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Introduction

It is well known that the climate was warmer corresponding with "Medieval climate anomaly (MCA)" or "Medieval warm period (MWP)" in Europe from 9th to 12th centuries. In Japan, Maejima and Tagami (1986) clarified that the 7th to 9th centuries were cool period and the 10th to 14th centuries were warm period, by analyzing the historical records such as "*Nihonkishoshiryo*". In addition, Aono (2013) stated that the period from early to middle in 10th centuries was as warm as the present basing on the records of cherry blossoming. Furthermore, Yoshino (2009) argued that the warm period with various scale of fluctuations continued from the 4th to 10th centuries. According to Kitagawa and Matsumoto (1998) analyzed carbon isotope variations in tree rings of *Yakusugi* cedars, the estimated temperature deviations from 8th to 12th centuries were 1.0℃ higher than the average during the last 2,000 years. However Maejima and Tagami (1986) pointed out three problems about reconstructions of the paleoclimate from historical documents as follows; (1) They reflect only local climate, (2) They do not indicate air stream or circulation conditions in most cases, but hygro-thermal conditions and (3) They are fragmental in space and time.

The purpose of this study is clarify the species and regional changes of climatic disasters from 7th to 12th centuries.

Study method

The descriptions of climatic disasters from the ancient times have been found in the historical documents, such as "*Nihonshoki*", "*Fusoryakuki*", "*Nihon-sandai-jitsuroku*" and the like. These descriptions have been kept in the meteorological archives.At first, the authors collected the data and construct a chronology of climatic disasters from 7th to 12th centuries from as follows meteorological archives : (1) "*Nihon no kishoshiryo* (The Central Meteorological Observatory and The Imperial Marine Observatory 1976)", (2) "*Nihon kanbatsu rin-u shiryo* (Arakawa, et al 1964)", (3) "*Nihon no tensai chihen* (The Civic Section of Tokyo Metropolitan Government 1976)", (4) "*Naraken kishosaigaishi* (Aoki 1956)" and (5) "*Kyoto kishosaigainempyo* (Kyoto Local Meteorological Office 1951)".

Secondly, these data are classified according to species and region of climatic disasters. Namely, they are grouped into 9 categories according to their species: (1) storms, (2) floods, (3) long rains, (4) thunder storms, (5) whirlwinds, (6) droughts, (7) hail storms, (8) heavy snows and (9) frosts. In these climatic disasters, the cases of storms, floods, long rains and thunder storms may be difficult to distinguish from each other because storms and long rains could have been accompanied with floods. In this paper, we classified these data basing on the way of "*Nihonkishoshiryo*" [i]. On the place names where occurred climatic disasters, the old place names are arranged into 6 categories as follows:

(1) "Nara" includes its old names "Yamatokoku" and "Yamato".

(2) "Kyoto" includes its old names "Yamashiro-koku" and "Yamashiro".

(3) "Kinki district" includes "Kinai" and "Kinki-shokoku", but excludes the cases classified as (1) or (2). It means that climatic disasters occurred in Kyoto, Nara and neighboring area simultaneously.

(4) "All provinces" includes "Shokoku" and "Zenkoku", but excludes the cases classified as (1), (2) or (3).

(5) Description excludes the above place names, being classify into "the others".

(6) Nameless places are grouped into "Unknown".

If the kinds, place names and dates of climatic disasters obtained from some of five archives are same, the authors counted as one disaster.

Results

Features of climatic disasters from 7th to 12th centuries

The authors describe 1,220 climatic disasters and 1,281 place names in this study.

Figure 1 shows the secular change of climatic disasters compared with the estimated temperature deviations reconstructed from tree ring analysis by Kitagawa and Matsumoto (1998) based on every decade. As shown in Figure 1, the fluctuations of the number of climatic disasters are in parallel approximately with the estimated temperature deviations. That is, climatic disasters tend to increase when estimated temperature deviations are greater. Especially, two peaks of the number of climatic disasters are found. They are the periods from the latter half of the 9th century and the first half of the 11th century simultaneously with rises in temperature. Around the middle of 11th century, there was a significant decrease in number of climatic disasters. The correlation coefficient between the number of climatic disasters and the estimated temperature deviations is 0.35, which is a positive correlation at significant level of 5%.

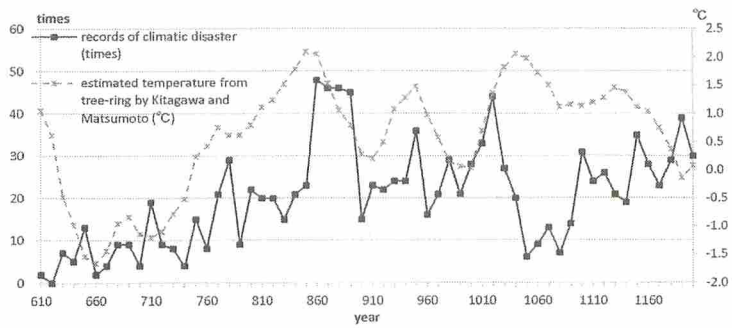

Figure 1. The secular changes of estimated temperature deviations by Kitagawa and Matsumoto (1998) and climatic disasters from 7th to 12th centuries.

* On this estimated temperature deviations, the authors read the data from the figure on the tree-ring analysis of carbon isotope by Kitagawa and Matsumoto (1998) and calculated five decadal moving averages of the estimated temperature deviations in order to smooth out the fluctuation of temperature deviations.

The species and spatial changes of climatic disasters from 7th to 12th centuries and their secular change

Table.1and Figures 2-(a) and 2-(b) show the classifications of climatic disasters by their species and spaces.

On the whole of climatic disasters from 7th to 12th centuries, the most common climatic disaster is storm (26.1%), next is drought (19.8%) and third is thunder storm (18.9%). The disasters caused by heavy rain such as storms, floods and long rains occupy about half of them. The most common area is Kyoto making up 48.3%. The second is Nara 7.9% and third is the Kinki district 4.1%. Some of the other place names and its percentages are Ise 3.8%, Kamakura 0.7%, Kii 0.5%, Omi 0.5%, Kawachi 0.5% and Kyushu district 0.5%.

Figure 3-(a) shows secular changes of percentages (%) of climatic disasters. Droughts account for the greatest percentage before 8th century and since then they decrease gradually with more or less fluctuations. Conversely, disasters caused by heavy rain represent the majority of disasters after 9th century. As shown in this Figure 3-(b), the percentage of disasters is remarkable covered by Nara until the latter half of 8th century. On the contrary, Kyoto occupies half of them, whereas historical description in Nara nearly vanished from the 9th century because historical descriptions concentrate into capital city of the times. From this analysis we can conclude that there were frequent droughts and descriptions of climatic disasters in Nara before 9th century while there were more disasters caused by much rain and descriptions of climatic disasters in Kyoto from 9th to 12th centuries.

Figure 4 shows that the percentages of climatic disasters from 7th to 12th centuries in Nara, compared with Kyoto. Droughts in Nara makes up 23.8%, in contrast to Kyoto which shows only 7.4%. On the contrary, about the floods, Kyoto shows about 10% higher than Nara. Especially, climatic disasters relative to rainfall are more than 70% in Kyoto.

The Nara and Kyoto basins belong to the Setouchi climate that has relatively less of rain in Japan. Nevertheless, in Nara a lot of irrigation ponds were built due to frequently occurring droughts from the ancient times and there were more than ten thousand irrigation ponds. Moreover, a number of hidden wells were constructed at rice fields in addition to irrigation ponds (Aoki 1961; Nara Local Meteorological Office 1997; Nara Prefecture 2014). Meanwhile, some significant proverbs meaning that Nara had a distressing lack of water remain such as "*Yamato Hideri* (weather in Nara is dry)", "*Yamato Honen Komekuwazu*" which means that it rains properly to fruitful harvest in Nara while poor harvest in other areas caused by much rains. It is also said that droughts in Nara have been fateful events since the dawn of history (Tsujita 1961) and it has brought civilizations of poor water supply to the people in Nara as mentioned above. On the contrary, the Kyoto basin had been frequently tormented with floods by heavy rains from 9th century in spite of belonging to the Setouchi climate same as the Nara basin. As another factor such as the concentration of rivers, it is assumed that the flood disasters in Kyoto are brought about by like the Kamogawa, Katsuragawa and other rivers. As a matter of fact, the people of Kyoto have suffered Kamogawa River floods frequently since 8th century (Katahira 2012). In addition, Kyoto is the so-called "metropolis of water" which means that plenty water has brought about cultures as tea, sake, tofu, dyeing and so on (Suzuki 2003, 2010, Kappa Research Group 2013).

Marumoto (2014) calculated the P.E. (potential evapo-transpirations) and water budgets in Nara and Kyoto by Thornthwaite's method and confirmed that the water deficit in Nara is more than Kyoto and vice versa on water surplus. From this result, it can be said that the droughts occurred more frequently in Nara due to water deficit while the floods occurred more often due to water surplus in Kyoto.

Table.1 Contents of climatic disasters and their percentages from A.D.601 to A.D.1200

	Storms	Floods	Long rains	Thunder storms	Whirl -winds	Droughts	Hail storms	Heavy snows	Frosts	total
601～610	0 (0.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (100.0)
611～620	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
621～630	0 (0.0)	1 (14.3)	1 (14.3)	0 (0.0)	0 (0.0)	2 (28.6)	2 (28.6)	0 0.0	1 (14.3)	7 (100.0)
631～640	2 (40.0)	1 (20.0)	1 (20.0)	0 (0.0)	0 (0.0)	1 (20.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (100.0)
641～650	2 (15.4)	1 (7.7)	1 (7.7)	1 (7.7)	0 (0.0)	1 (7.7)	6 (46.2)	0 (0.0)	1 (7.7)	13 (100.0)
651～660	0 (0.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (100.0)
661～670	0 (0.0)	1 (25.0)	0 (0.0)	2 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (25.0)	0 (0.0)	4 (100.0)
671～680	3 (33.3)	1 (11.1)	0 (0.0)	0 (0.0)	0 (0.0)	4 (44.4)	1 (11.1)	0 (0.0)	0 (0.0)	9 (100.0)
681～690	2 (22.2)	0 (0.0)	0 (0.0)	1 (11.1)	0 (0.0)	6 (66.7)	0 (0.0)	0 (0.0)	0 (0.0)	9 (100.0)
691～700	1 (25.0)	2 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (25.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (100.0)
701～710	7 (36.8)	0 (0.0)	3 (15.8)	2 (10.5)	0 (0.0)	7 (36.8)	0 (0.0)	0 (0.0)	0 (0.0)	19 (100.0)
711～720	5 (55.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (44.4)	0 (0.0)	0 (0.0)	0 (0.0)	9 (100.0)
721～730	1 (12.5)	2 (25.0)	0 (0.0)	3 (37.5)	1 (12.5)	1 (12.5)	0 (0.0)	0 (0.0)	0 (0.0)	8 (100.0)
731～740	1 (25.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (75.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (100.0)
741～750	3 (20.0)	1 (6.7)	1 (6.7)	3 (20.0)	0 0.0	6 (40.0)	1 (6.7)	0 0.0	0 0.0	15 (100.0)
751～760	5 (62.5)	0 (0.0)	0 (0.0)	0 (0.0)	1 (12.5)	0 (0.0)	0 (0.0)	2 (25.0)	0 (0.0)	8 (100.0)
761～770	4 (19.0)	4 (19.0)	1 (4.8)	1 (4.8)	0 (0.0)	10 (47.6)	1 (4.8)	0 (0.0)	0 (0.0)	21 (100.0)
771～780	11 (37.9)	3 (10.3)	1 (3.4)	6 (20.7)	0 (0.0)	6 (20.7)	2 (6.9)	0 (0.0)	0 (0.0)	29 (100.0)
781～790	2 (22.2)	2 (22.2)	0 (0.0)	2 (22.2)	0 (0.0)	3 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)	9 (100.0)
791～800	4 (18.2)	5 (22.7)	1 (4.5)	3 (13.6)	0 (0.0)	3 (13.6)	2 (9.1)	4 (18.2)	0 (0.0)	22 (100.0)
801～810	5 (25.0)	3 (15.0)	4 (20.0)	0 (0.0)	0 (0.0)	5 (25.0)	2 (10.0)	1 (5.0)	0 (0.0)	20 (100.0)
811～820	2 (10.0)	2 (10.0)	2 (10.0)	1 (5.0)	1 (5.0)	7 (35.0)	1 (5.0)	4 (20.0)	0 (0.0)	20 (100.0)
821～830	1 (6.7)	2 (13.3)	3 (20.0)	3 (20.0)	0 (0.0)	5 (33.3)	0 (0.0)	1 (6.7)	0 (0.0)	15 (100.0)
831～840	7 (33.3)	2 (9.5)	1 (4.8)	4 (19.0)	1 (4.8)	6 (28.6)	0 (0.0)	0 (0.0)	0 (0.0)	21 (100.0)
841～850	3 (13.0)	5 (21.7)	2 (8.7)	4 (17.4)	1 (4.3)	3 (13.0)	1 (4.3)	3 (13.0)	1 (4.3)	23 (100.0)
851～860	14 (29.2)	11 (22.9)	1 (2.1)	10 (20.8)	1 (2.1)	3 (6.3)	2 (4.2)	3 (6.3)	3 (6.3)	48 (100.0)
861～870	13 (28.3)	3 (6.5)	9 (19.6)	7 (15.2)	0 (0.0)	8 (17.4)	1 (2.2)	1 (2.2)	4 (8.7)	46 (100.0)
871～880	5 (10.9)	3 (6.5)	7 (15.2)	14 (30.4)	3 (6.5)	7 (15.2)	1 (2.2)	5 (10.9)	1 (2.2)	46 (100.0)
881～890	6 (13.3)	4 (8.9)	9 (20.0)	15 (33.3)	3 (6.7)	2 (4.4)	0 0.0	4 (8.9)	2 (4.4)	45 (100.0)
891～900	3 (20.0)	4 (26.7)	1 (6.7)	1 (6.7)	1 (6.7)	3 (20.0)	0 (0.0)	2 (13.3)	0 (0.0)	15 (100.0)

	Storms	Floods	Long rains	Thunder storms	Whirl -winds	Droughts	Hail storms	Heavy snows	Frosts	total
901～910	4 (17.4)	3 (13.0)	5 (21.7)	4 (17.4)	0 (0.0)	7 (30.4)	0 (0.0)	0 (0.0)	0 (0.0)	23.0 (100.0)
911～920	6 (27.3)	2 (9.1)	2 (9.1)	2 (9.1)	0 (0.0)	7 (31.8)	3 (13.6)	0 (0.0)	0 (0.0)	22 (100.0)
921～930	5 (20.8)	5 (20.8)	2 (8.3)	4 (16.7)	1 (4.2)	6 (25.0)	0 (0.0)	1 (4.2)	0 (0.0)	24 (100.0)
931～940	4 (16.7)	2 (8.3)	3 (12.5)	6 (25.0)	1 (4.2)	5 (20.8)	0 (0.0)	2 (8.3)	1 (4.2)	24 (100.0)
941～950	8 (22.2)	3 (8.3)	10 (27.8)	4 (11.1)	0 (0.0)	8 (22.2)	0 (0.0)	2 (5.6)	1 (2.8)	36 (100.0)
951～960	4 (25.0)	1 (6.3)	2 (12.5)	2 (12.5)	0 (0.0)	6 (37.5)	0 (0.0)	0 (0.0)	1 (6.3)	16 (100.0)
961～970	4 (19.0)	6 (28.6)	5 (23.8)	3 (14.3)	0 (0.0)	3 (14.3)	0 (0.0)	0 (0.0)	0 (0.0)	21 (100.0)
971～980	7 (24.1)	3 (10.3)	3 (10.3)	6 (20.7)	0 (0.0)	4 (13.8)	4 (13.8)	2 (6.9)	0 (0.0)	29 (100.0)
981～990	8 (38.1)	1 (4.8)	3 (14.3)	2 (9.5)	0 (0.0)	6 (28.6)	1 (4.8)	0 (0.0)	0 (0.0)	21 (100.0)
991～1000	6 (21.4)	4 (14.3)	3 (10.7)	7 (25.0)	0 (0.0)	6 (21.4)	1 (3.6)	1 (3.6)	0 (0.0)	28 (100.0)
1001～1010	7 (21.2)	2 (6.1)	7 (21.2)	12 (36.4)	1 (3.0)	4 (12.1)	0 (0.0)	0 (0.0)	0 (0.0)	33 (100.0)
1011～1020	19 (43.2)	2 (4.5)	2 (4.5)	16 (36.4)	0 (0.0)	3 (6.8)	1 (2.3)	1 (2.3)	0 (0.0)	44 (100.0)
1021～1030	11 (40.7)	3 (11.1)	2 (7.4)	4 (14.8)	0 (0.0)	5 (18.5)	1 (3.7)	1 (3.7)	0 (0.0)	27 (100.0)
1031～1040	5 (25.0)	3 (15.0)	2 (10.0)	3 (15.0)	0 (0.0)	6 (30.0)	0 (0.0)	1 (5.0)	0 (0.0)	20 (100.0)
1041～1050	1 (16.7)	2 (33.3)	0 0.0	0 0.0	0 0.0	3 (50.0)	0 0.0	0 0.0	0 0.0	6 (100.0)
1051～1060	3 (33.3)	2 (22.2)	1 (11.1)	2 (22.2)	0 (0.0)	1 (11.1)	0 (0.0)	0 (0.0)	0 (0.0)	9 (100.0)
1061～1070	3 (23.1)	1 (7.7)	1 (7.7)	2 (15.4)	0 (0.0)	5 (38.5)	1 (7.7)	0 (0.0)	0 (0.0)	13 (100.0)
1071～1080	0 0.0	4 (57.1)	0 (0.0)	1 (14.3)	0 (0.0)	1 (14.3)	1 (14.3)	0 (0.0)	0 (0.0)	7 (100.0)
1081～1090	4 (28.6)	2 (14.3)	0 (0.0)	3 (21.4)	0 (0.0)	5 (35.7)	0 (0.0)	0 (0.0)	0 (0.0)	14 (100.0)
1091～1100	11 (35.5)	6 (19.4)	3 (9.7)	3 (9.7)	0 (0.0)	6 (19.4)	0 (0.0)	2 (6.5)	0 (0.0)	31 (100.0)
1101～1110	5 (20.8)	1 (4.2)	4 (16.7)	8 (33.3)	0 (0.0)	3 (12.5)	2 (8.3)	1 (4.2)	0 (0.0)	24 (100.0)
1111～1120	9 (34.6)	4 (15.4)	1 (3.8)	5 (19.2)	0 (0.0)	4 (15.4)	2 (7.7)	0 (0.0)	1 (3.8)	26 (100.0)
1121～1130	7 (33.3)	6 (28.6)	1 (4.8)	3 (14.3)	0 (0.0)	2 (9.5)	2 (9.5)	0 (0.0)	0 (0.0)	21 (100.0)
1131～1140	6 (31.6)	4 (21.1)	2 (10.5)	5 (26.3)	0 (0.0)	1 (5.3)	1 (5.3)	0 (0.0)	0 (0.0)	19 (100.0)
1141～1150	14 (40.0)	8 (22.9)	0 (0.0)	8 (22.9)	4 (11.4)	0 (0.0)	1 (2.9)	0 (0.0)	0 (0.0)	35 (100.0)
1151～1160	14 (50.0)	4 (14.3)	1 (3.6)	5 (17.9)	0 (0.0)	4 (14.3)	0 (0.0)	0 (0.0)	0 (0.0)	28 (100.0)
1161～1170	6 (26.1)	2 (8.7)	3 (13.0)	2 (8.7)	0 (0.0)	7 (30.4)	2 (8.7)	1 (4.3)	0 (0.0)	23 (100.0)
1171～1180	7 (24.1)	6 (20.7)	0 (0.0)	7 (24.1)	4 (13.8)	5 (17.2)	0 (0.0)	0 (0.0)	0 (0.0)	29 (100.0)
1181～1190	11 (28.2)	6 (15.4)	3 (7.7)	11 (28.2)	0 (0.0)	6 (15.4)	1 (2.6)	1 (2.6)	0 (0.0)	39 (100.0)
1191～1200	8 (26.7)	6 (20.0)	2 (6.7)	8 (26.7)	0 (0.0)	4 (13.3)	0 (0.0)	2 (6.7)	0 (0.0)	30 (100.0)
Totals	319 (26.1)	169 (13.9)	122 (10.0)	231 (18.9)	24 (2.0)	242 (19.8)	47 (3.9)	49 (4.0)	17 (1.4)	1220 (100.0)

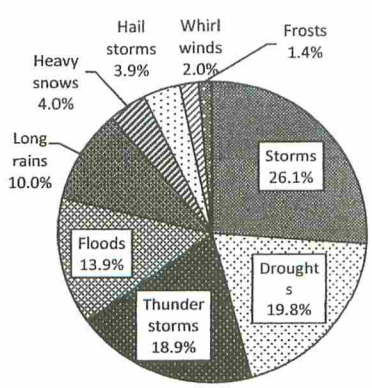

Figure 2-(a).
The ratio of contents of climatic disasters from 7th to 12th centuries

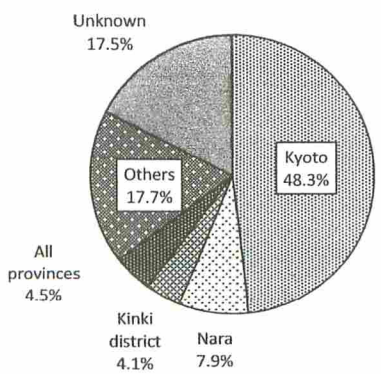

Figure 2-(b)
The ratio of place names of climatic disasters from7th to 12th centuries

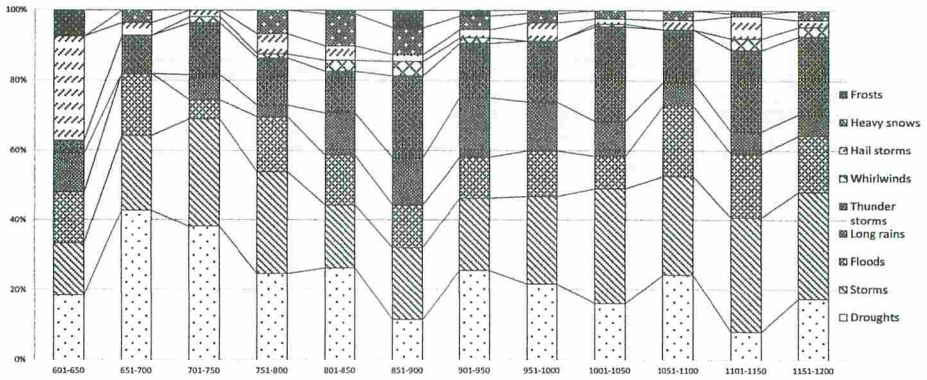

Figure 3-(a). The five decadal change of percentage on climatic disasters from7th to 12th centuries

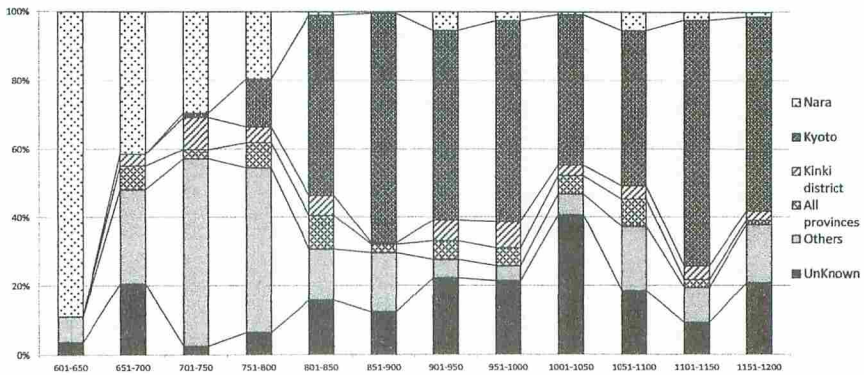

Figure 3-(b). The five decadal change of place names of climatic disasters from 7th to 12th centuries

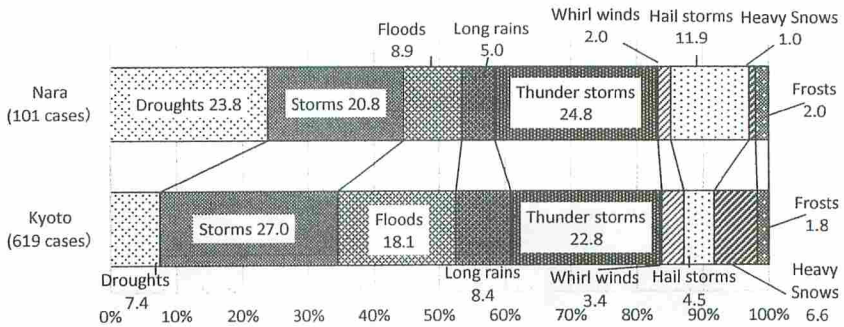

Figure 4. The percentages of climatic disasters from 7th to 12th centuries in Nara and Kyoto

Summary

In this study, the authors describe 1,220 climatic disasters and 1,281 its place names from 7th to 12th centuries. In consequence, the climatic disasters in Japan from 7th.to 12th centuries are characterized as follows. Climatic disasters increased during the latter half of the 9th and first half of the 11th centuries and

they tend to increase when estimated temperature deviations are greater. Droughts were the major climatic disasters before the 9th century while disasters caused by too much rain prevailed from the 9th century. But the regions of descriptions on climatic disasters clearly changed from Nara to Kyoto in the latter half of the 8th century. From these results, it is considered that the climatic disasters may have effects on the local climate.

References:

Aoki, S. 1956. *The history of climatic disasters in Nara (Naraken kishosaigaishi)*. Nara: Yotokusha. (J)

Aoki, S. 1961. Naraken ni okeru kiko to saigai, In *Nara Bonchi*, ed. Nara Women's University Department of Geography, 28-44. Tokyo: Kokon Shoin. (J)

Aono, Y. 2013. Climate reconstruction by using of cherry blossom phenological data in Kyoto. *The Historical Geography* 55(5):48-52. (JE)

Arakawa, H., Osumi, K. and Tamura, K. 1964. *Nihon kanbatsu rin-u shiryo*. Tokyo: Meteorological Research Institute. (J)

The Central Meteorological Observatory and The Imperial Marine Observatory. 1976. *Nihon no kishoshiryo (1)-(3)*. Tokyo: Hara Shobo. (J)

Kappa Research Group, 2013. *Kyoto water guide*. Kyoto: Kyotoshimbun shuppan center. (J)

Katahira, H. 2010. *Heiankyo no Saigai emaki —Mizu no shurai to hi no rensa —*. In *Kyo no fudo to keikan,* ed. Ritsumeikan University Department of literature, 28-47. Kyoto: SHIRAKAWA SHOIN. (J)

Katahira, H. 2012. *17 seiki kohan ni okeru kamogawa no kozui to teibo no kensetsu,* In *Kyoto no rekishisaigai.* Ed. Yoshikoshi, A and Katahira, H. 46-63, Kyoto: Shibunkaku. (J)

Kitagawa, H. and Matsumoto, E. 1998. Yakusugi nenrin no tanso doitaihi hendo kara suiteisareru kako 2000 nenkanno kikohendo. *Meteorological Research Notes* 191: 1-13. (J)

Kusakabe, M. 1977. 19 seikimatsu madeno Kinki chiho no kishosaigai. *Journal of Meterological Research* 29 :1-50. (J)

Kyoto Local Meteorological Office. 1951. *Kyoto kisho saigai nempyo*. Kyoto.(J).

Maejima, I. and Tagami, Y. 1986.Climatic change during historical times in Japan —Reconstruction from hazard records—. *Geographical Reports of Tokyo Metropolitan University* 21:157-171.

Marumoto, M. 2014. Hydro-climatological features in Nara and Kyoto basins —Year climatic analysis by Thornthwaite's method—. *Quarterly Journals of Geography (Kikan Chirigaku)* 66: 82-93. (JE)

Mizukoshi, M. 2014. *Kokiroku niyoru 11 seikino tenkokiroku.* Tokyo: Tokyodo Shuppan. (J)

Mizukoshi, M. 2012. *Kokiroku niyoru 12 seikino tenkokiroku.* Tokyo: Tokyodo Shuppan. (J)

Nara Local Meteorological Office. 1997. *Naraken no kisho hyakunen*. Nara (J).

Nara Prefecture, 2014. Yoshinogawa bunsui mizu tono tatakai —Yamatoheiya ni okeru samazamana kufu —. http://www.pref.nara.jp/dd.aspx?menuid=12078. (last accessed 16 January 2015), (J)

Nishikawa, Y. 1963. The Studies of history on disaster in Japan. *Journal of Japan Society of Engineering Geology* 9:129-136. (J)

Robert, B.H. 1932. The Yamato basin, Japan. *Annals of Association of American Geographer* 22:243-295.

Suzuki, M. 2003. *Motto shiritai mizu no miyako Kyoto.* Kyoto, Jimbunshoin. (J).

Suzuki, M. 2010. *Mizu ga kataru kyo no miyako no kurashi –densetsu, meisui, shoku no bunka-*. Kyoto, SHIRAKAWA SHOIN. (J).

Takahashi, M. 2012.*Kinse ni okeru Kyoto Kamogawa・Katsuragawa no suigai*, In *Kyoto no rekishisaigai*. ed.Yoshikoshi, A. and Katahira, H. 33-45, Kyoto: Shibunkaku. (J)

Tagami, Y. 2012. On the "Medieval climate anomaly" and climate instability around the end of 9th century. *Memoirs of the Faculty of Human development University of Toyama* 7 : 91-105. (JE)

Tagami, Y. 2013. Climate disaster and disaster prevention prayer, and Climate variation in ancient and medieval times. *The Historical Geography* 55(5):23-38. (JE)

The Civic Section of Tokyo Metropolitan Government. 1976. *Nihon no tensai chihen*. Tokyo (J)

Tsujita, U. 1961. Nara bonchi no chirigakuteki kenkyu, In *Nara bonchi*, ed. Nara Women's university department of geography, 12-27. Tokyo: Kokon Shoin. (J)

Yamamoto, T. 1976. *Kiko no kataru Nihon no rekishi*. Tokyo: Soshiete. (J)

Yamakawa, S. 1993. Natural disasters and climatic variations in Little ice age. *Journal of Geography (Chigaku Zasshi)* 102: 183-195. (JE)

Yoshino, M. 2009. Climatic change and human activities in the 4th to 10th centuries. *Journal of Geography (Chigaku Zasshi)* 118:1221-1236. (JE)

Yoshino, M. 2011. *Kodai Nihon no Kiko to Hitobito*. Tokyo: Gakuseisha. (J)

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