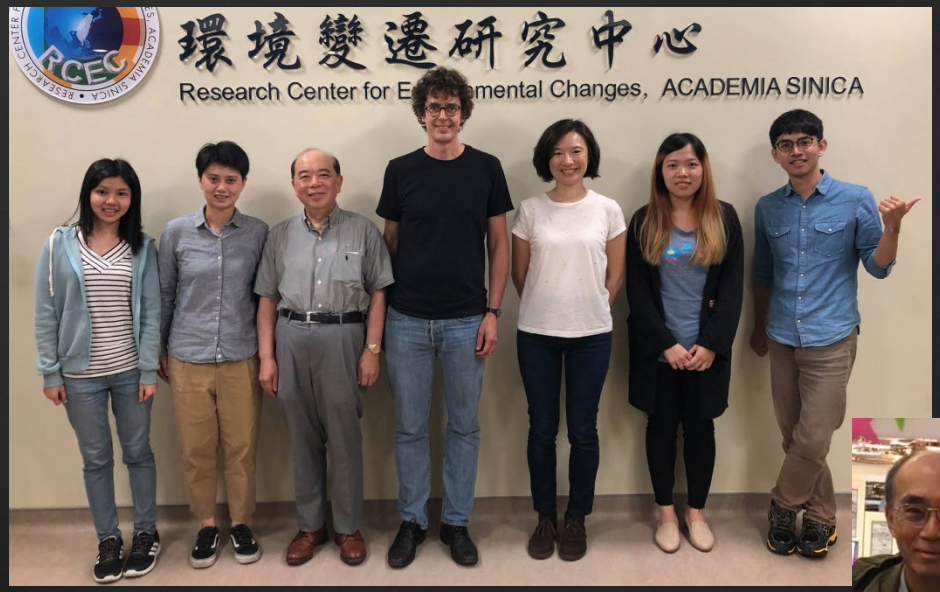
Reconstructed **E**ast **A**sian **C**limate **H**istorical **E**ncoded **S**eries (REACHES)

Reconstructed typhoon series 1644-1911 and implications of general atmospheric-oceanic circulation



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Outline

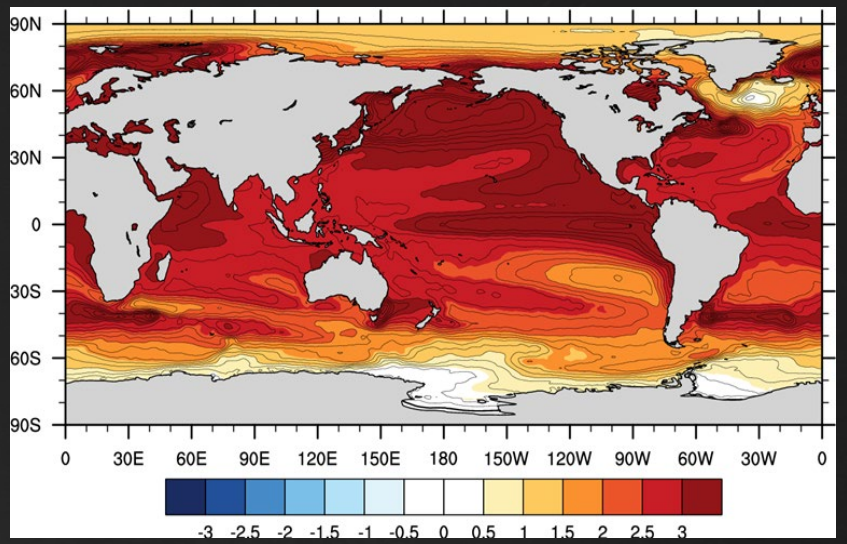
- **Motivation and objectives**
- **Research data**
- **reconstruction method**
- **Results**
  Typhoon series in 1644-1911
  Spatial-temporal pattern of typhoon activities
  Intercomparison and validation
  Implications of linkages with general oceanic-atmospheric circulation
- **Summary**

Under global warming

Northward shift of typhoon tracks under global warming

(MRI model, RCP8.5 scenario)
(Sugi et al. 2015: decreasing number of typhoons & increasing intensity)

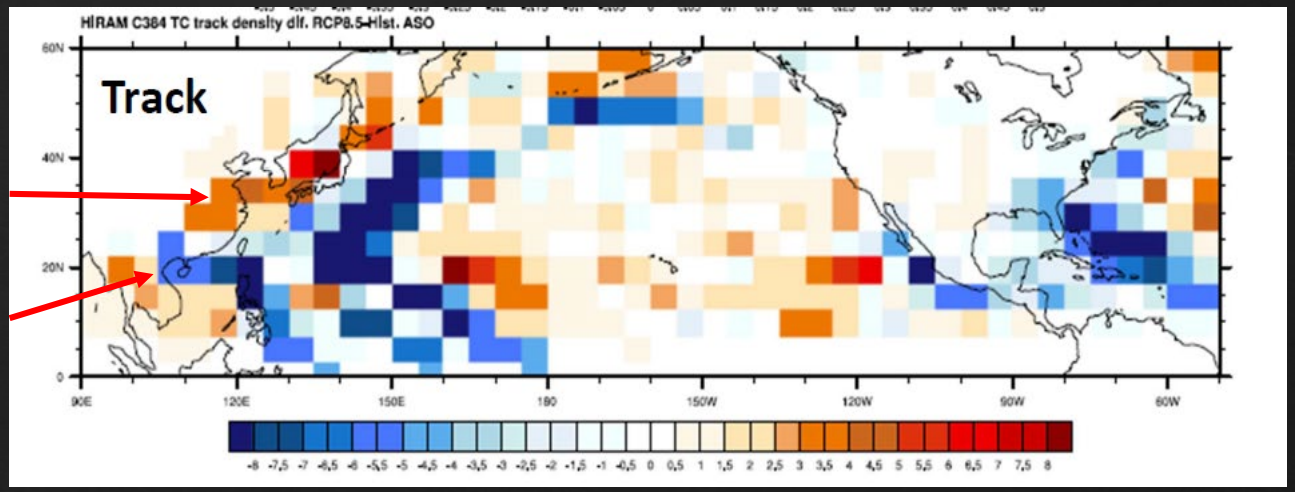
SST: Future (2086-2095) – Present (1979-2008)



Tropical cyclone track density: Future – Present

Increasing

Decreasing



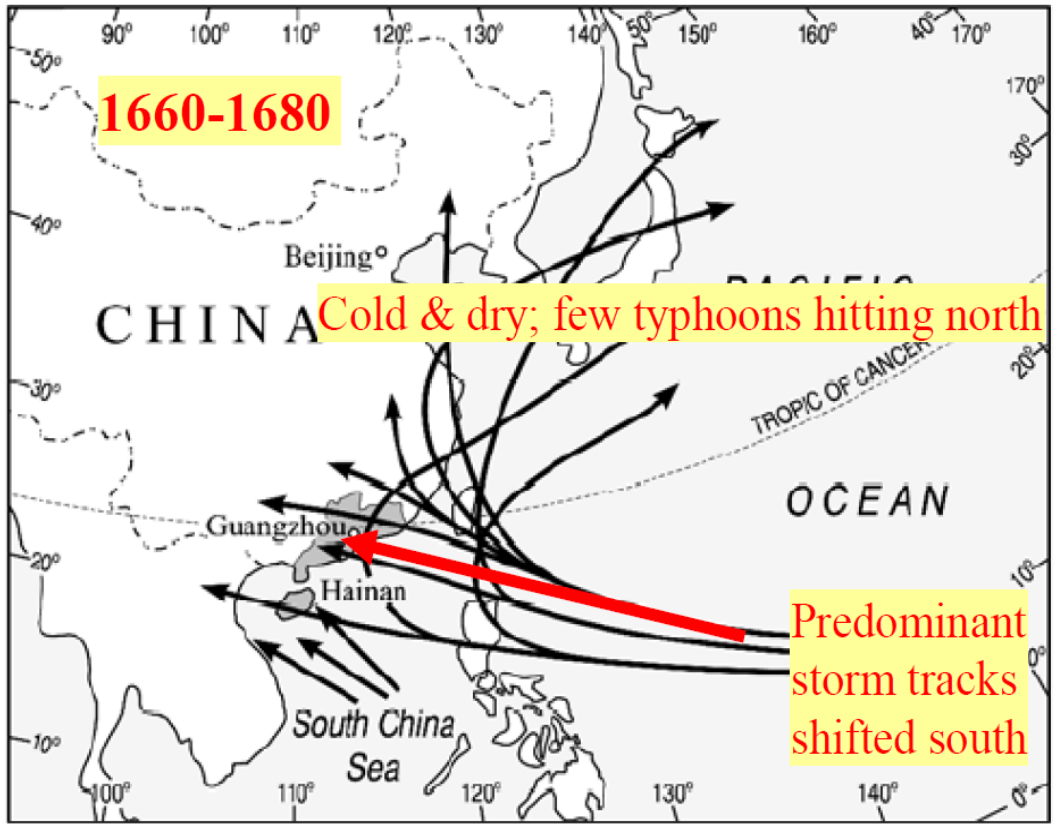
Motivation

Peak TC activity in Guangdong during 1660-1680, the coldest period during Little Ice Age.

- **Hypothesis:**
  May southward shift of TC during 1660-1680 due to WP SST (esp. La Nina conditions) and interactions with general atmospheric circulations?

Hypothesis:

Southward shift of typhoon tracks during AD 1660-1680



Liu et al., 2001

Motivation

Objectives

- Typhoon as extreme event and natural disaster
- Lack of instrumental data for sufficiently long time period to analyze typhoon activities
- Development of Paleotempestology

Building High resolution and quality data for reconstructing *annual* typhoon frequencies (and/or activities) in the last hundreds of years

www.nature.com/scientificdata

SCIENTIFIC DATA

OPEN

Data Descriptor: Construction of the REACHES climate database based on historical documents of China

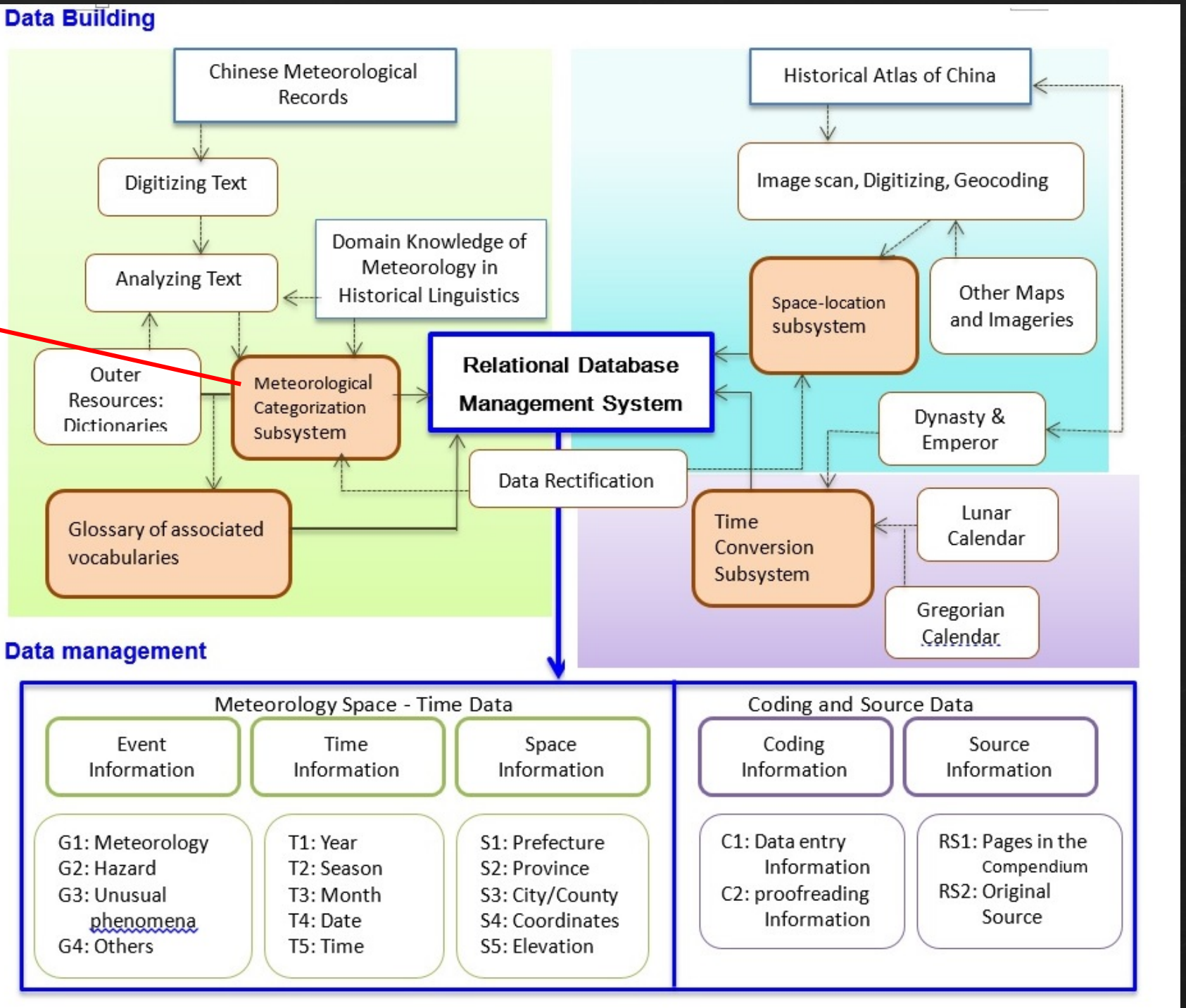
Pao K. Wang[1], Kuan-Hui Elaine Lin[1], Yi-Chun Liao[2], Hsiung-Ming Liao[3], Yu-Shiuan Lin[1], Ching-Tzu Hsu[1], Shih-Ming Hsu[1], Chih-Wei Wan[1], Shih-Yu Lee[1], I-Chun Fan[3], Pei-Hua Tan[4] &

A Compendium of Chinese Meteorological Records in the Last 3,000 Years (Zhang De'er eds. 2004,2013)

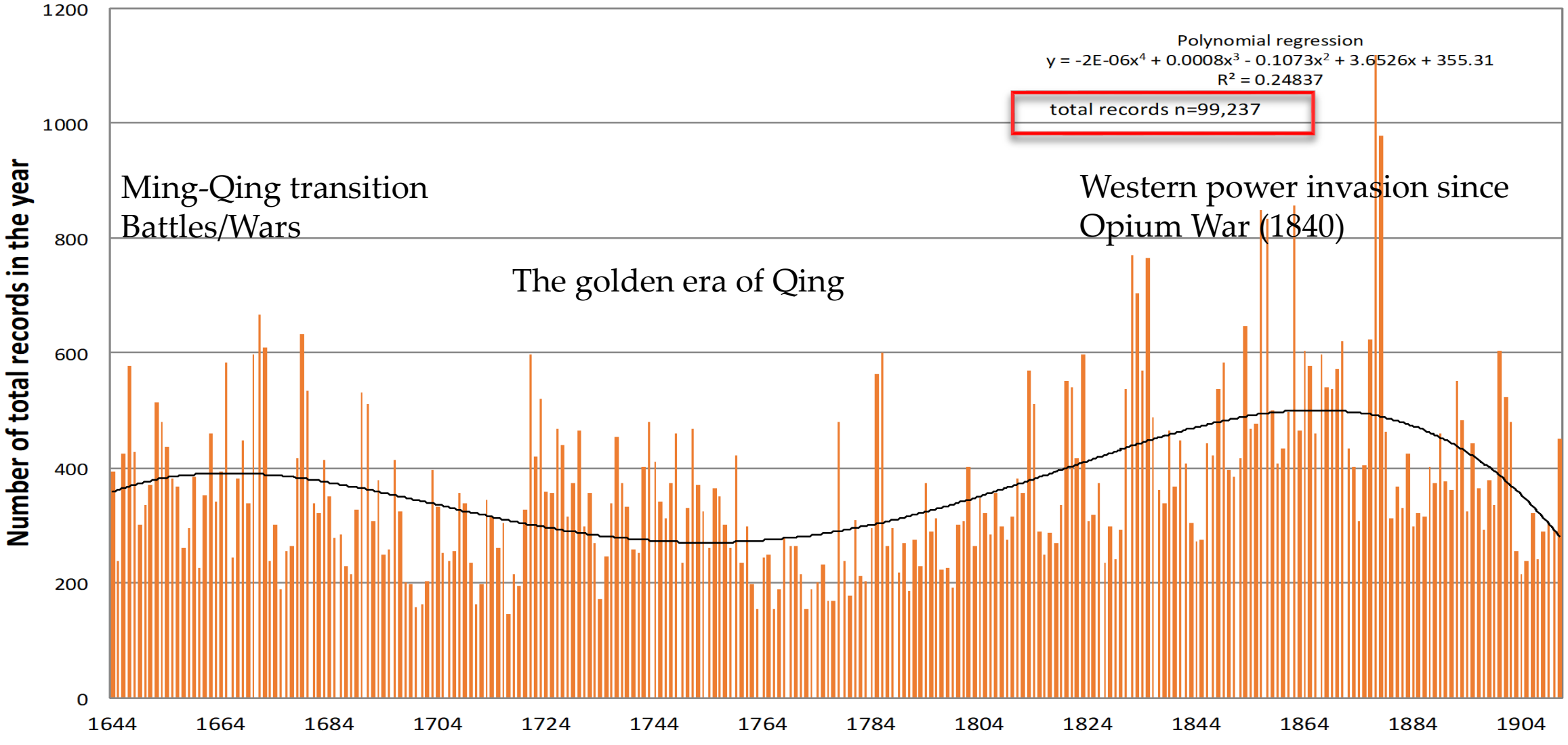
typical contents which contain time, location and type of events. Chinese historical times and location names are converted into Gregorian calendar and latitudes and longitudes. A hierarchical database system is developed that consists of the hierarchies of domains, main categories, subcategories, and further details. Historical events are then digitized and categorized into such a system. Code systems are developed at all levels such that the original descriptive entries are converted into digitized records suitable

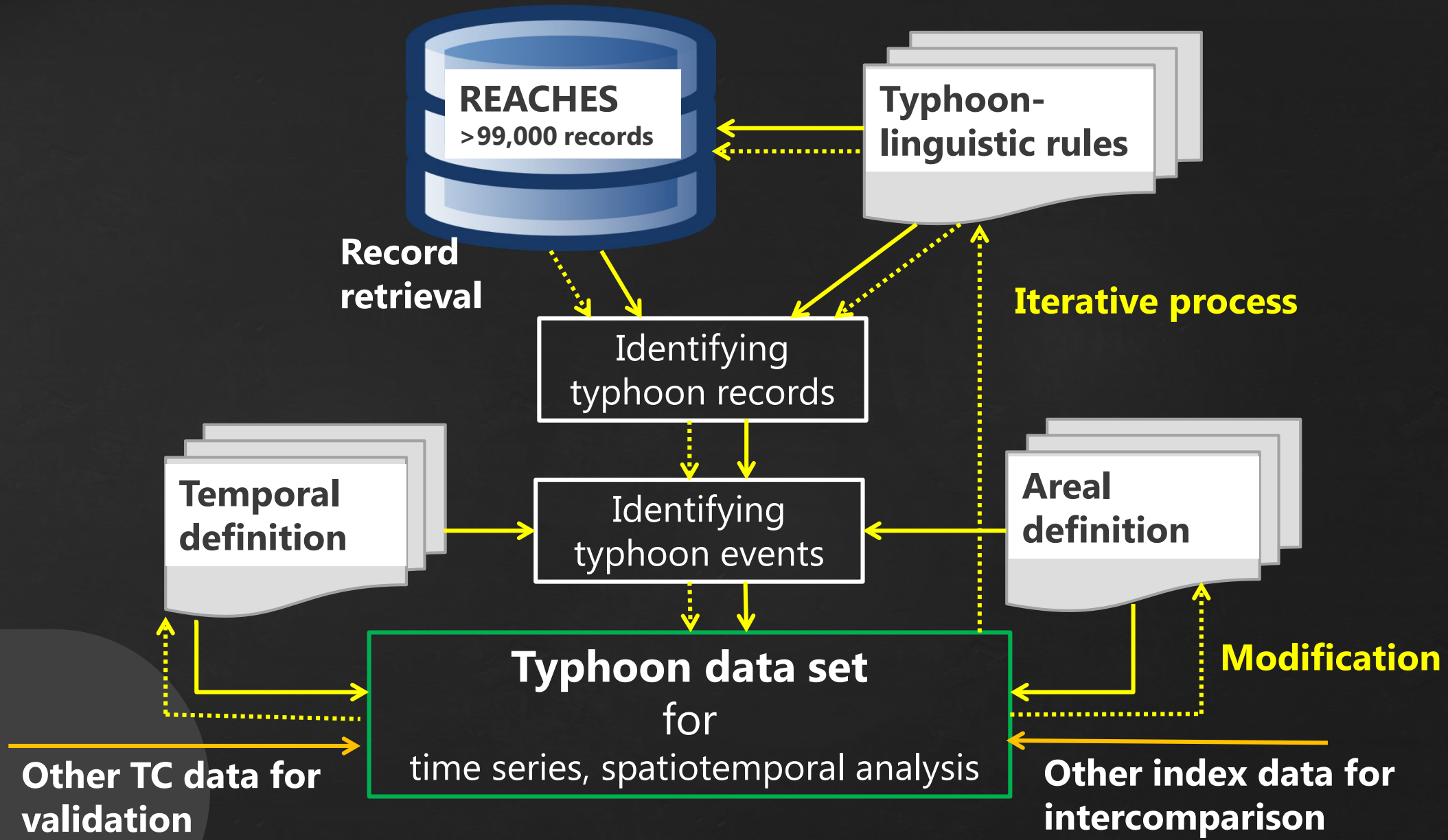
Digitization of records

4 domains (meteorology, hazard, abnormal events, and others), **28 main categories**, **231 subcategories**, and more than **1,350 vocabularies**



Statistics of REACHES records, **Qing dynasty 1644-1911**





Methods: Reconstructing typhoon series

Lin et al. (2018) under review

Method: reconstructing typhoon series

Typhoon-linguistic rules

Records documented with ‘typhoon’ (颱) or ‘hurricane’ (颶) (MUST)(Code 1501*****), with descriptions of other compounding effects such as strong wind, torrential rain and storm surge

1,538 records retrieved from REACHES

Temporal definition

± 1 days

Areal definition

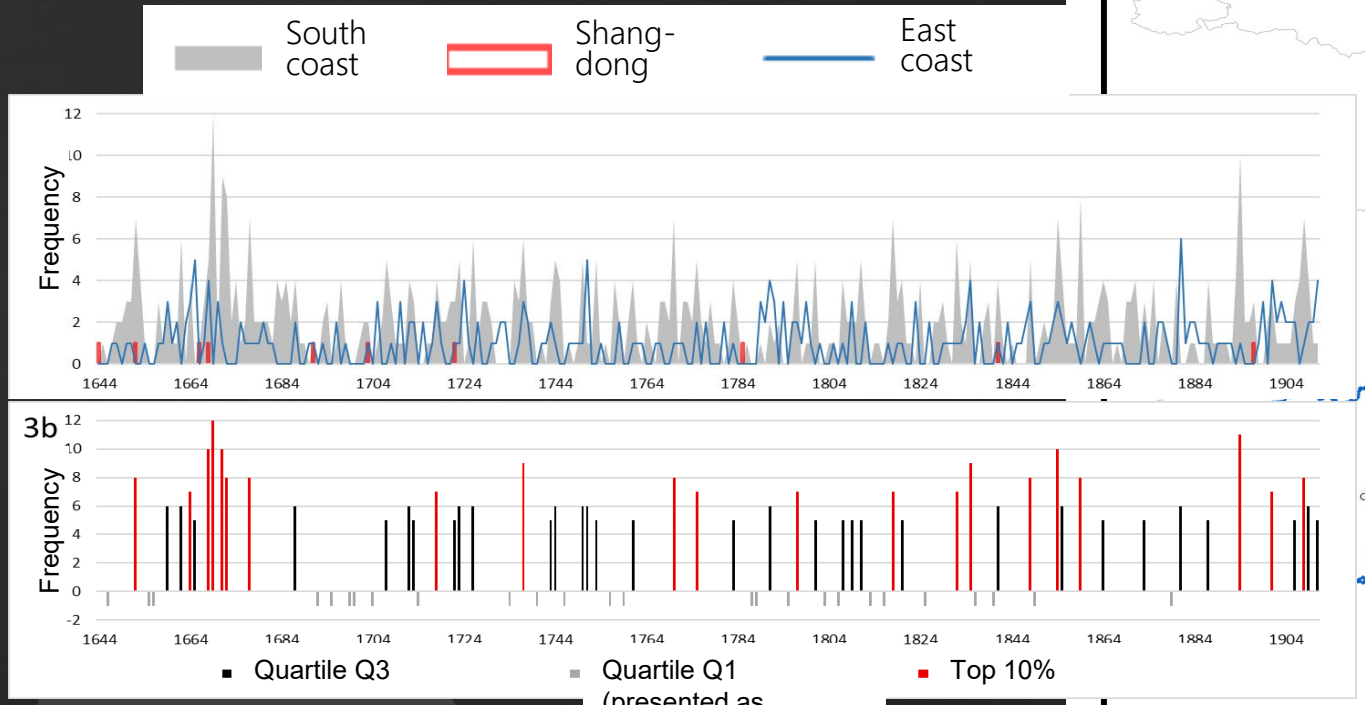
±2 degree latitude/longitude

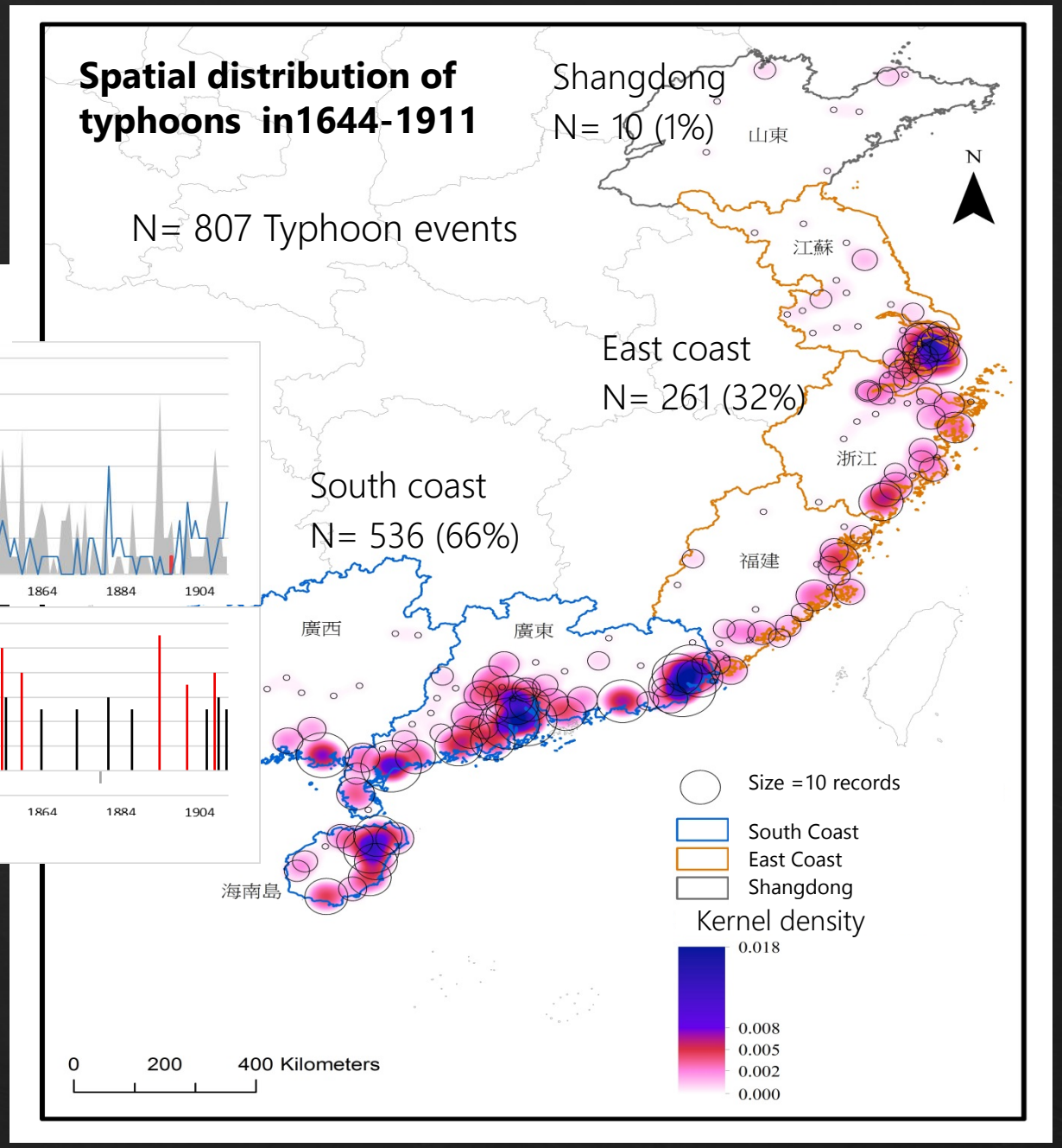
Records of the proximity were combined to account for one single typhoon event.

N=807 typhoon events in 1644-1911

1644-1911 annual average: 3.02

1650-1680 annual average: 4.5

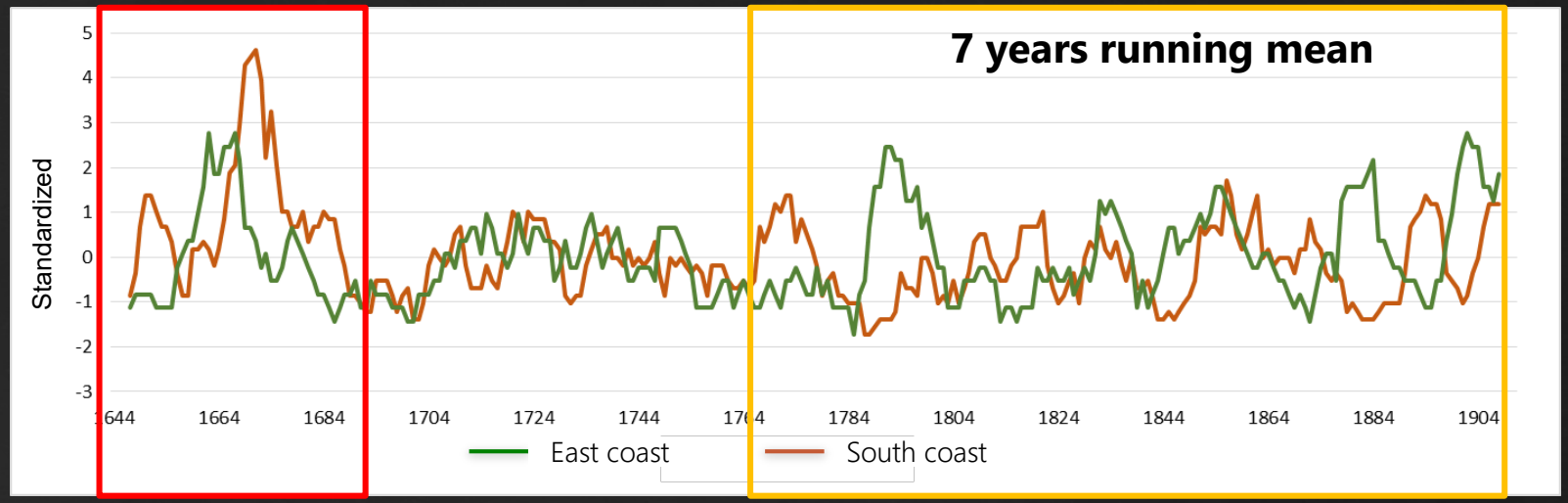


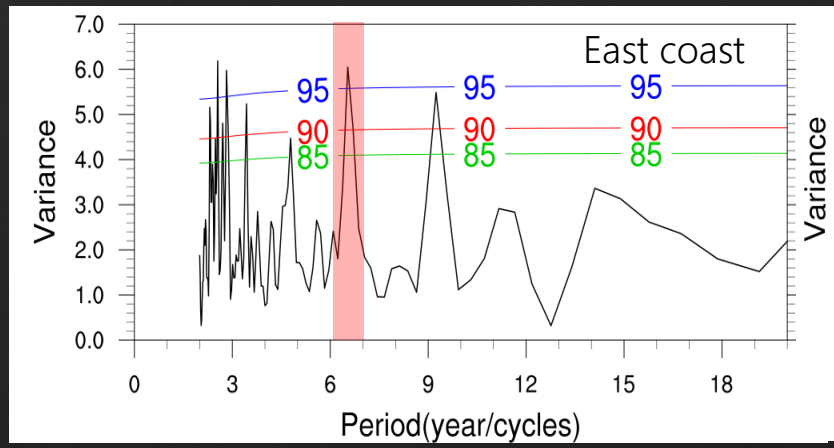


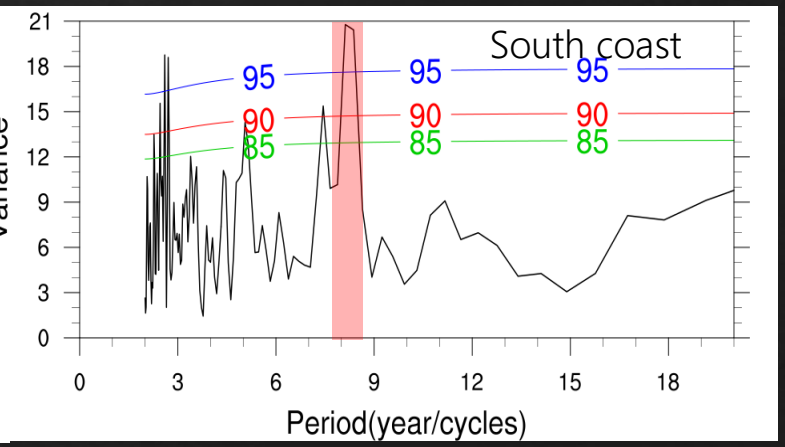
Results

Spatial-temporal patterns

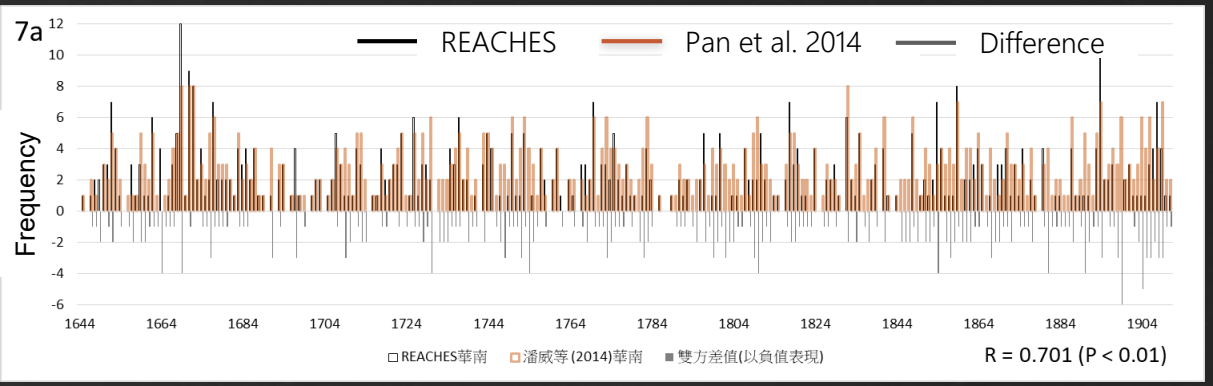
- **Consistent centennial scale fluctuation:**
  Active in 1640-1690
  Less active in 1690-1760
  Active in 1760-1910
- **Out of phase interannual variabilities** can be observed between East and South coasts

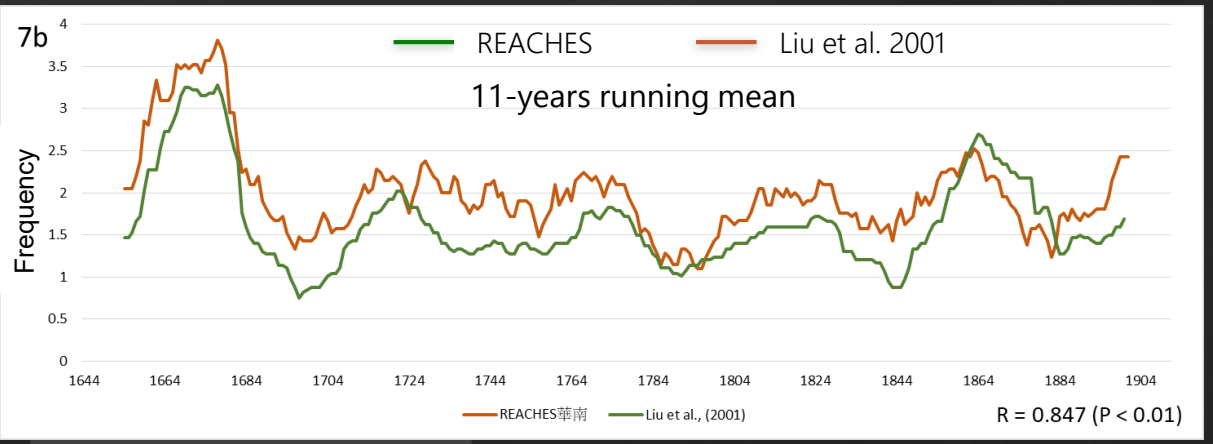




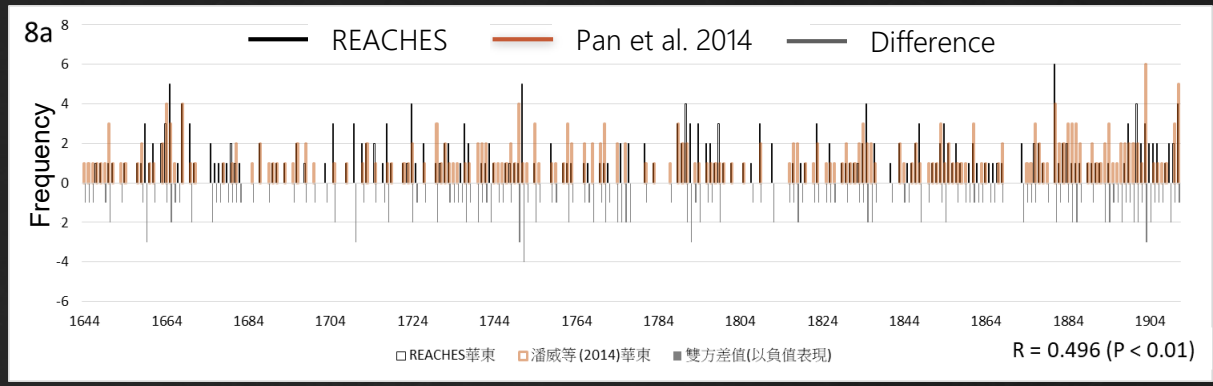


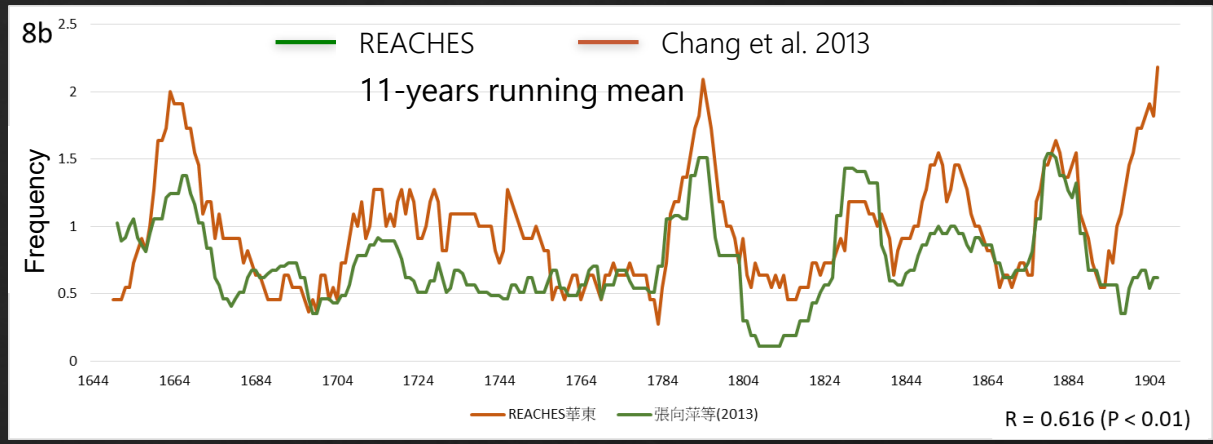
South coast





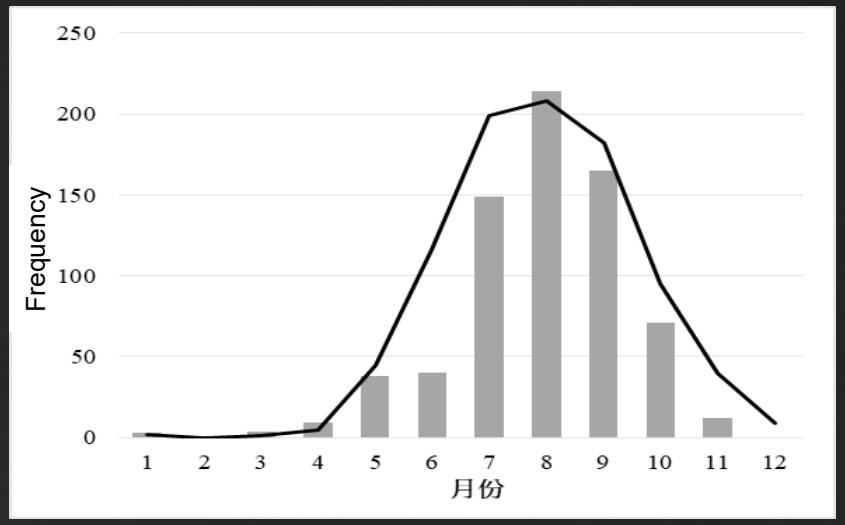
East coast



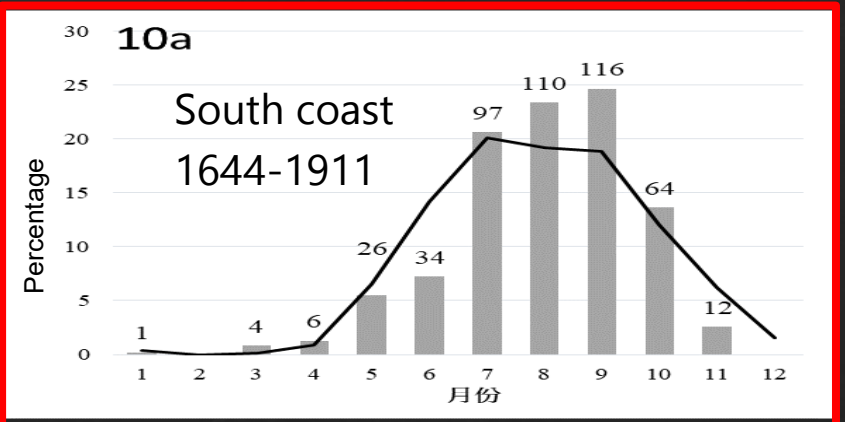


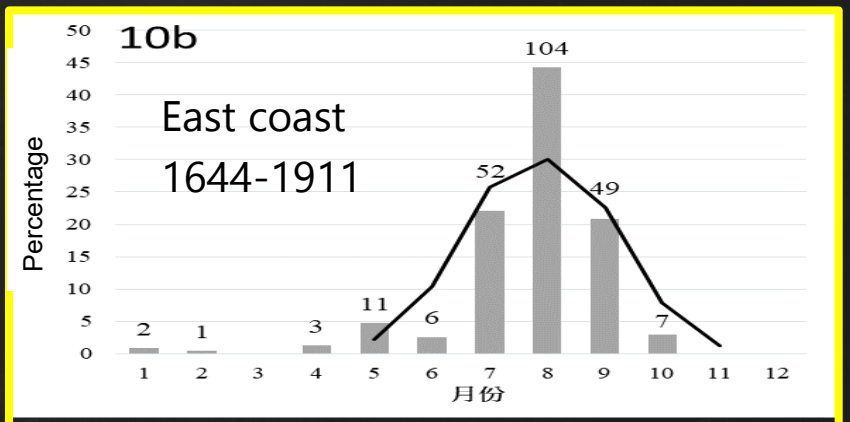
Validation

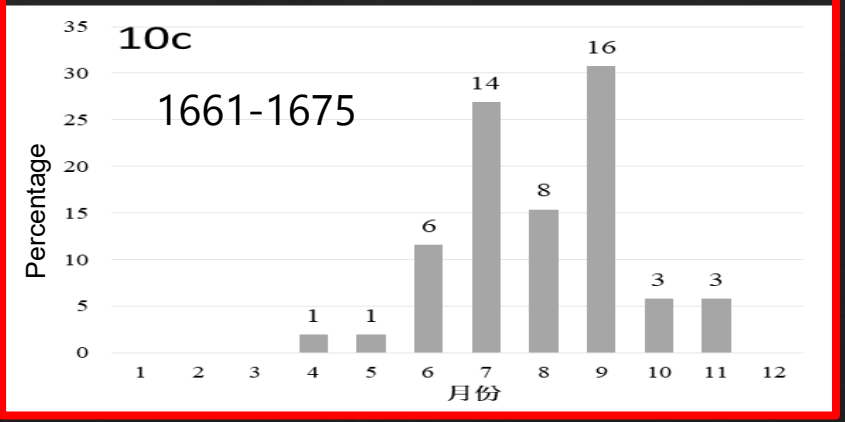
Monthly distribution consistent with IBTrACS obs. Data

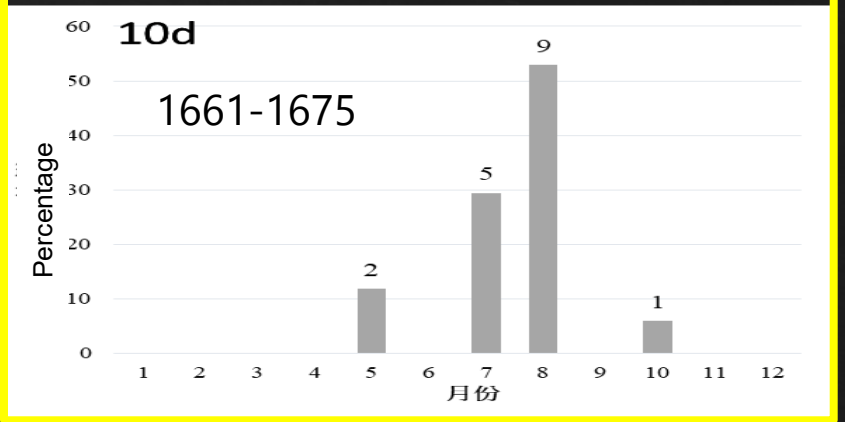


Monthly distribution of typhoon frequency. **Bars show REACHES** reconstructed typhoon frequency 1664-1911; **black curves are IBTrACS 1884-2013** typhoon data









Monthly

Implications of general atmospheric-oceanic circulation

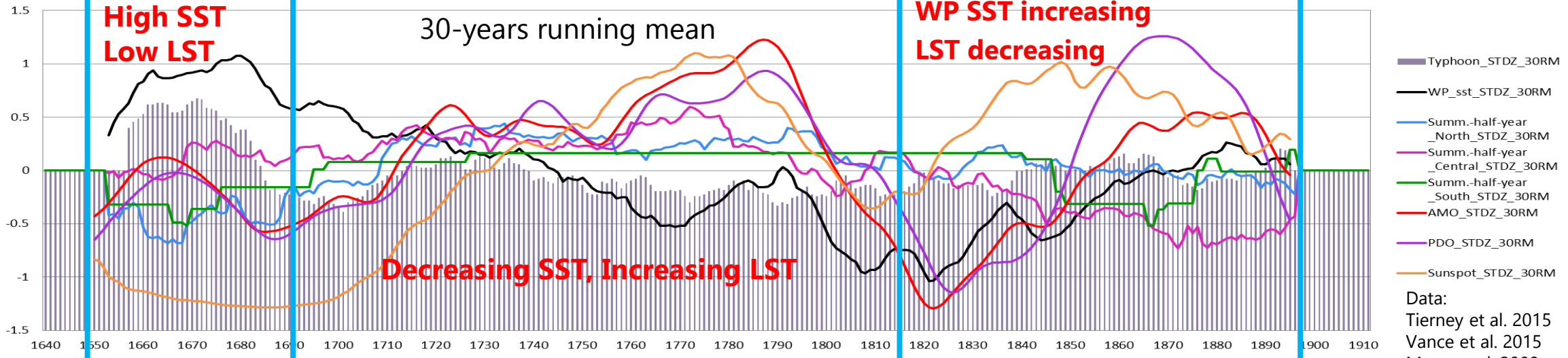
SST, LST (North, Central, South China), AMO, PDO and typhoons

30-years running mean

High SST
Low LST

WP SST increasing
LST decreasing

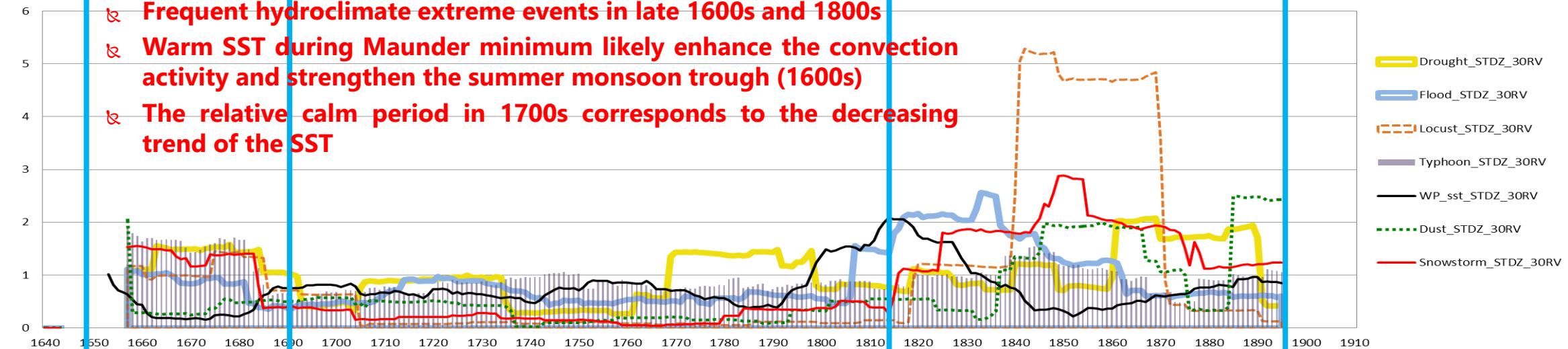
Decreasing SST, Increasing LST

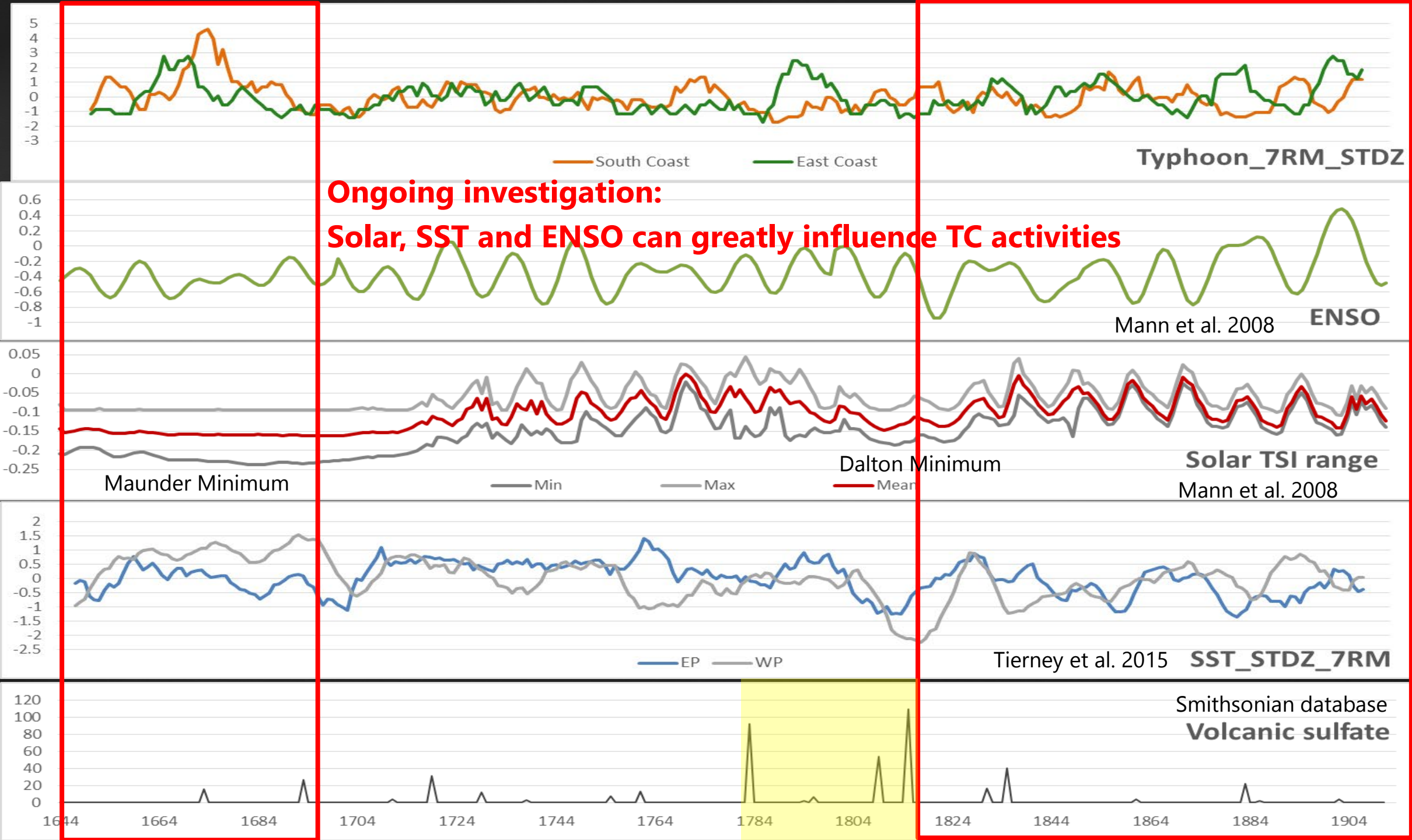


Data:
Tierney et al. 2015
Vance et al. 2015
Mann et al. 2008

SST, Typhoon, Drought, Flood, snowstorm 30-years running variance

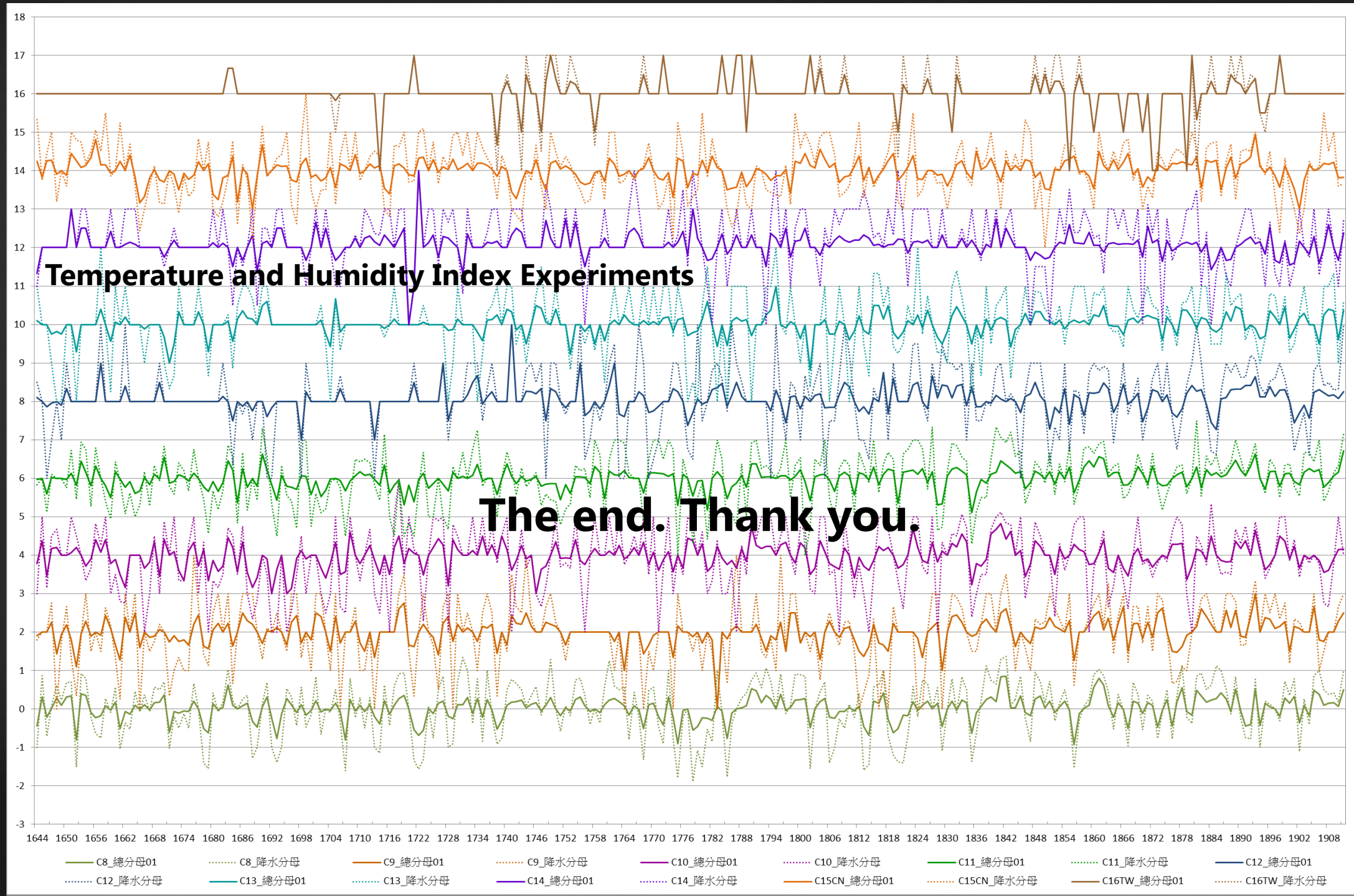
- **Frequent hydroclimate extreme events in late 1600s and 1800s**
- **Warm SST during Maunder minimum likely enhance the convection activity and strengthen the summer monsoon trough (1600s)**
- **The relative calm period in 1700s corresponds to the decreasing trend of the SST**




South Coast
East Coast
Typhoon_7RM_STDZ
Ongoing investigation:
Solar, SST and ENSO can greatly influence TC activities
Mann et al. 2008
ENSO
Maunder Minimum
Dalton Minimum
Min
Max
Mean
Solar TSI range
Mann et al. 2008
EP
WP
Tierney et al. 2015
SST_STDZ_7RM
Smithsonian database
Volcanic sulfate
1644
1664
1684
1704
1724
1744
1764
1784
1804
1824
1844
1864
1884
1904

Summary

- Tropical cyclone records exhibit interannual and decadal fluctuations in both east and south coasts of China.
- Frequent hydroclimate extreme events in late 1600s and 1800s, in contrast to the relative stable period in 1700s.
- The western Pacific SST dominates convection activity and strengthen the summer monsoon trough which may play an important role during Maunder Minimum.
- The circulation characteristics in different periods remain further studies.


Temperature and Humidity Index Experiments
The end. Thank you.
C8_總分母01
C8_降水分母
C9_總分母01
C9_降水分母
C10_總分母01
C10_降水分母
C11_總分母01
C11_降水分母
C12_總分母01
C12_降水分母
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C13_降水分母
C14_總分母01
C14_降水分母
C15CN_總分母01
C15CN_降水分母
C16TW_總分母01
C16TW_降水分母