4 May 2020
@EGU2020

Reconstruction of Solar Radiation Based on Historical Weather Records in Japan

- Climatic Condition and Market Economy in The Famine of 1830s -

Mika ICHINO[1], Takehiko MIKAMI[2], Kooiti MASUDA[2] Yasuo TAKATSUKI[3]

1. ROIS-DS Center for Open Data in the Humanities / National Institute of Informatics, Tokyo, Japan.
2. Tokyo Metropolitan University, Tokyo, Japan
3. Research Institute for Economics and Business Administration, Kobe University, Kobe, Japan

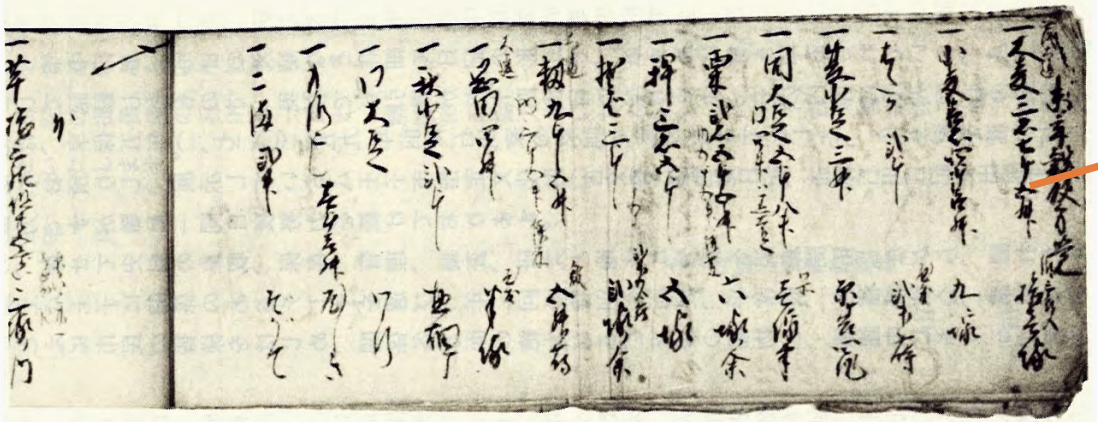
Introduction

Historical diaries in Japan

- Plenty of diaries from 17th to 19th centuries in Japan
- Some of them have daily weather descriptions like “fine”, “cloudy”, “rainy”, etc.
- Useful for climate reconstruction, however, they are not instrumental observations

Weather in Historical Diaries

元文４年10月



元文４年　穀取覚

Daily weather descriptions

Nov. 1739
(western calendar)

Harvests

Annual Report

Ishikawa's diaries have been recorded by a family of farmers in the Tokyo suburbs since 1720 and includes various records using the Japanese calendar.

How weather description has been used

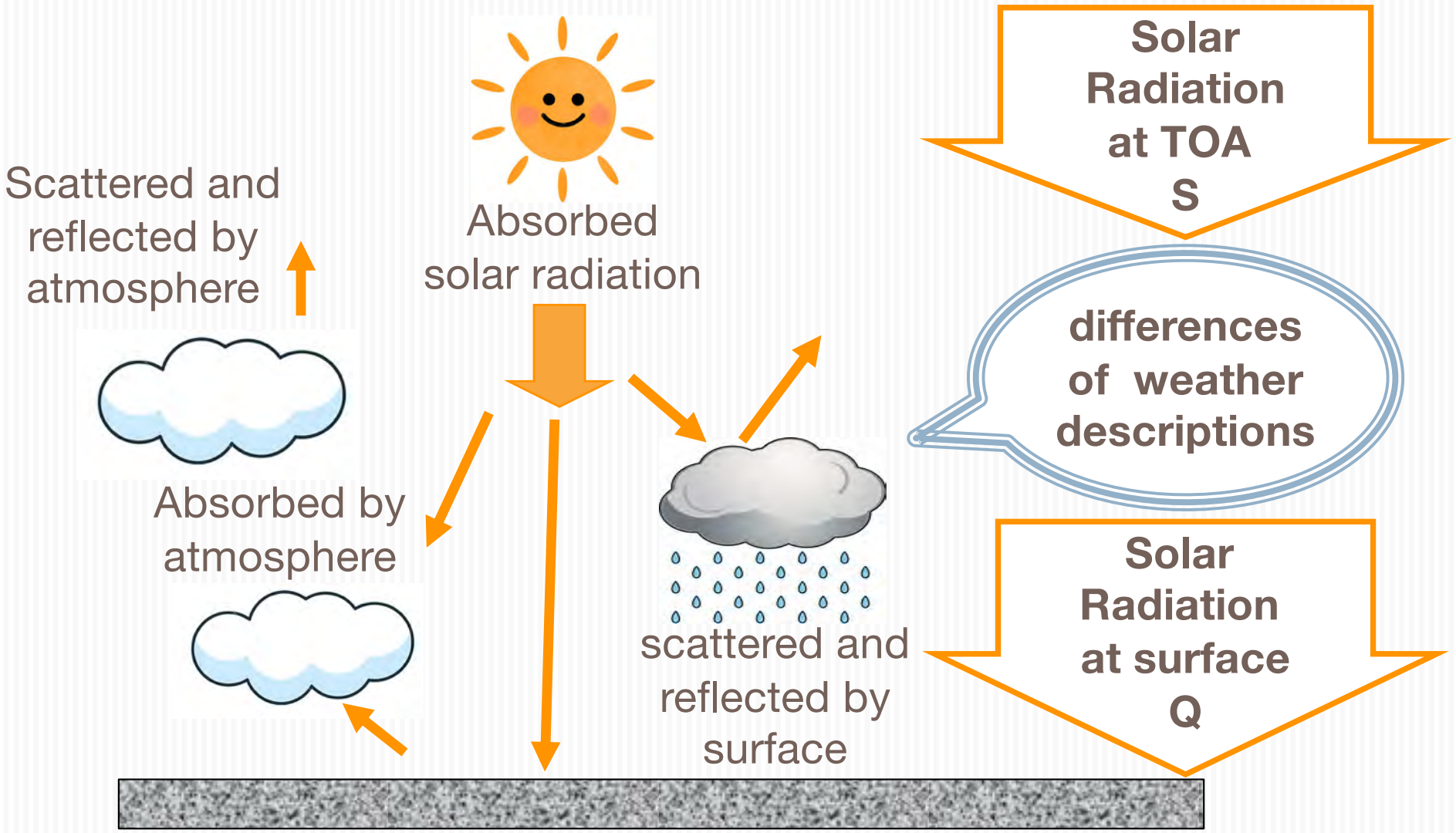
- For reconstructing climatic variation or events
- Diaries have records every day in all seasons
- Reconstruction with higher temporal resolution than other proxies (e.g. tree rings, lake sediments)
- Our method, Estimating solar radiation, is effective for all seasons
- Most of other methods are effective for some season only (summer or winter)

4 May 2020
@EGU2020

Target of Reconstruction: Solar Radiation

2019/5/4

What do weather descriptions indicate?



Weather descriptions represent weather conditions, which makes a difference in the amount of solar radiation on the surface.

Variables of solar radiation

$$q = Q / S$$

q: Standardized solar radiation (daily) [non-dimensional]

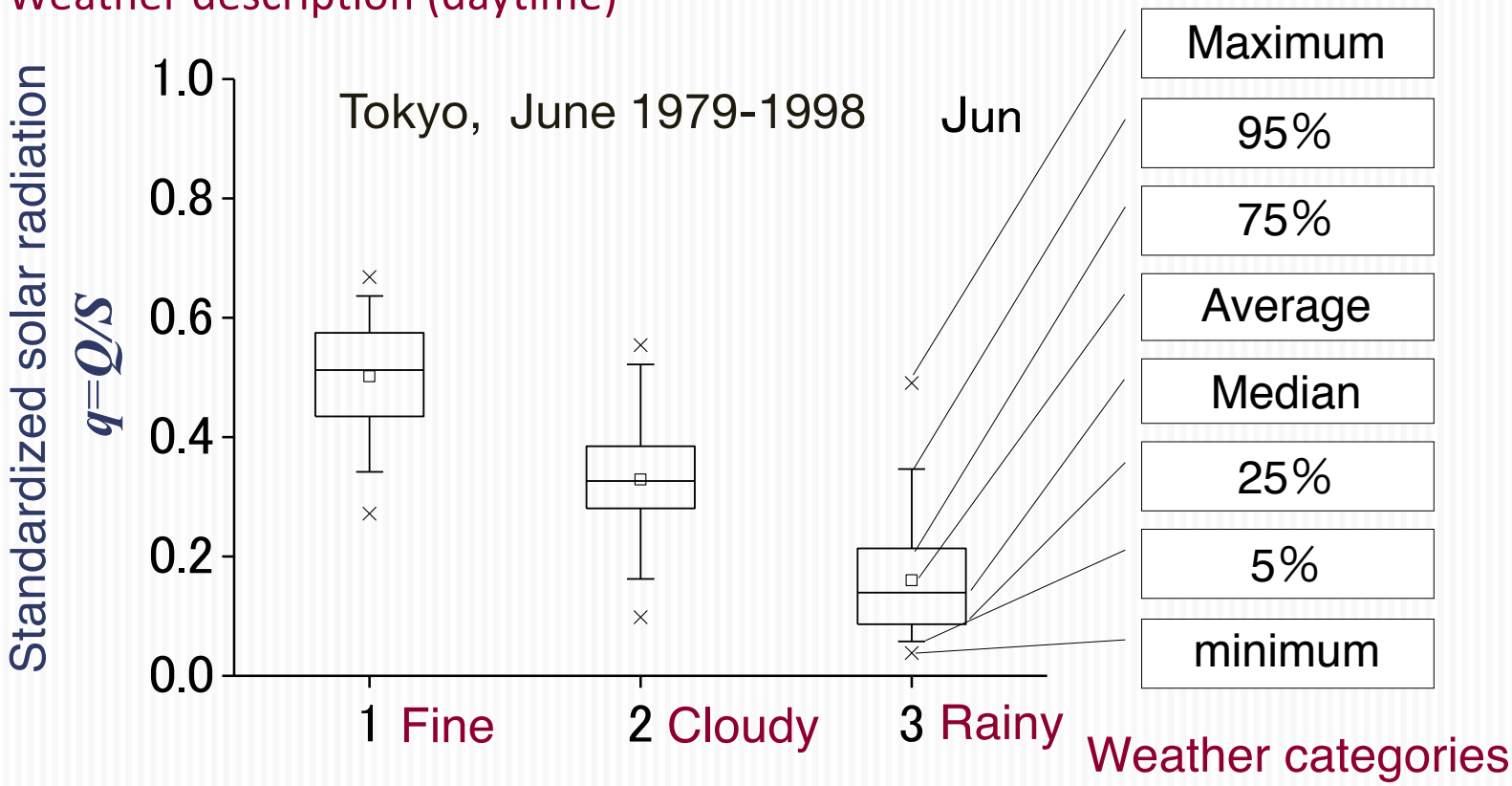
Q: Downward solar radiation at surface (daily) [W/m^2]
conventionally called “global solar radiation”

S: Solar radiation arriving at the top of the atmosphere (daily) [W/m^2]

- “Solar constant”: assumed to be constant (1370 W/m^2)
- Orbital parameters: assumed to be constant (“modern”)
- Geometrical calculation (following a textbook of meteorology)

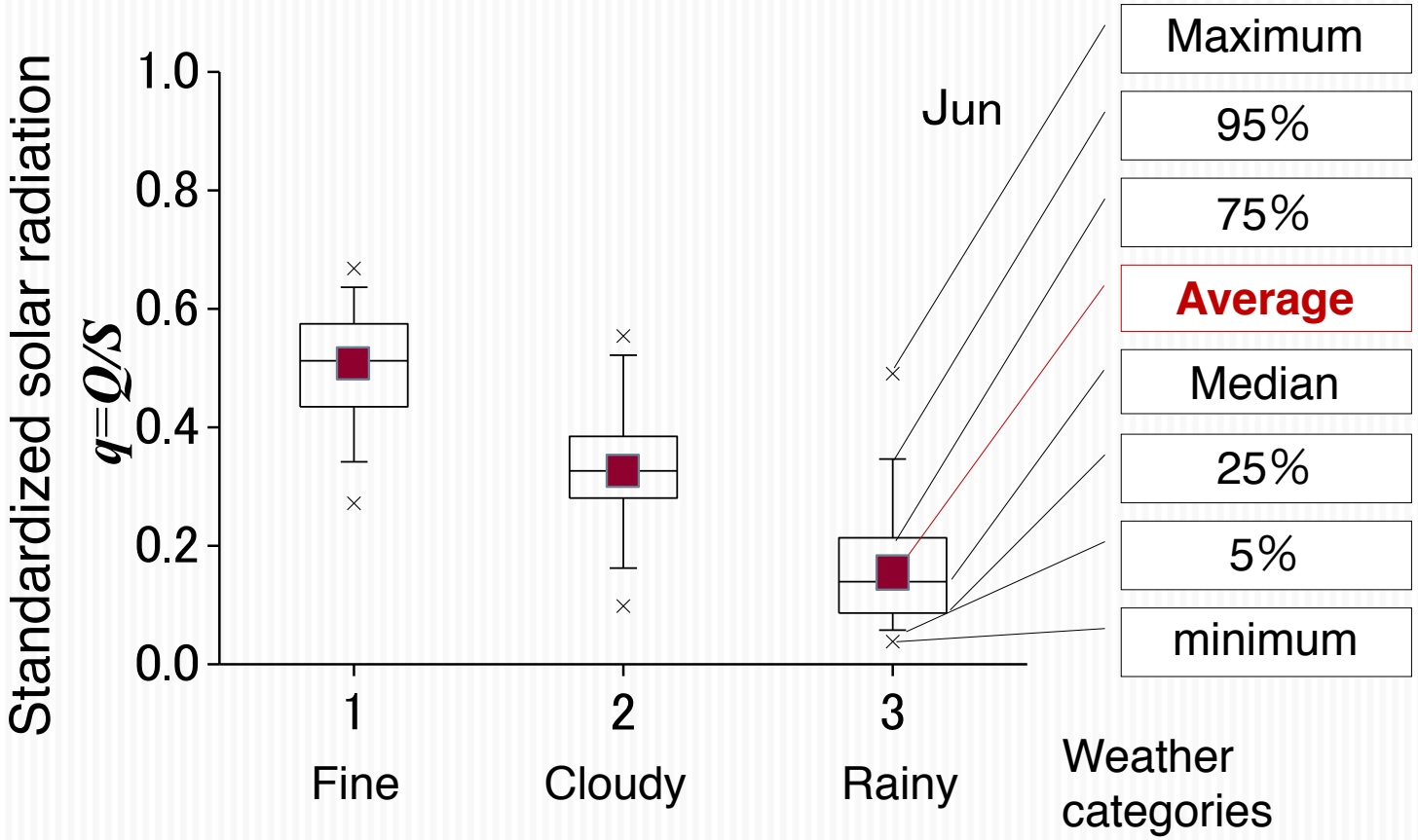
Global solar radiation sorted by weather condition

- Weather descriptions are classified into 3 categories based on weather conditions
  - Data: Observations by JMA
  - Global solar radiation (daily)
  - Weather description (daytime)



Average of $q(k)$

- Statistics are evaluated for each category, the average for each category, $q_{ave}(k)$, will be used in our method of estimation.



How to estimate solar radiation

$$Q_e = q_{ave}(k_j) * S_j$$

k : weather category level

q: Standardized solar radiation

$q_{ave}(k)$: Average ratio of global solar radiation according to the weather description

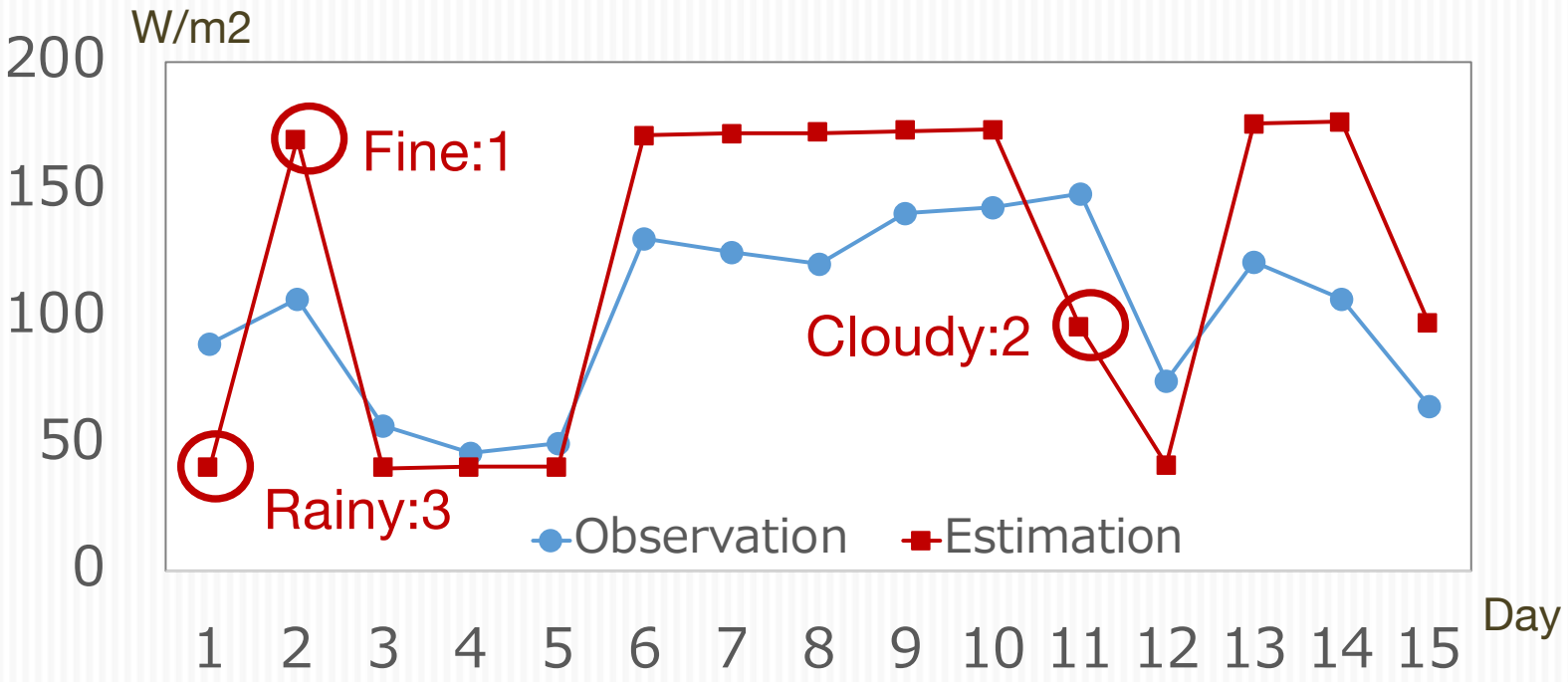
S : daily solar radiation arriving at the top of the atmosphere

Qe : estimated solar radiation

j : a day in a month

The method for estimation

- Classifying weather into 3 categories
- Substituting “Climatological” monthly mean of the same weather category into a value



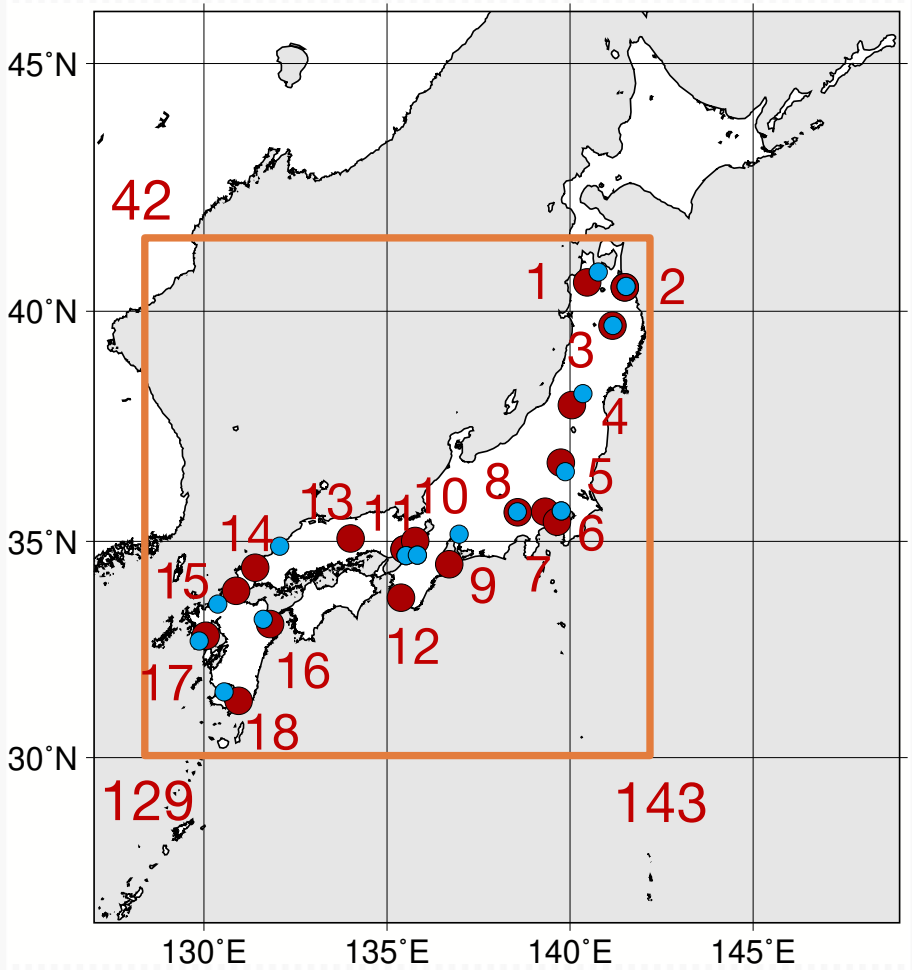
4 May 2020
@EGU2020

Reconstruction of Solar Radiation

Reconstruction of solar radiation

- Estimating monthly mean global solar radiation based on the weather records
  - Using historical diary documents of 18 locations
  - Between 1821 and 1850
- Showing distribution maps of monthly mean solar radiation ratio to normal
  - Normal means the average of estimations for 30 years from1821 to 1850
- Discussing that seasonal climatic conditions and their interannual and subseasonal fluctuation
- Focusing on the years of Tempo Famine

Locations of Diaries and Data



Red: Locations of Diaries

1.Hirosaki 2.Hachinohe
3.Morioka 4.Kawanishi 5.Nikko
6.Yokohama 7.Hachioji 8.Kofu
9.Ise 10.Kyoto 11.Osaka
12.Tanabe 13.Tsuyama 14.Hagi
15.Kitakyushu 16.Usuki
17.Isahaya 18.Koyama

Blue: Locations of Observatories

Where data is used for calculating q_{ave} is available for estimating historical solar radiation

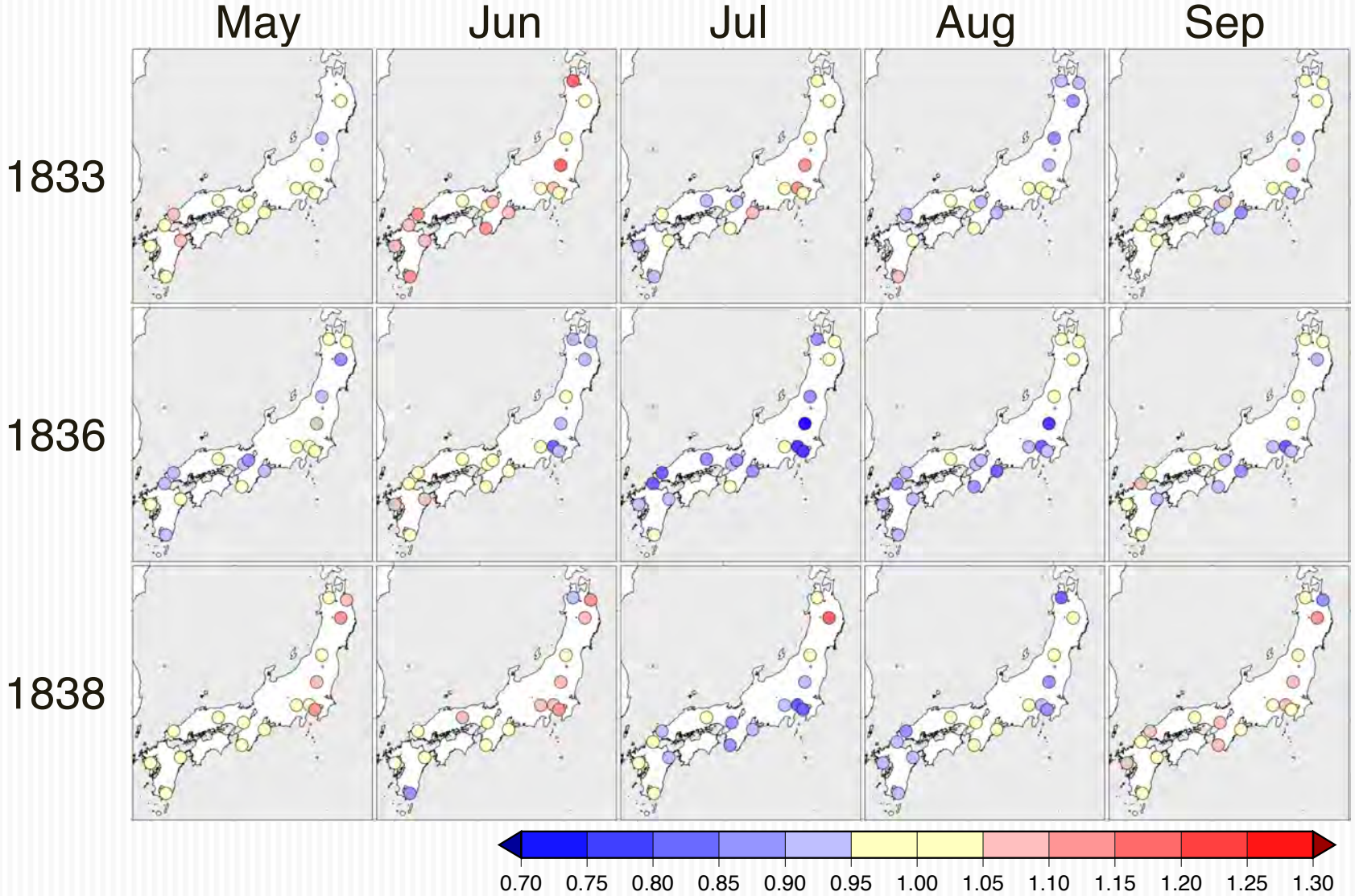
Addition locations to that in the abstract

What happened in1830s?

- A severe famine occurred between 1833 – 1839
  - Tempo Famine
- The most severe famine occurred in 1836
- Frequent cold summers and crop failures
- Not clear how the famine occurred and lasted

Solar radiation in years of famine

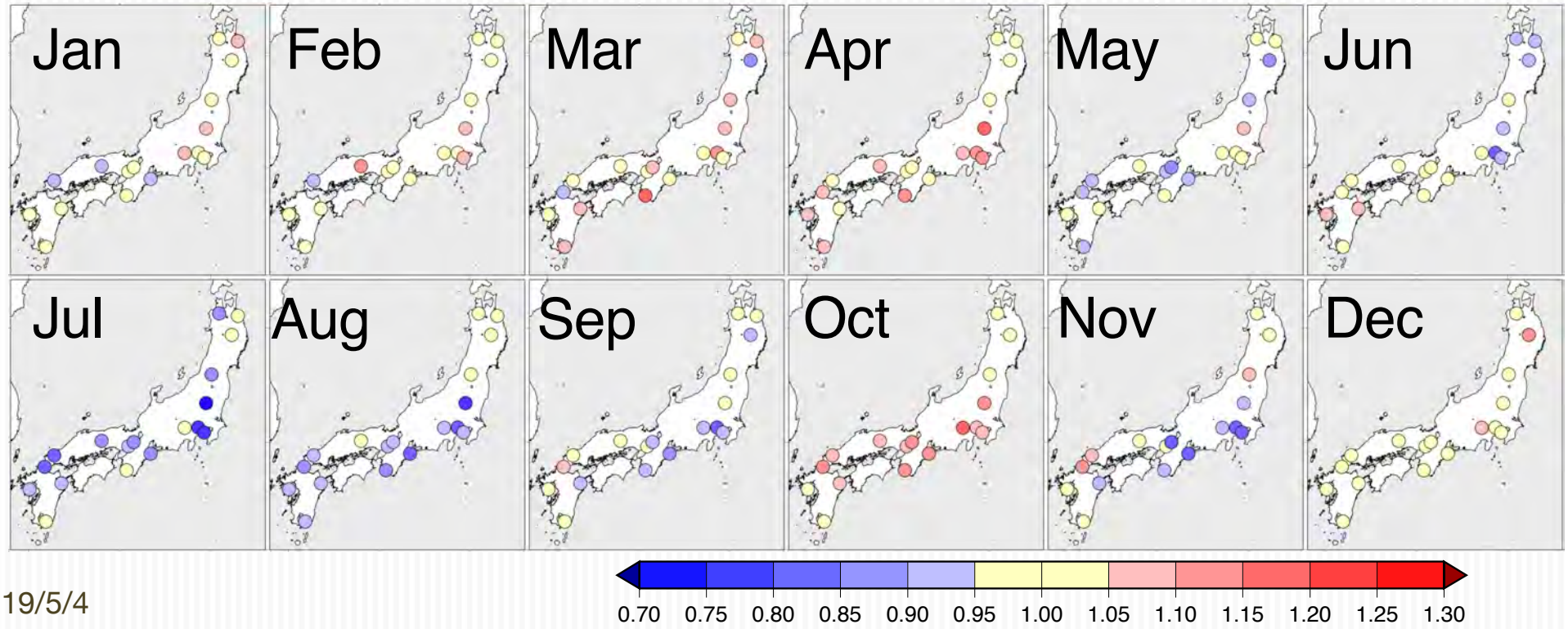
Ratio to average estimations between 1821–1850



Blue dots show lower values, red dots show higher values than normal

Solar radiation in 1836

- Blue dots spread in summer
- Lower values had been ongoing from May to September in the central area of Japan
- Suggesting that climatic condition similar to Baiu was prolonged, and that it was cold in Tohoku



4 May 2020
@EGU2020

Commodity Price Fluctuation during 1830's

Yasuo Takatsuki
yasuo.takatsuki@gmail.com

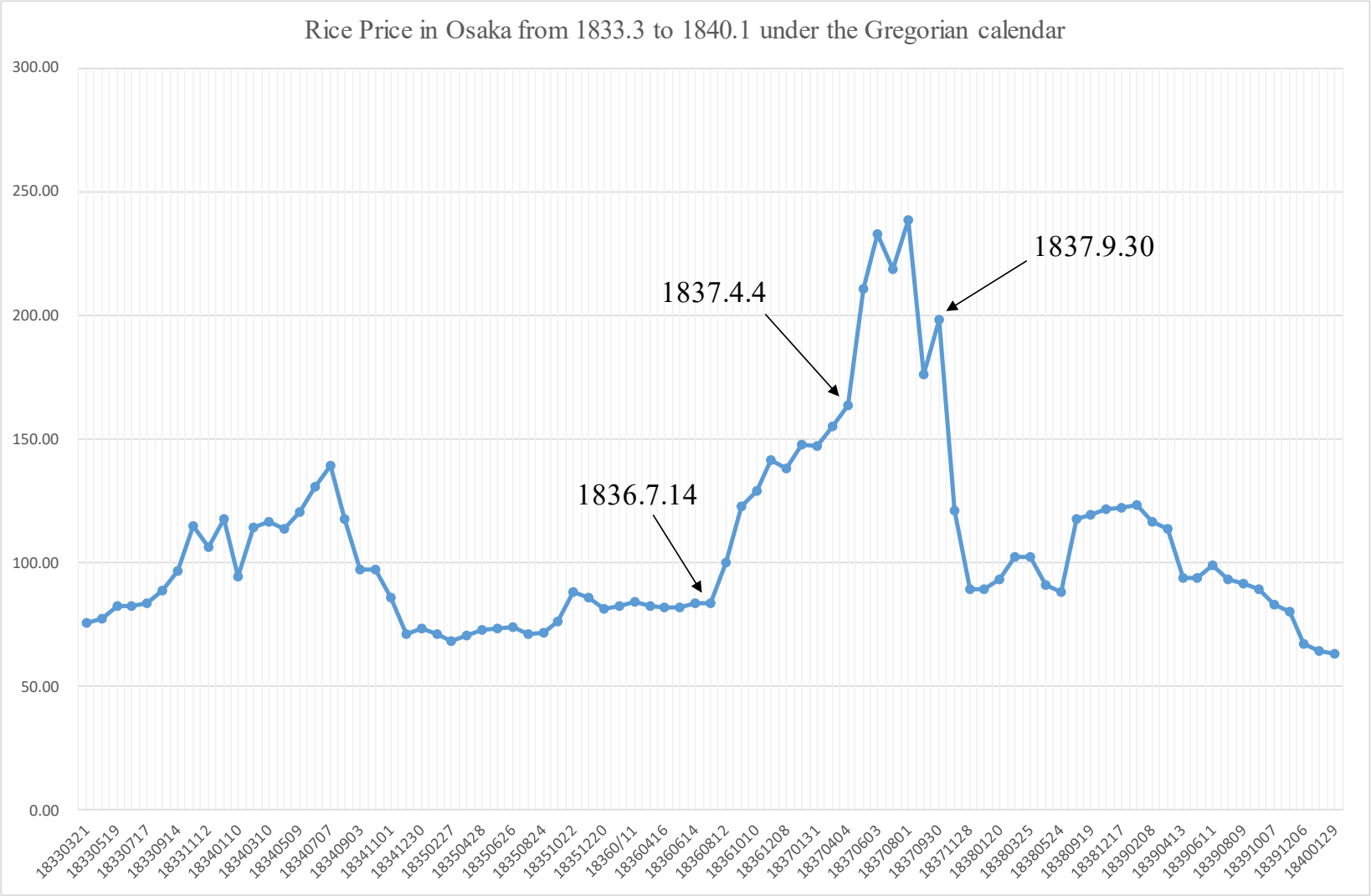
Monthly Commodity Price Data during 1830's

- Data Source: `諸相庭之扣' (Record of Market Activities)
  - This contains monthly reports on the prices of key products. Among these vast records, we will take advantage of the documents cover the period from 1833 to 1839 which record the monthly price of rice.
  - Monthly price here means the price in the beginning of each month in principal. In some cases, the price in the end of month is recorded on behalf of the price in the beginning of next month.
  - This record is under the lunisolar calendar. Thus we translate all the data into the Gregorian calendar base.
  - Unit of price is "monme（匁）", which indicates the amount of silver.

Monthly Commodity Price Data during 1830's

- Some tips about the data
  - We refer the rice price of Higo (肥後) bland in Osaka rice market. While Higo is one of the local district (now Kumamoto prefecture in the West side of Japan), Higo rice price in Osaka does not mean the price at Higo. Osaka rice market was the center market at that time, where over 30 bland of rice were traded. Higo is one of the representative bland at the market. Thus we can recognize Higo rice price in Osaka as the "average price" among whole country.
  - Tokugawa Shogunate, governor at that time, set a benchmark price of rice at 60 monme.

Rice Price in Osaka from 1833.3 to 1840.1 under the Gregorian calender



Monthly Commodity Price Data during 1830's

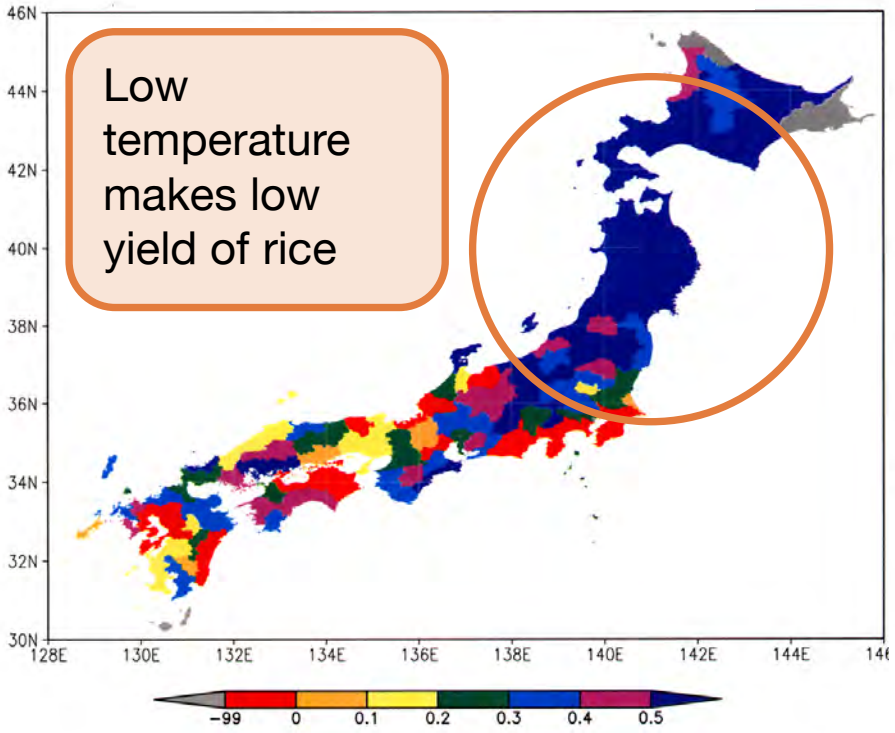
- Abnormal rise in 1836
  - For 1836, we can observe the sharp rise of the price in July. It suggests that market had reacted to bad climate condition before the harvest season (from September to October in principal).
  - After this sharp rise, four times higher than usual, rice price reached a plateau then fell in October 1837.
  - While the rice price in 1833 and 1838 also rose up in summer, they were only two times or three times higher than usual and, more importantly, they quickly bounce backed.

Discussions

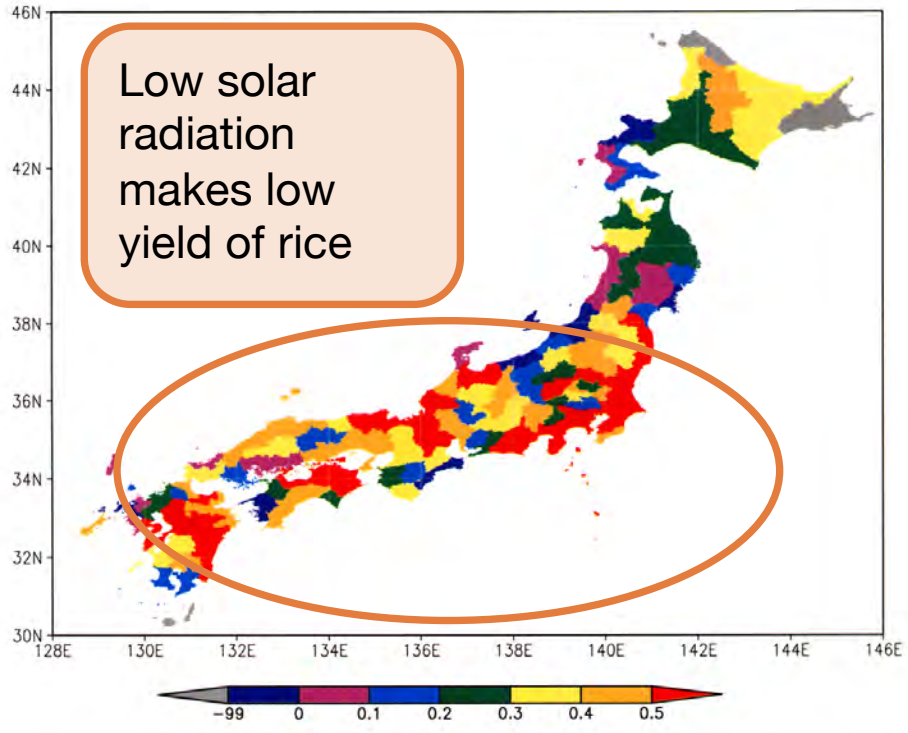
The relationship between climatic variation and harvests of rice in Japan

- The harvests of rice are affected more strongly by the global solar radiation than temperature in most of Japan.

Effect of Temperature



Effect of Solar radiation

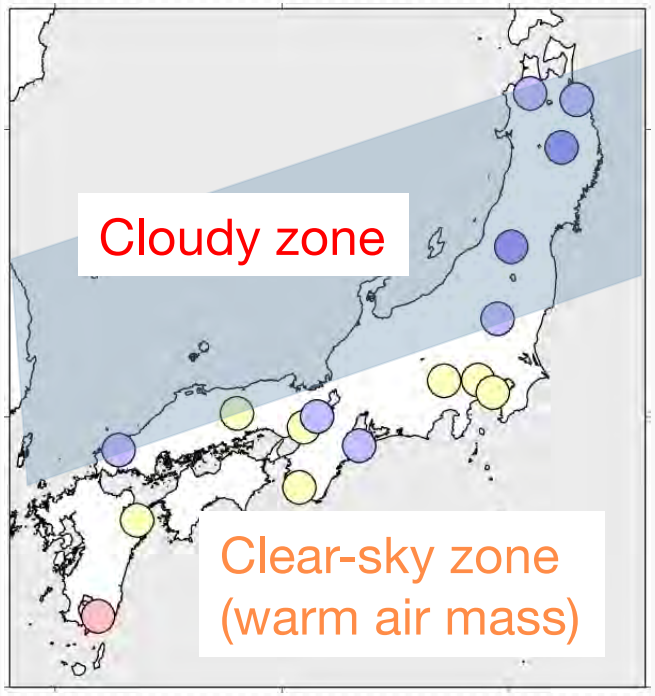


[From Nishimori and Yokozawa （2001）]

Different weather patterns among summers of famine

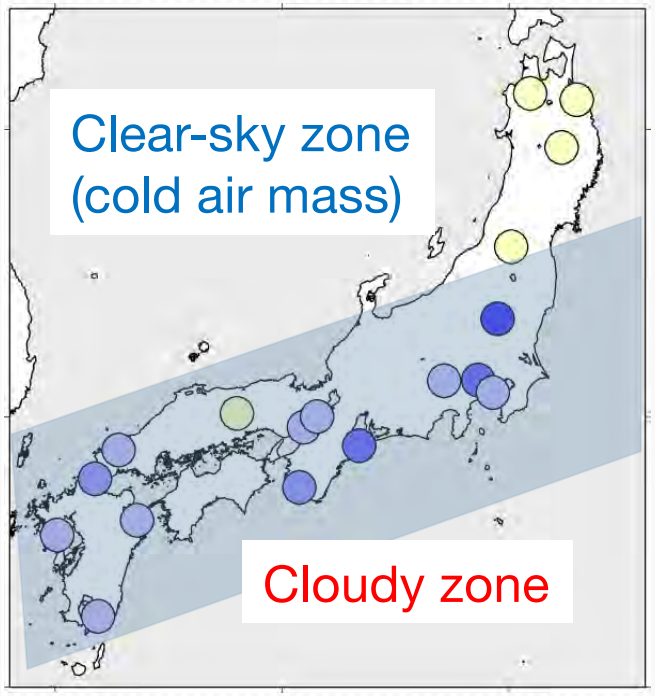
- Interpretation of spatial distributions with knowledge of synoptic climatology

August 1833



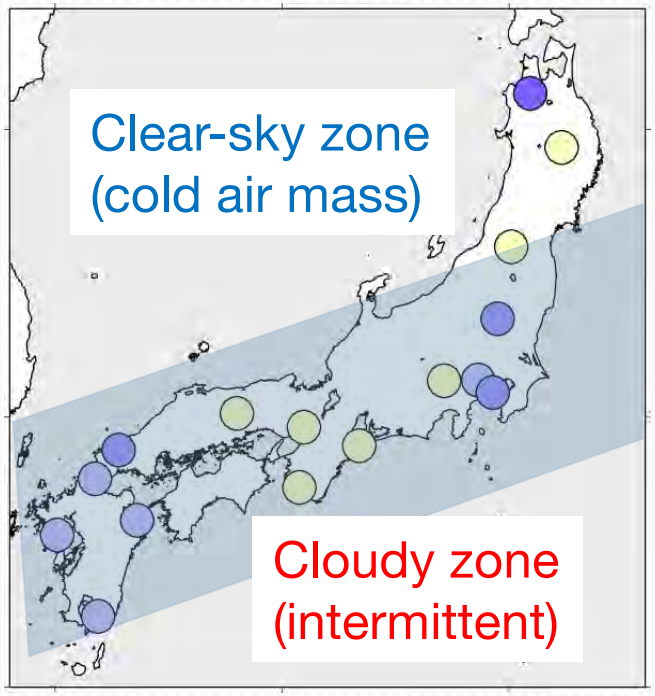
Cold summer in Tohoku (NE Japan)

August 1836



Very cold summer all-around Japan

August 1838



Cold summer all-around Japan

A key climatic condition affecting society in the famine year ?

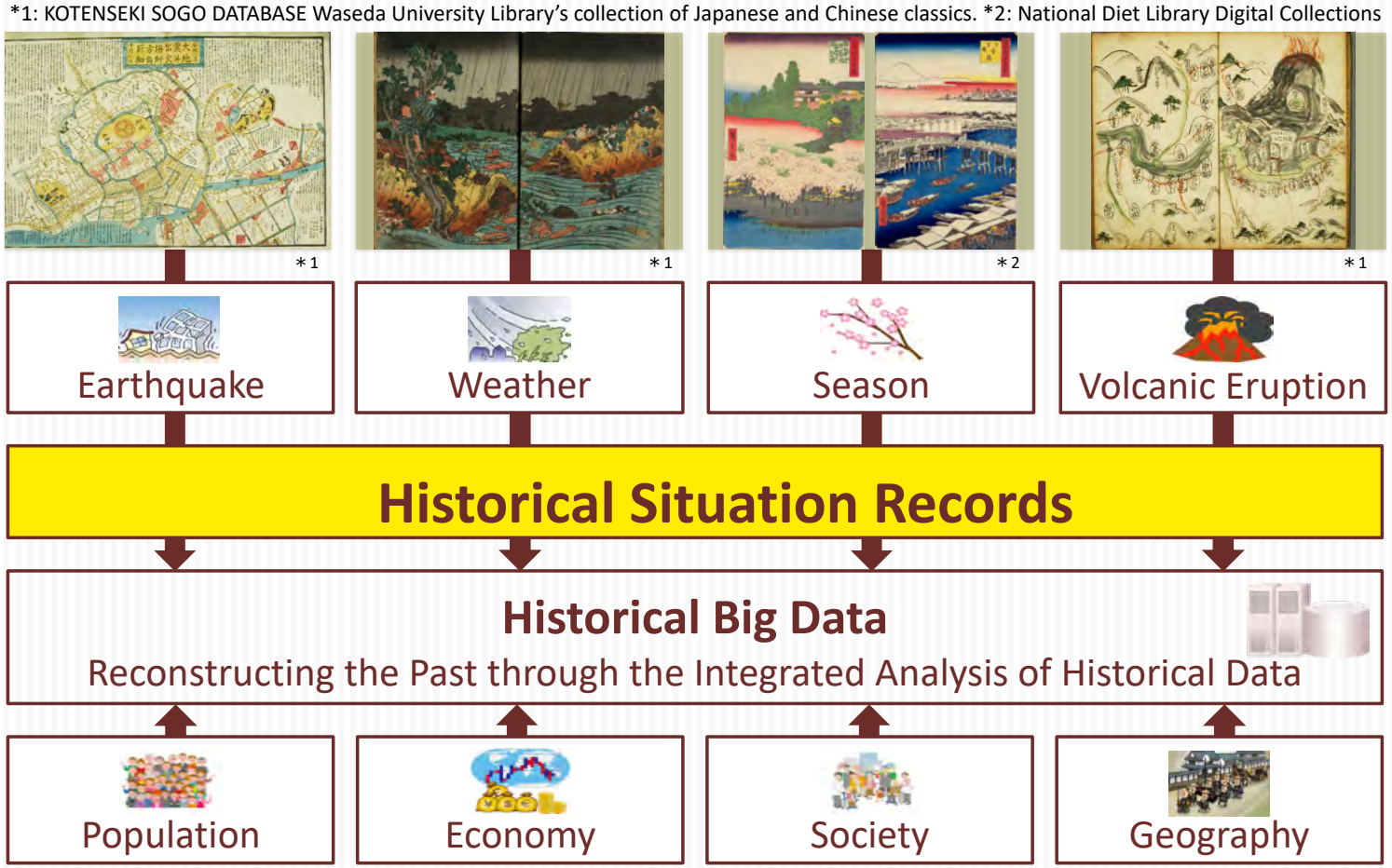
- In summer of 1836
  - We consider “Very cold summer all-around Japan” caused Rice Price in Osaka rose up more abnormally than that in 1833 and 1838
    - Low temperature in Northern Japan
    - Lower values of solar radiation in the central area of Japan
  - Cross check between the reconstructed solar radiation and the rice price data support thus enables us to conclude that there existed a big difference even among the years recorded as “famine years” on the historical documents

Ongoing Work

- Adding more locations
- Examining the relationship between climate and price of other crops, such as winter wheat, barley, soybeans
- We have started
  - Collaborative studies of interaction between climate, economics and humans
  - Atmospheric data assimilation with daily weather descriptions
  - An initiative called "Historical Big Data”

Historical Big Data

To facilitate interdisciplinary sharing of information available from historical documents



http://codh.rois.ac.jp/historical-big-data/

Reference

Part of our story has been published in a paper (in Japanese) by

Ichino, Mikami & Masuda (2018) in
J. Geography / Chigaku Zasshi (地学雑誌)
Vol. 127, p. 543-552
https://doi.org/10.5026/jgeography.127.543

EGU General Assembly 2020

Center for Open Data in the Humanities
ROIS-DS人文学オープンデータ共同利用センター
http://codh.rois.ac.jp/

大学共同利用機関法人 情報・システム研究機構
データサイエンス共同利用基盤施設
Joint Support-Center for Data Science Research (ROIS-DS)

大学共同利用機関法人
情報・システム研究機構
Research Organization of Information and Systems

NII
Inter-University Research Institute Corporation /
Research Organization of Information and Systems
National Institute of Informatics

TOKYO METROPOLITAN UNIVERSITY

RESEARCH INSTITUTE FOR ECONOMICS AND BUSINESS ADMINISTRATION
RIEB
SINCE 1919
KOBE UNIVERSITY