漢文史料にみる太陽活動
Solar Activities Recorded in Chinese Histrocal Sources

2014/05/12 USSS Seminar

早川尚志

Collabolator : 玉澤春史、磯部洋明

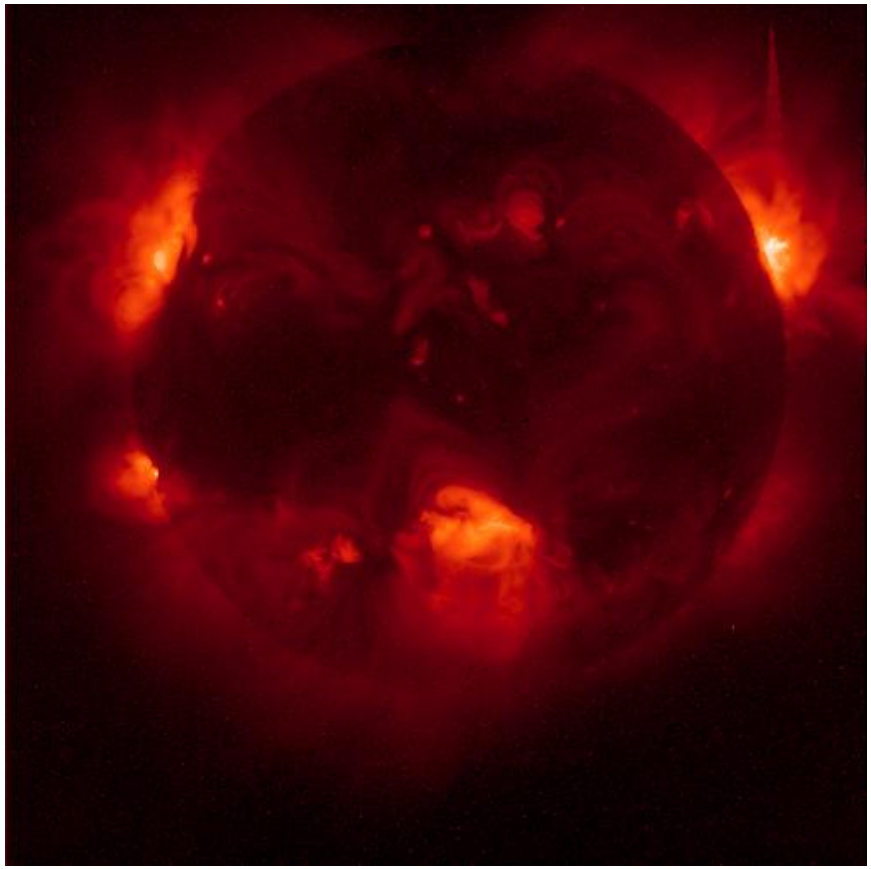
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Solar Activities



- Solar Activity seen by X-ray

Hiraiso Solar Terrestrial Research Center / CRL

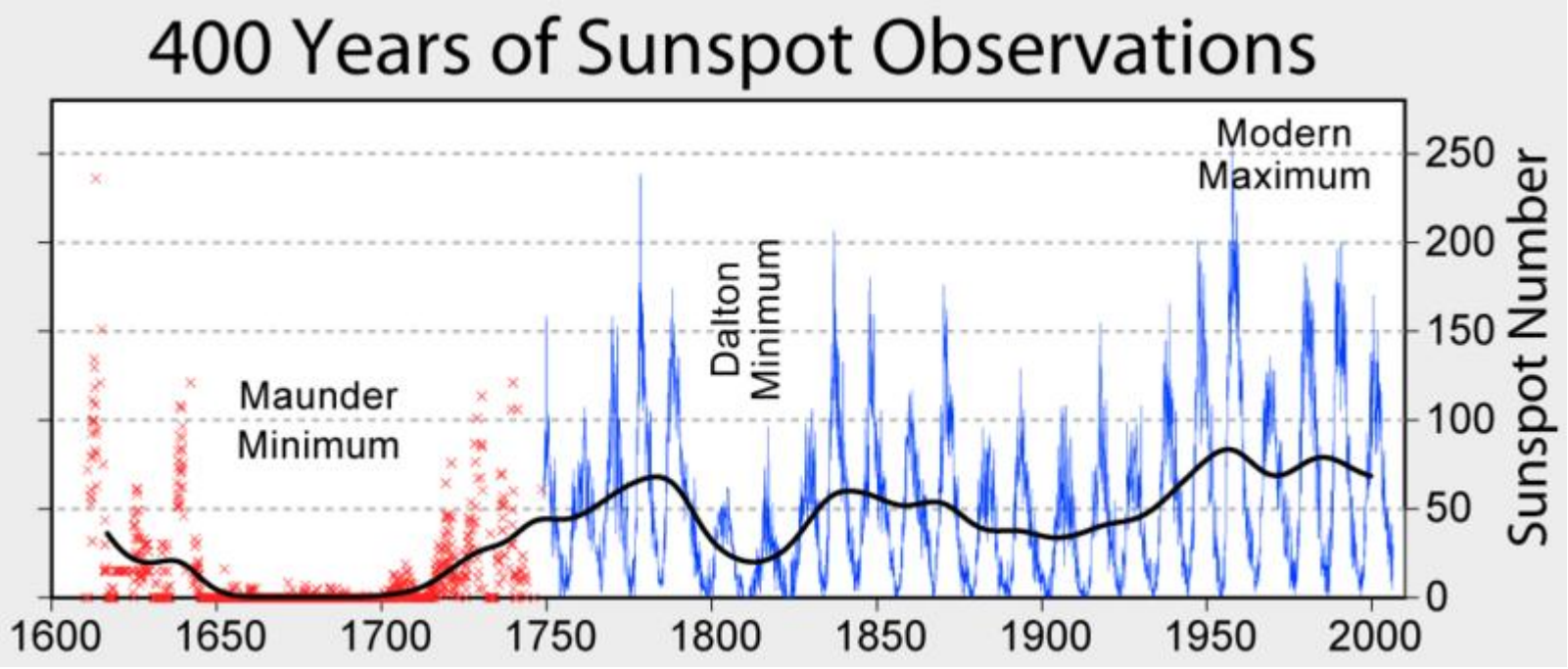


Aurora

[米戸 2007] © AstroArts Inc.

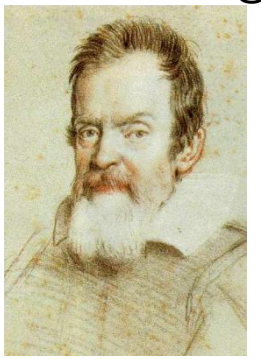
Black spots show how intensive solar activities are.

Records of Black Spots



©Global Warming Art

Black Spots have been observed since Galileo Galilei(1609~)



Galileo Galilei. Biblioteca Marucelliana所蔵

How to Survey Pre-modern Solar Activities

- 放射性同位元素の変動

: 屋久杉年輪/Tree-ring Chronology

ex. [Miyake 2012] indicates an astronomical event in 775

: 南極氷床コア/Ice Core from Antarctica

・From Historical Documents

: Chinese chronicles include long-term information;

BC3c.～AD17c.

Example of C14 Surveys

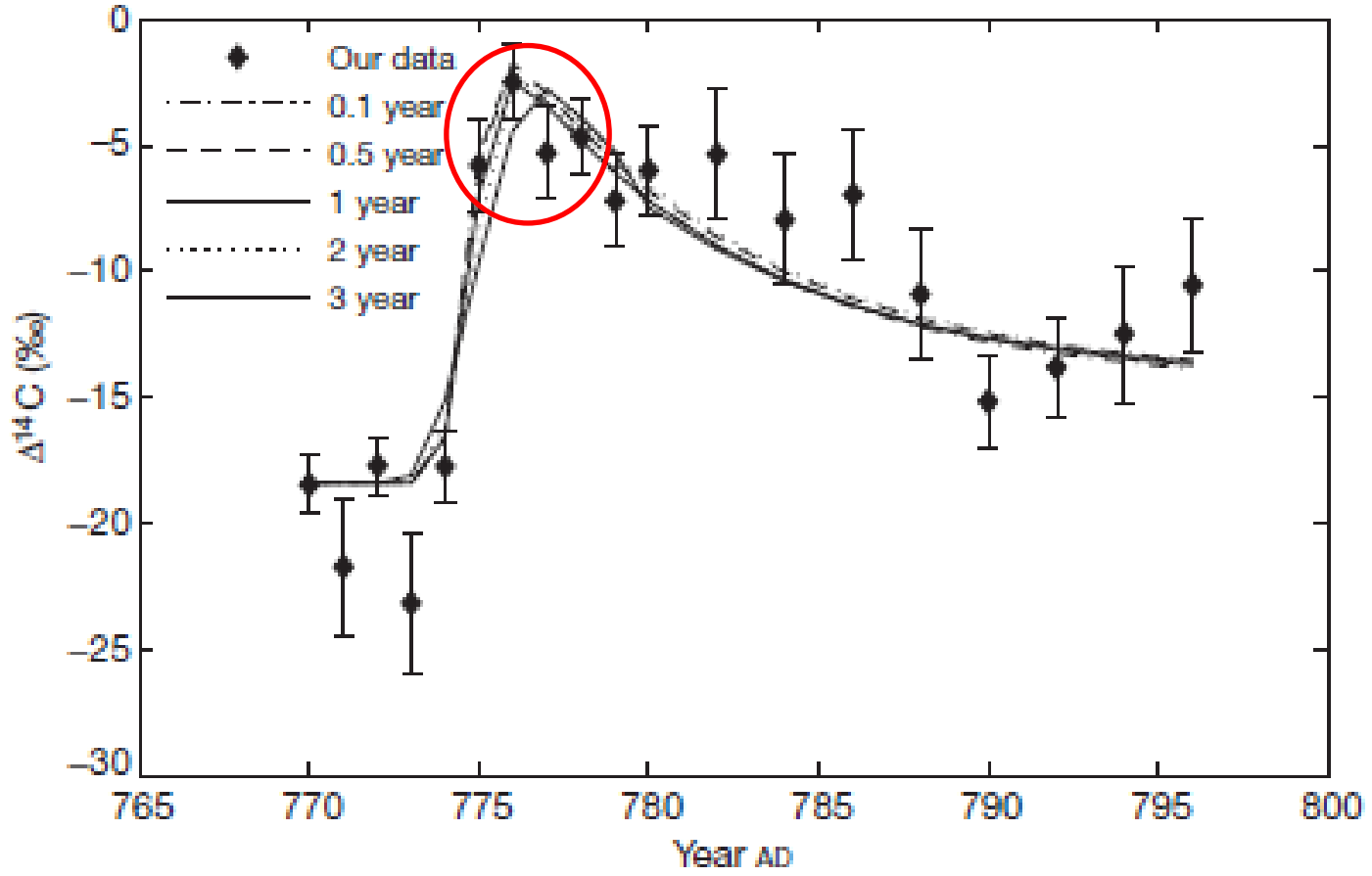


Figure 2 | Comparison of our data with a four-box carbon cycle simulation.

775年の天文イベント ©[Miyake 2012]

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Previous Studies: in JAPAN

- [Kanda 1933]
- introduced partial records of aurorae
- Historical terms for aurorae

: 赤気/Red Vapor

: 白気/White Vapor

: 虹/Rainbow



天文月報1933年11月号、神田茂「本邦における極光の記録」

Previous Research: ARABIC Countries

- [Basurah 2006]
- Introduced Arabic descriptions for aurorae
- 9～16c.
- Observed in South Mediterranean Countries
- Aurorae had been observed even in Cairo(N30)

Table 2
Characteristics of Auroras, dates, country, category and Arabic reference as listed at Table 3. The category classifications as DA (definite sighting of aurora), SA (suspected aurora, and AP (atmospheric phenomena)

Event No.	Descriptions	Date AD	Country	Category	Ref.
1	On Friday night, a reddish glow appeared in the sky and stayed until late at night. Later on it disappeared but two red columns remained until the dawn.	29 October 817	Iraq	DA	1
2	On Friday, at night 21 Safar there was in the sky an intense red glow. It started from the beginning of the night until the end. We have never seen such a thing before.	11 October 879	Morocco	DA	2
3	A huge red glow appeared in the atmosphere in Egypt. It was so red that when a man looks at another man's face he sees it red so is the walls.	7 May–4 June 897	Egypt	AP	3, 4 and 6
4	On Wednesday night, an intense red glow appeared in the city of Al-Salam (Baghdad) toward Makkah (South-West). Nothing like it has ever been seen before.	9 November 931	Iraq	AP	1
5	On the first night of year 328H (Hijri, Islamic Calendar), an intense red glow appeared in the atmosphere coming from North and West. It has great and numerous white pillars.	17 October 939	Syria	DA	5 and 6
6	Two hours after sunset on Thursday night a reddish glowing appeared on the horizon as an inferno way up in the sky emitting intense rays reflected on the palm trees and on tall buildings. People mistakenly thought it was the Sunrays at sunrise. The inferno decreased to one third just before daybreak and faded gradually up to afternoon, and on the west two firing arcs appeared at the horizon.	6 May 941	Spain	DA	7

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Historical Documents in China

- 二十五史: Chronicles in Chinese Dynasties
- BC206~

- Observed by specialists.
- Continuous observations are available.
- Observatories can easily be identified.
- Observation dates/times are precisely recorded.
- Directions, moves, colors are recorded.
- More objective than in Europe

[Keimatsu 1970-1976]

- Descriptions of aurorae and black spots are shown.
- Original texts, translations, and tables are given

:BC7c.~1130

- As the author has passed away
- 1130～17c.; Only tables are available.
- All the “luminous phenomena” are picked up.

  →Considerable other phenomena are included.
- Not few records go amiss.

[Saito 1992]

- All kinds of astronomical phenomena are recorded between BC7c.～960
- Has put astronomical analysis on eclipses.
- A milestone for historical astronomy
- With Original texts, without translations.
- Written in Japanese and not well-known.
- A part of records go amiss.

Recent Developments

- Chinese documents have gotten degitilized and published in 台湾中央研究院 since 1984:「新漢籍全文」



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Aurorae Recorded

- Recorded as 白気, 赤気, 青気, 黄気
- Colors can be derived from 陰陽五行説
- （ex. 776年1月12日 ）

:「大暦十年十二月丙子, 月出東方, 上有白氣十餘道, 如匹練, 貫五車及畢、觜觿、參、東井、輿鬼、柳、軒轅, 中夜散去」(新唐書天文志二836)

Related with a solar event in 775 [Cliver 2014]

陰陽五行説


「水」
1.黒 2.冬(玄冬)
3.北(玄武) 4.腎
「金」
1.白
2.秋(白秋)
3.西(白虎)
4.肺
「土」
1.黄
2.土用
3.中央(黄龍)
4.脾
「木」
1.青
2.春(青春)
3.東(青龍)
4.肝
「火」
1.赤 2.夏(朱夏)
3.南(朱雀) 4.心
1.色彩(五色)
2.季節(五時)
3.方位(五方)
4.臓器(五臓)

白気 and 赤気

白気/White Vapor？



[米戸 2007] © AstroArts Inc.

赤気/Red Vapor？



©NASA's Goddard Space Flight Center
October 24, 2011

Dubious words for Aurorae

- [Keimatsu 1969a-b] indicates some words;
- 流星/falling stars : 746 cases
- 天狗/celestial dogs : 114 cases
- 五色雲/rainbow clouds : 86 cases
- 虹/rainbows : 706 cases
- I am examining them one by one right now.

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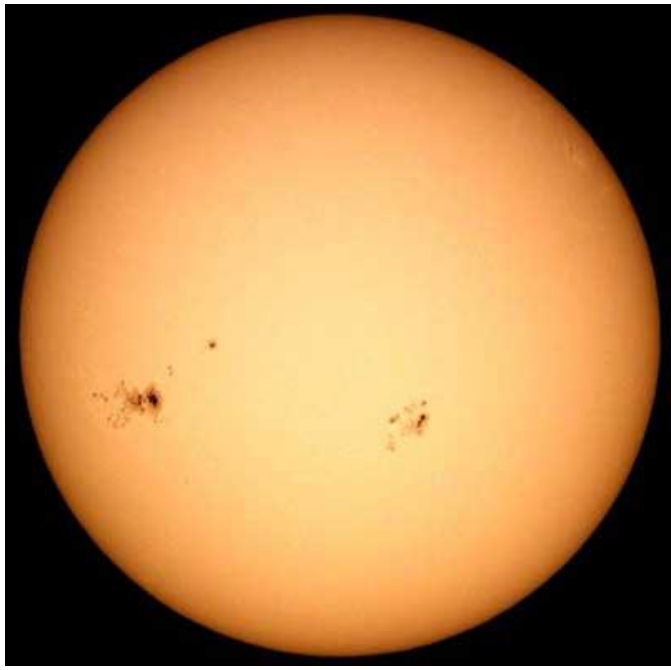
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Black Spots Recorded

- 黒子/Black Spot, 黒気/Black Vapor in the sun
- As large as…桃/peach, 李/plum, 盃/glass, 鶏卵/hen's egg, 鴨卵/duck's egg

- (ex. 355年4月4日)

:「永和十一年三月戊申，日中有黒子，大如桃，二枚」(晋書志第二 天文中344)



肉眼黒点
2000.9.21
©AstroArts

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Picks of this Survey

- Data between BC3～AD17c. are searched systematically by 新漢籍全文
- Only certain words have gotten picked up

- Aurorae: 429 cases

: 白気(247 cases/58%), 赤気(155 cases/36%), 黄気(24 cases/5%), 青気(3 cases/1%),

- Black spots: 146 cases
- Most frequent in 4c. and 12c.

Long-term Change of C14

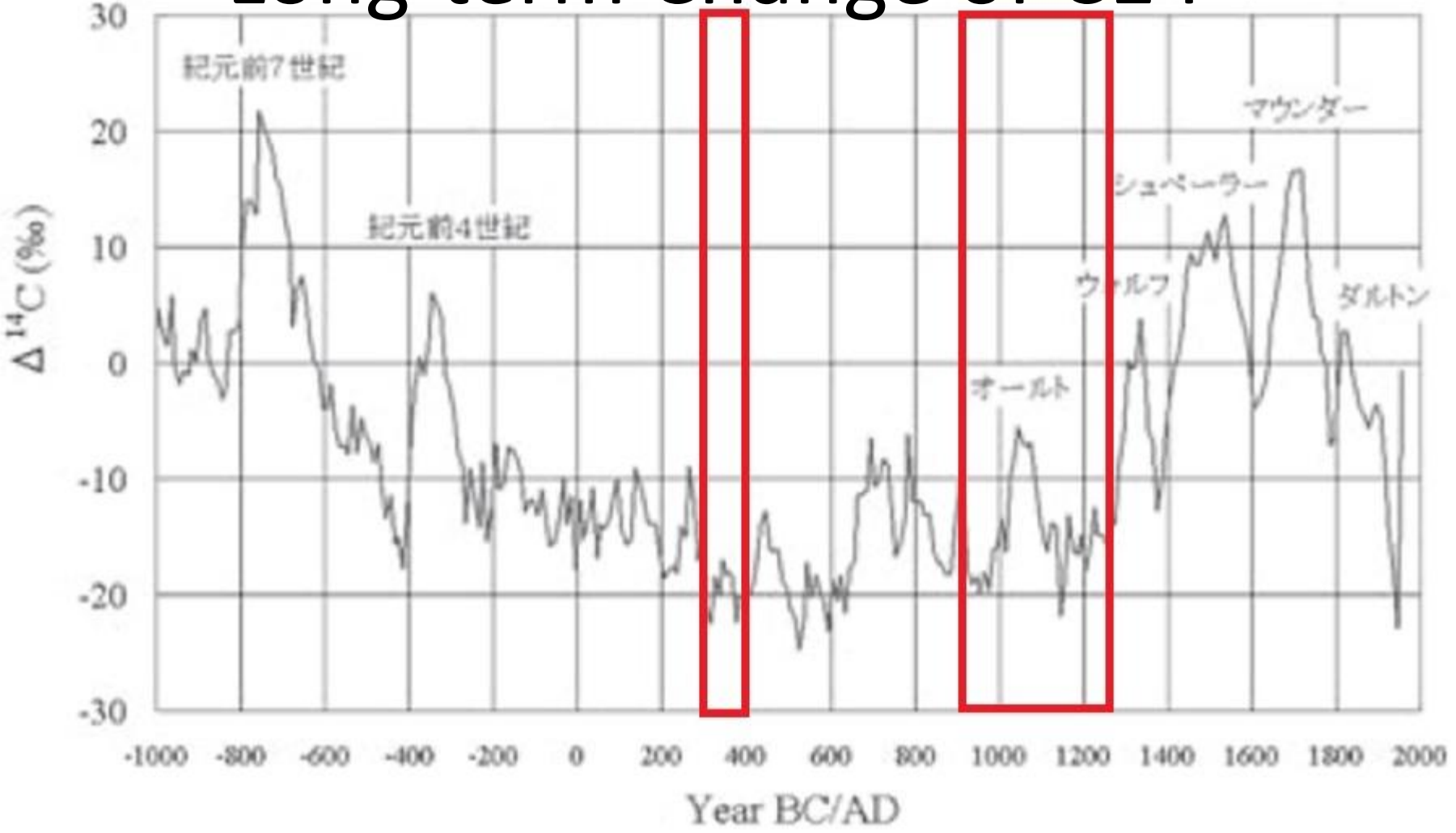
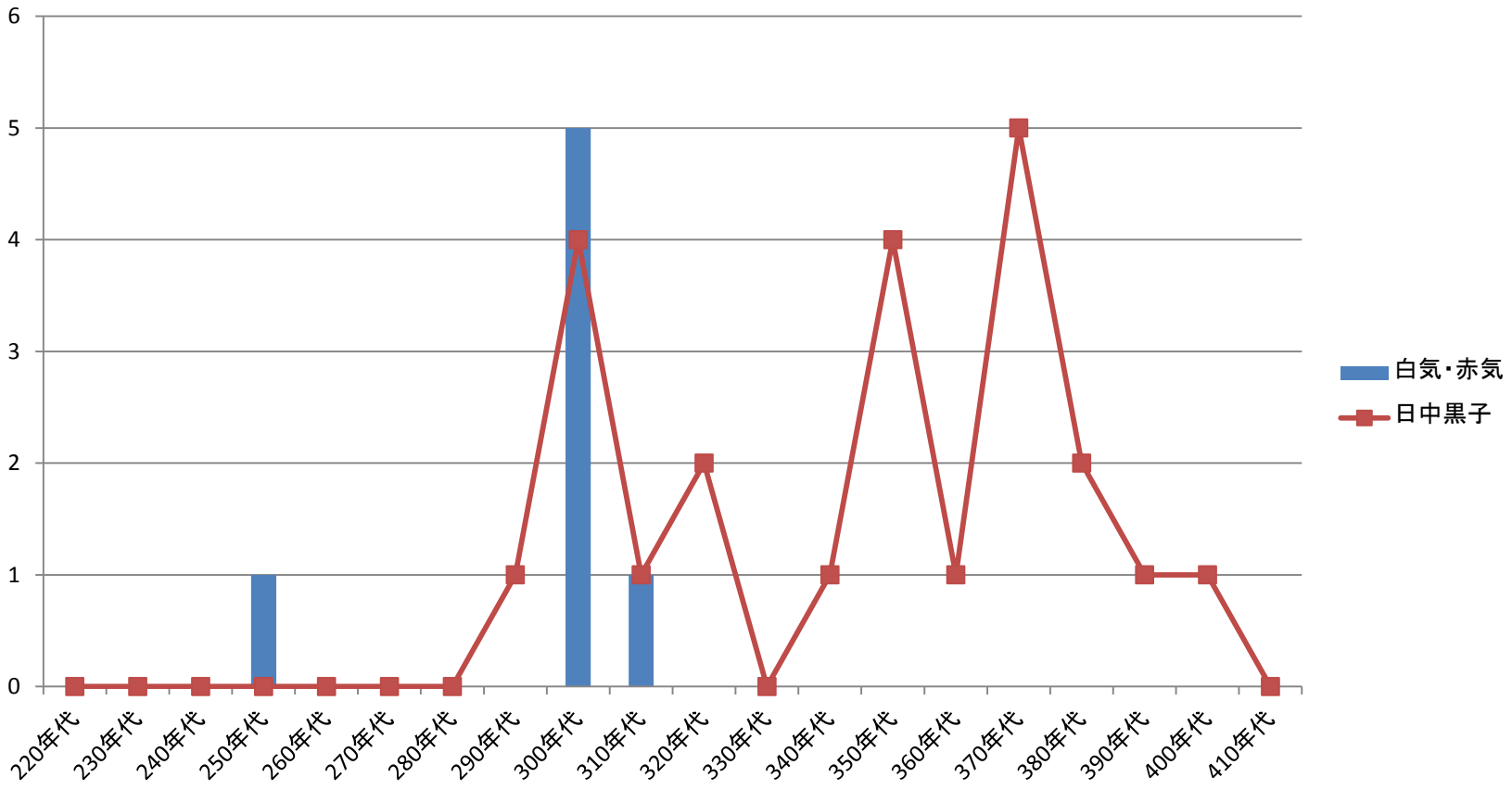


図 2　過去 3,000 年の ^{14}C 濃度変動（IntCal データ[3]）

^{14}C 濃度のピークに対応する太陽活動極小期の名前を付してある

©[Masuda 2012]に早川加筆

Solar Activities in 晋書(220-420)

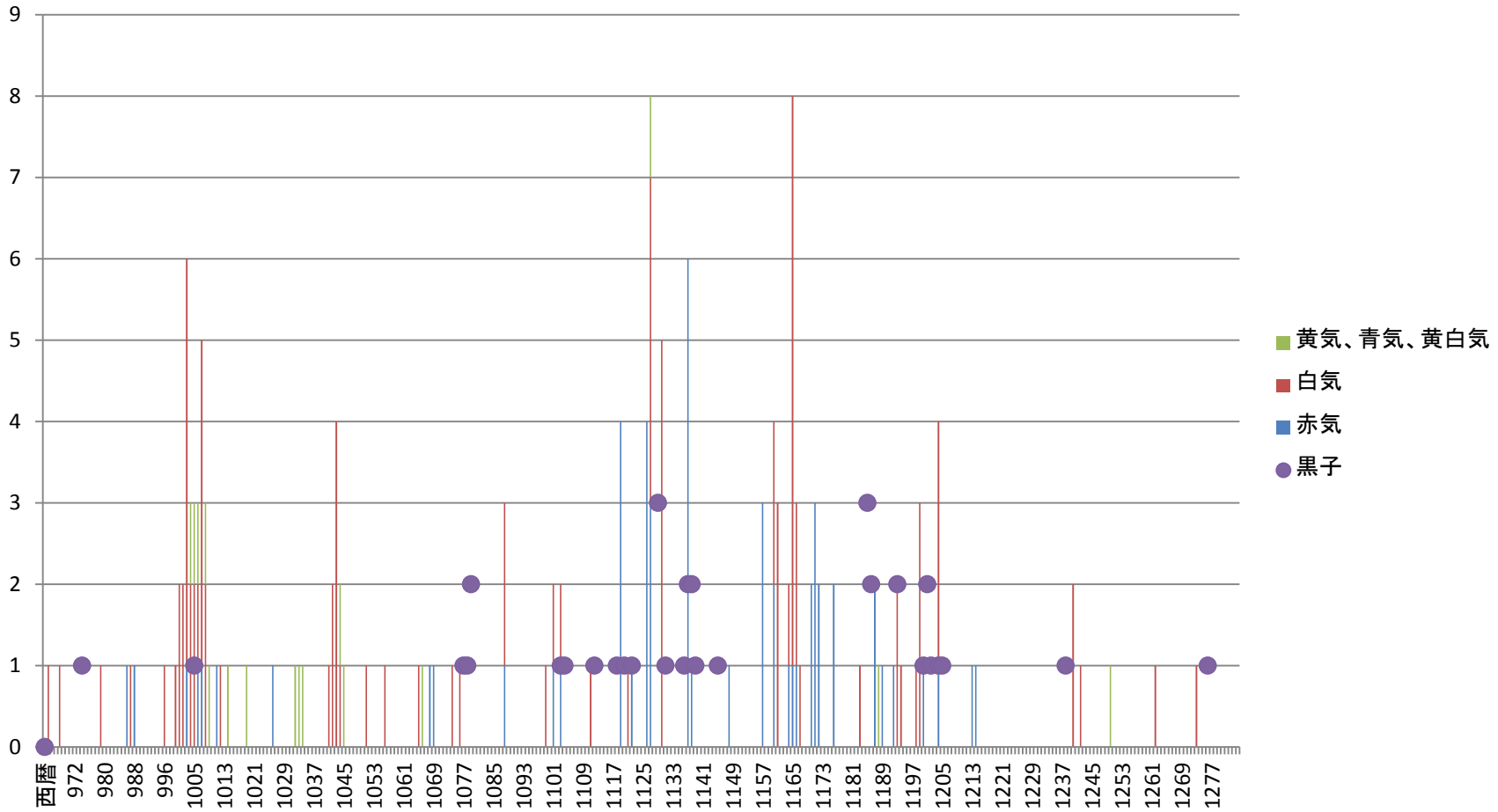


晋書の記述に基づき早川作成

Medieval Warm Period: MWP

- 10～14c.
- It was warm at least in Europe in this period.
- Still under discussion about the other area.
- Correlative with Medieval Maximum(1100-1250) in solar activities ?

Solar Activities in 宋史(960～1278)



宋史の記述に基づき、玉澤・早川が作成

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Summary and Future Work

- Records of “low altitude aurorae” and “visible sun spots” have gotten researched from historical documents to show how intensive solar activities.
- Significant peaks are found in 4c. and 12c.
- Correlevant to results of C14 isotope analysis
- Possibility to find out more about long-term change and extreme astronomical weather
- Under comparison with astronomical data

Reference

文献表

Basurah, H, M., Records of aurora in the Islamic chronicles during 9th–16th centuries, Journal of Atmospheric and Solar-Terrestrial Physics 68, 937–941, 2006.

Basurah, H, M., Auroras in Arabian Peninsula, JKAU: Sci., 22, 2, 195-200, 2010.

Cliver, E. W., On a solar originfor the cosmogenic nuclideevent of 775 AD, The Astronomical Journal, 781:32, 1-4, 2014.

Fritz, H., Verzeichniss Beobachteter Polarlichter. C. Gerold's & Sohn, Wien. 1873.

Keimatsu, M., A chronology of aurorae and sunspots observed in China, Korea and Japan, I, Ann. Sci. Kanazawa Univ., 7, 1-10, 1970.

Keimatsu, M., A chronology of aurorae and sunspots observed in China, Korea and Japan, II, AD 1-3 century, Ann. Sci. Kanazawa Univ., 8, 1-16, 1971.

Keimatsu, M., A chronology of aurorae and sunspots observed in China, Korea and Japan, III, 3-5 century, Ann. Sci. Kanazawa Univ., 9, 1-36, 1972.

Keimatsu, M., A chronology of aurorae and sunspots observed in China, Korea and Japan, IV, 6-8 century, Ann. Sci. Kanazawa Univ., 10, 1-32, 1973.

Keimatsu, M., A chronology of aurorae and sunspots observed in China, Korea and Japan, V, AD 801-1000, Ann. Sci. Kanazawa Univ., 11, 1-36, 1974.

Keimatsu, M., A chronology of aurorae and sunspots observed in China, Korea and Japan, VI, AD 1001-1130, Ann. Sci. Kanazawa Univ., 12, 1-40, 1975.

Keimatsu, M., A chronology of aurorae and sunspots observed in China, Korea and Japan, VII, A brief summary of the records from BC 687 to AD 1600, Ann. Sci. Kanazawa Univ., 13, 1-32, 1976.

Lee, E.H., The sunspot and auroral activity cycle derived from Korean historical records of the 11th–18th century. First International Symposium on Space Climate: Direct and Indirect Observations of Long-Term Solar Activity, Oulu, Finland., 2004.

Link, F., Obsevations et catalogue des auroras borealis apparentes en occident de 626 a 1600. Geofizicheskii Sbornik 10, 297–392, 1962.

Yau, K. K. C.; Stephenson, F. R.; Willis, D. M.. A catalogue of auroral observations from China, Korea and Japan (193 B.C. - A.D. 1770)., by Rutherford Appleton Lab., Chilton (UK), 1995.

Yau, K.K.C., Stephenson, F.R., A revised catalogue of Far Eastern observations of sunspots (165 BC to AD 1918).Quarterly Journal of Royal Astronomical Society 29, 175–197., 1988.

斉藤国治，小沢賢二（1992）『中国古代の天文記録の検証』雄山閣出版

- Thank you for your attention.
- 御清聴ありがとうございました。