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S1. IntCal data

To search for high-energy phenomena that created a rapid ^{14}C content increase within a single year, we examined IntCal09 dataset[10], which is a 5-year time series describing the ^{14}C content of trees over a period of approximately ten thousand years. For the last 3000 years, only three periods in this time series show a rate of increase (change in the amount of ^{14}C content/time) larger than 3 ‰/10yrs, at approximately BC 675 to 655, AD 760 to 785, and AD 1790 to 1820 (Fig.S1a). These three periods may therefore record high-energy events, but their time resolution is low and measurements with higher resolution are necessary to confirm that the increase really happened on a one-year time scale. The ^{14}C contents for AD 1790-1820 (Fig.S1b)[11] and 675-655 BC[12] have already been measured with high time resolution, and these studies did not find rapid increases.

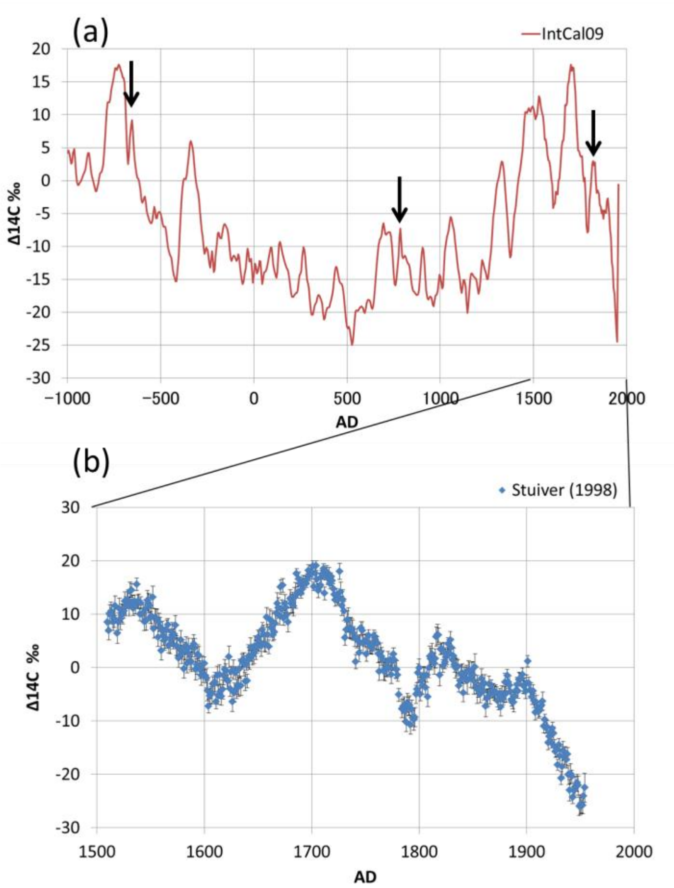

Figure.S1: (a) IntCal09 dataset of ^{14}C content covering the past 3000 years[10], each points representing a five-year interval. $\Delta^{14}C$ means permil (‰) deviation of $^{14}C/^{12}C$ ratio of a sample with respect to the modern carbon, after correcting for the age and isotopic fractionation (Stuiver and Polach, 1977)[30]. The variation of the ^{14}C content is caused by the change of the cosmic ray intensity, which is mainly modulated by the solar magnetic activity and geomagnetic field. The arrows indicate periods when the rate of increase was larger than 3[‰/10yrs]. (b) Annual $\Delta^{14}C$ data over the period AD 1510-1954, by Stuiver et al. (1998)[11]. Several of these data increase with one-year, but none at more than the 3σ significance level.

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S2. Values of $\Delta^{14}C$ data

Table.S1 shows values of $\Delta^{14}C$ on Japanese cedar trees from AD 750-820. We measured 2 times for samples of AD 750, 775, 777, 779, 780, 790, 792, 3 times for AD 774, 776, 778, and 5 times for AD 770, 772. Radiocarbon contents and their errors with multiple measurements were obtained as the weighted mean. Values of $\delta^{13}C$ are also shown. The values are given in ‰.

Table.S1 Values of $\Delta^{14}C$, error, and $\delta^{13}C$

	Tree-A			Tree-A			Tree-B			Resultant values	
AD	$\Delta^{14}C$	error	$\delta^{13}C$	$\Delta^{14}C$	error	$\delta^{13}C$	$\Delta^{14}C$	error	$\delta^{13}C$	$\Delta^{14}C$	error
750	-17.4	2.5	-21.4	-15.2	2.7	-22.5				-16.4	1.9
752	-16.0	2.5	-22.2							-16.0	2.5
754	-19.2	2.6	-22.5							-19.2	2.6
756	-20.1	2.6	-22.8							-20.1	2.6
758	-15.9	2.6	-21.6							-15.9	2.6
760	-16.0	2.6	-22.9							-16.0	2.6
762	-17.1	2.5	-21.8							-17.1	2.5
764	-18.8	2.6	-22.3							-18.8	2.6
766	-19.8	2.6	-22.4							-19.8	2.6
768	-13.5	2.6	-22.0							-13.5	2.6
770	-15.0	2.6	-22.3	-18.5	2.6	-21.8	-20.6	2.7	-21.9		
	-19.6	2.6	-23.0	-18.9	2.6	-21.8				-18.5	1.2
771							-21.7	2.7	-22.0	-21.7	2.7
772	-15.0	2.6	-21.4	-18.4	2.6	-21.6	-20.9	2.7	-21.7		
	-15.8	2.5	-20.7	-18.9	2.6	-22.0				-17.7	1.2
773							-23.2	2.8	-22.1	-23.2	2.8
774	-16.2	2.5	-21.6	-20.2	2.4	-21.6	-16.3	2.8	-22.2	-17.7	1.5
775	-6.0	2.4	-20.1				-5.5	2.8	-21.4	-5.8	1.8
776	-5.2	2.5	-21.0	-1.7	2.6	-20.6	0.3	2.8	-21.8	-2.5	1.5
777	-2.4	2.4	-20.8				-9.1	2.8	-21.3	-5.3	1.8
778	-1.5	2.4	-21.2	-5.6	2.6	-22.4	-7.8	2.8	-21.7	-4.7	1.5
779	-5.3	2.4	-20.2				-9.8	2.8	-21.4	-7.2	1.8
780	-8.6	2.6	-22.3	-3.7	2.4	-21.0				-6.0	1.8

782	-5.3	2.6	-22.5							-5.3	2.6
784	-7.9	2.6	-22.3							-7.9	2.6
786	-6.9	2.6	-22.2							-6.9	2.6
788	-10.9	2.6	-22.4							-10.9	2.6
790	-15.2	2.6	-22.3	-11.3	2.7	-22.0				-13.3	1.9
792	-13.3	2.6	-22.7	-14.5	3.2	-22.5				-13.8	2.0
794	-12.5	2.7	-22.7							-12.5	2.7
796	-10.5	2.6	-21.2							-10.5	2.6
798	-13.3	3.2	-21.7							-13.3	3.2
800	-12.3	2.6	-21.0							-12.3	2.6
802	-12.7	2.6	-20.9							-12.7	2.6
804	-8.9	2.7	-22.7							-8.9	2.7
806	-15.2	2.7	-21.5							-15.2	2.7
808	-14.2	2.7	-22.1							-14.2	2.7
810	-13.7	2.7	-21.8							-13.7	2.7
812	-15.9	2.6	-21.7							-15.9	2.6
814	-12.3	2.7	-21.9							-12.3	2.7
816	-12.2	2.6	-21.5							-12.2	2.6
818	-15.0	2.6	-21.3							-15.0	2.6
820	-17.4	2.6	-21.9							-17.4	2.6

S3. 4-Box carbon cycle model

Figure.S2 shows the 4-box carbon cycle model which is obtained by adding the stratosphere to the 3-box model (Nakamura et al., 1987[15]). We used following parameters; k_{ts}=1/3 [1/yr], k_{tb}=1/23 [1/yr], k_{tm}=1/11 [1/yr], N_s/N_a=0.15, N_t/N_a=0.85, N_b/N_a=2.52, N_m/N_a=2, $N_a=N_t+N_s$. Where, N indicate the total amount of ^{12}C. Subscripts t, s, b, and m represent troposphere, stratosphere, biosphere, and surface ocean water, respectively. The transfer coefficient of carbon from one reservoir (i) to another (j) is indicated as k_{ij}, and the mean residence time as $\tau_{ij} = 1/(k_{ij})$.

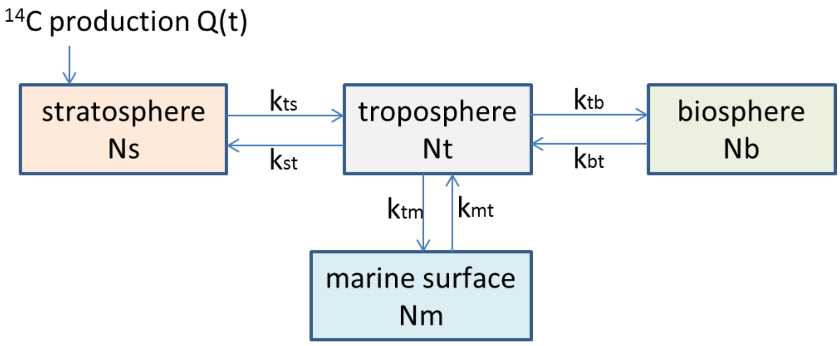

Figure.S2 4-box carbon cycle model

S4. Production rate of ^{14}C

Table.S2 shows the production rate of ^{14}C and the *reduced* χ-square value (DOF=16) for simulations of the change in $\Delta^{14}C$ with various values of input period corresponding to Fig.2.

Table.S2 Production rate of ^{14}C and the *reduced* χ-square value

Input period [yr]	Production rate [atom cm^{-2} s^{-1}]	*reduced* χ-squared value
0.1	1.9×10^{2} ($\pm4\times10^{1}$)	0.96
0.5	3.9×10^{1} (±7)	0.96
1	1.9×10^{1} (±4)	0.96
2	9.8 (±2)	1.1
3	6.6 (±1)	1.6

S5. Discussions about the cause of 775 event

S5-1 SN explosion

According to Menjo et al.(2005), SN1006 and SN1054 were not detected by ^{14}C method. The unextincted peak apparent magnitude of these supernovae are estimated from -4 to -9 [18], corresponding brightness we can see even during daytime. More details of these SN are listed in table.S3. Since we detected AD 775 event by ^{14}C, its apparent magnitude must be brighter than SN1006 and SN1054. Then historical documentation should have recorded AD 775 event, however there are no such record for our present knowledge (European and Chinese SN records[31], comet lists[32,33], and auroral reports[34]). However, there is a historically unrecorded SNR (Cas-A; estimated to have occurred ~300 years ago). And furthermore, the remaining historical documentation from 8th century is poor, then we cannot exclude SN as a cause of AD 775 event.

Next, although we looked at a catalogues of nearby SNR searched by X-ray and radio (catalog by Green[35] and Chandra X-ray[36]), there is no remnants corresponding to SN775. However, Vela Jr. which is SNR and is not whomping bright in X-ray and radio has been found by ^{44}Ti line recently[19,20,21]. This SNR is estimated to have a distance of some hundreds pc and an age of 10^3-10^4 years old. For these reason, we cannot exclude that cause of AD775 is Vela Jr. or other undetected SNR.

Table.S3 Information of SN1006 and SN1054 (Crab)[18]

Supernova	Year (AD)	Distance (kpc)	Peak visual magnitude	Type
SN1006	1006	2.0	-9.0	Ia
Crab	1054	2.2	-4.0	Core-collapse

S5-2 Comparison of ^{14}C with ^{10}Be

A 12‰ increase of $\Delta^{14}C$ in one year due to an SPE corresponds to a 80-200% increase in the ^{10}Be production rate over 30 years[5]. The variation in ^{10}Be in Dome Fuji[14] is too small to be explained by the same AD 775 SPE event. However, this estimate is based on the measured SPEs (SPE1956, 1989 or SPE average over the last decades), of which the hardest energy spectrum is that of 1956 SPE. If the cause of the AD 775 event was an SPE, its spectrum should be much harder than that of the 1956 SPE. In this case, the increase in ^{10}Be production should have been less than 80% since the production rates of ^{14}C and ^{10}Be are different due to the energy spectrum of the SPE. Thus, we cannot quite exclude an SPE as the explanation for the increase in $\Delta^{14}C$ from analysis of the ^{10}Be record.

S6. Methods

Two Japanese cedar trees (*Cryptomeria japonica*) from Yaku Island in southern Japan were used for this study. Each tree ring was absolutely dated by dendro-chronology, which is based on matching the pattern of ring widths to a known standard. Consecutive single-year rings from AD 750 to 820 for Tree A and from AD 770 to 779 for Tree B were prepared for ^{14}C analysis with accelerator mass spectrometer (AMS). Each annual ring was carefully sliced to separate it from the others. Alpha-cellulose, which does not move between annual rings, was extracted from each sample using the following method: (1) washing with distilled water in an ultrasonic bath; (2) soaking in HCl, NaOH and HCl solutions (Acid-Alkali-Acid treatment); (3) bleaching with hot $NaClO_2$/HCl; and (4) washing with boiling distilled water.

The treated material was then combusted with CuO in vacuum to CO_2. The produced CO_2 was purified with cold traps and was graphitized by hydrogen reduction with an iron catalyst in a vacuum line. We measured the ^{14}C content in the graphite target using an AMS system at Nagoya University.

Since AMS provides a relative measurement, standard samples (NIST SRM4990C oxalic acid, the new NBS standard) were measured in the same batch. Blank samples were also measured to determine the ^{14}C background (commercial oxalic acid was obtained from Wako Pure Chemical Industries). Six NIST standard samples and two blank samples were used for this purpose. The standard deviation of the six NIST standard samples was consistent with the statistical error. The concentration of ^{14}C is expressed as $\Delta^{14}C$, which means permil (‰) deviation of $^{14}C/^{12}C$ ratio of a sample with respect to the modern carbon, after correcting for the time passed from tree-ring formation to ^{14}C measurements and for carbon isotopic fractionation[30]. The typical precision of $\Delta^{14}C$ in a single measurement is 2.6‰.

References

[31] Stephenson, F.R. & Clark, D.H. Historical Superovas. *Scientific American*, **234**, 100-107 (1976).

[32] http://cometography.com (G.W. Kronk's Cometography Web Site).

[33] Parkenier, D.W., Xu, Z., & Jiang,Y. Archaeoastronomy in East Asia : Historical Observational Records of Comets and Meteor Showers from China, Japan & Korea. Cambria Press (2008).

[34] U. Dall'Olmo. An additional list of Auroras from European sources from 450 to 1466 A.D. *J. Geophys. Res.,* **84**, 1525-1535 (1979).

[35] Green, D.A. A revised Galactic supernova remnant catalogue. *Bull. Astr. Soc. India*, **37**, 45-61 (2009).

doi:10.1038/nature11123

[36] http://hea-www.harvard.edu/ChandraSNR/snrcat_gal.html (Chandra Supernova Remnant Catalog).