EGU22-1490
Session NH10.15
Vienna, Austria & Online | 23-27 May 2022

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CTBTO PREPARATORY COMMISSION | COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION

Frequency of radionuclides in remote atmospheric observations of historic nuclear test explosions compared to lists of radionuclides considered for nuclear explosion monitoring

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Overview

Input data:

- Publications on remote atmospheric observations of historic nuclear test explosions conducted between 1964 and 1996.

Method:

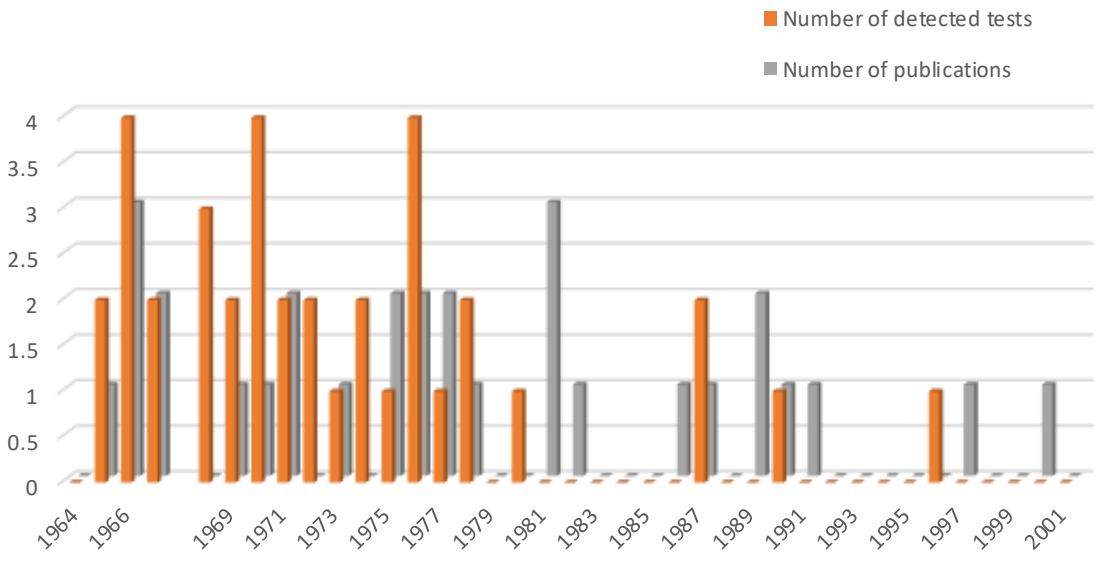
- Determine the frequency of observed radionuclides and compare it with several radionuclide lists considered for nuclear explosion monitoring.

Objective:

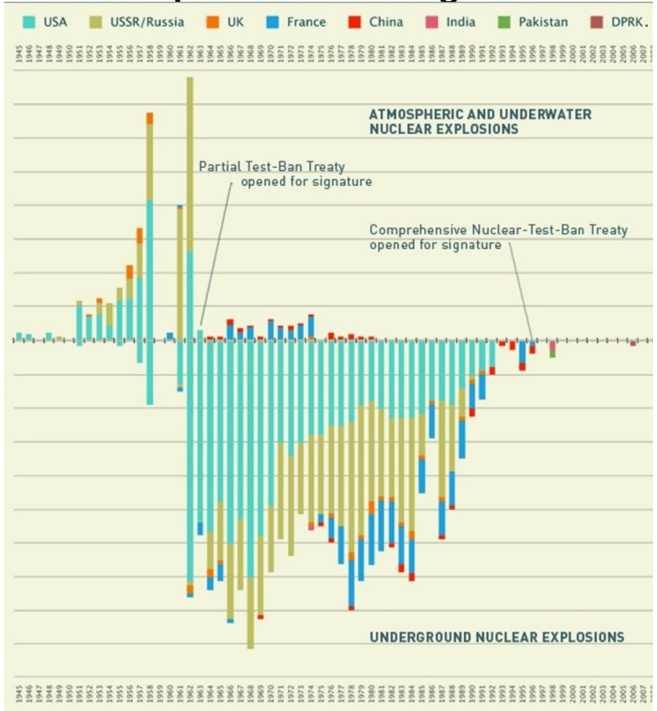
- Identify opportunities for validating monitoring methods to identify the source of an event relevant for the Comprehensive-Nuclear-Test Ban Treaty (CTBT).

Statistics on time of historic tests and publications

Number of tests per year that were detected (in total: 35) *and* Number of publications (in total: 30)



All atmospheric and underground tests



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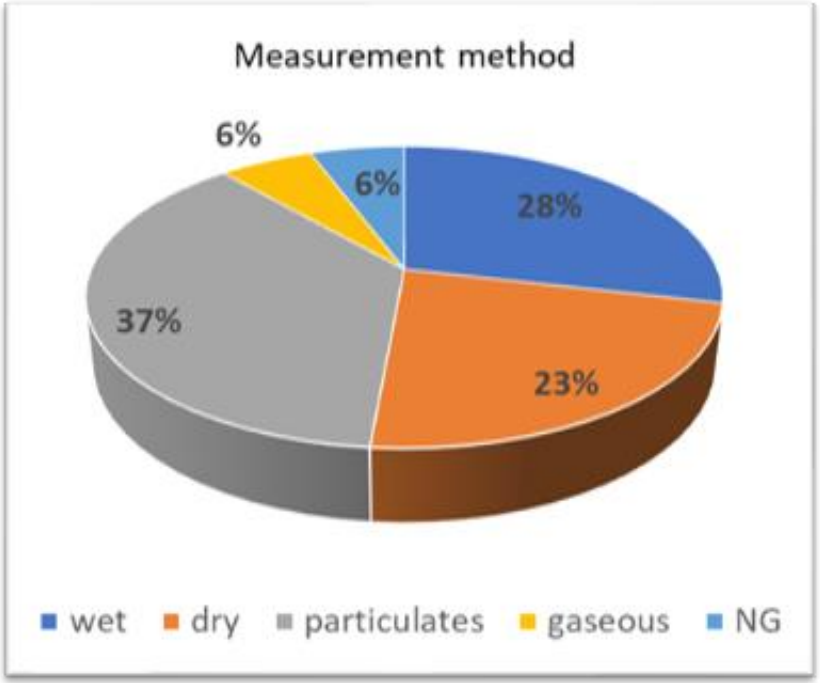
Statistics on time of historic tests and publications

Measurement Methods:

1. Wet deposition like rain and snow (isotope identification)
2. Dry deposition like swipe sampling (isotope identification)
3. Particulate filters (air concentration)
4. Gaseous samples (isotope identification)
5. Noble gas sampling (air concentration)

Methods 3 and 5 are applied in the IMS.

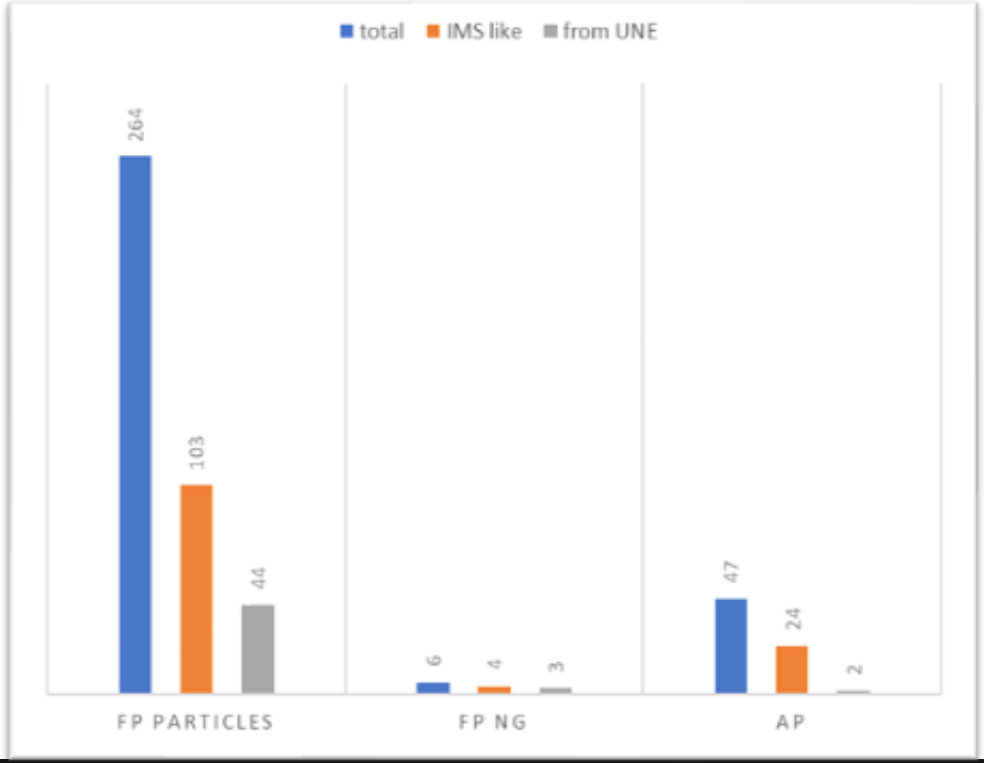


For more detail about the historic publications see presentation of M. Kalinowski at CTBT: Science and Technology Conference 2021: https://conferences.ctbto.org/event/7/contributions/1007/

Statistics on time of historic tests and publications

Detected isotopes

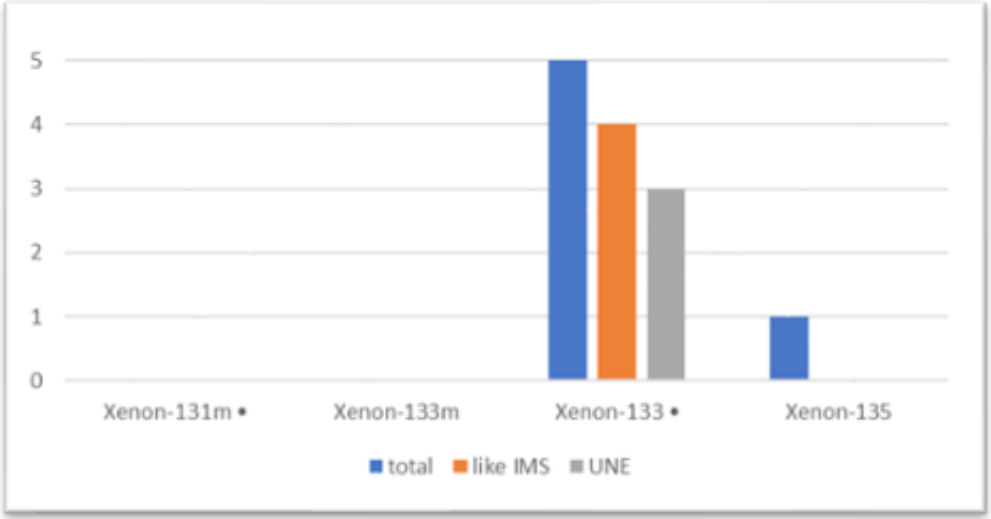
- The historic observations are mainly particle born radionuclides in filter samples.
- Only in six cases, radioxenon was reported.
- Most of the radionuclides in filter samples are fission products, some are activation products.



Statistics on time of historic tests and publications

Detected radioxenon isotopes

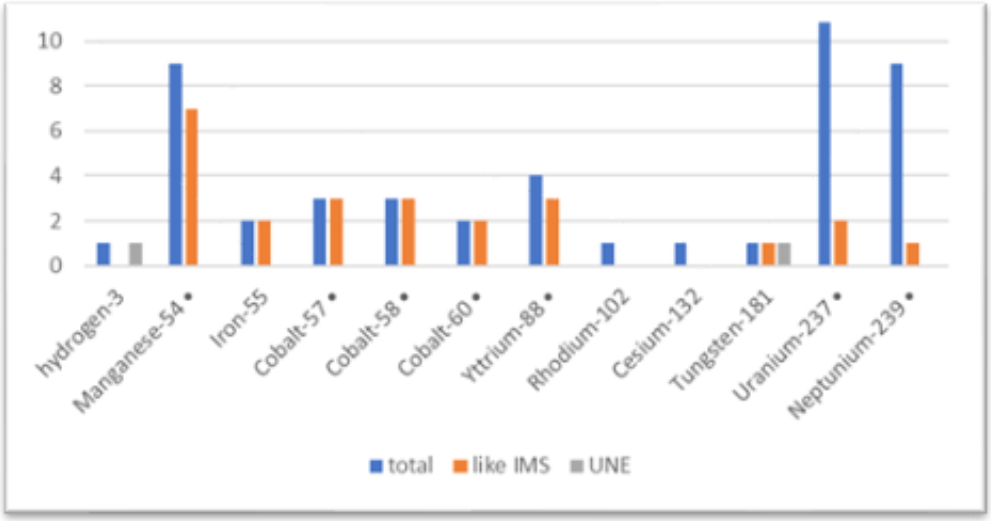
- In six cases, radioxenon was reported, but only four cases were noble gas samples like in the IMS.
- Mainly Xe-133 was observed alone.



Statistics on time of historic tests and publications

Detected particle-born radionuclides that are not fission products

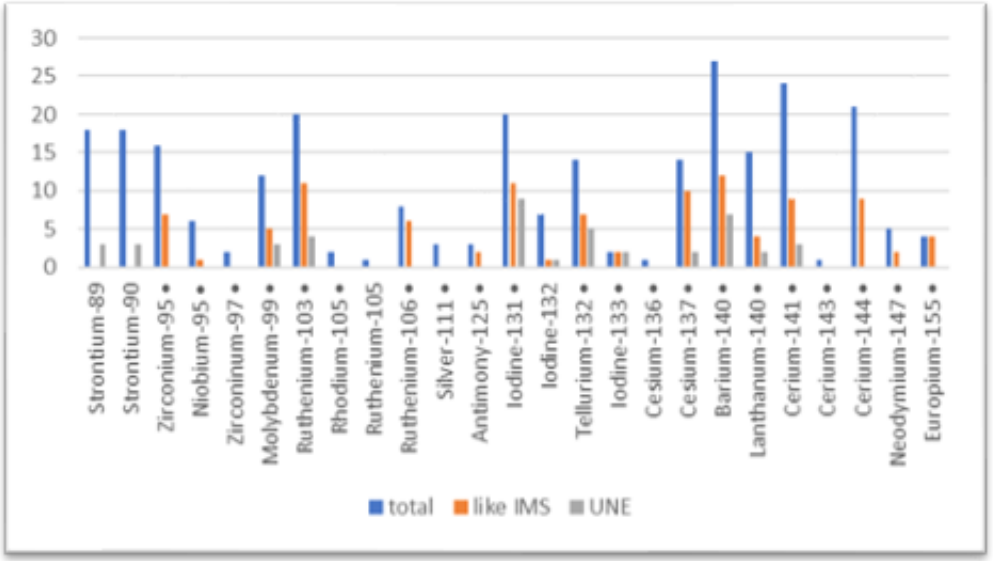
- Nine different activation products were reported in IMS like filter samples.
- The most frequently found activation product is manganese-54.



Statistics on time of historic tests and publications

Detected fission products

- 17 different fission products were reported in IMS like filter samples.
- The most frequently found fission product is barium-140.



Check observation frequency against radionuclide lists

Radionuclide lists considered for nuclear explosion monitoring:

1. CTBTO (2001): CTBT-relevant radionuclides for sample categorization
2. De Geer (2001): CTBT-relevant radionuclides according to model and experience
3. Miley et al. (2001): Likelihood of detecting radionuclides at IMS stations and laboratories
4. Matthews (2005): 20 fission products and 3 fuel products with verification significance

Rank in frequency of observations by the IMS

Check observation frequency against radionuclide lists

Radionuclide lists considered for nuclear explosion monitoring:

1. CTBTO (2001): CTBT-relevant radionuclides for sample categorization

All 17 historically observed fission products in IMS-like samples are included in the CTBTO list of relevant radionuclides.

All but one of 9 activation products in IMS-like samples are included as well.
Not included is Fe-55.

2. De Geer (2001): CTBT-relevant radionuclides according to model and experience

Same as above because CTBTO (2001) was mainly derived from De Geer (2001).

Check observation frequency against radionuclide lists

Radionuclide lists considered for nuclear explosion monitoring:

3. Miley et al. (2001): Likelihood of detecting radionuclides at IMS stations and laboratories
   Ru-103, Sb-125 Eu-155 do not appear
   Ru-106, I-131, I-132, I-133 appear in the list of isotopes to be detected in the laboratory
   no activation products considered

4. Matthews (2005): verification significance
   Ru-106, Sb-135, Cs-137, Eu-155 do not appear
   U-237 and Np-239 appear as fuel products
   but no activation products considered

Check observation frequency against radionuclide lists

Rank in frequency of the 25 radioisotopes most frequently seen by the IMS

Fission products

Nb-95:	17	Xe-131m:	2
Tc-99m:	12	Xe-133m:	4
I-131:	7	Xe-133:	1
I-132:	14	Xe-135:	6
I-133:	18		
Cs-137:	5		
Ba-140:	23		
La-140:	15		

Activation products

Mn-54:	19
Co-60:	9

Summary

Results in comparing the radioisotopes detected from historic nuclear tests with

1. Radionuclide lists considered for nuclear explosion monitoring:

- CTBTO (2001) and De Geer (2001): include all isotopes except Fe-55 that were reported from historic tests
- List of radioisotopes that are reduced to put focus on most significant radioisotopes are missing several ones that were actually observed following nuclear tests

2. Rank in frequency of the 25 radioisotopes most frequently seen by the IMS

- 14 of the most frequently observed radionuclides were observed in debris from nuclear tests.
- The four radioxenon isotopes are among the top 6 most frequently observed isotopes while being the most likely ones to escape from underground nuclear tests.

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