

Such a religious interpretation of lightning was shared also by the ancient Chinese, though their descriptions were usually more abstract. The Chinese established a bureaucratic system quite early, perhaps as early as 18 centuries B.C. The emperors, as rulers of this bureaucratic system, were thought to derive their powers directly from God. For this reason the emperors were often called the Sons of God. Consequently only God Himself could give commands to these emperors. If they behaved benevolently, then they would receive mercies from God. If they behaved evilly, they would be punished by God. But how does one know what God is feeling about the rulers? The feelings of God, according to some ancient astrologers, would be manifested by unusual phenomena. Thus the author (or, possibly, authors) of I-Ching claimed "God reveals (unusual) phenomena to indicate the auspiciousness of evil. Wise men would follow these indications closely." Clearly it was important for the emperors to decipher the messages carried by these unusual phenomena. The responsibility of decipherment usually fell upon the shoulders of royal astronomers (ironically they could also be astrologers at the same time).

Not surprisingly unusual lightning and thunder were considered as one of the important "phenomena" to be worried about. For example, winter thunderstorms, being rare, were considered an ill omen and consequently were noted frequently in ancient chronicles whenever they occurred. There were, of course, other people who had more scientific views about these unusual phenomena. Here, we have selected some accounts of unusual lightning events as reported in the ancient Chinese literature. The sources of these reports include official histories, provincial records, and private notes. The phonetic translations of Chinese characters have been taken from Mathews (1931).

SCIENTIFIC AMERICAN.

Credit: COURTESY OF WILBANKS

It's been more than 30 years—during the Blizzard of 1978 to be exact—since Neil Stuart saw "thundersnow," a weather phenomenon featuring the unusual combination of thunder, lightning and snow. The National Weather Service (NWS) meteorologist was 10 years old, living near Boston. The storm—which he says "is famous in meteorological circles" and influenced his career path—dumped 27 inches (67 centimeters) of snow on the ground over two days. The heaviest snow, however, came during a six-hour thundersnow storm that delivered one foot of snow over a six hour period.*

Seeing thundersnow come down is "like watching a time-lapse movie of the snow building up, because it falls so quickly," Stuart says.

Thunder and lightning during a snowstorm is different from a run-of-the-mill snowstorm; it is extremely rare—fewer than 1 percent of observed snowstorms unleash thundersnow, according to a 1971 NSW study. But recorded observations of the phenomenon date back to 250 B.C., say ancient Chinese records translated in 1980 by atmospheric scientist Pao-Kuan Wang, now of the University of Wisconsin–Madison.

Wang (1980): thunderstorm frequency in winter：冬雷

章安鎮高宗謂宰臣曰雷聲甚厲前史以為君弱臣
強四夷兵不制是夕金人破明州壬戌又雷紹興五
年九月戊寅雷十月丁巳雷六年十月丙午雷九年
九月甲午十月丁卯雷十一年十一月己酉雷十五
年十月辛卯十二月甲寅雷十六年溫州大雷雹震
死六人於龍翔寺十八年閏月甲戌雷十九年十月
甲寅雷二十一年二月辛未南安軍大雷雹大庾縣
震死四人十一月辛未夜震雷十二月癸酉雷二十
二年十二月戊寅己卯雷二十六年十二月甲子雷
二十七年九月癸未雷三十一年正月丁丑雷乾道

三年十一月丙寅雷雨不克郊戊辰日南至大震雷
八年九月乙酉雷九年閏月癸卯雷淳熙九年九月
壬午雷十二年十一月戊子雷十二月丁丑雷十三
年正月己丑雷後三十五日雪十四年十一月乙卯
雷十六年七月乙丑大雷震太室齋殿東鴟吻紹熙
元年九月辛酉雷十一月壬午日南至郊祀風雨大
至帝震恐因致疾四年十一月己卯日南至辛巳雷
五年十月癸巳大雷雹慶元二年正月戊子雷十一
月雷三年十月癸亥雷六年九月己未雷嘉泰二年
正月己巳雷三年正月雷四年正月辛卯雷開禧二

冬雷30年及50年累積頻率

Winter Thunder and Climatic Change in China

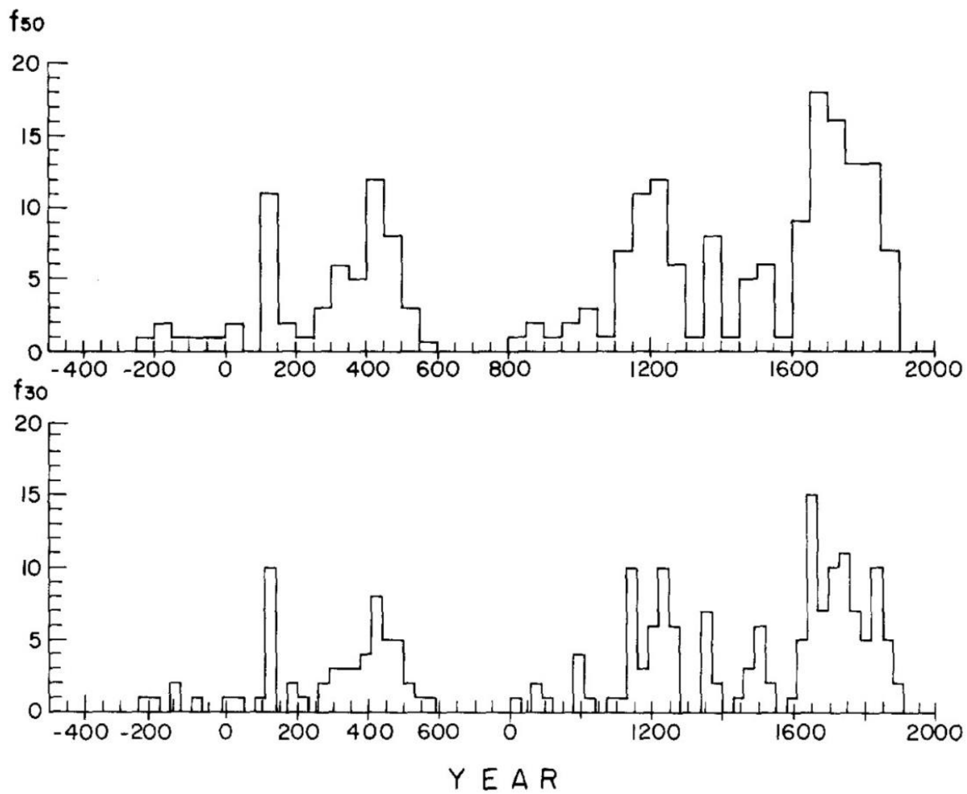
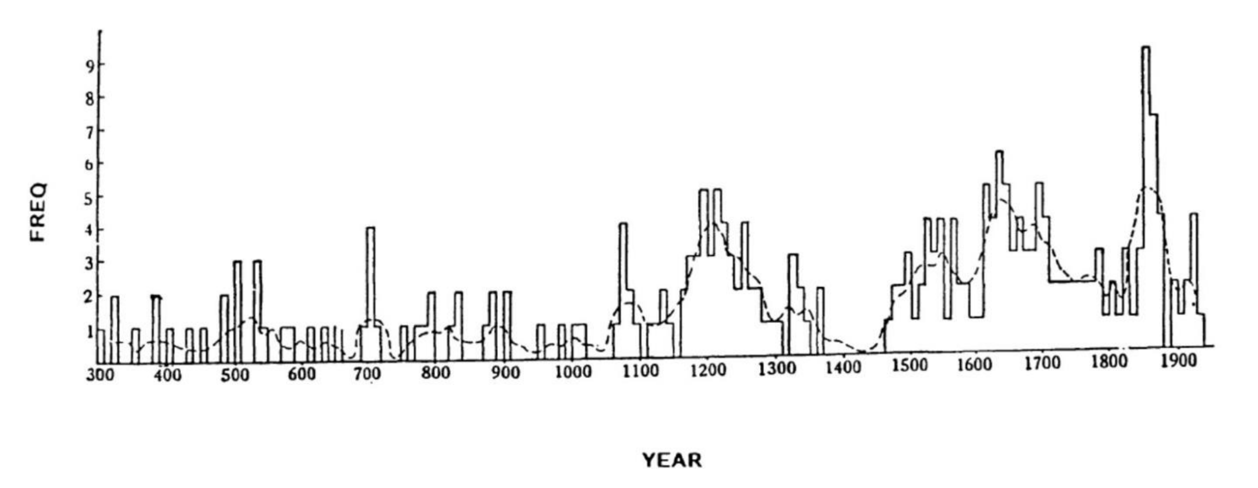


Fig. 2. Secular variation of (a) f_{50} and (b) f_{30}.

Wang, 1980

Zhang (1984) : dust fall 30 year freq.



竺可楨從物候資料重建溫度序列

- Ko-Chin Chu (1973, later spelled as Zhu Kezhen 竺可楨）used phenological records (river freezing, flow blossoming, swallow arrival, first thaw, etc.) to construct a temperature curve of China in historical time.

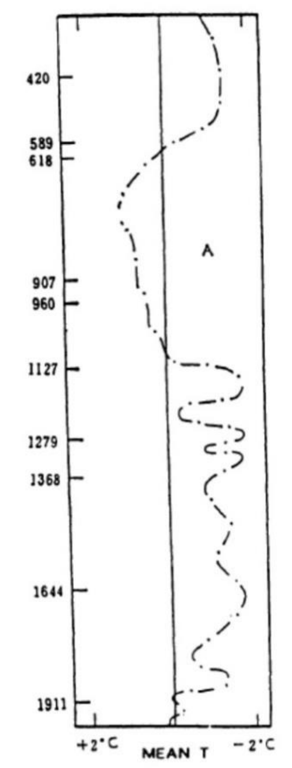


Fig. 7. Temperature fluctuations of China (Zhu, 1973).

Winter thunder, dust fall, temperature

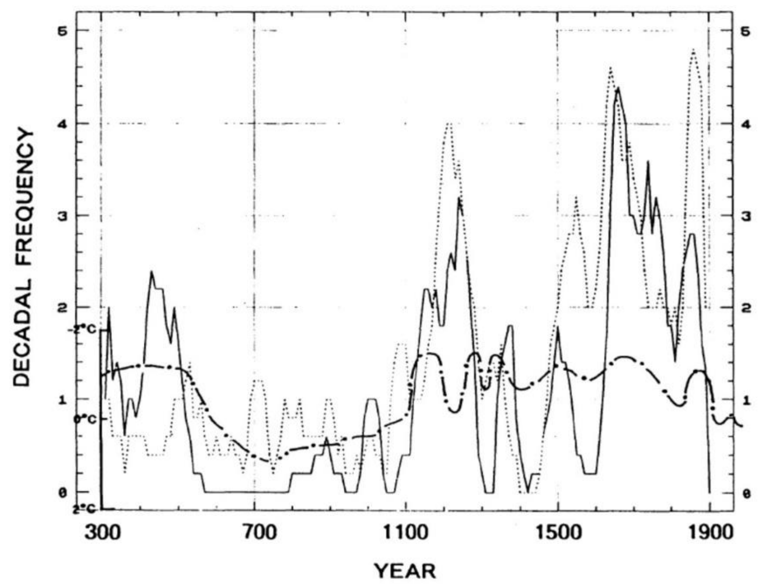


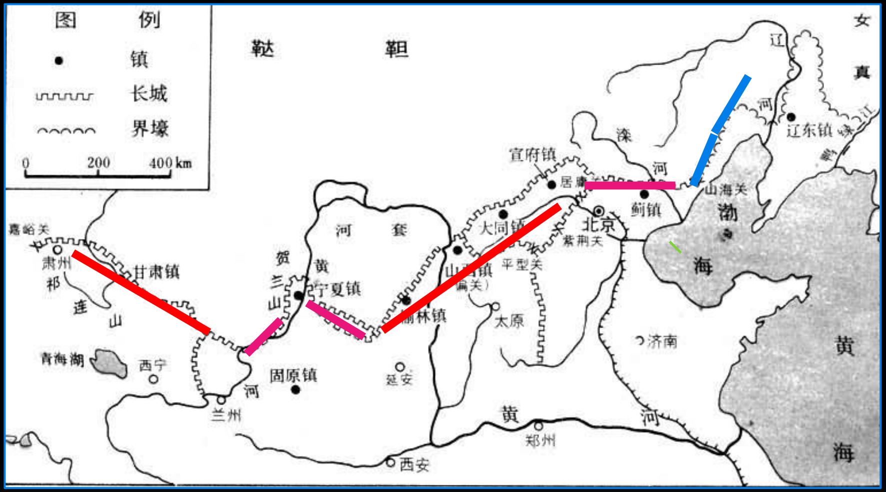
Fig. 24. Superimposition of winter thunderstorm frequency (Wang, 1980) dustfall frequency (Zhang, 1984), and winter temperature (Zhu, 1973). The frequency curves represent the 50-year moving average of decadal frequencies.

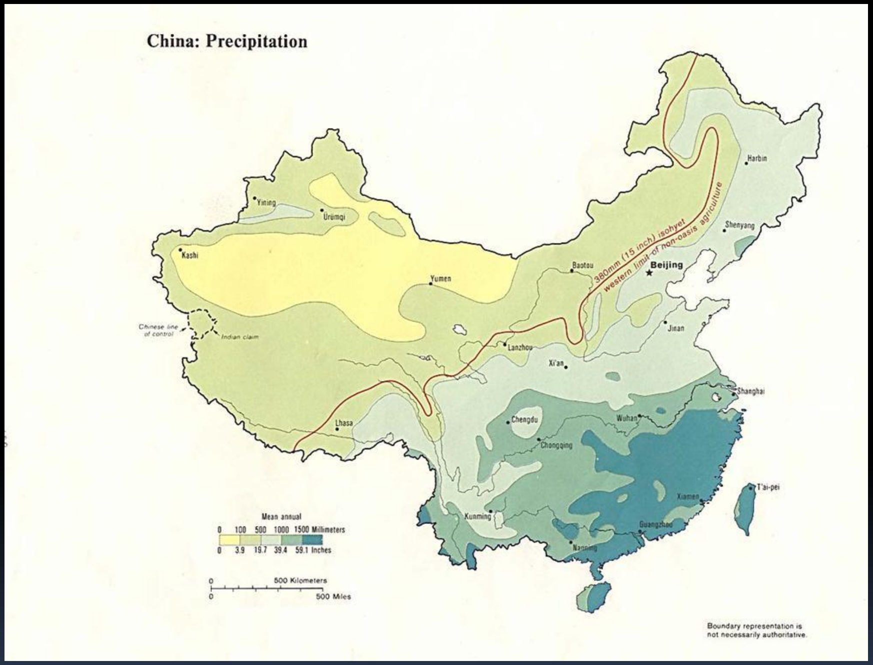
歷史文獻記錄之可信度?

- 歷史文獻可能大量遺失或被蓄意損毀
- 歷史家選擇性記載? （對某皇朝或皇帝選擇性記載好或惡）
- 資訊之時空均勻性?

Wars, politics, and climate

Great wall and precipitation





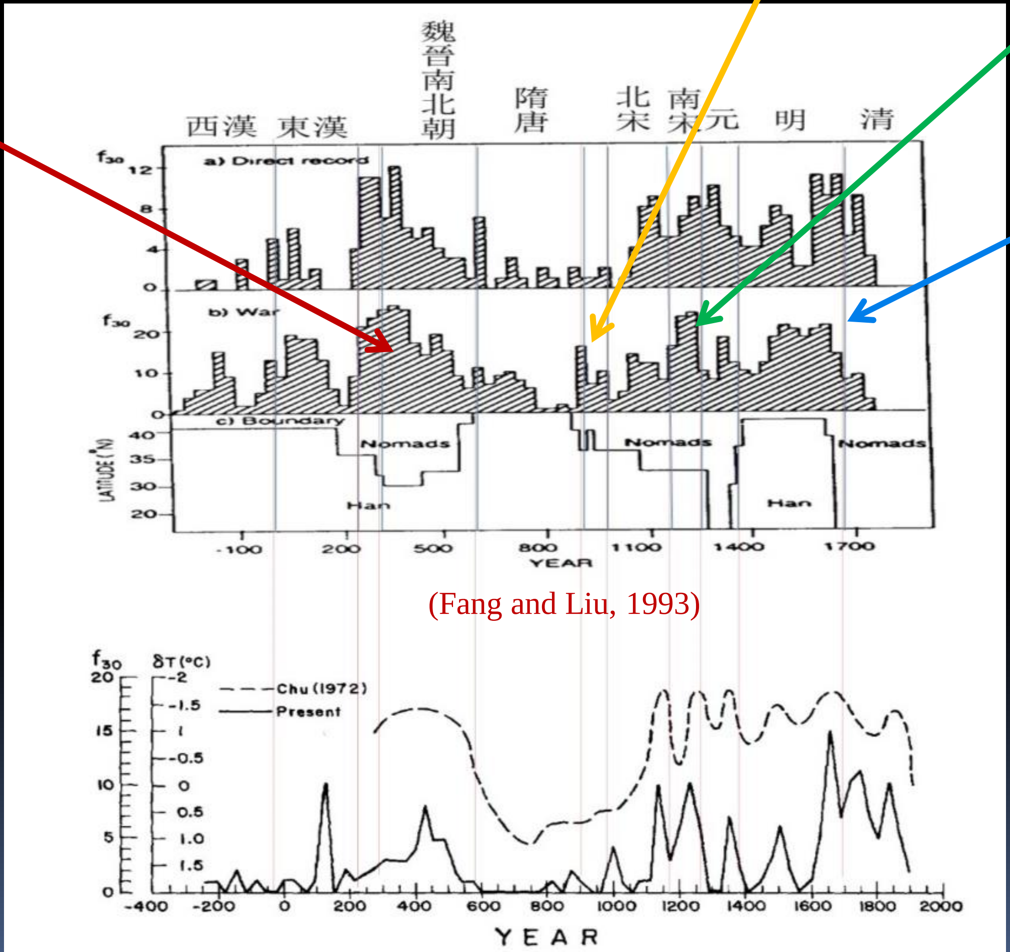
戰爭、疆域和氣候

永嘉之亂
311 AD

五代十國

1276年
元軍攻入臨安

- 明末大旱、飢荒--高迎祥、李自成、張獻忠
- 1620 後金入塞

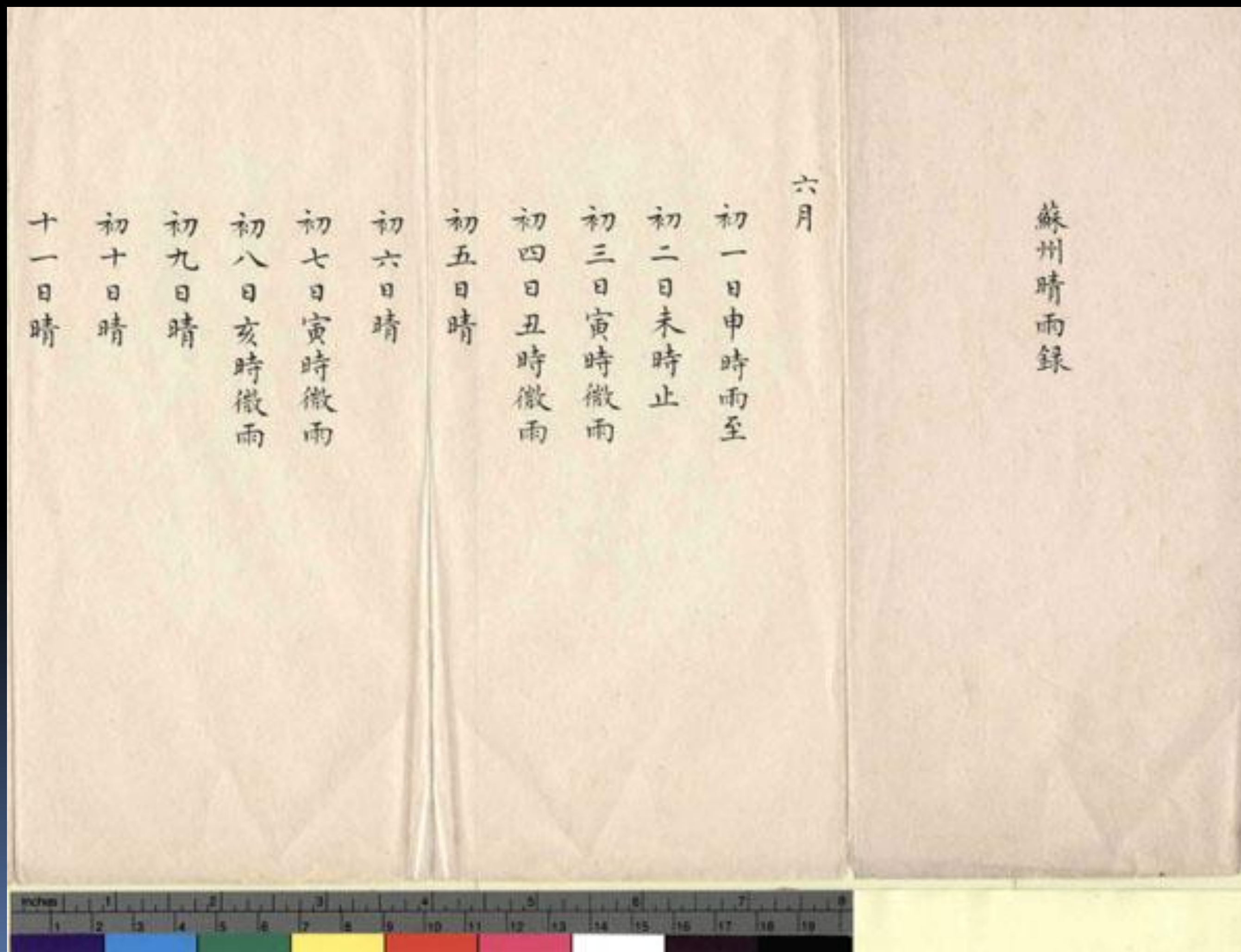


(Fang and Liu, 1993)

高時空解析度之氣候資料

Even higher time resolution

故宮晴雨錄


蘇州晴雨錄

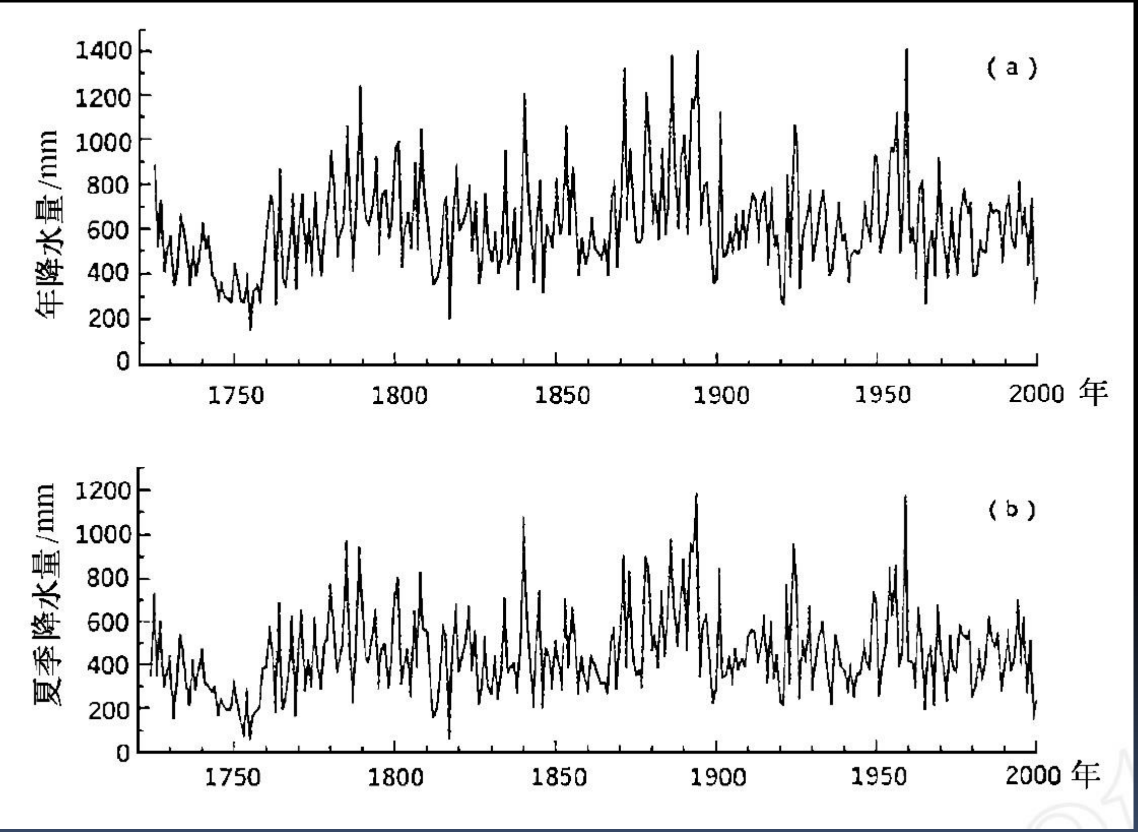
六月
初一日申時雨至
初二日未時止
初三日寅時微雨
初四日丑時微雨
初五日晴
初六日晴
初七日寅時微雨
初八日亥時微雨
初九日晴
初十日晴
十一日晴

十二日晴西南風
十三日晴西南風
十四日晴西南風
十五日晴西南風
十六日晴西南風
十七日晴西南風
十八日晴西南風
十九日晴西南風
二十日陰東北風戌刻大雷雨竟夜
二十一日陰東北風辰大雨至申刻
二十二日晴東北風
二十三日晴東南風
二十四日晴西南風
二十五日晴東北風
二十六日陰東北風
二十七日陰東北風微雨數次
二十八日陰東北風
二十九日陰東北風

乾隆七年六月　十二　日

乾隆七年七月初七日江寧織造臣李英
[illegible]到五月晴雨冊便一摺無批照例收貯訖此

- 北京“晴雨錄”逐日天氣記錄(1724～1904 年)
- 1841-1919帝俄北京氣象台儀器觀測記錄



Zhang and Liu, 2002

南京、蘇州、杭州夏季降水

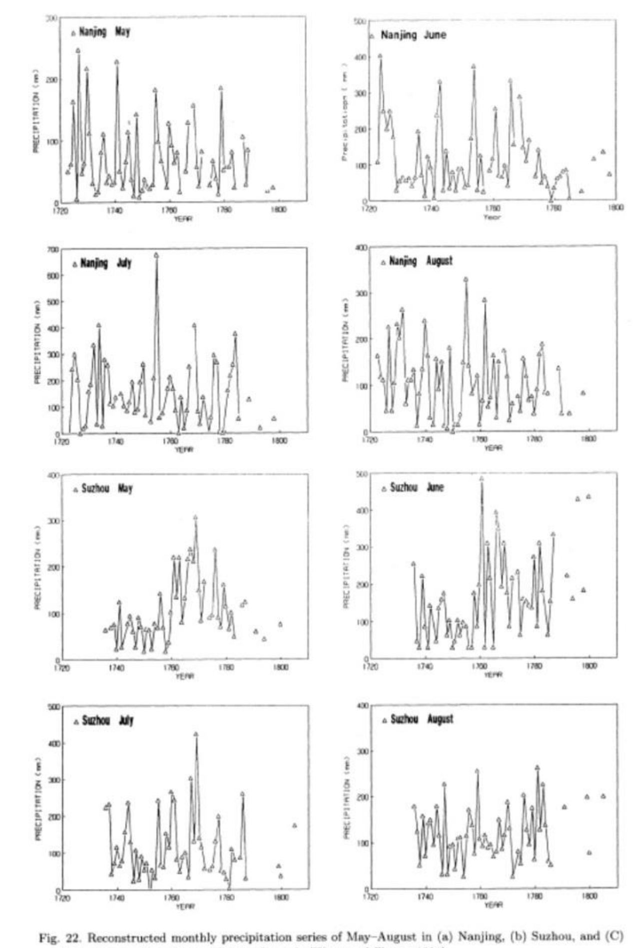


Fig. 22. Reconstructed monthly precipitation series of May–August in (a) Nanjing, (b) Suzhou, and (C) Hangzhou based on Clear and Rain Records (Wang and Zhang, 1991).

Wang and Zhang, 1991

18世紀長江下游梅雨期及長度

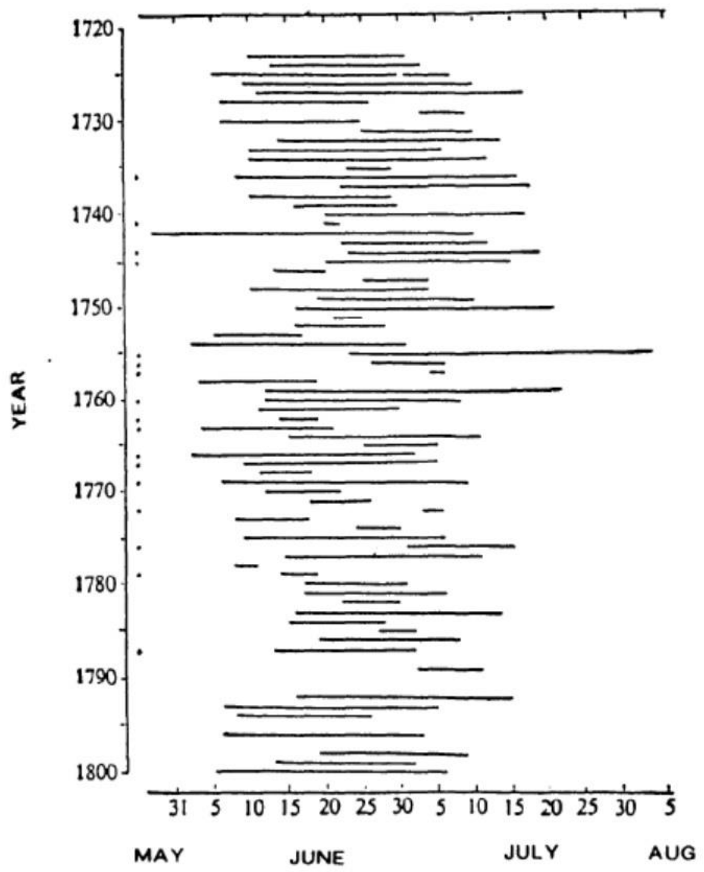


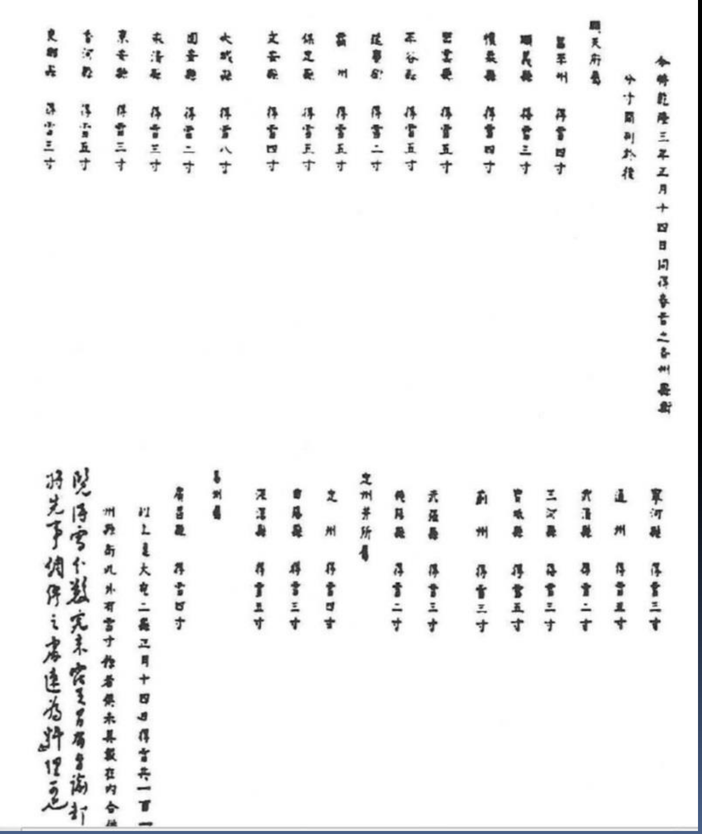
Fig. 23. Meiyu seasons in Lower Yangtze reaches in the 18th century (Zhang and Wang, 1991).

Zhang and Wang, 1991

Other documentary sources

奏摺、方志、日記等等

雨雪分寸



日記

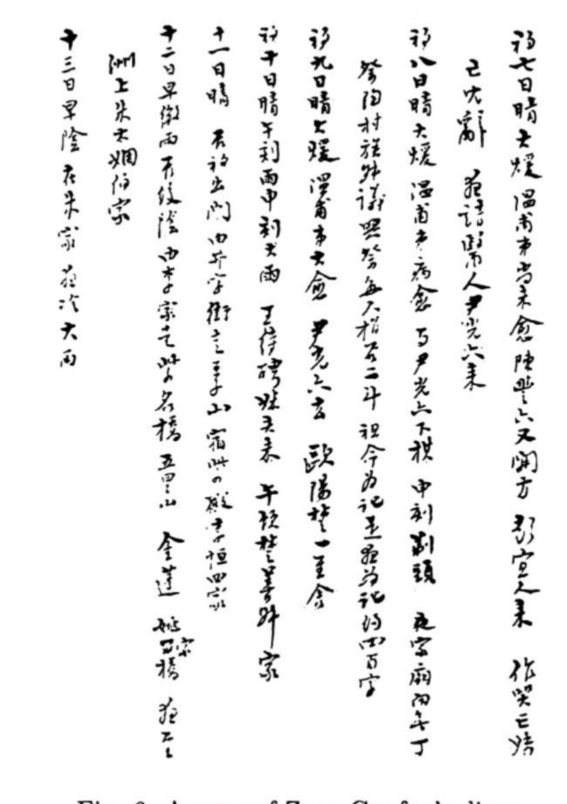
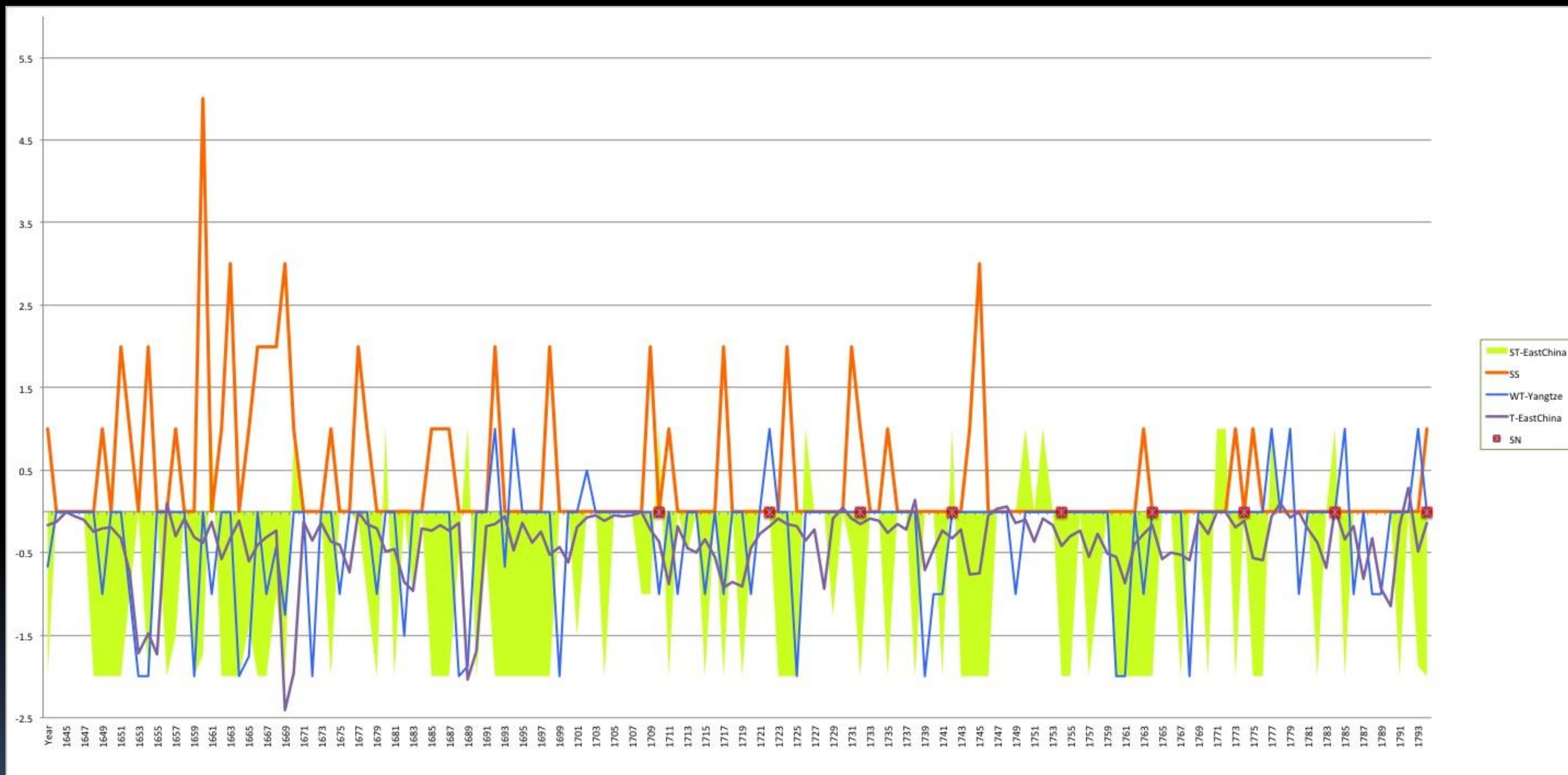
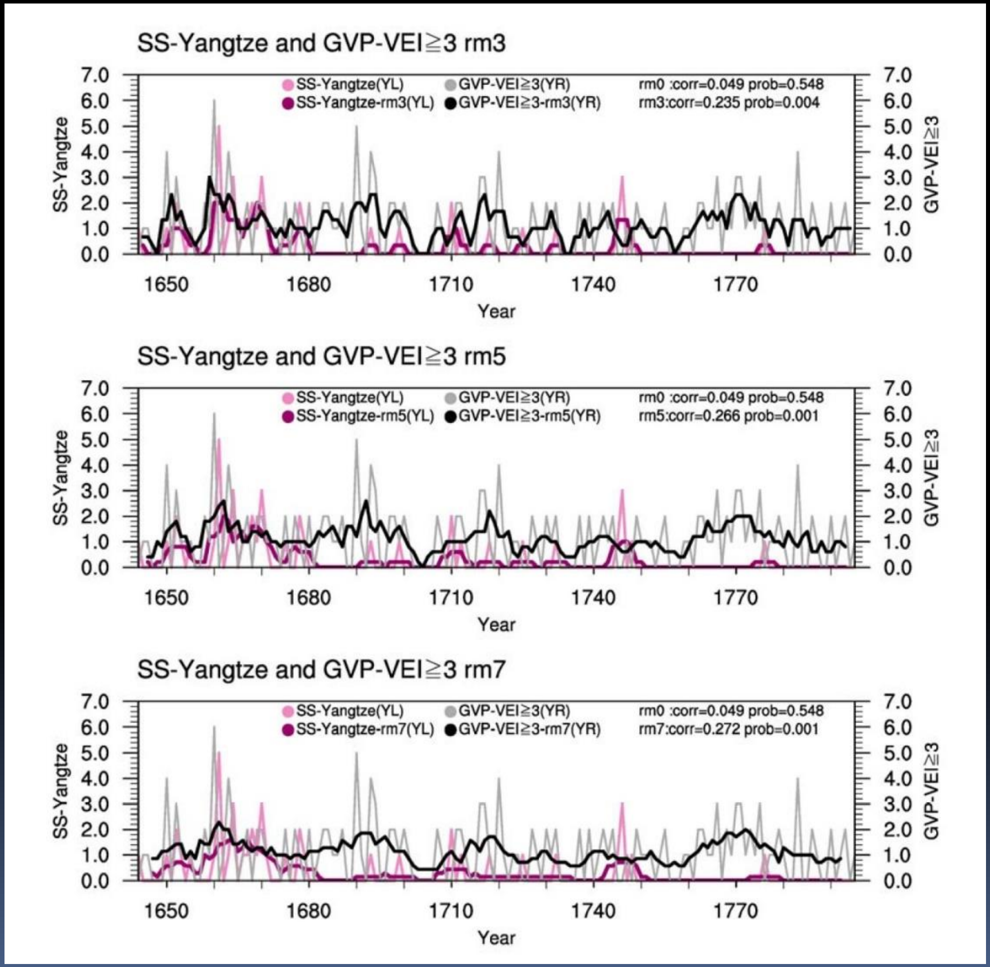


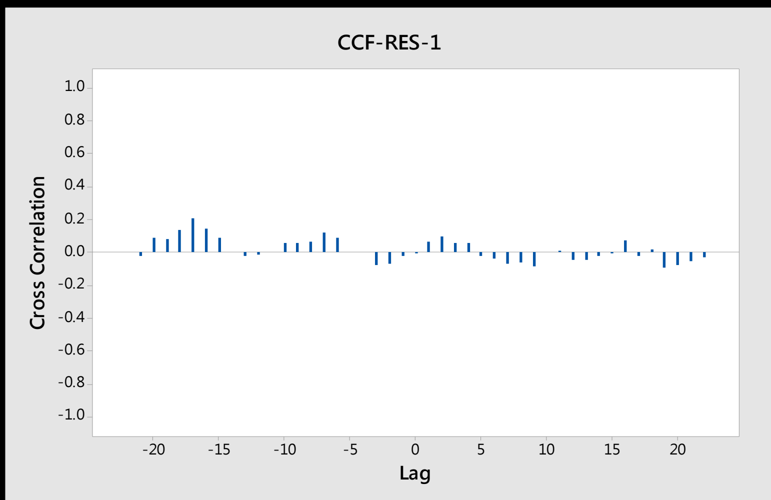
Fig. 6. A page of Zeng Guofan's diary.

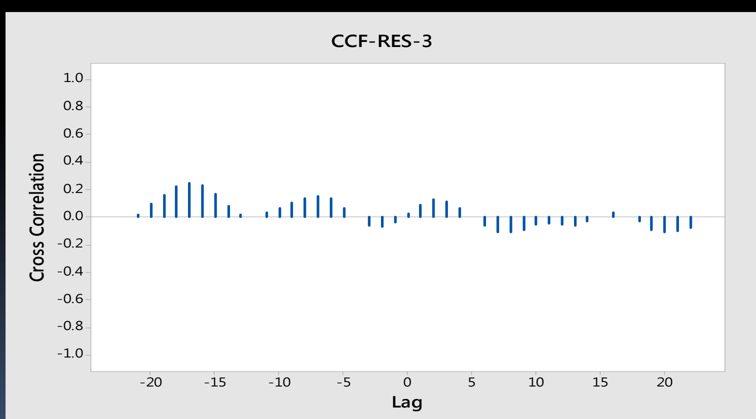
上海夏季降雪記錄

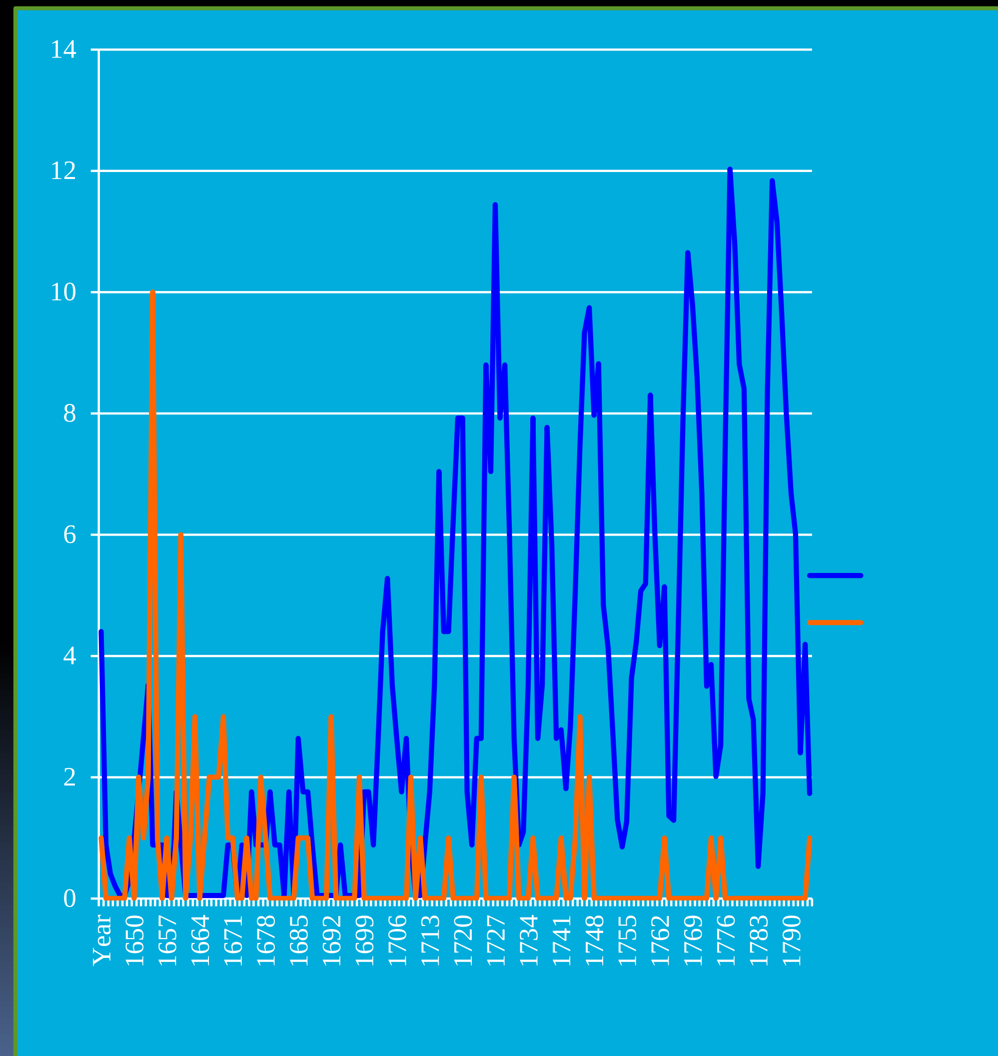



SS-Yangtze and GVP-VEI≧3 rm3
SS-Yangtze(YL)
SS-Yangtze-rm3(YL)
GVP-VEI≧3(YR)
GVP-VEI≧3-rm3(YR)
rm0 :corr=0.049 prob=0.548
rm3:corr=0.235 prob=0.004
SS-Yangtze
GVP-VEI≧3
Year
SS-Yangtze and GVP-VEI≧3 rm5
SS-Yangtze(YL)
SS-Yangtze-rm5(YL)
GVP-VEI≧3(YR)
GVP-VEI≧3-rm5(YR)
rm0 :corr=0.049 prob=0.548
rm5:corr=0.266 prob=0.001
SS-Yangtze
GVP-VEI≧3
Year
SS-Yangtze and GVP-VEI≧3 rm7
SS-Yangtze(YL)
SS-Yangtze-rm7(YL)
GVP-VEI≧3(YR)
GVP-VEI≧3-rm7(YR)
rm0 :corr=0.049 prob=0.548
rm7:corr=0.272 prob=0.001
SS-Yangtze
GVP-VEI≧3
Year

太陽黑子與上海夏雪


CCF-RES-1
Cross Correlation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-20
-15
-10
-5
0
5
10
15
20
Lag


CCF-RES-3
Cross Correlation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-20
-15
-10
-5
0
5
10
15
20
Lag


14
12
10
8
6
4
2
0
Year
1650
1657
1664
1671
1678
1685
1692
1699
1706
1713
1720
1727
1734
1741
1748
1755
1762
1769
1776
1783
1790

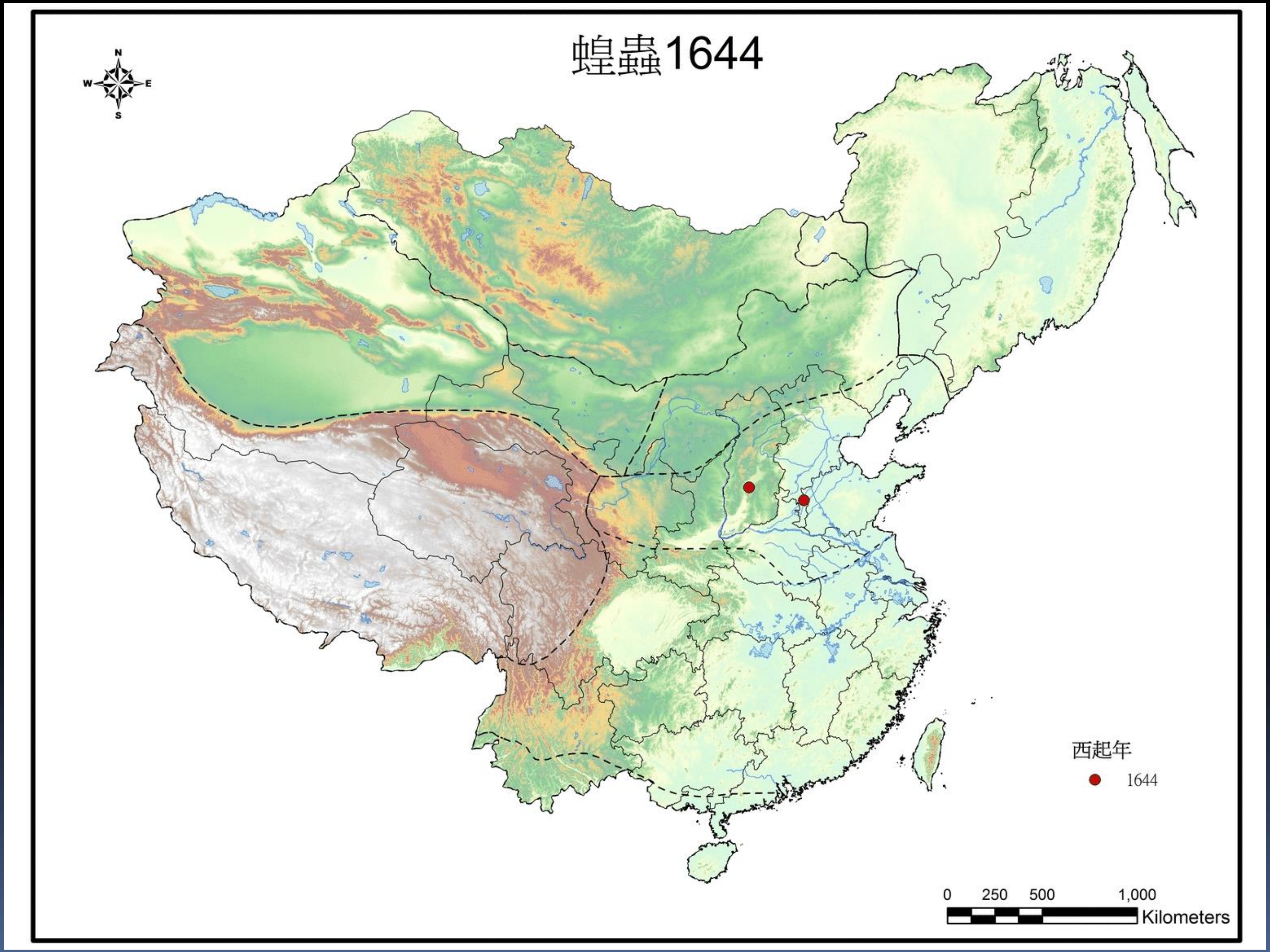
環流

- 目前的氣候序列著重在冷熱與乾濕等熱力序列
- 動力因子—環流的資訊往往由上述序列間接推出，但其模糊性頗高
- 有沒有可以較直接重建環流的氣候記錄？

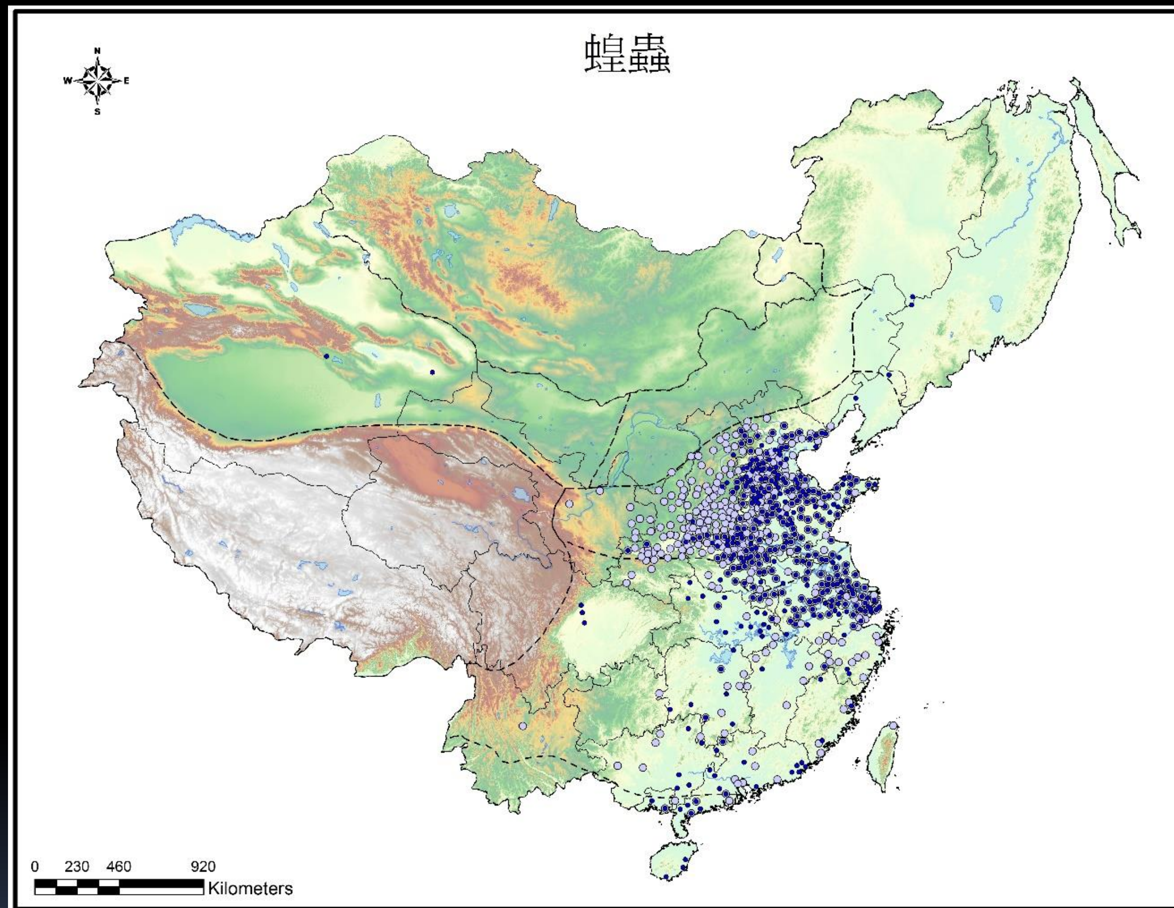
蝗蟲與季風

- 根據聯合國1960年代在東非地區對沙漠蝗災的研究結果表明，蝗蟲之動向為季風所控制
- 蝗蟲群基本上是隨著季風鋒面(monsoon front)移動。在一群中，它們的飛行方向卻是十分混亂
- 因此，蝗蟲群的前緣大致可代表季風鋒面
- 從歷史上之蝗災序列能否大致重建東亞季風之長期動向？

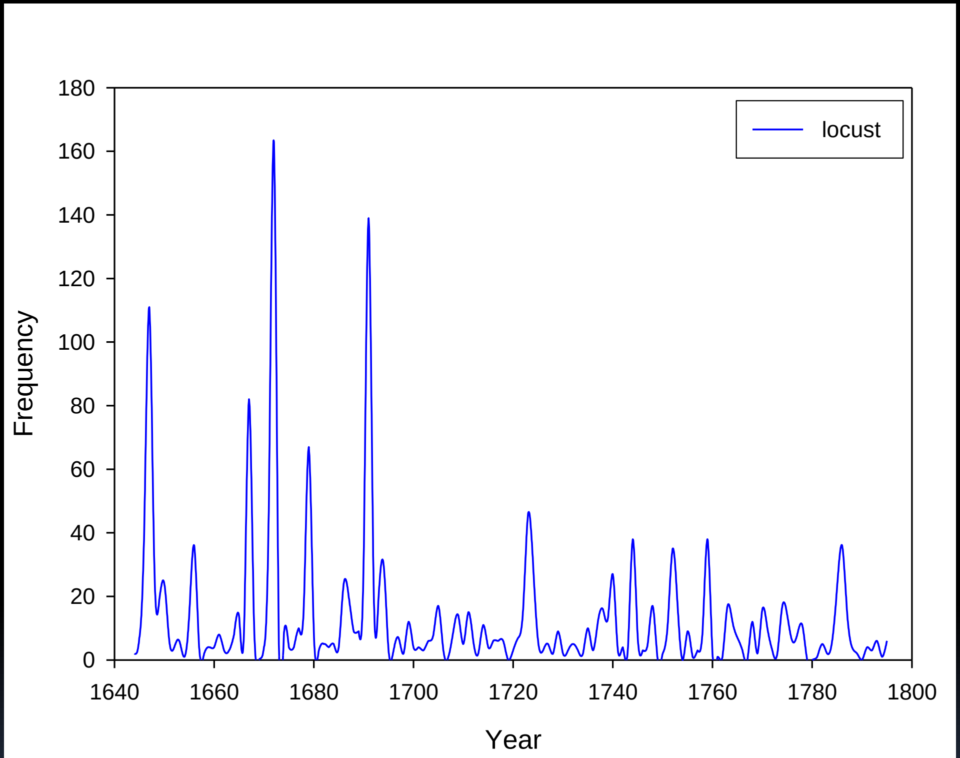
1644-1795蝗蟲記錄

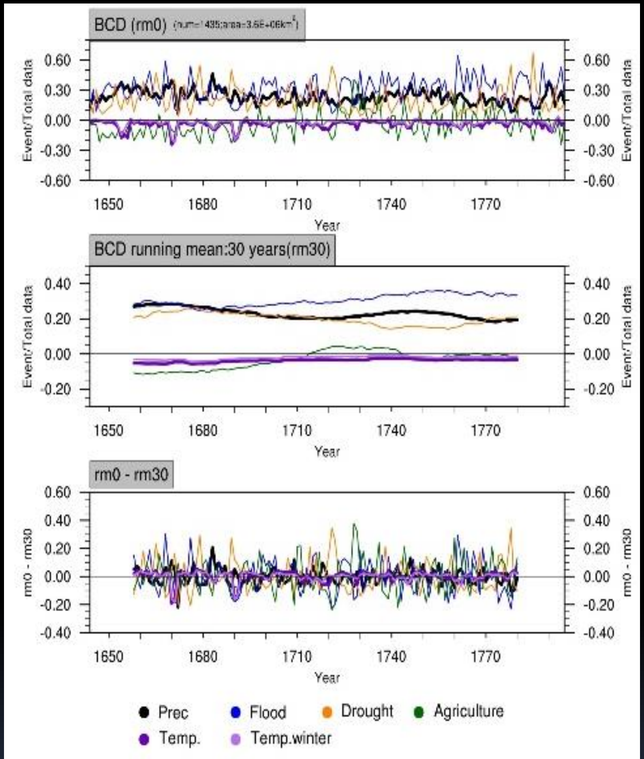


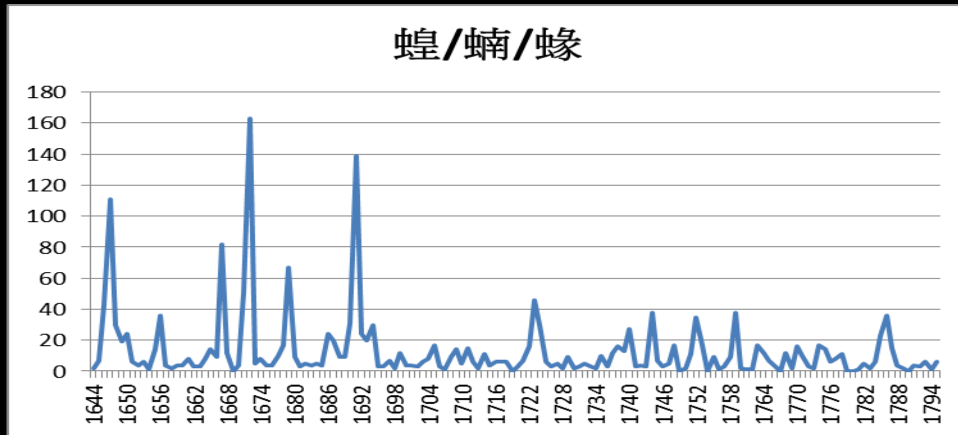
淺藍-17世紀，深藍-18世紀

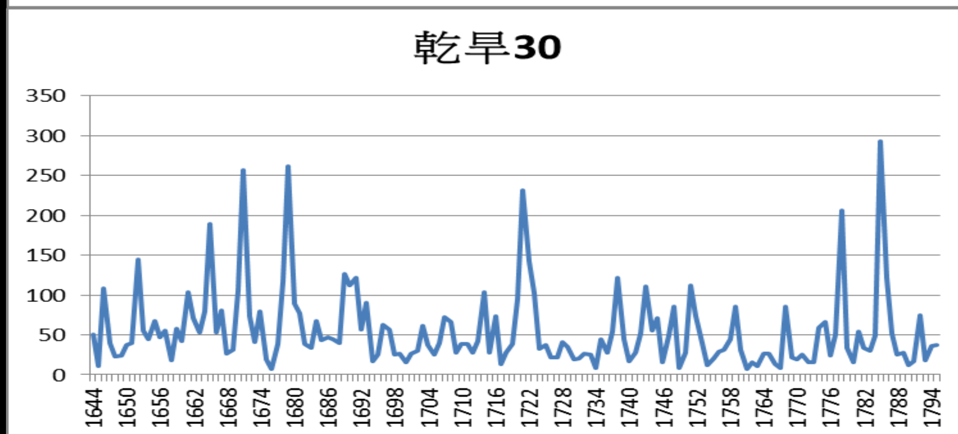


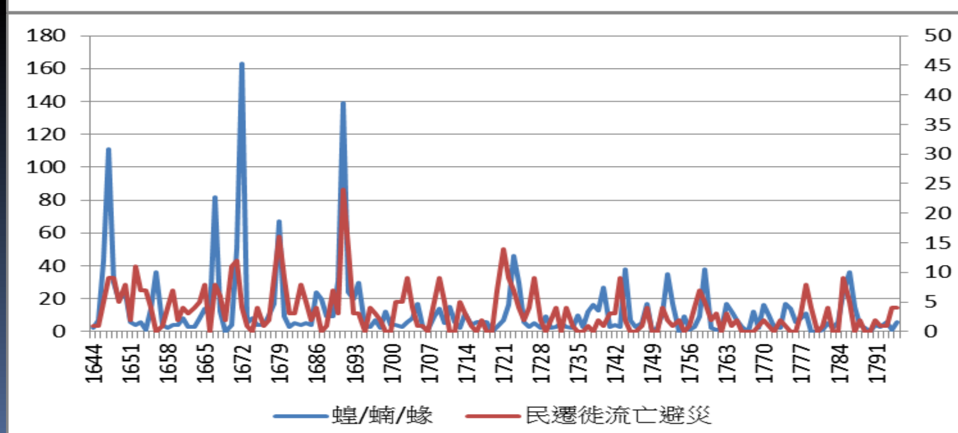
- 17世紀夏季季風之西界比18世紀更西？
- 是否意味太平洋高壓之西界？


locust
Frequency
Year
0
20
40
60
80
100
120
140
160
180
1640
1660
1680
1700
1720
1740
1760
1780
1800


BCD (rm0)
Event/Total data
Year
BCD running mean:30 years(rm30)
rm0 - rm30
1650
1680
1710
1740
1770
Prec
Flood
Drought
Agriculture
Temp.
Temp.winter

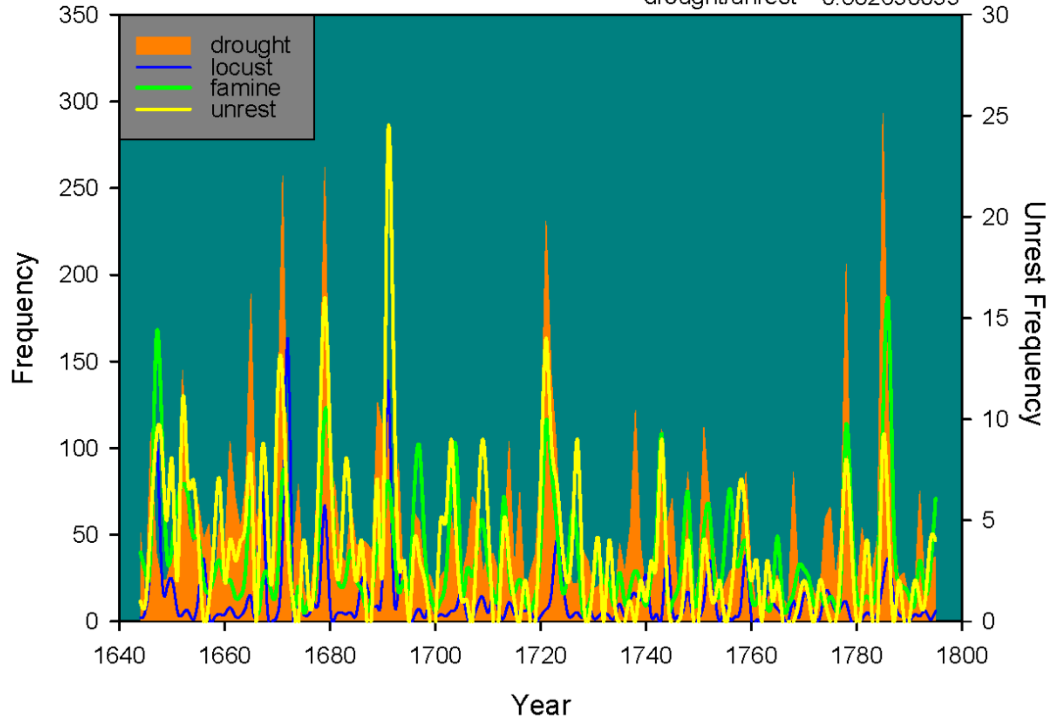

蝗/蝻/蝝
180
160
140
120
100
80
60
40
20
0
1644 1650 1656 1662 1668 1674 1680 1686 1692 1698 1704 1710 1716 1722 1728 1734 1740 1746 1752 1758 1764 1770 1776 1782 1788 1794


乾旱30
350
300
250
200
150
100
50
0
1644 1650 1656 1662 1668 1674 1680 1686 1692 1698 1704 1710 1716 1722 1728 1734 1740 1746 1752 1758 1764 1770 1776 1782 1788 1794


180
160
140
120
100
80
60
40
20
0
50
45
40
35
30
25
20
15
10
5
0
1644 1651 1658 1665 1672 1679 1686 1693 1700 1707 1714 1721 1728 1735 1742 1749 1756 1763 1770 1777 1784 1791
蝗/蝻/蝝
民遷徙流亡避災

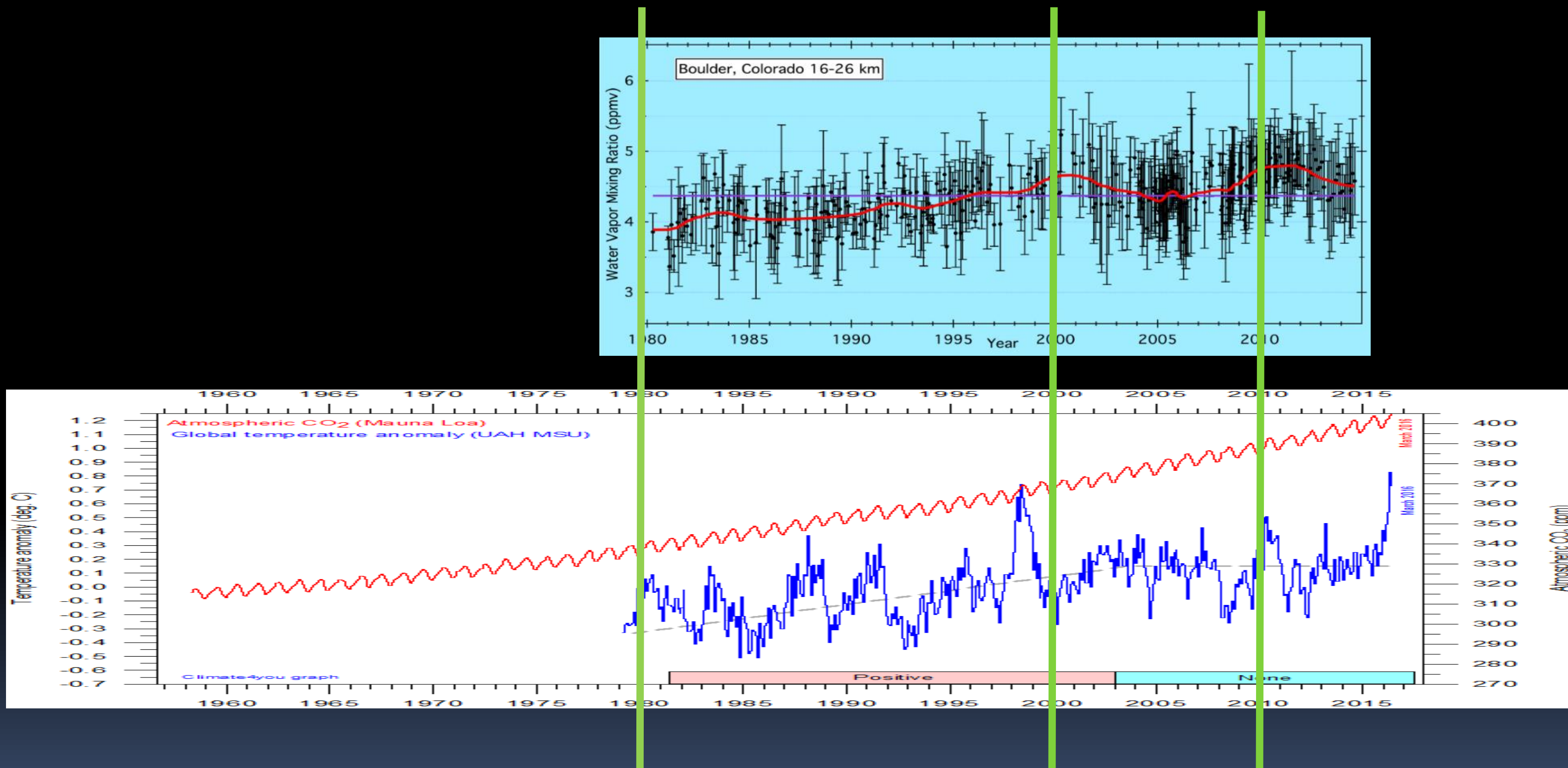
Correlation coefficient

locust/unrest	0.45016698
locust/drought	0.296298809
locust/famine	0.365165477
drought//famine	0.578751805
famine/unrest	0.626156296
drought/unrest	0.582690099



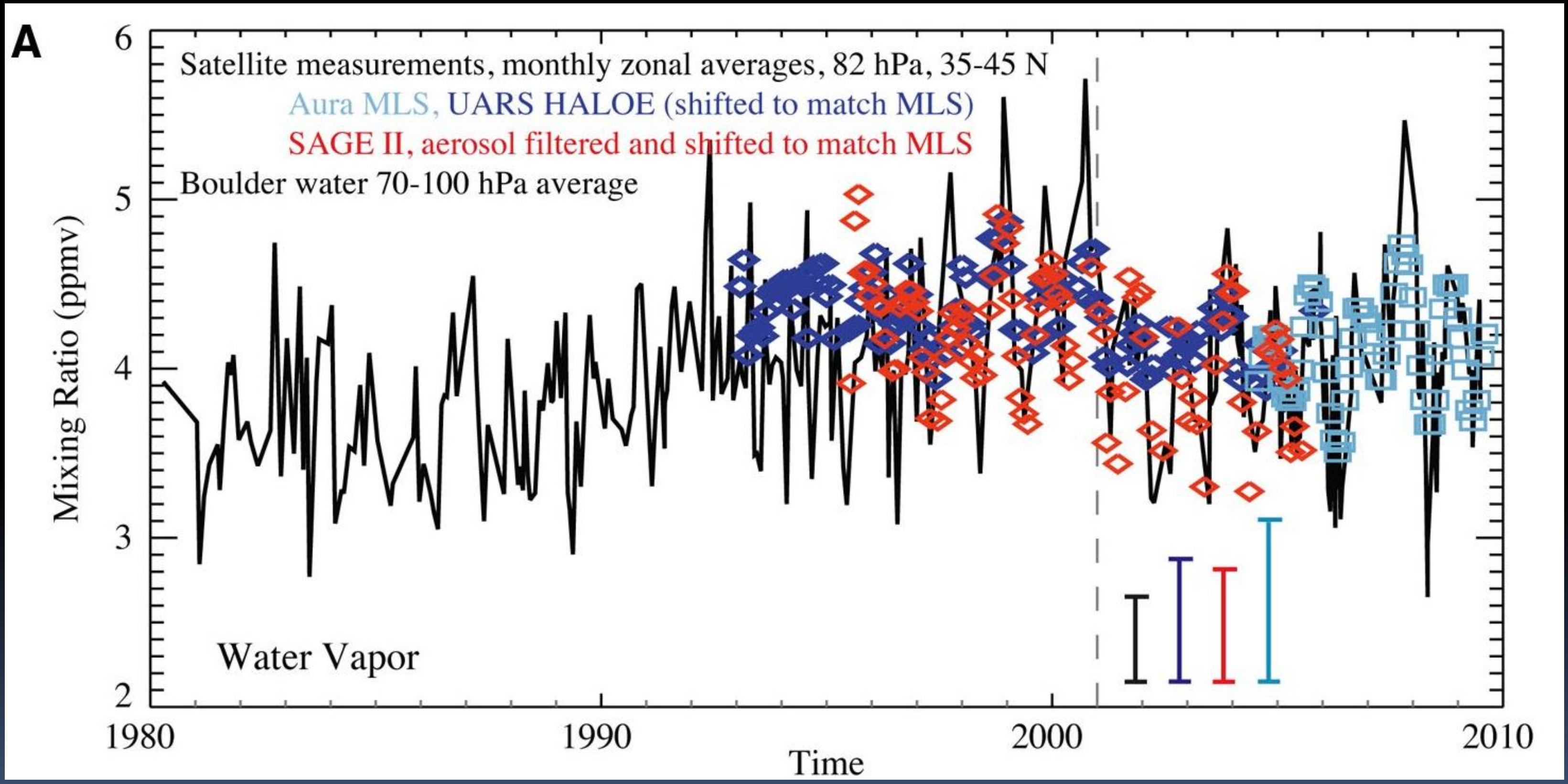
模式的可信度？

Could stratospheric water vapor play a role in global warming?



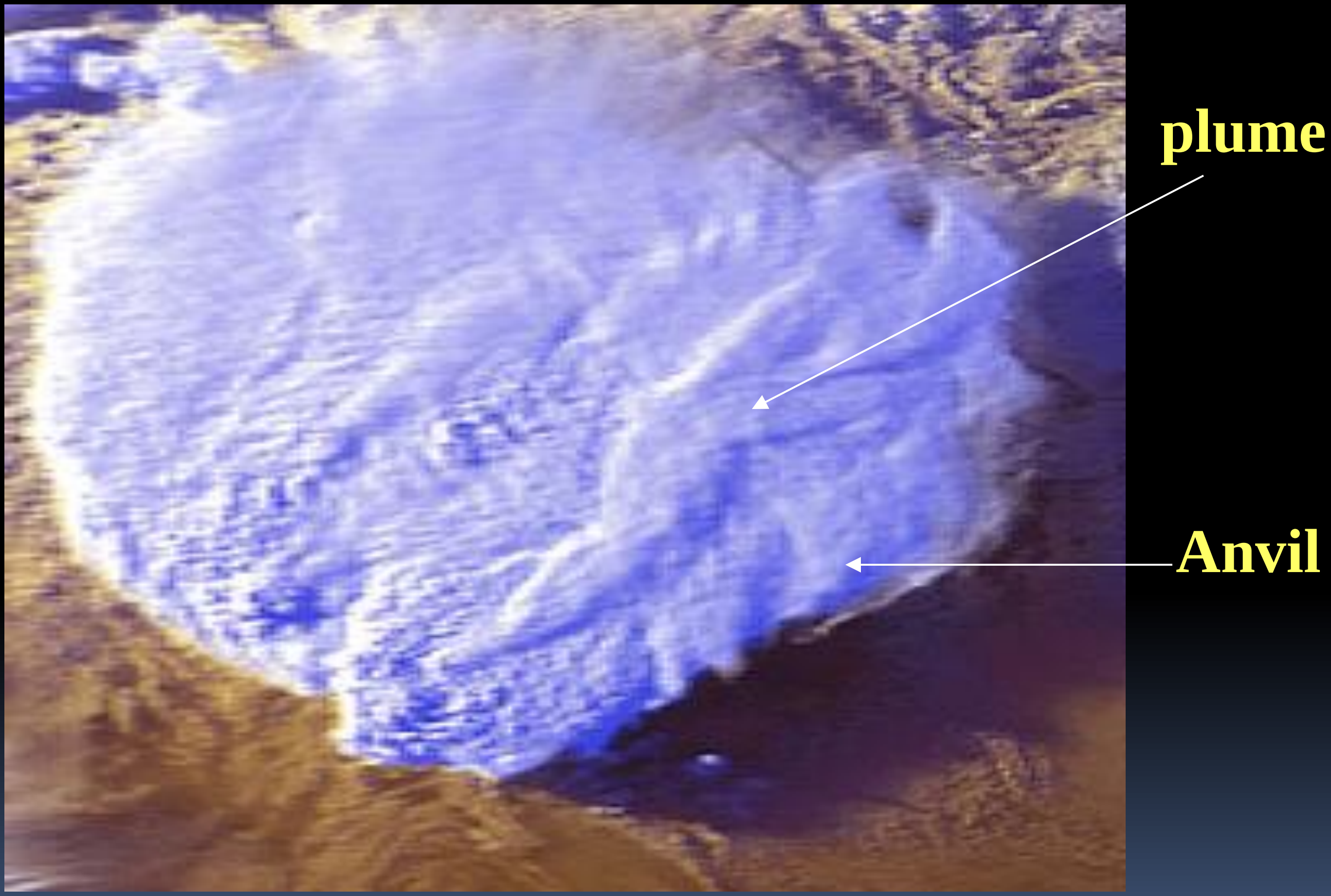
Is stratospheric water vapor concentration changing?

(yes, and the change can be up to 50% in 30 years)

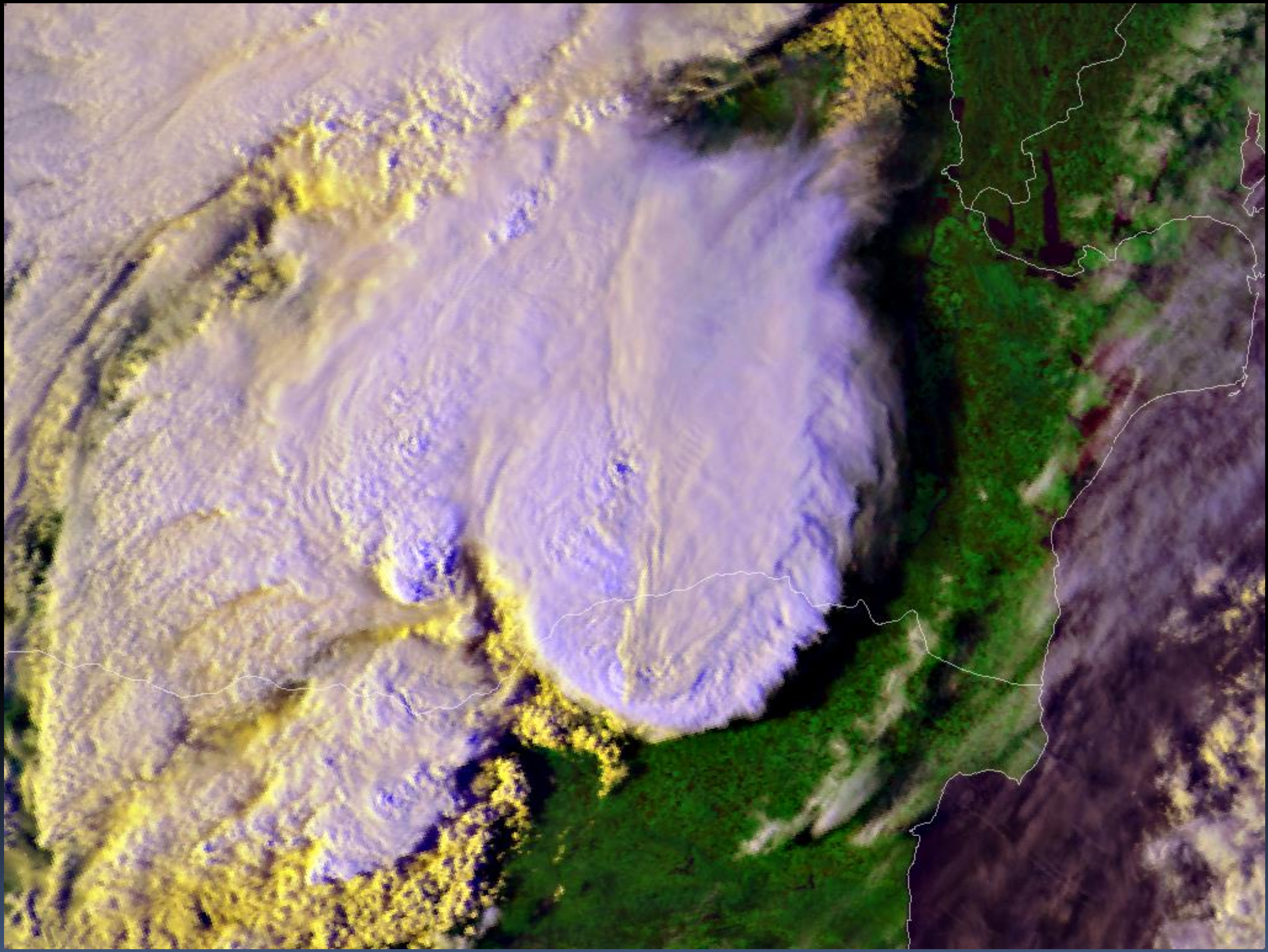


(Solomon et al., 2010)

Satellite observation of middle latitude deep convective storms



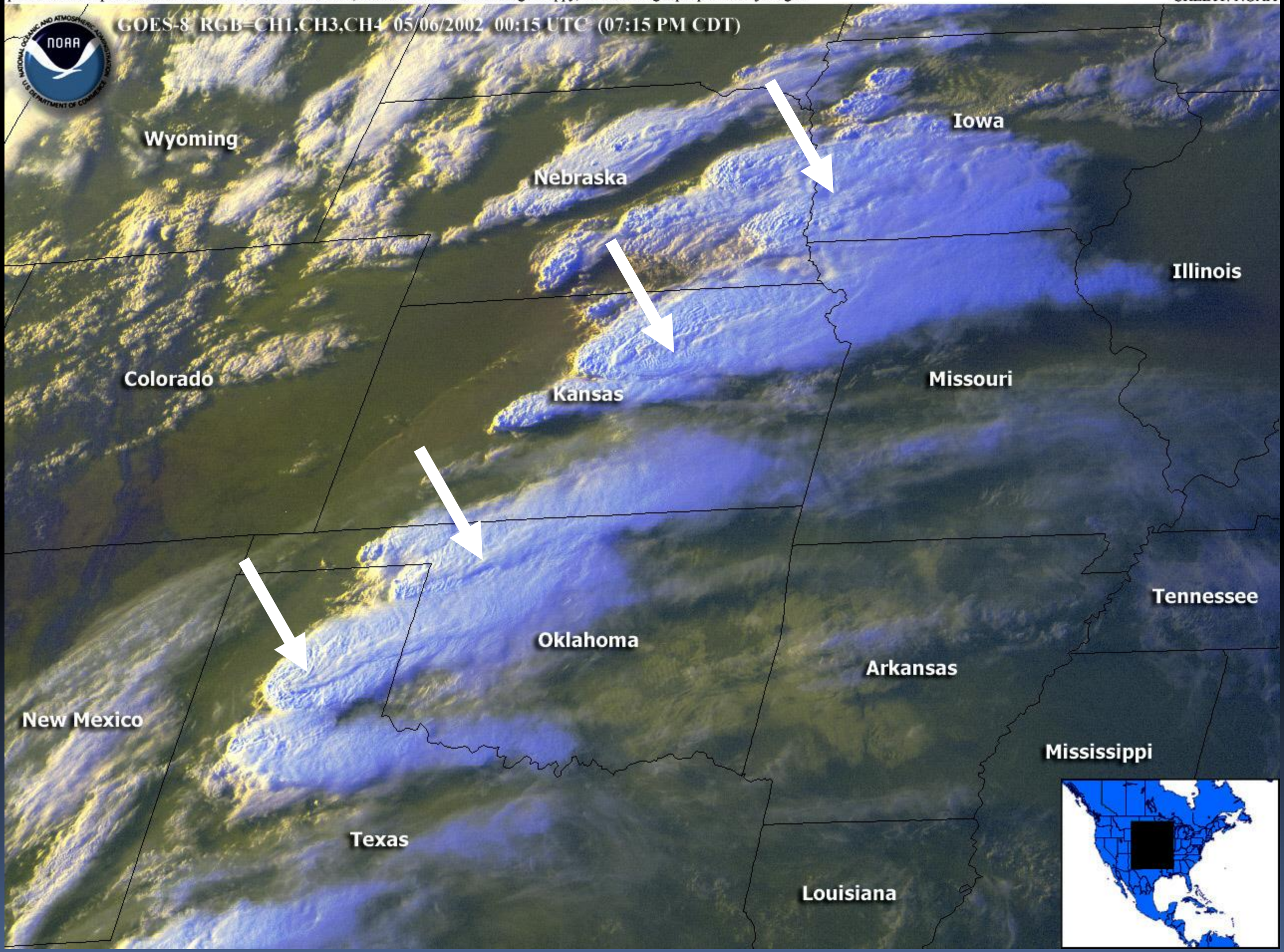
Storms over Balearic Islands

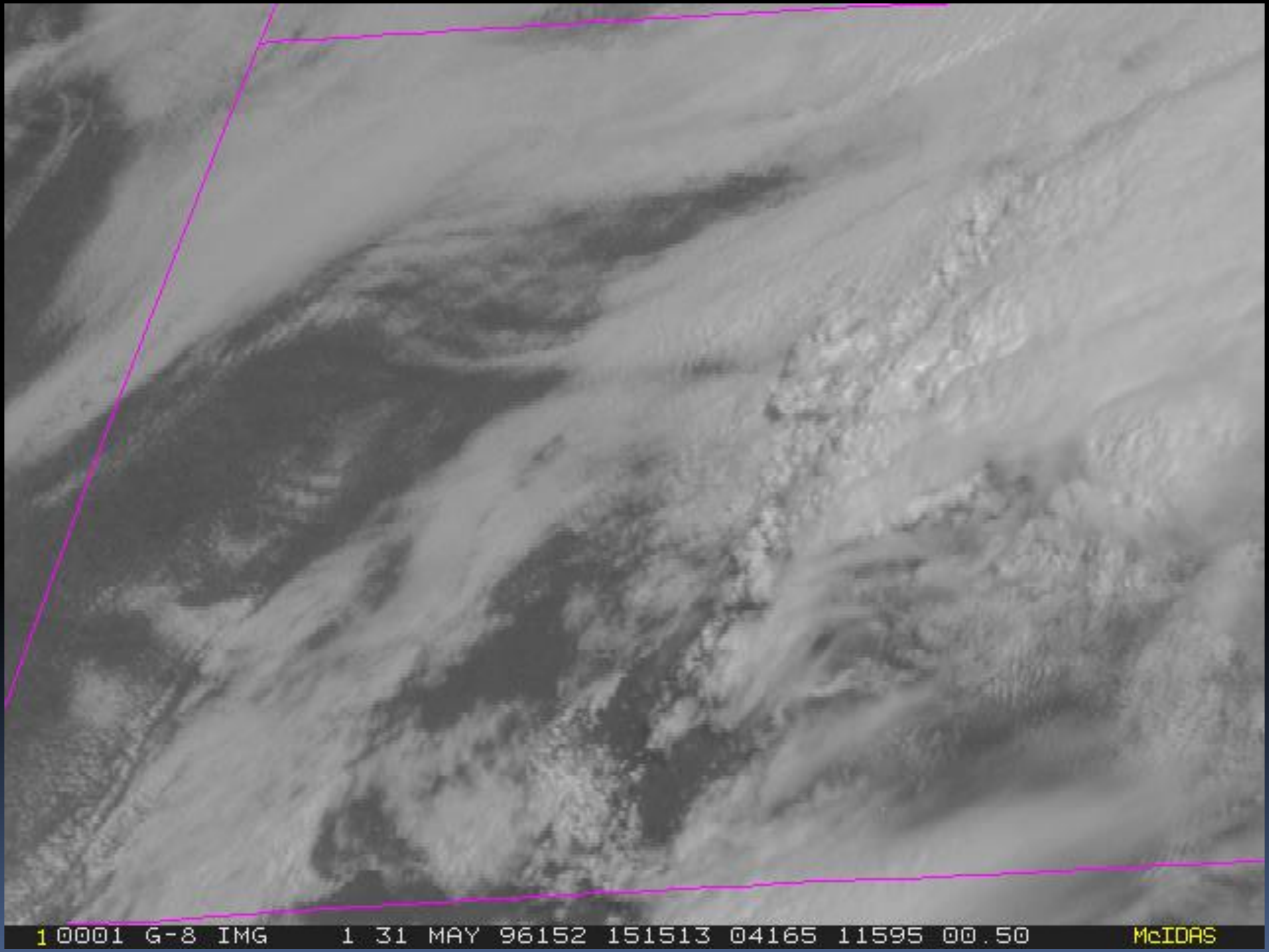


GOES visible images—nearly every active cell is associated with plumes

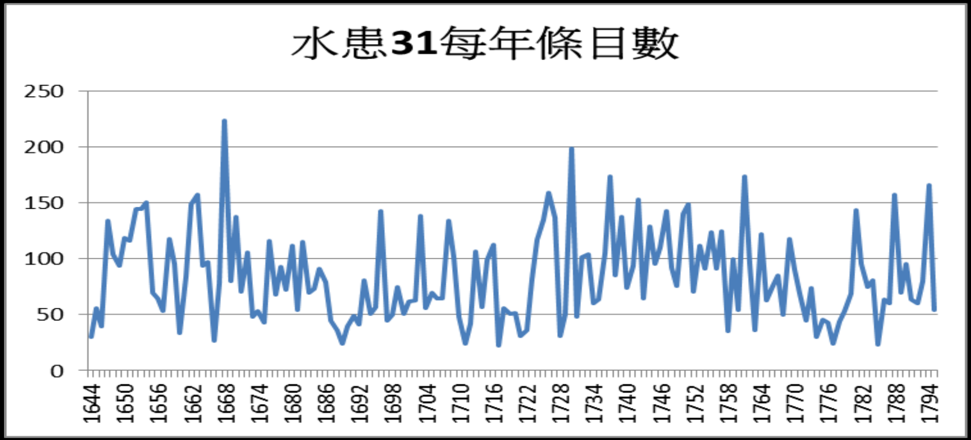
This GOES-8 image shows severe thunderstorms that moved through the Plains Sunday evening. These supercell thunderstorms produced hail up to the size of baseballs and 26 tornadoes, one of which moved through Happy, Texas killing 3 people and injuring 4.

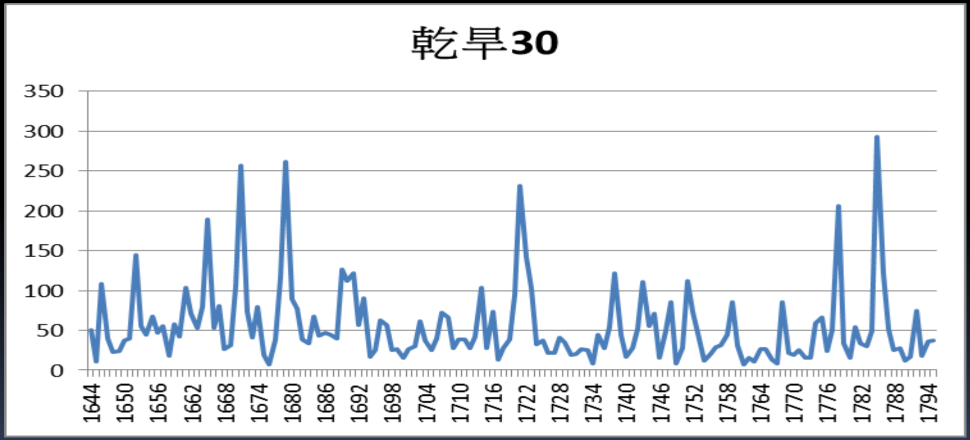
CREDIT: NOAA

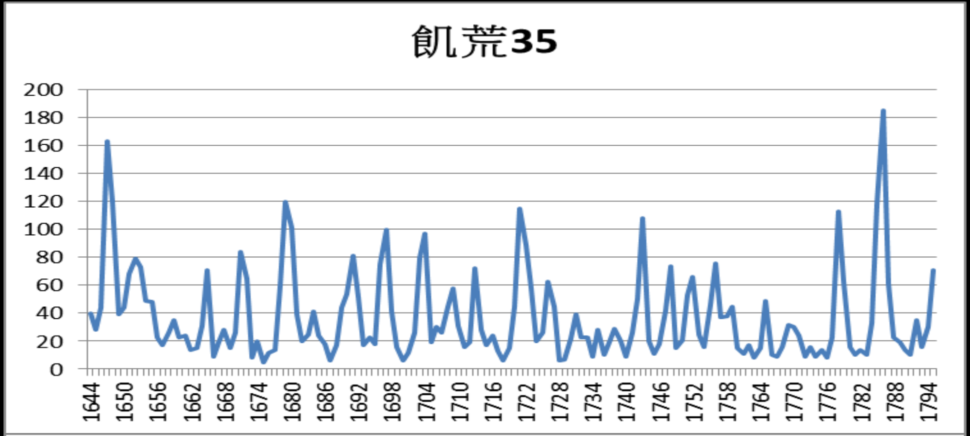


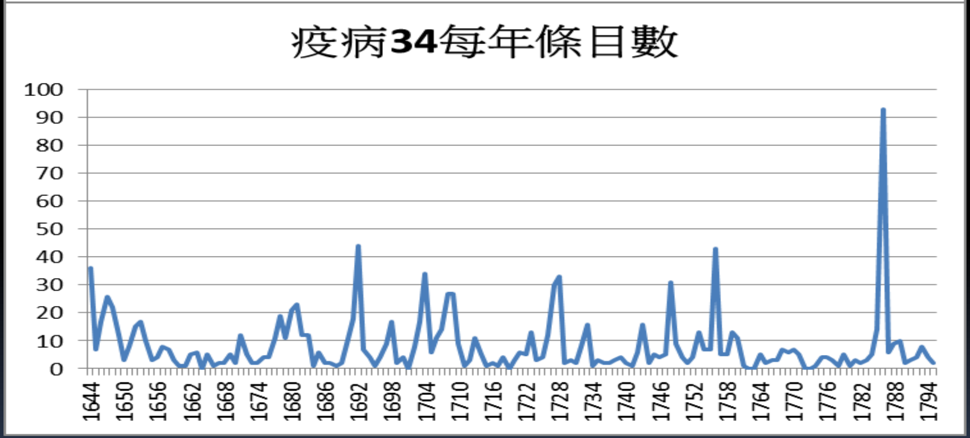

1 0001 G-8 IMG 1 31 MAY 96152 151513 04165 11595 00.50 McIDAS

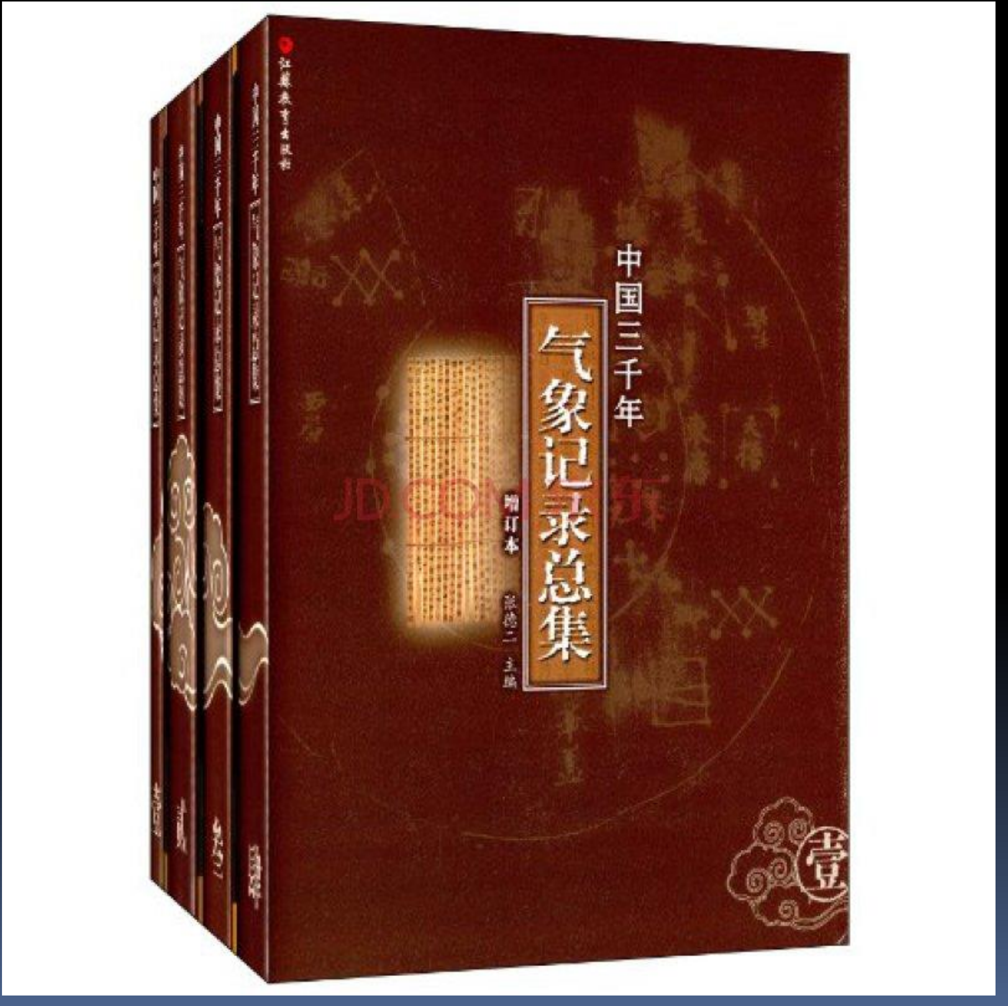
Thank you!

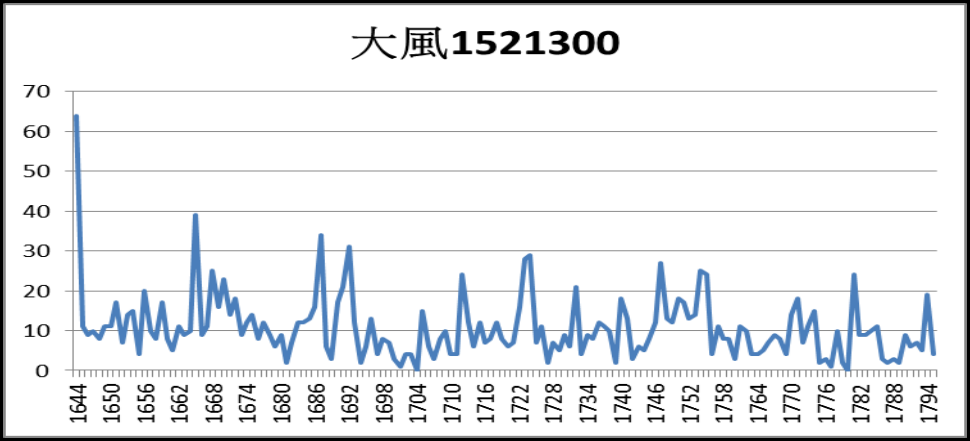

水患31每年條目數
250
200
150
100
50
0
1644
1650
1656
1662
1668
1674
1680
1686
1692
1698
1704
1710
1716
1722
1728
1734
1740
1746
1752
1758
1764
1770
1776
1782
1788
1794


乾旱30
350
300
250
200
150
100
50
0
1644
1650
1656
1662
1668
1674
1680
1686
1692
1698
1704
1710
1716
1722
1728
1734
1740
1746
1752
1758
1764
1770
1776
1782
1788
1794


飢荒35
200
180
160
140
120
100
80
60
40
20
0
1644
1650
1656
1662
1668
1674
1680
1686
1692
1698
1704
1710
1716
1722
1728
1734
1740
1746
1752
1758
1764
1770
1776
1782
1788
1794


疫病34每年條目數
100
90
80
70
60
50
40
30
20
10
0
1644
1650
1656
1662
1668
1674
1680
1686
1692
1698
1704
1710
1716
1722
1728
1734
1740
1746
1752
1758
1764
1770
1776
1782
1788
1794


中国三千年
气象记录总集
增订本
张德二 主编
壹


大風1521300
70
60
50
40
30
20
10
0
1644
1650
1656
1662
1668
1674
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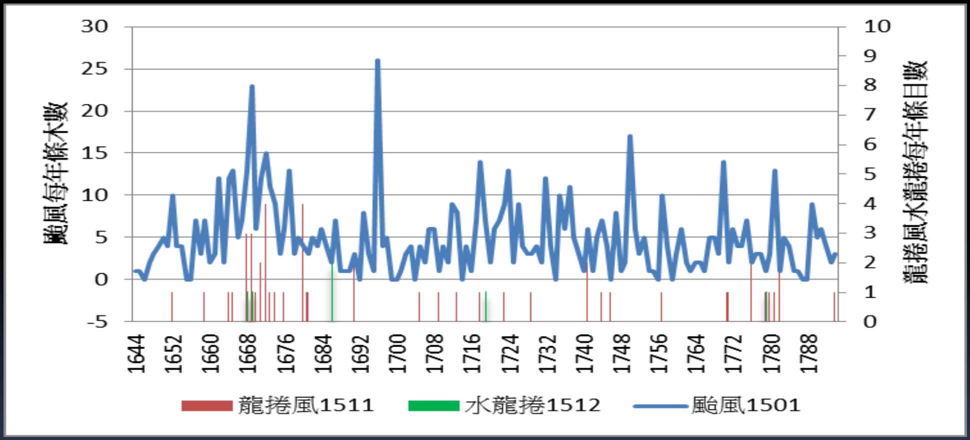
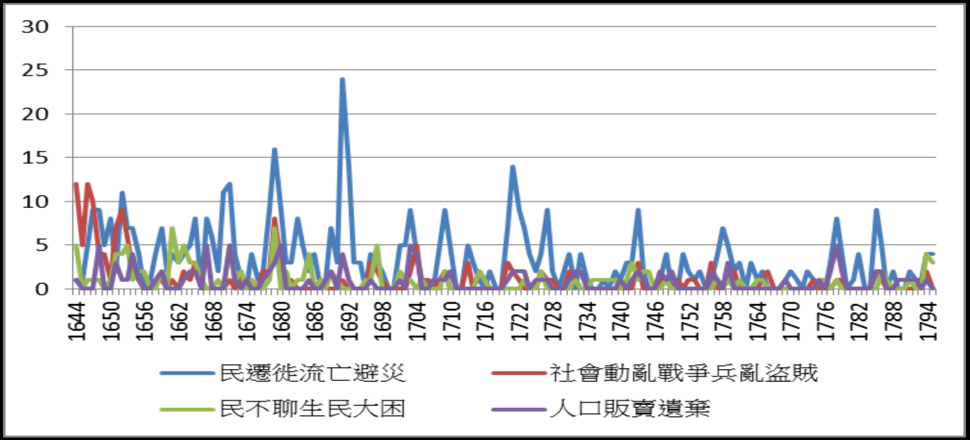
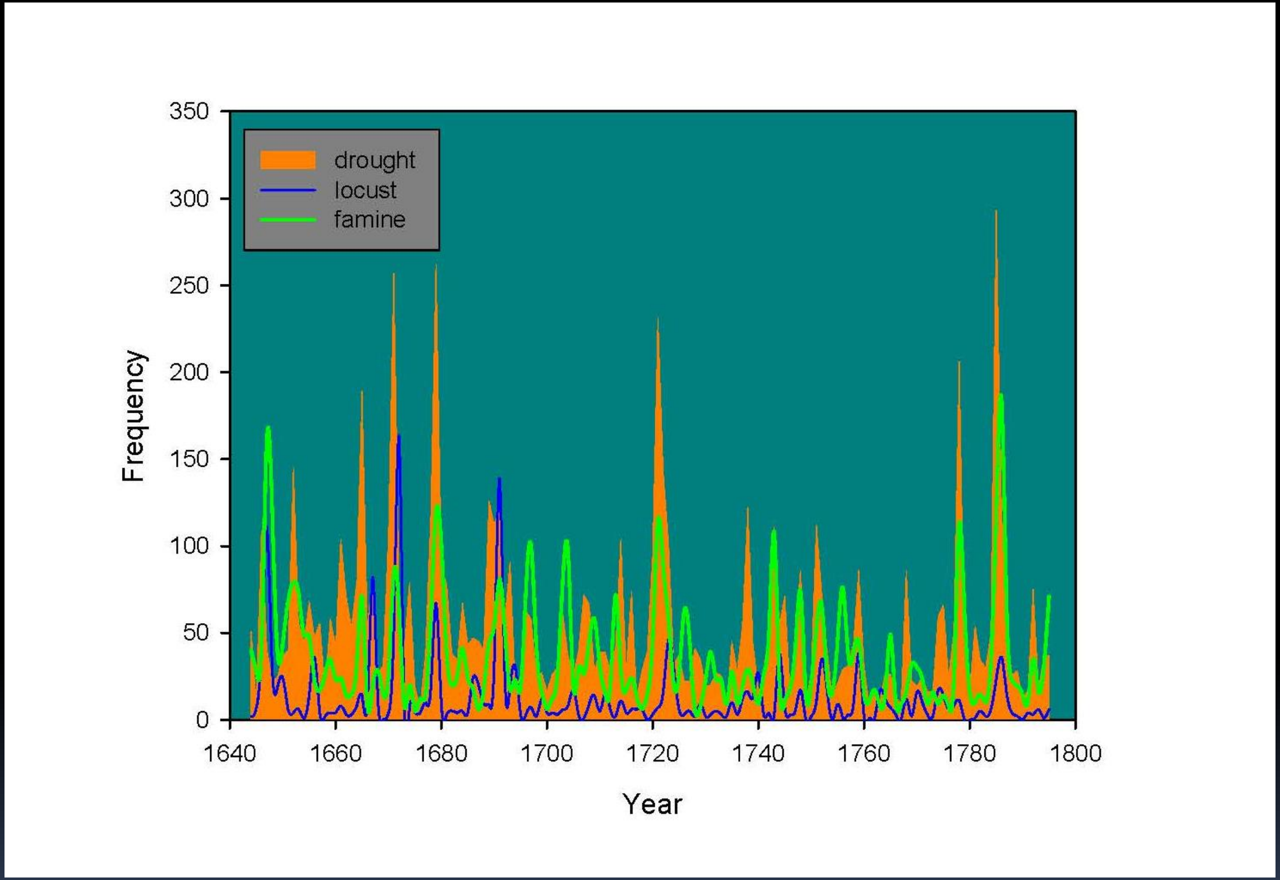
1686
1692
1698
1704
1710
1716
1722
1728
1734
1740
1746
1752
1758
1764
1770
1776
1782
1788
1794


颱風每年條木數
龍捲風水龍捲每年條目數
30
25
20
15
10
5
0
-5
10
9
8
7
6
5
4
3
2
1
0
1644
1652
1660
1668
1676
1684
1692
1700
1708
1716
1724
1732
1740
1748
1756
1764
1772
1780
1788
龍捲風1511
水龍捲1512
颱風1501


30
25
20
15
10
5
0
1644
1650
1656
1662
1668
1674
1680
1686
1692
1698
1704
1710
1716
1722
1728
1734
1740
1746
1752
1758
1764
1770
1776
1782
1788
1794
民遷徙流亡避災
社會動亂戰爭兵亂盜賊
民不聊生民大困
人口販賣遺棄


drought
locust
famine
Frequency
Year
350
300
250
200
150
100
50
0
1640
1660
1680
1700
1720
1740
1760
1780
1800

Europe-China-Japan

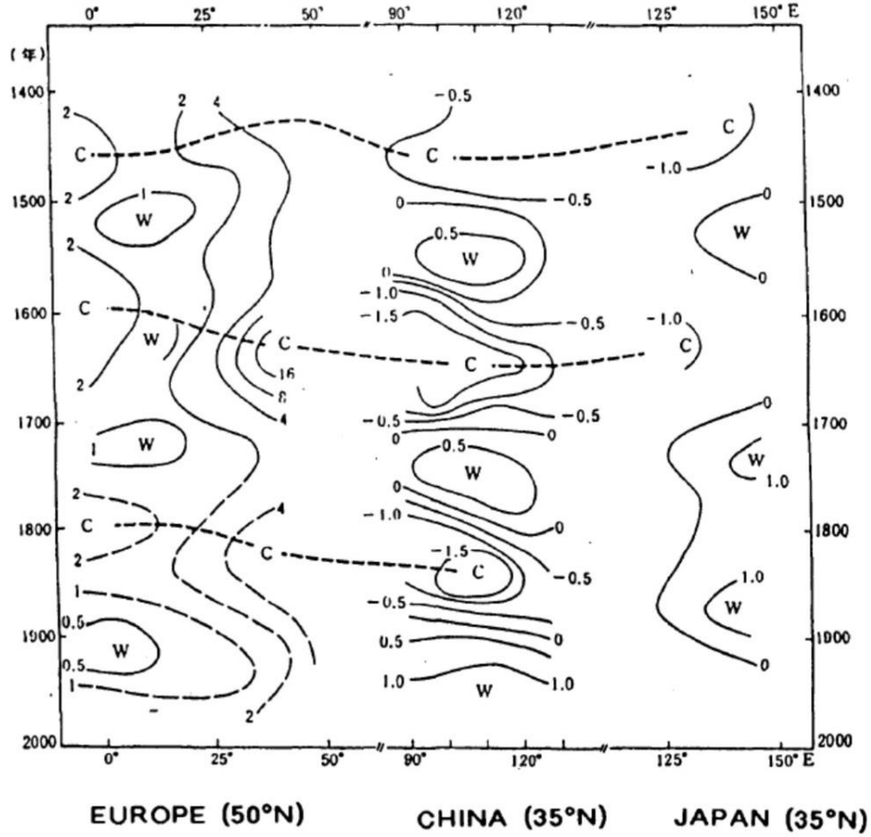


Fig. 26. Comparison of the climatic changes between China, Europe, and Japan. "C" represents cold and "W" represents warm. (Zhang, 1991).