Examination of data range for fitting Omori-Utsu law to temporal decay of aftershocks presented in historical materials on the 1830 Kyoto earthquake: Reason for the difference of numbers of aftershocks in the same place

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We study the temporal decay of aftershock sequences of the 1830 Kyoto earthquake. Omori(1908) examined aftershock sequences including that of the 1830 Kyoto earthquake. Matsui and Oike (1997) attempted to determine epicenter of the 1830 Kyoto earthquake by using the number of felt aftershocks in time range from the main shock to the next morning in several observational areas including Kyoto. They used two different numbers as the number of felt aftershocks for Kyoto: 100 written in Banzai Rakki and 4 written in Tansui Nikki. In the case using the former number, they obtained the epicenter consistent with that obtained by Usami (1996). However, in the case using the latter number, they obtained an epicenter near the northern shore of the lake Biwa, and the epicenter is inconsistent with distribution of damage caused by the earthquake. They did not pursue the reason of the discrepancy between two numbers for Kyoto.

In order to solve the above mentioned discrepancy among the earthquake records for Kyoto, we include another record Tenpo Zakki in addition to Banzai Rakki.Both records show quite different numbers of daily aftershocks during several days, though they were written in the same place. Kitahara and Ohmura (2012) suggest that the original record was written by an officer in Nijo-jo Castle and was copied many times. They made a graph of temporal decay of daily numbers of aftershocks for a period of one month after the main shock. However, they made neither analysis of the aftershock sequences nor information evaluation of the records.

We examined carefully description of daily aftershocks in both records to know the reason for the differences of the numbers of felt aftershocks. The records show the sizes of earthquakes by the diameters of handwritten circles for each day. Comparing the diameter of standard circle for every day, we infer that writers of the records used different criterion to count the numbers of felt aftershocks.

We measure the diameter of standard circle for every day, and find the diameter changes with day. Fig.1 shows the daily variation of diameter of standard circle in the both records. The vertical axis shows the count threshold of circle diameter (arbitrary unit), and horizontal axis shows the date. Fig.1 suggests that the threshold count level used in Banzai Rakki is larger than that used in Tenpo Zakki. This result means that the number of counted aftershocks becomes smaller in Banzai Rakki than in Tenpo Zakki. The interpretation is consistent with the actual difference of the number of aftershocks in the both records. The threshold level for counting used in Banzai Rakki changes more rapidly with time than that used in Tenpo Zakki (Fig.1). Especially, the change of the threshold level from 7/3 to 7/5 is not negligible in Banzai Rakki.

The above information evaluation of the two records reveals the difference of the two records written in the same place. We fit Omori-Utsu law (Utsu, 1961) to the aftershock sequences after 7/5. We assume that the c value is 0.1 and the p values fall in about 1.2. We obtain a better fit in Tenpo Zakki (Fig.2). Our study may suggest that Tenpo Zakki may have better information quality than Banzai Rakki and the numbers of aftershocks after 7/5 should be used for study of the 1830 Kyoto earthquake.

Keywords: the 1830 Kyoto earthquake , aftershock sequence, Omori-Utsu law

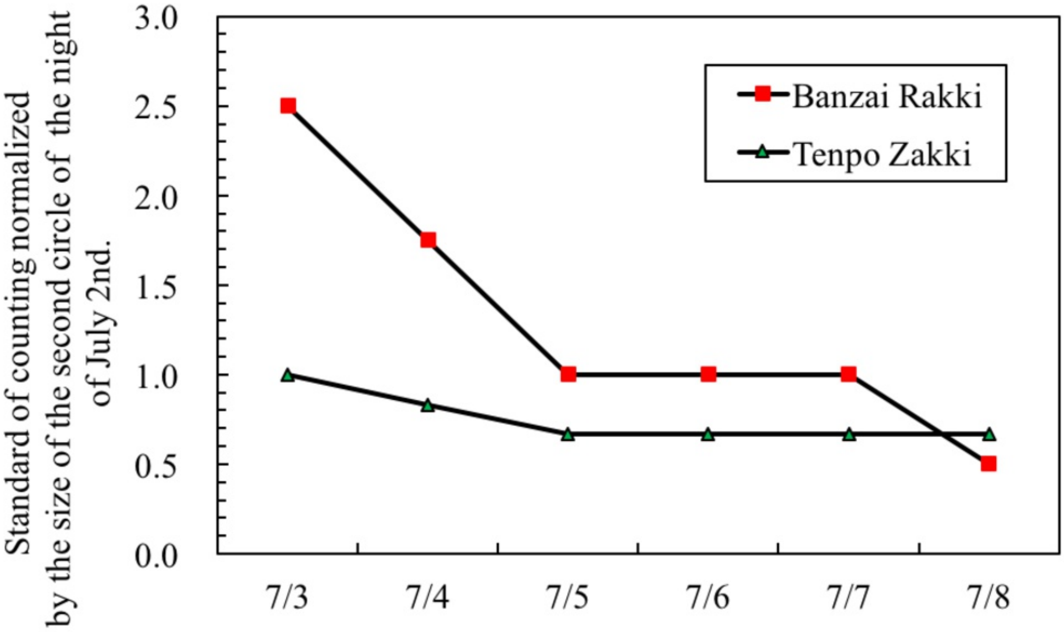

Fig.1 Comparison of two records

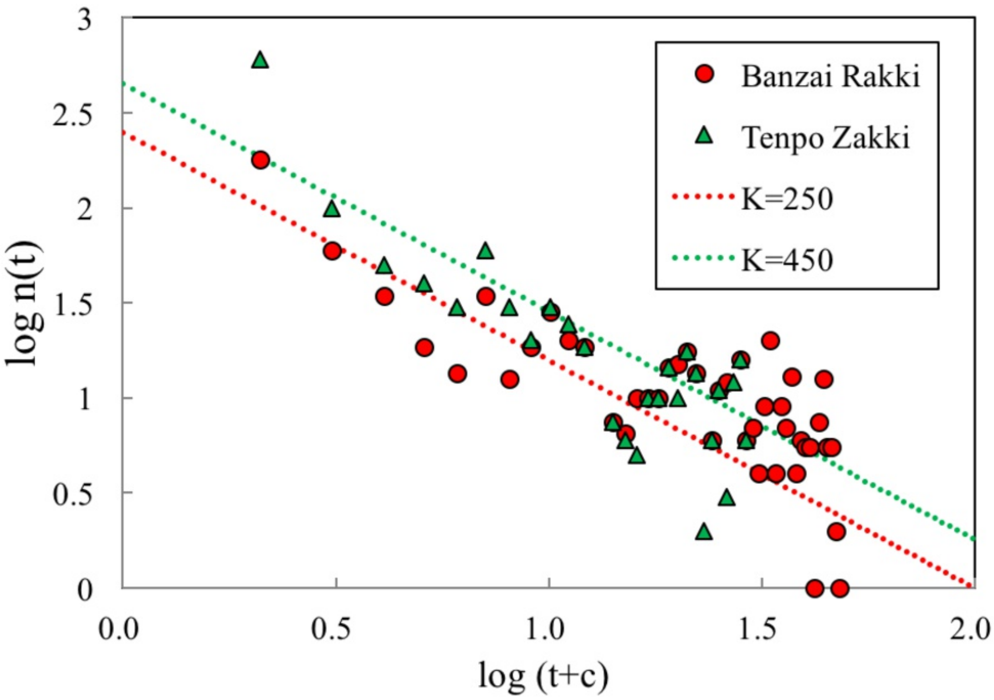

Fig. 2 Temporal decay of the aftershocks of the 1830 Kyoto earthquake with lines (p=1.2) from Omori-Utsu law (Utsu, 1961)