Characterization and evolution of global Xe background between 2016 and 2018

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ABSTARCT

Monitoring atmospheric radioxenons is essential for confirming an underground nuclear weapon test. Accordingly, it is crucial to the international monitoring system (IMS) of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) to monitor radioxenon worldwide. Four of the xenon isotopes are of interest for CTBT verification; ^{131m}Xe, ^{133m}Xe, ^{133}Xe and ^{135}Xe. In a nuclear explosion, the four isotopes are produced in sufficient quantities and have half-live times long enough to allow an appreciable amount to travel and reach IMS radioxenon stations. Therefore, understanding the Xenon background at the IMS stations is important to CTBT verification process. In this work, a comparative study between the global radioxenon background in 2016, 2017 and 2018 is conducted to determine the evolution of Xe background for all the available IMS stations. The stations with pronounced changes in its Xe background were identified and the ratios between different Xe isotopes were calculated and analyzed.

XENON BACKGROUND

Table 1: Four Xe isotopes measuring frequency and the categories in 2016, 2017 and 2018.

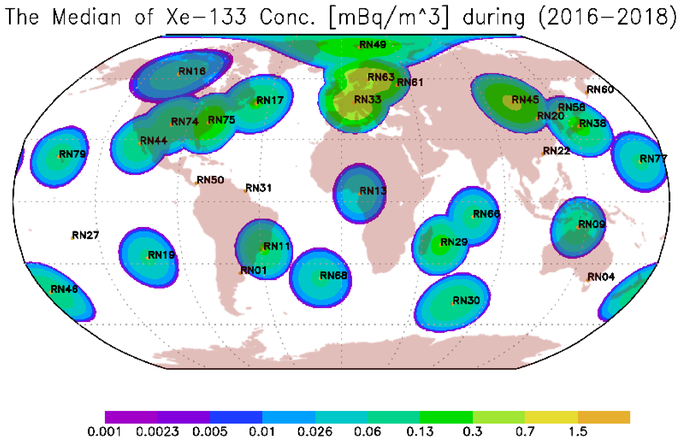
- Total Number of samples: 37747

		2016	2017	2018	Total
133	cat. B	2174	2168	1989	6331
	cat. C	200	281	252	733
131m	cat. B	889	1158	958	3005
	cat. C	6	67	10	83
133m	cat. B	586	654	685	1925
	cat. C	1	3	7	11
135	cat. B	319	383	419	1121
	cat. C	2	4	2	8
Abnormal Val.		340	608	475	1423
Cat. C		303	502	419	1224

Table 2: Simultaneous measurement of different Xe isotopes in 2016, 2017 and 2018

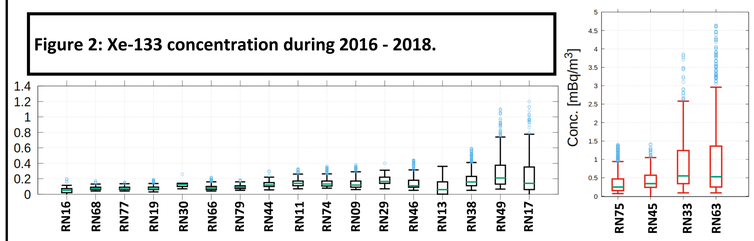
	2016	2017	2018	Total
131m,133m,133,135	5	12	7	24
131m,133m,133	69	147	124	340
131m,133,135	17	33	26	76
131m,133m,135	19	27	36	82
133m,133,135	21	34	11	66
Total	131	253	204	588

Figure 1: The geographical distribution of the median value of Xe-133 from 2016 to 2018



Evolution of XENON BACKGROUND

Figure 2: Xe-133 concentration during 2016 - 2018.



- Most of stations have lognormal distribution.
- The geographical distribution of the median value of Xe-133 concentration is consistence with the distribution of nuclear facilities (nuclear power plants, and medical isotopes facilities).

Figure 3: The geographical distribution of the change in the median value of Xe-133 concentration: from to 2016 to 2017

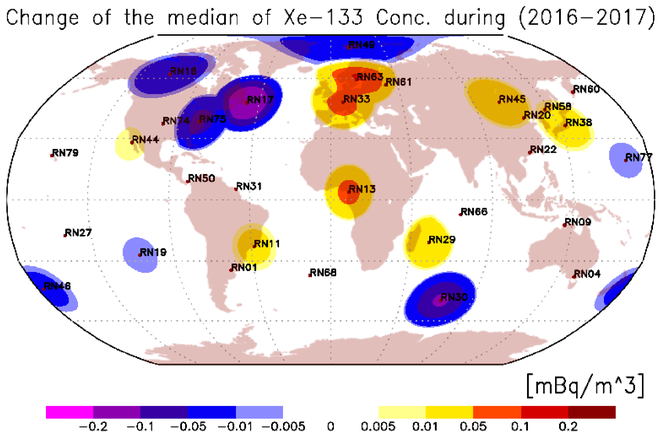
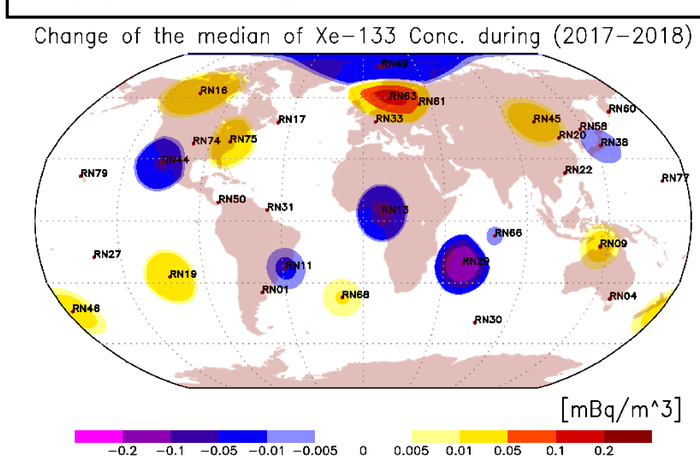


Figure 4: The geographical distribution of the change in the median value of Xe-133 concentration from to 2017 to 2018



Xe-Isotopic Graph

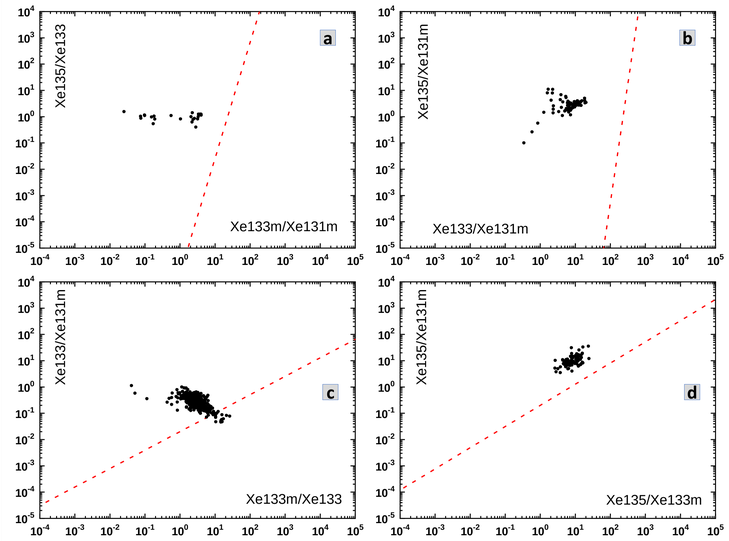


Figure 5:
a) Four Xenon isotopes ratios.
b) Xenon ratios without Xe-133m.
c) Xenon ratios without Xe-135.
d) Xenon ratios without Xe-133.

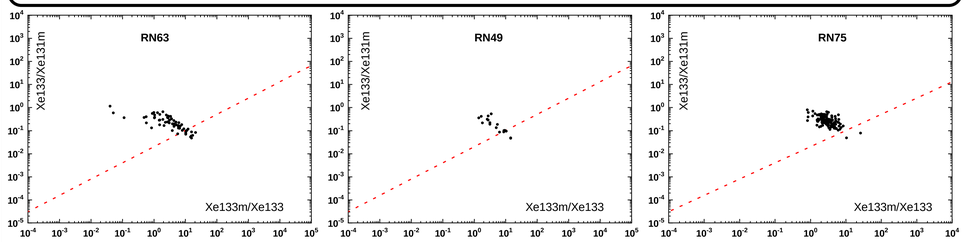
Xenon isotopic ratios are calculated and the separation line between the nuclear explosion regime and civil regime is drawn according to Kalinowski[1].

- All the alarm events (below separation line) are in Figure 3c. Kalinowski[2] indicated that there are some events under separation lines, which are related to nuclear reactors. These exceptional events may happen during the refuel process or new fuel cycle.

Table 3: All 22 alarm events in Figure 5c.

Year	2016	2017	2018
Events	6	6	10
RN63	2	4	7
RN49	3	1	2
RN75	1	1	0
RN46	0	0	1

Figure 6: Xenon isotopes ratios between Xe-133/Xe131m and Xe133m/Xe133 for RN63, RN49 and RN75 IMS stations.



References:

1- M. B. Kalinowski and C. Pistner. Isotopic signature of atmospheric xenon released from light water reactors. Journal of Environmental Radioactivity, 88(3):215–235, 2006.

2- M. B. Kalinowski and et al. Discrimination of Nuclear Explosions against Civilian Sources Based on Atmospheric Xenon Isotopic Activity Ratios. Pure and Applied Geophysics, 167(4-5):517–539, 2010.

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